NICAD Batteries Require Proper Care

by
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Nickel-cadmium (NICAD) batteries have almost replaced lead-acid batteries, especially in turbine-powered aircraft. While many of the safety practices and procedures for handling and servicing lead-acid batteries are similar to those specified for NICAD units, there are several important differences and peculiarities of which maintenance technicians should be aware. The following information is intended only to alert technicians to certain areas of concern.

Although all NICAD batteries function on the same basic principles, differences in design and construction may require different maintenance, inspection and servicing procedures. Technicians should refer to the manufacturer's manual for the specific battery in use for appropriate guidance.

Principles of Operation Described

All vented NICAD batteries (those which use a liquid electrolyte solution between the plates) consist of an electrochemical system in which the active materials contained in the cell plates undergo changes in oxidation state with little or no change in physical state. These active materials do not dissolve in the alkaline electrolyte while going through the changes in oxidation state. As a result, NICAD batteries are normally very long-lived when properly serviced and maintained.

Although some of the electrochemical mechanisms involved in the charge, discharge and storage of the NICAD battery are complex, the general workings within the cell that enable it to store an electrical charge (then discharge and be recharged) are known.

In a discharged condition, the active materials in the battery are:

- Cadmium hydroxide in the negative plates; and,
- Nickel hydroxide in the positive plates.

The electrolyte is a solution of 30 percent potassium hydroxide and 70 percent distilled or deionized water. The purpose of the electrolyte is to transport ions between the positive and negative cell plates. Unlike the electrolyte in a lead-acid battery, the NICAD electrolyte does not change significantly in specific gravity during the charge and discharge processes. As a result, hydrometer measurements of electrolyte specific gravity cannot be used to determine the state of charge of a NICAD battery. Under normal usage, the electrolyte chemical (potassium hydroxide) is never added in service. Only pure distilled or deionized water is used to maintain the liquid level in the individual cells.

With the application of a charging current, the active materials undergo a chemical change. The negative material gradually loses its oxygen and is converted to metallic cadmium. The positive material is gradually brought to a higher state of oxidation. As long as the charging current continues to flow through the battery, these changes will take place until the active materials in both electrodes are completely converted.

As the battery approaches its fully charged condition, the water component of the electrolyte is subject to electrolysis effects and some gas may be emitted through the cell vent(s). The gas evolved at the negative plates is hydrogen and at the positive plates it is oxygen. The amount of gas emitted depends on the temperature and the charge rate during the charging cycle. If the charging is continued beyond the fully charged condition, electrolysis will be increased and the gassing rate will be accelerated.

In the discharge mode, when the battery is supplying current, the chemical reactions that occurred during charge are reversed. The active material in the negative plates regains oxygen and changes to cadmium hydroxide. The active material in the positive plates changes to nickel hydroxide as it loses its higher state of oxidation. No gassing occurs during a normal discharge of the battery.

Special Charging and Testing Equipment Required

The simple charging devices used for lead-acid batteries are not acceptable for charging NICAD batteries. Only units provided or approved by the NICAD battery manufacturers should be used to test and recharge their batteries.

NICAD batteries may be charged by two methods.

Constant voltage charging is a process in which the voltage output of the charger is maintained constant throughout the charge. This method, which uses a voltage-regulated charging circuit, is the one normally used in the aircraft (or other vehicle) installation. Constant voltage charging can replace in a matter of minutes most of the charge depleted by a starting cycle.

This method provides a rapid, but not necessarily full recharge, and capacity imbalances can be created among the cells during discharge/charge cycles. The continuous overcharging also results in the consumption of water from the electrolyte. These factors dictate the need for a periodic reservicing of the battery to ensure the unit's full capacity.

The initial surge of current to a nearly discharged battery during constant voltage charging can be up to 10 times the rated capacity of the battery the system is capable of providing. This initial surge tapers off as the battery reaches a higher level of charge. The magnitude of the initial surge current depends upon factors such as:

- Output voltage of the charging source — the higher the voltage, the higher the charge current;
- State-of-charge of the battery — a more severely discharged battery will accept a higher current than a partially charged one; and,
- Battery temperature — the higher its temperature, the more depressed the battery voltage and the greater the charge current.

A review of these factors provides insight into the "thermal runaway" phenomenon to which NICAD batteries are exposed. Each factor magnifies the effect of the others, thereby increasing the potential for thermal runaway to occur. This potential problem led to the requirements for battery temperature sensing and overheat warning devices in modern aircraft equipped with NICAD batteries.

Constant current charging of NICAD batteries is the preferred method for use in shop equipment and ground servicing. In this method, a predetermined and relatively constant current is maintained throughout the charge and overcharge intervals. While this method is slower, it provides a better cell balance and ensures full battery capacity.

