

Power Products Guide

Installation and Operation Guide



Part #60-9003-092
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Revision T, November 2017

Foreword

This instruction manual is designed to help you gain a thorough understanding of the operation of the equipment. Teledyne Isco recommends that you read this manual completely before placing the equipment in service.

Although Teledyne Isco designs reliability into all equipment, there is always the possibility of a malfunction. This manual may help in diagnosing and repairing the malfunction.

If a problem persists, call or e-mail Teledyne Isco technical support for assistance. Simple difficulties can often be diagnosed over the phone. For faster service, please have your serial number ready.

If it is necessary to return the equipment to the factory for service, please follow the shipping instructions provided by technical support, including the use of the **Return Material Authorization (RMA)** specified. **Be sure to include a note describing the malfunction.** This will aid in the prompt repair and return of the equipment.

Teledyne Isco welcomes suggestions that would improve the information presented in this manual or enhance the operation of the equipment itself.

Teledyne Isco is continually improving its products and reserves the right to change product specifications, replacement parts, schematics, and instructions without notice.

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Power Products Guide

Section 1 Introduction

1.1 Overview

This guide provides information about the power sources that are available for Isco products.

Teledyne Isco offers rechargeable lead-acid and nickel-cadmium batteries, and also makes power supplies that convert 120 volt AC power to 12 volts DC. This guide provides information about the rechargeable batteries and descriptions of the AC power packs.

Some power products have manuals of their own. Those products are shipped with their own manuals. Products that have their own manuals are discussed only briefly here.

1.2 Model Numbers

Teledyne Isco has assigned **model numbers** to most power products. The three-digit model numbers start with *9XX*.

- The **910 series** are 120-volt high capacity power packs and battery-backed power packs:
 - **Model 913**–High Capacity Power Pack, 120 VAC
 - **Model 914**–Battery Backed Power Pack, 120 VAC
- The **920 series** are 240-volt high capacity power packs and battery-backed power packs.
 - **Model 923**–High Capacity Power Pack, 240V
 - **Model 924**–Battery Backed Power Pack, 240V
- The **930 series** are rechargeable nickel-cadmium batteries.
 - **Model 934**–Nickel-Cadmium Battery 12V, 4.0 Ah
Note that “Ah” stands for ampere-hours, the standard rating that battery manufacturers use to describe battery capacity. (See Section 2 for a more thorough description.)
- The **940 series** are sealed rechargeable lead-acid batteries.
 - **Model 946**–Lead-Acid Battery 12V, 6.5 Ah
 - **Model 947**–Lead-Acid Battery 12V, 6.5 Ah (for the 4100 Series Flow Loggers)
 - **Model 948**–Lead-Acid Battery 12V, 55 Ah
- **Solar panels** are used to charge Isco lead-acid batteries.
- The **960 series** are battery chargers.
 - **Model 961**–Wall Charger for Nickel-Cadmium Batteries - 120 VAC, 400 mA output

- **Model 963**–Desktop Single Station Lead-Acid Battery Charger - for lead-acid batteries, 120 or 230 VAC
- **Model 965**–Five Station Battery Charger - for one to five lead-acid or nickel-cadmium batteries, 120 or 240 VAC.

1.3 Compatibility of Batteries and Chargers

Refer to Table 1-1 below to check the compatibility of various Isco batteries and chargers.

| Table 1-1 Battery/Charger Compatibility | | | | |
|--|-------------------------|------------|-----|-----|
| | Model of Battery | | | |
| Model of Charger | 934 | 946 | 947 | 948 |
| Solar Panel | | n | n | n |
| 961 | n | | | |
| 963 | | n | n | |
| 965 | n | n | n | |
| Automatic Charger | | | | n |
| Model of Power Pack | | | | |
| 913 | n | o | | |
| 914 | no charger | no charger | | |
| 923 | n | o | | |
| 924 | no charger | no charger | | |
| n Recommended | | | | |
| o Possible when following the instructions printed on the side of the battery. | | | | |

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Section 2 Batteries

2.1 General Information

Teledyne Isco offers two different batteries for use with its equipment. Both batteries fit inside of or on top of Isco equipment and fasten to the equipment with rubber draw catches. Both have advantages and disadvantages. The choice is ultimately up to you.

The most common battery is the **Isco Model 934 Nickel-Cadmium Battery**, which is described in Section 2.2. Each cell in the nickel-cadmium battery provides 1.2 VDC and has a capacity of 4 ampere-hours (Ah). It takes ten of these cells connected in series to make a battery of 12 volts. The cells are packaged in an environmentally-sealed plastic housing, supplied with a cable and two-pin M/S connector, and provide 12 volts DC.

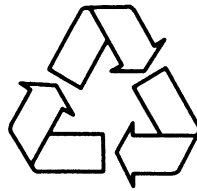
Also available is the **Isco Model 946 Lead-Acid Battery**, described in Section 2.3. This battery is a six-cell, plastic-cased, 6.5 Ah, gelled-electrolyte type, supplied with a connector. It delivers 12 volts. A lead-acid cell provides 2.2 volts, so six are required for 12 volts. These batteries are popularly known as **gel-cells**.

2.1.1 Battery Recycling and Disposal

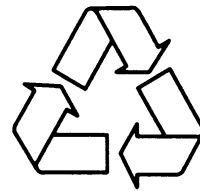
Batteries of all types are a significant source of toxic and environmentally hazardous materials, primarily heavy metals. The disposal of lead-acid, nickel-cadmium, and alkaline batteries in landfills every year represents a growing threat to the environment. Legislation requiring the recycling and/or proper disposal of rechargeable batteries has been passed in most states.

Because the laws vary from state to state, and in each locality, it is your responsibility to find out how to recycle or dispose of these products properly.

Since July 1, 1993, we have labeled all equipment containing batteries with the three-arrow recycling logo and the type of battery (**Ni-Cd** [nickel-cadmium] or **Pb** [lead-acid]).



Ni-Cd



Pb

The product you have purchased contains a rechargeable battery. This battery is recyclable. Disposal of this battery at the end of its useful life in the municipal waste stream may be illegal, depending on the laws of your state or locality. Check with solid waste officials in your area for information on recycling options or proper disposal.

2.1.2 Battery Ratings (Ampere-Hours)

Battery manufacturers rate the capacity of batteries in **ampere-hours**, (availability of current over time). Typically, manufacturers rate battery capacity at a certain current over a specific period of time. The product of this value is the **ampere-hour rating** of the battery.

Typical ratings for the discharge of nickel-cadmium batteries are over **10 hours** and for lead-acid batteries are over **20 hours**. As a result, a rating of 4 or 6.5 ampere-hours for a battery does **not** mean you can draw 4 or 6.5 amperes from the battery for one hour. The actual amount at the one-hour rate is typically **one-half** the “rated” capacity of the battery, or less. To determine the actual battery rating, you must take the nominal capacity (**4 or 6.5 ampere-hours**) and divide it by **10 or 20**, depending on the battery type.

In the case of the Model 934 Nickel-Cadmium Battery, you use a figure of **0.4**, and for the Model 946 Lead-Acid Battery you will use **0.325**. Customarily, currents below 1.0 ampere are expressed in milliamperes (**mA**). This means you can expect to discharge the nickel-cadmium battery at **400 mA** for 10 hours. You would expect to discharge the lead-acid battery at **325 mA** for 20 hours.

Battery manufacturers provide curves in their literature showing the discharge rates in percentages of “C,” which stands for **rated capacity in ampere-hours (Ah)**. If you discharge the battery at rates greater than the 20-hour rate, you can draw more current, but for a **considerably** shorter time; that is, the value of time multiplied by current will amount to **much less** than “C.” For more than 20 hours, you can draw less current for a longer time.

For times beyond 20 hours, the product of current and time will amount to **more** than “C,” at least, up to a point. The value of “C,” or more likely a percentage of it, is also used to describe the proper charging current for a battery.

“C” is useful for determining how long you can power an Isco instrument from a particular battery. Teledyne Isco provides average current consumption figures for most equipment. You can use these figures as a rough estimate to calculate the expected life of a battery connected to that equipment.

2.1.3 Determining Life Expectancy of Charge

In this example, a flow meter has an average current draw of 26 mA. We want to power it with an Isco Nickel-Cadmium Battery. The battery has a capacity of 4.0 Ah. First, convert 4.0 Ah into 4,000 mA-h (milliampere-hours). Then divide 4,000 mA-h by 26 mA. The result is 153.8 hours. Dividing 153.8 by 24 (hours/day), we get 6.41, or almost 6¹/₂ days. Note that you convert the battery ampere-hour rating to milliampere-hours to make the rating match the equipment current rating, which is in milliamperes. If you prefer, you could leave the battery value in ampere-hours and convert the flow meter current rating from 26 mA to 0.026 amperes.

If you want to use the Isco Lead-Acid Battery, you would convert the ampere-hour rating from 6.5 A-h to 6,500 mA-h, and divide that by 26 mA to get 250 hours. Dividing 250 by 24, we get 10.4 days.

Note that the figures given for current consumption for various Isco products are **average** figures based on very specific operating conditions (for flow meters), such as a bubble rate of one bubble per second and a chart advance rate of one inch per hour. If you set the chart advance faster, or increase the bubble rate, the current consumption will increase.

In the same way, current consumption for a sampler depends on how often the unit takes a sample. That will vary widely from one sampling program to another. Note that the current figures supplied are **average currents**, meaning that when the plotter or the pump run, **peak current** consumption will be considerably greater.