Many shops use a “two-level” or “stepped” constant current procedure in which the battery is charged at a specified rate for a given period and then at a reduced rate for a second interval. This method provides a complete charge in a shorter period, but it may require more monitoring by the technician or a more sophisticated charging unit.

Store Batteries Charged or Discharged

NICAD batteries may be stored charged or discharged for extended periods without damage. Manufacturers’ manuals may contain specific instructions if a battery is to be stored for an extended period in a discharged state. There may also be special procedures required for discharging and shorting of the cells to ensure cell equalization when storing a discharged unit.

If storing a battery for active standby use, a trickle-charging unit is recommended. When storing a battery on a trickle-charger, the electrolyte must be periodically checked to ensure adequate levels.

Charged NICAD batteries typically self-discharge slightly if stored without being on a trickle-charge unit. A fully charged battery can usually be stored for a short period and be suitable for immediate installation. Charge retention is affected by ambient temperature and higher temperatures will result in a greater loss of charge. To ensure full capacity, a unit in storage for more than 10 to 12 days should be charged before placing it in service.

Observe Safety Precautions For Service and Maintenance

Never mix or interchange lead-acid equipment with NICAD equipment. Separate shops are highly recommended. Chemically, the electrolyte used in lead-acid units is the opposite of that used in NICAD units. Even traces of the sulfuric acid from a lead-acid battery entering the electrolyte of a NICAD unit will result in damage. The acid fumes can also corrode the hardware of the NICAD unit.

Be careful when working near NICAD batteries. Rings, metal watchbands, bracelets, etc., should be removed. Avoid the use of uninsulated tools. Do not use metal brushes when cleaning batteries or battery components. Connectors must be properly torqued to ensure adequate contact and eliminate arcing under the high current flows existing in NICAD batteries. Keep fire and ignition sources away from the battery. Explosive hydrogen gas may

Potential NICAD Problems

Complaint	Possible Cause
Apparent loss of capacity	Normal from extended use in service on aircraft constant voltage bus. Usually corrected by deep cycle and reconditioning.
	Electrolyte level too low. Unit may require more frequent servicing to ensure adequate electrolyte.
	Aircraft generating system voltage regulator set too low. Check and adjust as required.
Excessive use of water	Leaky cells or defective caps. Inspect and repair as necessary.
	Cell imbalance. Recondition following manual.
	Charge voltage too high. Check and adjust aircraft generating system voltage regulator setting(s).
Foaming of electrolyte	Contaminant in electrolyte. Cell replacement probably required.
	Low electrolyte concentration following addition of water. May require discharging cell to recondition or replace.
Distorted battery case	Overheating or explosion within battery case. May be due to loose connection(s), plugged ventilation system, unusually high ambient temperatures, excessive charge rate.
Discolored connectors	Dirty or loose connectors. Clean and replace parts as required. Ensure proper mating and torque.

be emitted during the charging cycle.

Wear a face shield to protect eyes and facial skin. Wear rubber gloves and a full apron when servicing NICAD batteries. The electrolyte solution is caustic and can cause serious burns if it comes in contact with skin. The water used to wash the cells or battery case becomes caustic and contact with it should be avoided. Avoid the use of compressed air to dry moisture or blow away dirt, because the spray or particles can be extremely harmful to human tissue.

If electrolyte does come in contact with skin, flush it immediately with large quantities of water and neutralize it with a 10-percent boric acid and water solution, or a 3-percent vinegar solution, or lemon juice and water solution. If electrolyte gets into the eyes, flush them with water and get medical attention immediately.

Provide adequate ventilation in NICAD charging areas. Hydrogen and oxygen gases are generated during the charging process and should not be allowed to accumulate in a confined area. Battery covers should be removed or the battery vent connected to a ventilating system when charging.

Read and follow the manufacturer's manual. Do not assume that all NICAD batteries are the same just because they are interchangeable in the aircraft.♦

References

Operating and Maintenance Manual for Nickel-Cadmium Aircraft Batteries, SAFT America Inc.

Care and Maintenance of Nickel-Cadmium Batteries, Marathon Power Technologies Battery Products

What is "Airworthy"?

The term "airworthy" is used every day by aviation technicians, yet there is confusion and disagreement about the proper definition of this term. Unfortunately, the U.S. Federal Aviation Administration (FAA) has not included airworthy in its Federal Aviation Regulations (FAR) Part 1, which contains the official definitions of words used in the FAR.