The important issue here is to be aware that current consumption for your equipment will depend largely on your programming choices. Teledyne Isco cannot guarantee a specific current consumption for a product, because programming flexibility has so great an effect on it. You may have to experiment for some time to match the battery life expectancy with your programming choices.

2.1.4 Charged and Discharged Cell Voltages

When fully charged, a nickel-cadmium battery tests **1.2 to 1.3 volts** per cell. A lead-acid battery shows **2.2 to 2.3 volts** per cell. A nickel-cadmium cell is considered fully discharged below **1.0 volt**. A lead-acid battery is considered fully discharged at **1.75 volts** per cell. Both values are at normal (room) temperatures. You can see from these figures that a “dead” battery will not really be dead, with both batteries showing at least 10 volts left in them. Why not discharge this capacity to zero?

The answer lies in the fact that batteries are chemical in nature. Chemical reactions inside the cells provide the source of electricity. Discharging a battery to zero volts risks having either of two serious things occur. One is damage to the cell's plates from **depletion** of the active elements; the other is **cell reversal**. Because no two cells in a battery are identical, discharge occurs at different rates inside each cell. One cell usually reaches depletion before the others. If you continue to try to draw power from the battery, the cells with remaining capacity will **force**

current through the cell, in effect, charging it backwards. This amounts to the electrical reversal of the two poles of the cell, and can ruin either type of battery.

In nickel-cadmium batteries, cell reversal causes gas generation, and that may force the vents to open. In lead-acid batteries, the reversed cell presents a high resistance to the rest of the circuit, making recharging difficult. Finally, while the battery may show nearly full terminal **voltage**, there is, in fact, very little **current** capacity left in it.

2.1.5 Self-Discharge of Batteries

Self-discharge is the characteristic of all batteries that makes them run down completely over time, even though there is no load attached. Self-discharge is the result of inevitable chemical reactions occurring inside the cell. This characteristic is more serious in some types of batteries than others.

Nickel-cadmium and the newer nickel-hydrate batteries have **poor** charge retention. Loss of as much as **1% per day** of remaining charge has been reported. On the positive side, complete self-discharge of nickel-cadmium batteries does not permanently harm them. **Alkaline** (primary) cells, (**not** rechargeable) have **very good** charge retention, keeping most of their charge for several years at moderate (room) temperatures. **Lithium** batteries, also nonrechargeable and often used for memory backup, have **excellent** charge retention, as long as **ten** years. **Lead-acid** batteries have **good** charge retention, retaining about 50% of capacity after one year when stored at room temperature. However, you should never allow a lead-acid battery to self-discharge completely. Unlike the nickel-cadmium battery, complete self-discharge will generally **ruin** a lead-acid battery.

Because chemical reactions cause self-discharge, temperature has an effect. Avoid storing batteries in hot environments. The rate of chemical reaction **doubles** for every 10° C increase in temperature. Finally, note that the rate of self-discharge tends to increase as the batteries age, especially for nickel-cadmium types, while their ampere-hour capacity usually diminishes.

2.2 Model 934 Nickel-Cadmium Battery

The **Isco Model 934 Nickel-Cadmium Battery** is the most popular battery for Isco equipment. This battery offers advantages over other types of batteries, particularly lead-acid types. The number of charge/discharge cycles is quite high, as many as 500 or more, according to one manufacturer. A nickel-cadmium battery can stay discharged indefinitely, even at very low temperatures, without sustaining damage. This condition would ruin a lead-acid battery.



Figure 2-1 Model 934 Nickel-Cadmium Battery

The battery has an internal fuse, rated at approximately 50 amperes, to prevent the possibility of fire or burns in the event of a short circuit. If the internal fuse link blows, you will have to return the battery to the factory for repair.

 **CAUTION**

Do not test these batteries for charge by “sparking” the output, and be extremely careful putting meter probes inside the output connector. Any accidents resulting in a shorted output will damage the battery in less than three seconds.

One battery manufacturer states that the short-circuit discharge rate from a fully-charged nickel-cadmium battery can be as much as **50 to 100 times “C.”** For the Isco Model 934 Battery, this could be from **200 to 400 amperes** of discharge current. Usually, the resistance of the wires prevents so large a current from leaving the battery, but it is a dangerous level, in any case. Currents this large can do extensive damage, mostly from the heat generated. That is why the battery is fused.

2.2.1 Charging

You can recharge the nickel-cadmium battery with an Isco Power Pack, an Isco Battery Charger, or with the Model 965 Five Station Battery Charger. All these provide the proper current (**400 mA**) for charging the batteries. To charge the battery, connect the plug on the battery cable to the mating receptacle on the power pack, or the connector on the charger. Leave the battery on charge for **15 to 18 hours**. The Five-Station Battery Charger lets you charge as many as five batteries at once, and lets you charge both nickel-cadmium and lead-acid batteries, although not at the same time.

 **CAUTION**

Never charge any battery inside a sealed container or enclosure. Charging may release gases from the electrolyte. These gases can generate dangerous pressure as they try to escape

confinement from the cells or enclosure. The gases may be explosive and they can also be irritating to smell.

All rechargeable batteries, whether nickel-cadmium or lead-acid, have one-way safety vents that open to relieve internal pressure generated by overcharging or very heavy discharge. **Their purpose is to keep the battery from bursting, catching fire, or even exploding.**

These vents **do not open** during normal operation. If they do open, it indicates battery abuse. Venting shortens battery life by depleting irreplaceable electrolyte. Avoid causing any of the conditions that can make this happen.

2.2.2 Charging Temperature

One manufacturer of nickel-cadmium cells recommends charging them within a temperature range of **32° F (0° C) to 110° F (45° C)**. Below 32° F, charging increases the gas pressure within the cell, and that may force the safety vent to open. Above 110° F, charging efficiency decreases, and the high temperature accelerates deterioration of the plate separator material, hastening end-of-life.

Measuring nickel-cadmium batteries shows an almost-constant output voltage from charged to discharged. This is because the electrolyte, water and potassium hydroxide (KOH), is not depleted of ions (which affects conductivity) during discharge, as is the electrolyte in lead-acid batteries. As a result, you cannot measure the output voltage to calculate the remaining charge in the battery. You can achieve the recommended 15-hour charging interval by putting the battery on charge before leaving work in the evening and then taking it off when you come in the next morning (5 PM to 8 AM is 15 hours). As long as the battery is accepting the charge, it will stay cool to the touch. When fully charged, the battery will feel warm, as it dissipates the charging current as heat. Discontinue charging when the battery feels warm.

2.2.3 Avoiding Self-Discharge

As mentioned, nickel-cadmium batteries have a higher rate of self-discharge than other types of batteries. After charging, always try to return the battery to service within a reasonable period of time (one to two weeks at most), to ensure the availability of most of the battery's capacity. Self-discharge does not affect the life or usability of nickel-cadmium batteries, and it does not mean the batteries are bad. It just means that the batteries will not deliver full-rated capacity if you do not return them to service promptly after charging.

Do **not** store the batteries in a hot environment, such as a room with a furnace, boiler, or heater, or in direct sunlight, if at all possible. The self-discharge characteristic seems to increase with age, probably due to the deterioration of the plate separator material and the growth of crystalline “whiskers” between the plates.

We suggest you discontinue the use of “old” batteries. Rapid self-discharge is often the actual cause of unreliability in older batteries, not diminished capacity. The manufacturer of the cells used in the Isco battery considers end-of-life to have occurred when battery capacity has dropped to **80%** of the rating for new cells.

Finally, if you cannot return the battery to service immediately or don't know the charge condition, simply “top off” the charge for a few hours.

2.2.4 Effects of Overcharging the Battery

Overcharging the nickel-cadmium battery causes the cells to heat up. Over time this heating breaks down the separator material used between the plates inside the cells, encouraging the growth of the crystalline whiskers, causing shorts. Prolonged overcharging will shorten the life of the cells; try to avoid it.

2.2.5 Using Other Battery Chargers

Teledyne Isco does **not** recommend the use of chargers designed for lead-acid batteries, such as automotive battery chargers. The open-circuit voltage of lead-acid chargers is generally not high enough to fully charge a nickel-cadmium battery, and these chargers are usually not current-regulated. Neither does Teledyne Isco recommend using chargers intended for other types of nickel-cadmium batteries, especially the so-called “fast-charge” types. These chargers are designed for use only with compatible “fast-charge” cells and can charge the proper batteries in as little as one hour (**1.0 “C”**). Isco batteries use “standard” cells intended for charging at **400 mA (0.1 “C”)** for **15 to 18 hours**. Chargers that provide more current than this may cause overheating and that may force the safety vents to open, releasing water. **You cannot replace this water.**

Chargers that deliver too little current to the batteries may never charge them to full capacity, and may themselves be damaged from the overload. Do not attempt to use any other charging apparatus without an **accurate digital multimeter** to monitor the charging current. If the charger delivers more than **600 mA**, Teledyne Isco recommends you do not use it. If it delivers less than **100 mA**, the charging period becomes too long. Even then the battery may never recharge completely. **Be sure of proper polarity before connecting any other charging apparatus!** If you use an Isco Power Pack, you can overcharge the battery occasionally with little loss of capacity. However, you should avoid chronic or prolonged overcharging. Again, return the battery to service promptly.

2.2.6 “Memory” Effects

For a long time, people believed that nickel-cadmium batteries were subject to “memory” effects, and that a complete charge/discharge cycle (exercising the battery) was necessary to maintain battery capacity. “Memory” is the characteristic a battery may develop of appearing to have lost some of its capacity after a few shallow discharges.

The battery will only discharge to the same shallow point. It is now known that the memory effect is not a problem with Isco equipment under normal operating conditions, because most Isco

applications generally involve a deep or full discharge. If it does occur, it is temporary, and you can reverse it by a deep discharge and charge. If you discharge the battery to random depths, charge for random amounts of time, and subject the battery to various duty cycles, the memory effects will not be present.

2.2.7 Servicing the Nickel-Cadmium Battery

This section covers replacement of the connect cable. You can make this repair yourself. However, some familiarity with electrical/electronic repair procedures is necessary. You must know how to solder, make proper splices, and insulate them safely. You must follow the color codes used to maintain proper polarity on the battery after the repair. If you are not familiar with these procedures, or are uncomfortable doing them, return the battery to Teledyne Isco for repair. If the fuse is all right and only the cable needs replacing, Teledyne Isco suggests making the repair after the battery has been discharged.

2.2.8 Replacement of the Battery Cable

If the cable on the nickel-cadmium battery is damaged or inoperative, you can replace it in the field. Remove the screws holding the battery cover. Lift the cover from the case to reveal the cable connections. To make replacement easier, the connections are outside the potting wax. To replace the cable, simply cut away the old cable and splices, **one wire at a time**, and solder in a replacement. Carefully insulate the exposed wires with shrink tubing (preferred) or electrical tape. Replace the battery case cover and screws.

| |
|--|
|  WARNING |
|--|

When replacing a battery cable, be careful not to short the leads from the battery together, or you may irreparably damage the battery and you may also risk personal injury. Insulate splices carefully. Replace only one wire at a time.

2.3 Model 946 Lead-Acid Battery

While the nickel-cadmium battery has traditionally been the usual battery for powering Isco products, Teledyne Isco also offers a 6.5 ampere-hour gelled-electrolyte 12-volt lead-acid battery (see Figure 2-2). Either battery will operate an Isco sampler, flow meter, portable pump, or other equipment satisfactorily, but there are differences in the charging and operating characteristics of the lead-acid battery.

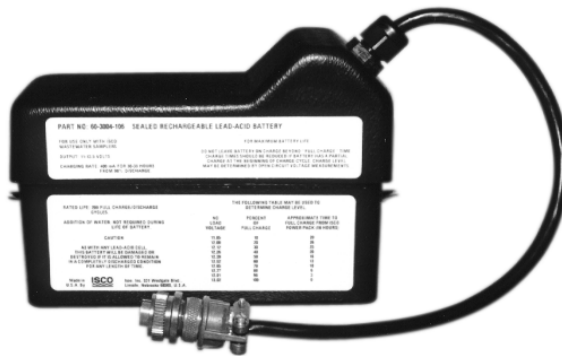


Figure 2-2 Model 946 Lead-Acid Battery

The lead-acid battery offers higher capacity than the nickel-cadmium battery at a lower price. However, fewer charge-discharge cycles are generally possible. If your experience has been with the nickel-cadmium battery, please study the following before using the lead-acid battery.

- **Do not run an instrument to complete discharge of the battery.** Total discharge of gelled-electrolyte batteries can cause cell reversal, and this can ruin the battery. One manufacturer recommends **10.5 VDC, loaded at 400 mA**, as complete discharge of a 12-volt battery.
- **Although it may appear that there is still much power left when the battery voltage drops to 10.5 VDC, in fact, there is very little.** Trying to use all remaining power from a battery will cause cell reversal. The weakest cell is the first to fail in a battery. The first cell depleted will be forced into reversal by the rest of the battery, **if the load is still connected.**
- **Recharge lead-acid batteries as soon as possible after use.** Unlike nickel-cadmium batteries, if you leave lead-acid batteries partially or fully discharged for any period of time, they may not recharge to full capacity. Eventually they will not accept or retain a charge at all.
- **Battery life is related to the depth of the discharge cycle.** One manufacturer specifies that you can expect only 200 cycles at 100% discharge for each cycle. With a 50% depth of discharge, this number increases to over 400 cycles. With a 30% depth of discharge, cycle expectancy increases to over 1,000.
- **Avoid the use of lead-acid batteries in subfreezing environments, especially where you expect deep discharge.** One manufacturer recommends that you use them above 5° F (–15° C). While a fully-charged lead-acid battery will withstand cold temperatures, a discharged battery can freeze if the temperature is low enough, and that can ruin it. If frozen, the battery could

swell and crack the case. This will ruin the battery and could also release toxic substances.

- **You can easily damage a gelled-electrolyte lead-acid battery by overcharging.** By necessity, the amount of water in a gelled-electrolyte battery is quite limited. The batteries have a one-way safety vent in each cell that releases water when overcharging causes the pressure to build up inside the battery. Unlike wet-cell lead-acid batteries (such as automotive types), you cannot replace the water. Repeated venting will dry out the cells and kill the battery. Optimal charging causes the battery to release no water vapor and very little gas from the plates.
- **Lead-acid batteries are not charged the same way as a nickel-cadmium battery.** Proper charging is done with a constant voltage and a tapering (or declining) current.

Chargers for nickel-cadmium batteries typically use a **constant-current** method. Overcharging is more likely to damage a lead-acid battery by forcing the vents open and drying it out.

2.3.1 Charging Lead-Acid Batteries

Isco's **Model 963 Single Station Battery Charger** can be used to charge lead-acid batteries.

In addition, the **Isco Model 965 Five-Station Battery Charger** has outputs that can be switched for lead-acid batteries.

Some battery manufacturers recommend charging the lead-acid battery near room temperature (70° F or 23° C), if possible. Chargers are typically designed to operate at room temperature. Temperatures deviating significantly either direction from room temperature may cause inaccuracies in charging the lead-acid battery, with potentially harmful long-term effects. The **Model 965 Five-Station Battery Charger** contains compensation for charging at higher and lower temperatures, but the other chargers do not.

When charging lead-acid batteries of any type, please consider the following:

- Disconnect the battery from the equipment it is powering before charging.
- Connect the battery to the charger before plugging the charger in or turning it on; this prevents sparks.
- Never charge the battery in a sealed container, nor in an unventilated room.
- Do not let the charger run unsupervised or for a long period of time.
- Do not charge the battery upside down.
- Charging produces explosive gases; do not charge near open flames or sparks.
- Do not smoke around the battery while it is charging.

- Do not overcharge the battery.
- Unplug the charger from the AC supply before disconnecting the battery. This will prevent any sparking that could ignite the gases produced by charging.

Charge retention is substantially better for lead-acid batteries than for nickel-cadmium types. While a nickel-cadmium battery can self-discharge completely in a matter of months, a lead-acid battery will still have 50% of capacity for nine months to a year when stored at room temperature (70° F or 23° C). At 100° F (38° C), the time drops to four months. At 40° F (5° C), the time is over a year.

However, if a lead-acid battery does self-discharge completely, **it will often be ruined**, due to sulfation of the plates. This is very different from the nickel-cadmium battery, which is not harmed by remaining in the discharged state, even for considerable periods of time.

The voltage available from a lead-acid battery drops in a straight line as the battery discharges. This is due to depletion of sulfate ion from the electrolyte, raising the internal resistance. Available voltage drops gradually from approximately **12.5** at full charge to **10.5** at total discharge (under load). Note that it is important to measure the battery under load. A discharged lead-acid battery may still show 12.5 VDC, when measured with no load. Nickel-cadmium batteries show essentially constant voltage across most of the discharge range.

2.3.2 Using Other Battery Chargers

Note that an earlier version of the five-station charger is for use with nickel-cadmium batteries only. **It is possible to use chargers for Isco nickel-cadmium batteries to charge lead-acid batteries, but it is NOT recommended!**

You must be careful to avoid overcharging, since a nickel-cadmium charger delivers too much current in the latter stages of charging. Since its open-circuit voltage is high (30 VDC), the current will remain constantly high, no matter what the charge state of the battery is. If not turned off at the proper time, the charger will boil the electrolyte. There is a table printed on the lead-acid battery that tells you how long to charge with a nickel-cadmium charger.

Because of the risk of damage to the battery from a nickel-cadmium charger, consider using an accurate digital voltmeter to monitor the charge voltage. Discontinue charging when the battery voltage reaches **15.0 VDC**. Charging until the battery “feels warm” is not a reliable indicator for these batteries, as you may already have overcharged them. Discontinue charging if you hear a bubbling sound coming from the batteries.

2.4 Model 948 Lead-Acid Battery

In addition to the Model 946 and 947 Lead-Acid Batteries, Teledyne Isco offers a much larger battery, the Model 948. This battery, which resembles an automotive battery, has a capacity of 45 ampere-hours, **eight and a half times** the capacity of Models 946 and 947.

Like the Model 946 battery, the Model 948 is a gelled-electrolyte, maintenance-free battery. This battery is particularly well-suited to installations that have moderate-to-heavy power requirements. It is also suitable for installations that have fairly low power requirements, but because of their location, must operate unsupervised for long periods of time.



Figure 2-3 Model 948 Battery

Teledyne Isco offers the battery, a convenient carrying case (recommended) and a six-foot **connect cable**. The cable terminates in a two-pin M/S connector suitable for attachment to Isco samplers and flow meters. The cable is protected with grease where it connects to the battery.

Teledyne Isco also offers a special **battery charger** suitable for recharging the Model 948 Battery (Figure 2-4). We recommend the use of this charger, as it automatically senses when the battery is charged and reduces the current to a safe level, thus avoiding the possibility of overcharge. Most automotive-type chargers do not have this capability.