The FAA has, however, defined this word in the *Airworthiness Inspector's Handbook*, #8300.9:

> Section 15. Interpretation of the Term "Airworthy"
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> 185. Purpose. While this section does not deal with airworthiness certificates, the analogy of the conditions necessary for issuance of the certificate is used to clarify the term "airworthy." The term is not defined in the FAA act or the regulations; however, a clear understanding of its meaning is essential for use in the agency's enforcement program.
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> 186. General. A review of case law relating to airworthiness reveals two conditions must be met for an aircraft to be considered airworthy. These conditions are:
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> a. The aircraft must conform to its type design (certificate). Conformity to type design is considered attained when the required and proper components are installed and they are consistent with the drawings, specifications, and other data that is a part of the type certificate. Conformity would include applicable supplemental type certificates and field approved alterations.
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> b. The aircraft must be in condition for safe operation. This refers to the condition of the aircraft with relation to wear and deterioration. Such conditions could be skin corrosion, window delamination/crazing, fluid leaks, tire wear, etc.
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> 187. Discussion. Section 603(c) of the act and FAR Sections 21.183(a), (b), and (c) all relate to the two conditions necessary for the issuance of an airworthiness certificate. The statutory language establishes

the two conditions as: (1) The aircraft must conform to the type design (certificate): and (2) it is in a condition for safe operation. The above conditions are further reflected as terms and conditions appearing upon the front of the Standard Airworthiness Certificate, FAA Form 8100-2.

188. Conclusion. An aircraft can be considered airworthy when the administrator finds it conforms to the specifications of its type certificate, and it is in a condition for safe operation. If one or both of these conditions are not met, the aircraft would be unairworthy.

A similar interpretation of airworthy is included in FAA Advisory Circular 20-5F, *Plane Sens*e.

Aeroquip Bulletin Illustrates Hose Problems

Aeroquip Corp.'s aerospace group has introduced *Bulletin AA91*, which discusses and illustrates how to recognize seven of the most common hose line problems before they cause major difficulties.

Included in the bulletin is information on how to identify:

- Kinked hose;
- Twisted hose;
- Scuffed hose;
- Brittle hose;
- Rusty hose;
- Seeping hose; and,
- Broken braids.

For a free copy of the bulletin, contact: Aeroquip Corp., Advertising Department, 3000 Strayer, Maumee, OH 43537 U.S.

Lockheed Aeromod Center Trains Aviation Structural Repair Technicians

The Lockheed Aeromod Center in Tucson, Arizona, U.S., working in conjunction with Pima Community College's aviation department, has developed a program to qualify technicians in heavy structural repair techniques and skills.

The first class of 29 technicians graduated earlier this year after attending more than 1,215 hours of classroom and hands-on training. The demand for structural repair skills was illustrated by the job offers made to this first class of graduates. One student said that he received three job offers within a week after graduation. An airline offered employment to 21 of the class members.

The curriculum covers traditional metallic structures as well as state-of-the-art techniques in composite repairs and rework. Richard Scholl, vice president and general manager of Lockheed Aeromod said, "This program is a perfect example of how education and industry can work together to achieve a common goal."

The course requires full-time attendance, eight hours a day, five days a week. Several students left full-time jobs to enroll in the course. Seven of the initial class members have opted to continue their training and will be among the first to receive an associate degree in aviation structural repair. Initial response from industry has been very favorable and demand for these specially-trained technicians is expected to grow as more aging aircraft modification programs are developed.

MAINTENANCE ALERTS

This information is intended to provide an awareness of problem areas so that occurrences may be prevented in the future. Maintenance alerts are based upon preliminary information from government agencies, aviation organizations, press information and other sources. The information may not be entirely accurate.

Fuel Additives Found Harmful to Fuel Manifold Braze Connections

The Quality Assurance Bureau of China's Ministry of Aerospace Industry recently conducted an extensive investigation and analysis to determine the causes of an unusual number of fuel leakage instances in the fuel manifold assemblies of JT3d-7 engines used on Boeing 707 aircraft.

It was found that a primary cause of the unusually high failure rate experienced by certain operators was due to corrosive effects of an additive used to improve fuel performance. The study indicated that this additive reacted with the copper in the fuel manifold braze joints, resulting in destructive corrosion of the braze filler. The corrosive effects were found to increase exponentially with elevated operating temperatures in this area.

The analysis confirmed that the braze material was being attacked by an additive (number 33) present in the fuel. The corrosion rate and subsequent leakage was found to be predictable and directly related to the length of the brazed joint and the time it was subjected to elevated temperatures. Any discontinuities or bubbles in the braze joint were found to increase the rate of deterioration. The operator has established an in-service life-limit on the fuel manifold assemblies to reduce their exposure to potentially catastrophic fuel leaks.

Silicone Spray Can Affect Fire-blocking

A major U.S. airline recently issued an alert to its field maintenance personnel cautioning technicians to be careful when using silicone sprays in the vicinity of fire-blocking treated fabrics. The operator discovered that seat cover upholstery materials that originally met fire-blocking specifications later failed the tests after being exposed to silicone spray.