This charger has an output of 6 amperes and is supplied with leads terminated in alligator clips for easy connection to the battery. To recharge the Model 948, simply remove the top of the carrying case and connect the red (positive +) clip to the positive (+) terminal on the battery and the black (negative -) clip to the negative (-) terminal on the battery. Follow the instructions printed on the charger. For safe charging refer to the comments made for the Model 946.

If you want to charge the battery with a different charger, note the charging conditions indicated on the battery label. The battery manufacturer recommends that the initial charge not exceed **C/5**, which in this instance would be 9 amperes.

Chargers for smaller Isco batteries are not recommended for the Model 948, as they will take too long to recharge the battery. Note the nylon webbed strap around the battery case. Its purpose is to keep the case closed, **not** a carrying handle. Carry the battery case by the handles molded into both narrow ends of the case.



Figure 2-4 Model 948 Battery Charger

2.5 Use of Other Types of Batteries

In some circumstances, you may want to use batteries other than the nickel-cadmium and gelled lead-acid types. For long-term operation, the deep-cycle R-V or marine battery has been a popular and satisfactory choice, due to its high ampere-hour capacity and reasonable cost. In certain instances you can also use alkaline (non-rechargeable) batteries with Isco equipment. However, you should consider the environmental impact of alkaline batteries because of the one-time-only use and necessity of disposal of the spent batteries.

2.5.1 Alkaline (Nonrechargeable) Batteries

Generally, you should only consider alkaline batteries where power consumption by the equipment is extremely low and long periods of unsupervised operation are required. The samplers cannot use alkaline batteries, due to power requirements, and their use with flow meters is not recommended. One application where alkaline batteries are suitable is the 4100 series flow loggers. The flow loggers use two, 6-volt “lantern” batteries.

2.5.2 Deep-Cycle R-V or Marine Batteries

Similar in appearance and construction to an automotive battery, but specially designed to withstand deep discharges, the deep-cycle R-V or marine battery works with Isco samplers, flow

meters, pumps, and other equipment. These batteries are quite large compared to the standard Isco battery packs, so you must mount them separately from the equipment they are powering.

 **CAUTION**

Mount wet cell batteries securely so they cannot tip over. This is important because the acid in the electrolyte is both corrosive and toxic.

Connection between battery and equipment is with a special Isco cable. This cable has a two-pin M/S connector on one end and two large alligator clips on the other.

The positive clip (+) has red shrink tubing on its wire to correctly identify polarity. Verify polarity with a meter. Attach the clips to the proper terminals on the battery and plug the M/S connector into the instrument.

2.5.3 Maintenance and Charging

Keep the terminals on the battery posts clean at all times. Lead-acid batteries are notorious for “growing” corrosion on the battery posts. These deposits will rapidly cause the conductors to fail if allowed to form for any length of time. You can easily identify the corrosion as white flakes or powdery deposits. Corrosion on the terminals also can creep into the attached alligator clips, especially the positive one. These deposits are harmful because they will eventually corrode the metal (conductive) elements of the circuit completely away and because they form good insulators when dry. Grease, baking soda, and corrosion-inhibiting felt washers (available from auto-parts suppliers) are all helpful in keeping the connections between the battery and the cable reliable and corrosion-free.

If the battery is **not** the sealed type, you should check the level of the electrolyte in each cell every time you recharge it. Unsealed batteries have caps on top of the case that you can remove to check the electrolyte. Add **only** distilled water according to the battery manufacturer's recommendations; never add common tap water or more electrolyte. You can check charge condition and the condition of each cell with an ordinary battery hydrometer, a device that measures the specific gravity of the electrolyte. Follow the battery manufacturer's recommendations for charging the battery. An automotive-type charger is usually satisfactory for charging these batteries. Isco chargers are designed for batteries with low ampere-hour capacities; their use in this application is not recommended.

2.5.4 Hazard of Short Circuits

As advised for the nickel-cadmium battery, do not check the charge condition of either lead-acid or gelled-electrolyte batteries by “sparking” the output cables (momentarily shorting the wires together). These batteries, when fully charged, can deliver large amounts of current into a short circuit fault, especially if the short is close to the battery. While the current may not be as high as a nickel-cadmium battery, it is still considerable. Unlike nickel-cadmium batteries, lead-acid batteries are **not** internally

fused. Enough current can flow to burn up the wires quickly. It is possible for battery cables shorted together to “weld.” This will cause almost immediate melting and burning of the wire insulation until the wire melts open at some point.

 **WARNING**

Fire, severe burns to the hands, and the release of toxic fumes are all possible from such a mishap.

 **CAUTION**

If you intend to use any power source other than an Isco battery or power converter, be sure of **proper voltage** and **polarity** before connecting power to the equipment.

Never attach equipment to a power source of unknown polarity or voltage. **Never** attach equipment directly to an **AC** power source under any circumstances, regardless of voltage.

If you are in doubt, check the power with a **reliable DC voltmeter**. Failure to observe this caution could create a shock or fire hazard, cause serious damage to the instrument, and it could also put you at risk of serious personal injury.

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Section 3 Batteries for Flow Loggers

3.1 Internally Mounted Batteries

The flow loggers contain internal mounting provisions for two different types of batteries. The first type is a pair of standard 6-volt alkaline “lantern” batteries. The second is a 6.5 Ah, 12-volt lead-acid battery, similar to the standard Isco Lead-Acid Battery, but with a different cable and connector. You can also use the Solar Panel Battery Charger, modified to accept a standard Isco Lead-Acid Battery and supplied with an interconnect cable.

3.2 Model 947 Lead-Acid Battery

Electrically identical to the Model 946 Isco Lead-Acid Battery, this battery comes with its own special cable and connector. You must use this special arrangement with the flow loggers if you want the battery to be self-contained, as the standard Lead-Acid Battery will not fit inside the flow logger case. You can recharge this battery the same as you recharge the standard Isco Lead-Acid Battery.



Figure 3-1 Model 947 Flow Logger Battery

3.3 Alkaline “Lantern” Battery

Long used to power lanterns and other sporting equipment, the 6-volt alkaline lantern battery is a satisfactory **non-rechargeable** battery for the flow loggers. Because each battery only delivers 6 volts, you must use two of them (Figure 3-2).



Figure 3-2 Flow Logger Alkaline Battery

3.4 Flow Loggers - External Power Sources

Put the batteries into the flow logger case with the contact springs pointing towards the bottom of the battery compartment. Positioning is not critical, because the contact strips in the bottom of the compartment are laid out for universal acceptance. These batteries are available from Teledyne Isco or from any local hardware, sporting goods, or electronics wholesaler.

Note that this type of battery is **not** rechargeable, despite occasional claims to the contrary. Attempting to recharge alkaline batteries is reputed to be hazardous in some instances. Never dispose of alkaline batteries in a fire. Always dispose of discharged alkaline batteries in conformance with state and local environmental regulations.

If you want to use an external power source with the flow loggers, almost any of the Isco batteries and power supplies are suitable. The flow loggers have an external power connector on the case and there is a two-foot cable available to connect to an external power source.

Note that if you suspend a flow logger from the rungs of a manhole, use of an external power source is not practical, as you must secure both the flow logger and the battery. It is generally not possible to use an AC-powered unit in a manhole due to the lack of availability of an AC power connection. The following devices are suitable as **external** power sources for the flow loggers:

Batteries

- Isco Model 946 Lead-Acid Battery
- Isco Model 948 Lead-Acid Battery
- 12-Volt R-V Deep-Cycle or Marine Battery

Note

You can use the Isco Model 934 Nickel-Cadmium Battery with the flow loggers, but Teledyne Isco **does not** recommend it. This battery is not ideal for use with the flow loggers because of its self-discharge characteristic. Because the flow loggers need to operate over the long-term, the nickel-cadmium battery is more likely to run down from self-discharge than it is to run down from the flow logger power demands on it.

Power Products Guide

Section 4 Isco Battery Chargers and Power Packs

4.1 Isco Chargers and Power Packs

Teledyne Isco offers several battery chargers and two different power packs for use with all Isco products. You can use the power packs instead of the nickel-cadmium or lead-acid batteries to power the samplers, flow meters, or other equipment.

The power packs are made for operation from either nominal 120 VAC, 60 Hz (USA) or 220-240 VAC, 50 Hz (Europe and much of the rest of the world) power sources. The 120-volt models are supplied with the three-prong cord commonly used in the USA and Canada. The 220-240-volt models are supplied with the most common two-prong plug used in Europe.

4.2 Model 961 Battery Charger

The simplest charger is a wall plug-in transformer type, Model 961, intended for charging the Model 934 Nickel-Cadmium Battery. This charger provides the proper charging current (400 mA) for the nickel-cadmium battery. Only one version, powered from 120 VAC, is available.



Figure 4-1 Model 961 Wall Charger for Nickel-Cadmium Batteries

4.3 Model 963 Battery Charger

This charger is designed to charge the Model 946 and 947 Lead-Acid Batteries. It is capable of running from 120/230 VAC at 50/60 Hz. The Model 963 Battery Charger is listed by UL (Underwriters Laboratories) and is CE marked.

The Model 963 is a float type charger that will vary its output as the batteries become more charged, thus reducing the risk of overcharging.

A fully discharged 946 or 947 battery should be fully charged within 15 to 18 hours. These batteries will not be damaged by occasional or slight overcharging, but frequent or prolonged overcharging will result in reduced charge capacity and fewer charge/discharge cycles in the life of the battery.



Figure 4-2 Model 963 Battery Charger for Lead-Acid Batteries

4.4 Model 913 and 923 High Capacity Power Packs

The most popular power pack contains both a switching regulator and a current-limited battery charging output. The switching regulator provides a protected output of 12 VDC at 5 amperes. The charger's output is regulated at 400 mA, suitable for nickel-cadmium batteries.

The Model 913 is for 120 volts and Model 923 is for 230 volts.



Figure 4-3 Model 913 High Capacity Power Pack

4.5 Models 914 and 924 Battery-Backed Power Packs

The Battery-Backed Power Packs contain a 5-ampere switching regulator and a 1.2 ampere-hour, 12-volt nickel-cadmium battery as a backup power source. There is no external charging circuit; the charger is connected internally to the standby battery.

The Battery-Backed Power Packs provide uninterruptible switching from AC to the internal battery in the event of power failure. Use this power pack where power outages are frequent, but of **short-term duration** and where you cannot tolerate the loss of data during a power failure.

The internal battery has about 30% the capacity of a standard nickel-cadmium battery, so you should not attempt to use it as a combination of a standard power pack and battery. Do **not** use this product where power failures are both frequent and long. The limited capacity of the internal battery may run out before power is restored, or outages may be so frequent that the battery does not have enough time to recharge.

The Battery-Backed Power Pack is available in both nominal 120-volt (Model 914) and 240-volt (Model 924) versions.



Figure 4-4 Model 914 Battery-Backed Power Pack

4.6 Model 965 Five-Station Battery Charger

The Five-Station Battery Charger provides a convenient way to charge several Isco batteries at a time. It also provides the proper charging conditions for either type of battery: nickel-cadmium or lead-acid. Switches select operation from either 120 volts or 240 volts and charging for nickel-cadmium or lead-acid batteries.

This charger is listed by UL. This unit replaces a previous model that was designed only for charging nickel-cadmium batteries. You can charge as many as five batteries of either type (nickel-cadmium or lead-acid) at the same time with the Model 965. To charge either type of battery, simply attach the battery's connector to one of the output connectors on the charger. Make certain the selector switch is appropriate for the battery you are charging before applying power.

Generally the batteries (either type) will attain full charge within 15 to 18 hours. Occasional or slight overcharging of the batteries will not hurt them, but Teledyne Isco recommends that you avoid frequent or prolonged overcharging. Each Five-Station Battery Charger comes with its own manual. Operating instructions are provided in this manual, as well as other information, so it is not repeated here.



Figure 4-5 Model 965 Five-Station Battery Charger

4.7 Solar Panel Charger

Teledyne Isco offers the Solar Panel Battery Charger to make possible operation of battery-powered equipment in very remote locations where AC power is not available to run a standard charger or power pack. It is also intended for use where remoteness and/or inaccessibility make periodic battery exchanges by personnel expensive or impractical.

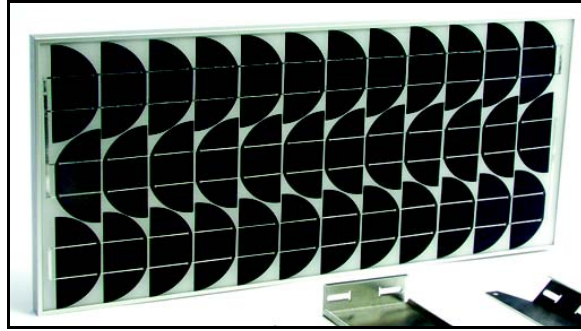


Figure 4-6 Solar Panel Charger

Note

Isco Solar Panels are suitable for charging Isco Lead-Acid Batteries only. **Do not attempt to use this charger with nickel-cadmium batteries.**

You can purchase 10-, 40-, or 110-watt solar panels, depending on your load current demands. The solar panel connects to the equipment with a special cable. You can mount the unit at the optimum angle to receive sunlight. This angle varies with location.

Note that the maximum current is only available part of the time. Output declines at both ends of the day and varies considerably with the changing of the sun's angle during the different seasons. The Solar Panel is provided with its own manual.

Power Products Guide

Appendix A Power Product Part Numbers

A.1 Part Numbers

This appendix contains a list of Isco power products and their corresponding part numbers.

Teledyne Isco, Inc.

Customer Service Department

P.O. Box 82531

Lincoln, NE 68501 USA

Phone: (800) 228-4373

(402) 464-0231

FAX: (402) 465-3022

E-mail: IscoCSR@teledyne.com

Table A-1 Power Product Part Numbers and Compatibility

| Product | Power/Usage | Part Number |
|---|--|--------------------|
| 934 Nickel-Cadmium Battery | 12 V, 4 Ah, not recommended for 4100 series | 60-1684-040 |
| 946 Lead-Acid Battery | 12 V, 6.5 Ah | 60-3004-106 |
| 947 Lead-Acid Battery | 12 V, 6.5 Ah 4100 only | 60-3114-011 |
| 948 Lead-Acid Battery | 12 V, 45 Ah | 68-3000-948 |
| Alkaline Lantern Battery (Energizer Model 529 ^a) | 6 V for 4100 and 2100 modules | 340-2006-02 |
| 945 Rechargeable Lead-Acid Lantern Battery | 6 V for 2191EX Zone 0 battery module and 2151 module only | 60-2004-041 |
| LTC2191EX Lithium Battery Pack | for 2191EX Zone 0 battery module only ^b | 68-2000-022 |
| SLA2191EX Rechargeable Lead-Acid Battery Pack | for 2191EX Zone 0 battery module only ^a | 68-2000-023 |
| 913 High Capacity Power Pack | 120 V, charges 934 ni-cad | 60-1684-088 |
| 923 High Capacity Power Pack | 230 V, charges 934 ni-cad | 60-3004-190 |
| 914 Battery Backed Power Pack | 120 V, no charger | 68-3004-130 |
| 924 Battery Backed Power Pack | 240 V, no charger | 68-3004-160 |
| Solar Panel Battery Charger | 10 W, charges 946, 947, and 948 lead-acid | 60-5314-478 |
| Solar Panel Battery Charger OEM | 40 W, for deep-cycle user-supplied lead-acid | 60-5314-347 |
| Solar Panel Battery Charger | 110 W, for user-supplied deep-cycle or marine lead-acid | 60-5314-629 |
| 961 Wall Charger | for 934 ni-cad | 60-3004-059 |
| 963 Desktop Charger | 120/230 V, for 946 and 947 lead-acid | 68-3004-198 |
| 965 Five-Station Battery Charger | For Isco lead-acid and ni-cad, w/ 120VAC power cord | 68-3000-965 |
| 965 Five-Station Battery Charger | For Isco lead-acid and ni-cad, w/ 240VAC power cord | 68-3000-966 |
| Automatic Battery Charger | 12 V, 6 A, for 948 battery only | 341-0118-12 |
| PowerSonic battery charger | Float voltage, 2A, for 2196EX only | 68-2000-044 |
| SV2191SLA Charger | US linecord, for SLA2191EX only | 68-2000-025 |
| SV2191SLA Charger | EU linecord, for SLA2191EX only | 68-2000-024 |

- a. Due to a significantly shorter battery life, the Energizer Model EN529 is not recommended for use with Isco equipment.
- b. To avoid overloading the fuses in the LTC2191EX lithium battery packs, disconnect the flow module(s) before installing or replacing the lithium battery packs. The SLA2191EX lead-acid battery packs do not contain fuses, and do not require that the flow module(s) be disconnected.

Power Products Guide

Appendix B Material Safety Data Sheets

B.1 Overview

This appendix to the manual provides Material Safety Data Sheets for Isco Power Products.

Teledyne Isco cannot guarantee the accuracy of the data. Specific questions regarding the use and handling of the products should be directed to the manufacturer listed on the MSDS.

MATERIAL SAFETY DATA SHEET

SANYO Batteries

SANYO Energy
2055 Sanyo Ave.
San Diego, CA 92154

Telephone No.: (619) 661-4888
www.sanyobatteries.com
In case of emergency contact:
CHEMTREC at (800) 424-9300

Date of Preparation: 6/23/03

Section I — Product Identification

Product Name: Nickel Cadmium Battery

Trade Name: CADNICA

Nominal Voltage: 1.2V

Chemical System: Nickel/Cadmium

Designated for Recharge:

Yes No

Section II — Composition / Information on Ingredients

IMPORTANT NOTE: The battery cell should not be opened or exposed to heat because exposure to the following ingredients contained within could be harmful under some circumstances.

| Chemical Name | CAS No. | % ¹ | PEL | TLV |
|---------------------|------------|----------------|------------------------|-----------|
| Cadmium | 7440-43-9 | 11-26 | 0.005 TWA ² | 0.05 TWA |
| Cadmium hydroxide | 21041-95-2 | 11-26 | 0.005 TWA | 0.05 TWA |
| Nickel (powder) | 7440-02-0 | 8-17 | 1 TWA | 1 TWA |
| Nickel hydroxide | 12054-48-7 | 5-12 | 1 TWA | 1 TWA |
| Potassium hydroxide | 1310-58-3 | < 3 | 2 Ceiling | 2 Ceiling |
| Nylon | N/A | < 2 | N/A | N/A |
| Steel | N/A | 12-13 | N/A | N/A |
| Other | N/A | < 1 | N/A | N/A |
| Total | | 100 | | |

- Notes: 1. Concentrations vary depending on the state of charge or discharge.
2. TWA is the time weighted average concentration over an 8-hour period.

Section III — Physical Data

The product is a manufactured article as described in 29 CFR 1910.1200. The battery cell is contained in a hermetically-sealed case, designed to withstand temperatures and pressures encountered during normal use. As a result, during normal use, hazardous materials are fully contained inside the battery cell. However, if exposed to a fire, explosion, extreme abuse, misuse, or improper disposal that results in breaching of the battery cell case, hazardous materials may be released. The following physical data relating to the hazardous materials contained within the battery cell are provided for the user's information. (Also see Section IV — Fire and Explosion Hazards, and Section VIII — Precautions for Safe Handling and Use.)

The information and recommendations set forth are made in good faith and believed to be accurate as of the date of preparation. SANYO ENERGY CORP. makes no warranty, expressed or implied, with respect to this information and disclaims all liabilities from reliance on it.

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Cadmium: Melting point (°F): 610 Boiling point (°F): 1,407
% Volatile by Volume: Vapor Pressure (mm Hg):
Evaporation Rate: Vapor Density (Air =1):
Specific Gravity (H₂O): 8.65 @77°F
Solubility in Water: Insoluble
Appearance and Odor: Silver-white, blue-tinged, lustrous metal

Cadmium Hydroxide: Melting Point (°F): Boiling Point (°C):
% Volatile by Volume: Vapor Pressure (mm Hg):
Evaporation Rate: Vapor Density (Air =1):
Specific Gravity(H₂O): 4.79
Solubility in Water: Practically insoluble
Appearance and Odor: Powder

Nickel Powder: Melting point (°F): 2,831 Boiling point (°F): 5,134
% Volatile by Volume: Vapor Pressure (mm Hg):
Evaporation Rate: Vapor Density (Air =1):
Specific Gravity (H₂O): 8.90
Solubility in Water: Insoluble
Appearance and Odor: Powder

Nickel Hydroxide: Melting point (°F): * Boiling Point (°F):
% Volatile by Volume: Vapor Pressure (mm Hg):
Evaporation Rate: Vapor Density (Air = 1):
Specific Gravity (H₂O):
Solubility in Water: Insoluble
Appearance and Odor: Apple green powder

* Note: decomposes above 392°F into NiO and H₂O.

Potassium Hydroxide: Melting point (°F):* Boiling Point (°F):
% Volatile by Volume: Vapor Pressure (mm Hg):
Evaporation Rate: Vapor Density (Air =1):
Specific Gravity (H₂O):
Solubility in Water: Soluble in 0.9 part water, 0.6 part in boiling water
Appearance and Odor: White or slightly yellow

* Note: Potassium hydroxide is present as a liquid or paste and acts as the electrolyte in the battery cell.

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Section IV - Fire and Explosion Hazard Data

Flash point: NA Lower Explosive Limit: NA Upper Explosive Limit: NA

Extinguishing Media: Any class of extinguishing medium may be used on the batteries or their packing material.

Special Fire Fighting Procedures: Exposure to temperatures of above 212°F can cause evaporation of the liquid content of the potassium hydroxide electrolyte resulting in the rupture of the cell. Potential for exposure to cadmium fumes during fire; use self-contained breathing apparatus.

Section V - Health Hazard Data

Threshold Limit Values: See Section II

Effects of a Single (Acute) Overexposure:

Inhalation:

During normal use inhalation is an unlikely route of exposure due to containment of hazardous materials within the battery case. However, should the batteries be exposed to extreme heat or pressures causing a breach in the battery cell case, cadmium dusts and fumes may be emitted. Inhalation of cadmium dusts or fumes may cause throat dryness, respiratory irritation, headache, nausea, vomiting, chest pain, extreme restlessness and irritability, pneumonitis, and bronchopneumonia. In the case of high concentration exposures (e.g., above 1 to 5 mg/m³ during an eight hour period) death may occur within several days after the exposure.

Ingestion:

If the battery case is breached in the digestive tract, the electrolyte may cause localized burns. Ingestion of cadmium compounds may result in increased salivation, choking, nausea, persistent vomiting, diarrhea, abdominal pain, anemia, tenesmus, and kidney dysfunction.

Skin Absorption:

No evidence of adverse effects from available data.

Skin Contact:

Exposure to the electrolyte contained inside the battery may result in chemical burns. Exposure to nickel may cause dermatitis in some sensitive individuals.

Eye Contact:

Exposure to the electrolyte contained inside the battery may result in severe irritation and chemical burns.

Carcinogenicity:

Cadmium and nickel have been identified by the National Toxicology Program (NTP) as reasonably anticipated to be carcinogens. U.S. EPA classified cadmium as a "B1" probable human carcinogen. The International Agency for Research on Cancer (IARC) recommended that cadmium be listed as a "2A" probable human carcinogen, and the American Conference of Governmental Industrial Hygienists (ACGIH) has proposed listing cadmium as an A2 carcinogen.

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Other Effects of Repeated (Chronic) Exposure:

Repeated overexposures to cadmium may result in lung cancer; lung, kidney, and liver dysfunction; skeletal disease (e.g., osteoporosis) and reproductive toxicity. Chronic overexposure to nickel may result in cancer; dermal contact may result in dermatitis in sensitive individuals.

Medical Conditions Aggravated by Overexposure:

A knowledge of the available toxicology information and of the physical and chemical properties of the material suggests that overexposure is unlikely to aggravate existing medical conditions.

Emergency and First Aid Procedures:

Swallowing:

Do not induce vomiting. Seek medical attention immediately.

Skin:

If the internal cell materials of an opened battery cell comes into contact with the skin, immediately flush with water for at least 15 minutes.

Inhalation:

If potential for exposure to cadmium or nickel fumes or dusts occurs, remove immediately to fresh air and seek medical attention.

Eyes:

If the contents from an opened battery comes into contact with the eyes, immediately flush eyes with water continuously for at least 15 minutes. Seek medical attention.

Section VI - Health Hazard Data

The batteries are stable under normal operating conditions.

Hazardous polymerization will not occur.

Hazardous decomposition products: oxides of cadmium and nickel.

Conditions to avoid: heat, open flames, sparks, and moisture.

Potential incompatibilities (i.e., materials to avoid contact with): The battery cells are encased in a non-reactive container; however, if the container is breached, avoid contact of internal battery components with acids, aldehydes, and carbamate compounds.

Section VII - Health Hazard Data

Spill and leaks are unlikely because cells are contained in an hermetically-sealed case. If the battery case is breached, don protective clothing that is impervious to caustic materials and absorb or pack spill residues in inert material. Dispose of as a hazardous waste in accordance with applicable state and federal regulations. Resultant spill residues may be characterized as D002 (caustic) and D006 (cadmium) pursuant to the federal Resource Conservation and Recovery Act (RCRA). See Section IV for response to fires or explosions.

The information and recommendations set forth are made in good faith and believed to be accurate as of the date of preparation. SANYO ENERGY CORP. makes no warranty, expressed or implied, with respect to this information and disclaims all liabilities from reliance on it.

Section VIII - Safe Handling and Use (Personal Protective Equipment)

Ventilation Requirements: Not required under normal use.

Respiratory Protection: Not required under normal use.

Eye Protection: Not required under normal use.

Gloves: Not required under normal use.

Section IX- Precautions for Safe Handling and Use

Storage:

Store in a cool place, but prevent condensation on cell or battery terminals. Elevated temperatures may result in reduced battery life. Optimum storage temperatures are between -31°F and 95°F.

Mechanical Containment:

If there are special encapsulation or sealing requirements, consult your SANYO Energy Corp. representative about possible cell hazard precautions or limitations.

Handling:

Accidental short circuit will bring high temperature elevation to the battery as well as shorten the battery life. Be sure to avoid prolonged short circuit since the heat can burn attendant skin and even rupture the battery cell case. Batteries packaged in bulk containers should not be shaken. Metal covered tables or belts used for assembly of batteries into devices can be the source of short circuits; apply insulating material to assembly work surface.

Soldering/welding:

If soldering or welding to the case of the battery is required, consult your Sanyo Energy Corp. representative for proper precautions to prevent seal damage or external short circuit.

Charging:

This battery is designed for recharging. A loss of voltage and capacity of batteries due to self-discharge during prolonged storage is unavoidable. Charge battery before use. Observe the specified charge rate since higher rates can cause a rise in internal gas pressure which may result in damaging heat generation or cell rupture and or venting.

Section X- Recycling and Disposal

SANYO encourages battery recycling. Our Nickel Cadmium batteries are recyclable through the Rechargeable Battery Recycling Corporation's (RBRC) **Charge Up to Recycle! Program**. For information call 1-800-8-BATTERY or see their website at www.rbr.org. Ni-Cd batteries must be handled in accordance with all applicable state and federal laws and regulations.



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DO NOT INCINERATE or subject battery cells to temperatures in excess of 212 F. Such treatment can vaporize the liquid electrolyte causing cell rupture. Incineration may result in cadmium emissions.

Section XI- Transportation

SANYO sealed Nickel Cadmium batteries are considered to be "dry cell" batteries and are not subject to dangerous goods regulation for the purpose of transportation by the U.S. Department of Transportation (DOT), the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA) or the International Maritime Dangerous Goods regulations (IMDG). The only DOT requirement for shipping Nickel Cadmium batteries is Special Provision 130 which states: "Batteries, dry are not subject to the requirements of this subchapter only when they are offered for transportation in a manner that prevents the dangerous evolution of heat (for example, by the effective insulation of exposed terminals)." IATA requires that batteries being transported by air must be protected from short-circuiting and protected from movement that could lead to short-circuiting. Nickel Cadmium batteries are classified as a D006 hazardous waste because of the presence of cadmium. This waste code is assigned because of toxicity, not corrosiveness. These batteries do not meet the definition of a corrosive waste.

The information and recommendations set forth are made in good faith and believed to be accurate as of the date of preparation. SANYO ENERGY CORP. makes no warranty, expressed or implied, with respect to this information and disclaims all liabilities from reliance on it.



Material Safety Data Sheet

24-HOUR EMERGENCY CONTACT
(336) 650-7245/7257
CHEMTREC (800) 424-9300

HMIS Hazard Rating

| | |
|--------------|---|
| HEALTH | 3 |
| FLAMMABILITY | 1 |
| REACTIVITY | 2 |

0 Minimal Hazard
1 Slight Hazard
2 Moderate Hazard
3 Serious Hazard
4 Severe Hazard

PREPARED BY: A.L. Csontos, Director-Environmental Engineering
MANUFACTURER: Douglas Battery Manufacturing Company
Product Information (800) 368-4527

Date Prepared: 5/05
500 Battery Drive, Winston-Salem, NC 27107
Internet Address: www.douglasbattery.com

THE INFORMATION BELOW IS BELIEVED TO BE ACCURATE AND REPRESENTS THE BEST INFORMATION CURRENTLY AVAILABLE TO US. HOWEVER, WE MAKE NO WARRANTY OF MERCHANTABILITY OR ANY OTHER WARRANTY, EXPRESS OR IMPLIED, WITH RESPECT TO SUCH INFORMATION, AND WE ASSUME NO LIABILITY RESULTING FROM ITS USE. USERS SHOULD MAKE THEIR OWN INVESTIGATIONS TO DETERMINE THE SUITABILITY OF THE INFORMATION FOR THEIR PARTICULAR PURPOSES.

SECTION 1 – IDENTITY

Common Name: LEAD/ACID STORAGE BATTERY
Chemical Name: Lead/Acid Storage Battery **Chemical Family:** Electric Storage Battery
DOT Shipping Name: Battery, Wet, Filled With Acid, 8, UN 2794, PG III

SECTION 2 – HAZARDOUS INGREDIENTS

| Principal Hazardous Component(s) (chemical & common name(s)) | C.A.S. | Hazard Category | % | ACGIH TLV | OSHA PEL/TWA |
|---|-----------|------------------------------------|------------|------------------------|------------------------|
| Lead/Lead Oxide/Lead Sulfate | 7439-92-1 | Acute-Chronic | 60 - 70% | 0.15 mg/m ³ | 0.05 mg/m ³ |
| Antimony | 7440-36-0 | Chronic | 0.5 - 2.5% | 0.5 mg/m ³ | 0.5 mg/m ³ |
| Arsenic | 7440-38-2 | Acute-Chronic | < 0.1% | 0.2 mg/m ³ | 0.01 mg/m ³ |
| Sulfuric Acid (Battery Electrolyte) | 7664-93-9 | Reactive-Oxidizer Acute-Chronic | 10 - 38% | 1.0 mg/m ³ | 100 mg/m ³ |
| Calcium | 7440-70-2 | Reactive | < 0.15% | Not Applicable | Not Applicable |

This Product description or Tradename contains toxic chemicals subject to reporting requirements under Section 313 of Title III the "Superfund Amendments and Reauthorization Act" of 1986 and 40 CFR 372 and California Proposition 65.

PROPOSITION 65 WARNING: Battery Posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm. Wash hands after handling.

SECTION 3 – PHYSICAL & CHEMICAL CHARACTERISTICS (Fire & Explosion Data)

Boiling Point Electrolyte Approx. 275° F **Vapor Pressure** Electrolyte 1 mm Hg @ 145.8°F **Specific Gravity** Electrolyte (H₂O = 1) 1.080-1.400 **pH** Electrolyte <1

Percent Volatile by Volume (%) Not Applicable **Vapor Density** Hydrogen (Air = 1):0.069
Electrolyte (Air = 1) :3.4 **Evaporation Rate** Not Applicable

Appearance and Odor *Battery:* Polypropylene or hard rubber case, solid.
Lead: gray, metallic, solid.
Electrolyte: Liquid, colorless, oily fluid; acid odor when hot or charging battery.

Flash Point Not Applicable **Flammable Limits in Air% by Volume** Hydrogen (H₂) 4.1% **Lower** 4.1% **Upper** 74.2% **Extinguisher Media** Halon, dry chemical
Polypropylene Auto-Ignition Temperature 675°F

Special Fire Fighting Procedures Lead/Acid batteries do not burn, or burn with difficulty. Extinguish fire with agent suitable for surrounding combustible materials. Cool exterior of battery if exposed to fire to prevent rupture. The acid mist and vapors generated by heat or fire are corrosive. Wear respiratory protection (SCBA) and protective clothing.

Unusual Fire and Explosion Hazards Hydrogen gas and sulfuric acid vapors are generated upon overcharging. Hydrogen gas may be flammable or explosive when mixed with air, oxygen, or chlorine. Ensure adequate ventilation of charging areas consistent with OSHA (29 CFR 1910 & 1926), National Fire Code, ACGIH and other relevant standards.

MSDS – 009 (rev.2)

SECTION 4 – PHYSICAL HAZARDS

| | | | |
|--|--|----------------------------|--|
| Stability | Stable | Conditions to Avoid | Avoid overcharging. Do not allow smoking, sparks, or open flame near batteries while charging. |
| Incompatibility (Materials to Avoid) | Keep battery case away from strong oxidizers. | | |
| Hazardous Decomposition Products | An explosive hydrogen/oxygen mixture within the battery may occur during charging. | | |
| Hazardous Polymerization | Will Not Occur | Do not overcharge. | |

SECTION 5 – HEALTH HAZARDS

| | | | |
|--|---|---|--|
| Threshold Limit Value (TLV) | Permissible exposure limit (PEL) | Sulfuric Acid | TLV 1.0 mg/m ³ (milligram per cu. meter) |
| | | Lead | TLV 0.15 mg/m ³ PEL 0.05 mg/m ³ |
| Signs and Symptoms of Exposure | | | |
| 1. Acute Exposure | Signs of exposure include prickling or burning sensation to skin, eyes or mucus membranes. Battery electrolyte can cause irritation of eyes, nose and throat. Short term liquid or vapor contact may result in irritation and acid burns to the exposed area. Ingestion of electrolyte may cause severe injury. | | |
| 2. Chronic Overexposure | Repeated contact with battery electrolyte (sulfuric acid) may cause drying of the skin which may result in irritation and dermatitis. Prolonged inhalation of a mist of sulfuric acid can cause inflammation of the upper respiratory tract. Ingestion of lead can result in symptoms of lead toxicity including anemia, fatigue, loss of appetite, cramping, and affects to neurological system. | | |
| Medical Conditions Generally Aggravated by Exposure | Exposures to acid mist may irritate pre-existing respiratory diseases. Acid exposure may aggravate skin diseases. Chronic exposure to lead and its compounds may aggravate some forms of kidney, liver and neurological diseases. | | |
| Routes of Entry | Electrolyte: ingestion, inhalation | Lead: Ingestion; lead and compounds not absorbed through skin | |
| Chemical Listed as carcinogen or Potential Carcinogen | No Info. Found | National Toxicology Program | Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> I.A.R.C. Monographs Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> OSHA Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> EPA CAG Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> |
| Human Health Effects | The international Agency for Research on cancer (IARC) has classified "strong inorganic acid mist containing sulfuric acid" as a Category 1 carcinogen, a substance that is carcinogenic to humans. This classification does not apply to liquid forms of sulfuric acid or sulfuric acid solutions contained within the battery. Inorganic acid mist (sulfuric acid mist) is not generated under normal use of this product. Misuse of the product, such as overcharging, may however result in the generation of sulfuric acid mist. | | |

Emergency and First Aid Procedures

Sulfuric Acid (Battery Electrolyte)

| | |
|---------------|--|
| 1. Inhalation | Move to Ventilated Area. Obtain medical attention. |
| 2. Eyes | Wash the eyes with copious quantities of running water for 15 minutes. Obtain medical attention. |
| 3. Skin | Flush area with large amounts of running water. Remove contaminated clothing and obtain medical attention. |
| 4. Ingestion | Wash out mouth with running water. Do not induce vomiting. Call Physician. |

SECTION 6 – SPECIAL PROTECTION INFORMATION

| | | | |
|---|---|--|---|
| Respiratory Protection (Special Type) | Sulfuric Acid Mist – Full face or half mask respirator with acid mist filter or SCBA. | | |
| Ventilation | Change air every 15 min. | Local Exhaust | No Mechanical (General) No Information Found |
| Protective Gloves | Acid resistant rubber or plastic | Eye Protection: Splash resistant goggles or safety glasses with face shield | |
| Other Protective Clothing or Equipment | Acid resistant rubber or plastic apron, boots and protective clothing. | | |

SECTION 7 – SPECIAL PRECAUTIONS AND SPILL / LEAK PROCEDURES

| | |
|--|--|
| Precautions to Be Taken | Store batteries in a cool, dry, well-ventilated area. Do not short circuit battery terminals or remove vent caps during storage or charging. Avoid rough handling which could result in spills or leaks. Do not smoke or use open flames in charging areas. Wash thoroughly after handling product. |
| Other Precautions | Avoid prolonged overcharging or combustion which could liberate hazardous gases and liquids including hydrogen, sulfuric acid, sulfuric acid mist, sulfur dioxide, sulfur trioxide, arsine, or stibine gas. Materials should be kept on site for spill neutralization and containment. |
| Steps to Be Taken in Case Material Is Released or Spilled | Wear protective clothing. Ventilate enclosed areas. Dike to contain contaminated materials and liquids. Limit site access to qualified emergency responders. Neutralize acid spills with sodium bicarbonate (soda ash), calcium carbonate, agricultural lime or equivalent commercial product. Collect all material for proper disposal. |
| Waste Disposal Methods | Return whole scrap batteries to distributor, manufacturer, or lead smelter for recycling. For neutralized spills, place residue into plastic containers with sorbent material, sand, or earth for disposal. Contact local and/or state environmental officials for proper disposal requirements. |

Panasonic

Panasonic Industrial Company
Division of Matsushita Electric
Corporation of America

Two Panasonic Way
Secaucus, New Jersey 07094
201.348.7000
Fax: 201.392.4782

Battery Sales Group

May 24, 1996

ISCO Inc.
P.O. Box 82531
Lincoln, NE 68501-2531

Material Safety Data Sheets (MSDS) are a subrequirement of the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard 29 CFR Subpart 1910.1200. This Hazard Communication Standard does not apply to various subcategories including anything defined by OSHA as an "article". OSHA has defined "article" as a manufactured item: (i) which is formed to a specific shape or design during manufacture; (ii) which has end use function(s) dependent in whole or in part upon its shape or design during end use; and (iii) which does not release, or otherwise result in exposure to, a hazardous chemical, under normal conditions of use. OSHA then goes on to define "hazardous chemical" and "exposure".

Because all of our batteries are defined as "articles", they are exempt from the requirements of the Hazard Communication Standard, 29 CFR 1910.1200, hence a MSDS is not required.

The following components are found in a Panasonic sealed lead acid battery:

| | | Weight Range |
|-----------------------------------|--------------------------------|--------------|
| Sulfuric Acid - Electrolyte | H ₂ SO ₄ | 10 - 20% |
| Lead - Negative Electrode | Pb | 30 - 60% |
| Lead Dioxide - Positive Electrode | PbO ₂ | 5 - 25% |
| Lead Sulfate - Positive Electrode | PbSO ₄ | 1 - 25% |

Concentrations of components depend on the state of charge or discharge and battery size. The hazardous waste code for lead acid batteries is D008. Please dispose of properly. If one of our batteries should leak electrolyte, wash the area with copious amounts of water.

Sincerely,

Battery Sales Group
Panasonic Industrial Company

产品中有毒有害物质或元素的名称及含量

Name and amount of Hazardous Substances or Elements in the product

| 部件名称 Component Name | 有毒有害物质或元素 Hazardous Substances or Elements | | | | | |
|------------------------|---|-----------|-----------|-----------------|---------------|-----------------|
| | 铅 (Pb) | 汞 (Hg) | 镉 (Cd) | 六价铬 (Cr(VI)) | 多溴联苯 (PBB) | 多溴二联苯 (PBDE) |
| 电池 Battery | O | O | X | O | O | O |

产品中有毒有害物质或元素的名称及含量：Name and amount of Hazardous Substances or Elements in the product

O: 表示该有毒有害物质在该部件所有均质材料中的含量均在ST/ 标准规定的限量要求以下。

O: Represent the concentration of the hazardous substance in this component's any homogeneous pieces is lower than the ST/ standard limitation.

X：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出ST/ 标准规定的限量要求。

(企业可在此处，根据实际情况对上表中打“X”的技术原因进行进一步说明。)

X: Represent the concentration of the hazardous substance in this component's at least one homogeneous piece is higher than the ST/ standard limitation.

(Manufacturer may give technical reasons to the “X”marks)

环保使用期由经验确定。

The Environmentally Friendly Use Period (EFUP) was determined through experience.

生产日期被编码在系列号码中。前三位数字为生产年(207 代表 2007 年)。随后的一个字母代表月份：

A 为一月，B 为二月，等等。

The date of Manufacture is in code within the serial number. The first three numbers are the year of manufacture (207 is year 2007) followed by a letter for the month. "A" is January, "B" is February and so on

产品中有毒有害物质或元素的名称及含量

Name and amount of Hazardous Substances or Elements in the product

| 部件名称 Component Name | 有毒有害物质或元素 Hazardous Substances or Elements | | | | | |
|------------------------|---|-----------|-----------|-----------------|---------------|-----------------|
| | 铅 (Pb) | 汞 (Hg) | 镉 (Cd) | 六价铬 (Cr(VI)) | 多溴联苯 (PBB) | 多溴二联苯 (PBDE) |
| 变压器 Transformer | X | O | O | O | X | O |
| 线路板 Circuit Board | X | O | O | O | O | O |
| 接头 Connectors | O | O | X | O | O | O |
| 主电源线 Line Cord | O | O | O | O | X | O |

产品中有毒有害物质或元素的名称及含量：Name and amount of Hazardous Substances or Elements in the product

O: 表示该有毒有害物质在该部件所有均质材料中的含量均在ST/ 标准规定的限量要求以下。

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产品中有毒有害物质或元素的名称及含量

Name and amount of Hazardous Substances or Elements in the product

| 部件名称 Component Name | 有毒有害物质或元素 Hazardous Substances or Elements | | | | | |
|------------------------|---|-----------|-----------|-----------------|---------------|-----------------|
| | 铅 (Pb) | 汞 (Hg) | 镉 (Cd) | 六价铬 (Cr(VI)) | 多溴联苯 (PBB) | 多溴二联苯 (PBDE) |
| 电池 Battery | X | O | O | O | O | O |

产品中有毒有害物质或元素的名称及含量：Name and amount of Hazardous Substances or Elements in the product

O: 表示该有毒有害物质在该部件所有均质材料中的含量均在ST/ 标准规定的限量要求以下。

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A 为一月，B 为二月，等等。

The date of Manufacture is in code within the serial number. The first three numbers are the year of manufacture (207 is year 2007) followed by a letter for the month. "A" is January, "B" is February and so on

Teledyne Isco One Year Limited Factory Service Warranty*

This warranty exclusively covers Teledyne Isco instruments, providing a one-year limited warranty covering parts and labor.

Any instrument that fails during the warranty period due to faulty parts or workmanship will be repaired at the factory at no charge to the customer. Teledyne Isco's exclusive liability is limited to repair or replacement of defective instruments. Teledyne Isco is not liable for consequential damages.

Teledyne Isco will pay surface transportation charges both ways within the 48 contiguous United States if the instrument proves to be defective within 30 days of shipment. Throughout the remainder of the warranty period, the customer will pay to return the instrument to Teledyne Isco and Teledyne Isco will pay surface transportation to return the repaired instrument to the customer. Teledyne Isco will not pay air freight or customer's packing and crating charges. This warranty does not cover loss, damage, or defects resulting from transportation between the customer's facility and the repair facility.

The warranty for any instrument is the one in effect on date of shipment. The warranty period begins on the shipping date, unless Teledyne Isco agrees in writing to a different date.

Excluded from this warranty are normal wear; expendable items such as desiccant, pH sensors, charts, ribbon, lamps, tubing, and glassware; fittings and wetted parts of valves; check valves, pistons, piston seals, wash seals, cylinders, pulse damper diaphragms, inlet lines and filter elements; and damage due to corrosion, misuse, accident, or lack of proper **installation or** maintenance. This warranty does not cover products not sold under the Teledyne Isco trademark or for which any other warranty is specifically stated.

No item may be returned for warranty service without a return authorization number (RMA) issued by Teledyne Isco.

This warranty is expressly in lieu of all other warranties and obligations and Teledyne Isco specifically disclaims any warranty of merchantability or fitness for a particular purpose.

The warrantor is Teledyne Isco, 4700 Superior, Lincoln, NE 68504, U.S.A.

***This warranty applies to the USA and countries where Teledyne Isco does not have an authorized dealer. Customers in countries outside the USA, where Teledyne Isco has an authorized dealer, should contact their Teledyne Isco dealer for warranty service.**

Problems can often be diagnosed and corrected without returning the instrument to the factory. Before returning any instrument for repair, please contact the Teledyne Isco Service Department for instructions and to obtain a return material authorization number (RMA).

Instruments needing factory repair should be packed carefully and shipped to the attention of the service department. Small, non-fragile items can be sent by insured parcel post. **PLEASE WRITE THE RMA NUMBER ON THE OUTSIDE OF THE SHIPPING CONTAINER** and enclose a note explaining the problem.

Shipping Address: Teledyne Isco - Attention Repair Service
4700 Superior Street
Lincoln, NE 68504 USA

Mailing Address: Teledyne Isco
PO Box 82531
Lincoln, NE 68501 USA

Phone: Repair service: (800) 775-2965 (lab instruments)
(866) 298-6174 (samplers & flow meters)
Sales & General Information: (800) 228-4373 (USA & Canada)

Fax: (402) 465-3001

Email: IscoService@teledyne.com



March 2, 2016 P/N 60-1002-040 Rev J



| | | |
|-----|---|------|
| 2-1 | Model 934 Nickel-Cadmium Battery | 2-5 |
| 2-2 | Model 946 Lead-Acid Battery | 2-9 |
| 2-3 | Model 948 Battery | 2-12 |
| 2-4 | Model 948 Battery Charger | 2-13 |
| 3-1 | Model 947 Flow Logger Battery | 3-1 |
| 3-2 | Flow Logger Alkaline Battery | 3-2 |
| 4-1 | Model 961 Wall Charger for Nickel-Cadmium Batteries | 4-1 |
| 4-2 | Model 963 Battery Charger for Lead-Acid Batteries | 4-2 |
| 4-3 | Model 913 High Capacity Power Pack | 4-3 |
| 4-4 | Model 914 Battery-Backed Power Pack | 4-4 |
| 4-5 | Model 965 Five-Station Battery Charger | 4-5 |
| 4-6 | Solar Panel Charger | 4-6 |

Battery/Charger Compatibility 2
Power Product Part Numbers and Compatibility 2