It was found that silicone spray lubricant had been used to free up sticky mechanisms on seats, trays or window closures, and atomized particles settled on the seat cover materials. The overspray was sufficient to mask the materials' fire-blocking capability and cause it to fail. Technicians have been instructed to prevent spray lubricants from contaminating the upholstery.

Commuter Accident Attributed to Maintenance Error

On Sept. 11, 1991, an EMB-120 commuter airplane, operated in the southwestern United States, crashed. The crew had initiated a descent from 24,000 feet. While passing through 11,800 feet, the leading edge of the left horizontal stabilizer separated from the airplane.

Subsequent investigation determined that loss of the leading edge's aerodynamic surface, combined with the sudden increase in drag caused by the exposed flat structural plane on the left side of the horizontal stabilizer, led to an almost immediate stall of the horizontal stabilizer and a rapid downward pitch of the airplane's nose. The negative loading on the airplane's structure resulted in the left wing folding under the fuselage and the subsequent breakup of the airplane. There were no survivors among the 14 persons aboard.

The investigation revealed that the airplane had undergone maintenance work in the company hangar the night before the accident. During the second shift, the scheduled removal and replacement of both the left and right horizontal stabilizer leading edge/deicer boot assemblies was undertaken. The removal of each leading edge required removal of more than 40 screws from each assembly. Two mechanics and an inspector were assigned to the task.

The crew gained access to the T-tail with a high stand, and the screws were removed from both the top and bottom of the right-side leading edge. One crew member walked across the top of the T-tail and removed the screws from the *top side only on the left-side leading edge.* A shift change took place before the work was completed and the bottom screws were never removed from the left-side leading edge assembly and, more importantly, the upper screws were not replaced. There was no entry in the work turnover form of the status of the work performed nor was the new supervisor verbally informed of the partial removal of the left-side leading edge hardware.

The right-side leading edge was subsequently replaced by the next shift, and both upper and lower screws reinstalled. The supervisor decided to postpone replacing of the left-side leading edge assembly due to limited time. The aircraft was moved out of the hangar and signed back into service.

The flight crew for the morning departure was not informed about the work performed on the horizontal stabilizer edges. Moreover, the top of the horizontal stabilizer cannot be seen in the course of a normal preflight walk-around inspection. The airplane was assigned to a morning passenger flight and the accident occurred on the return leg of the first flight.

Although the operator's manual had a clear procedure calling for a written record of work in progress on the detailed work cards, this procedure was not followed. The manuals also called for a verbal end-of-shift briefing by mechanics to their supervisors and a shift turnover briefing between the outgoing and incoming supervisors. These procedures were also not performed in accordance with the manual.

This accident is a tragic example of what can occur by a failure to follow established procedures and taking shortcuts. The importance of proper recording of work in progress and of performing a complete and thorough shift turnover cannot be overemphasized.

Lightweight Pressure Vessels Easily Damaged

One of the newer developments in lightweight pressure vessels used in newer aircraft is the use of an aluminum cylinder wrapped with Kevlar fibers sealed in epoxy. The aluminum provides the containment while the Kevlar provides the required strength to withstand the pressure. Such units weigh about 50 percent less than conventional steel bottles.

Once these containers are installed, they are relatively resistant to damage and abuse. Problems are apparently the result of careless handling after removal for servicing. Several units have been damaged in a manner indicating that they were scraped or dragged along the pavement after removal. The Kevlar wrapping has little resistance to abrasion and is easily damaged when mishandled. Pressure containment of such vessels is severely reduced if the Kevlar wrapping is damaged and it cannot be repaired.

The cost of unnecessarily scrapping a unit is a burden which no operator should have to bear. In addition to the cost factor, a technician or other innocent individual could be severely injured if a damaged container failed under pressure as a result of damage to the Kevlar wrapping.

NTSB Alerts Industry to Potential VOR/ILS Receiver Problems

In November 1990, a DC-9-32 aircraft operated by a European airline crashed during approach into the side of a mountain about five miles from the destination airport. There were no survivors among the 40 passengers and six crew members on board.

The subsequent accident investigation disclosed a possible failure mode of the very high frequency omnidirectional range (VOR)/instrument landing system (ILS) installed on the airplane that could have contributed to this controlled flight into terrain. The failure mode could have led the flight crew to believe incorrectly that they were on course and on the glidepath.

The airframe manufacturer found that it is possible that a short circuit or an open circuit in certain models of VOR/ILS receivers could cause navigation instruments to indicate "zero deviation." Thus, raw data deviation information on the attitude direction indicator, displayed by the flight director bars and the horizontal situation indicator, could center and remain centered with no failure or warning flag in view. In addition, this short circuit or open circuit could prevent the autopilot and the ground proximity warning system (GPWS) from receiving the proper course and glidepath deviation signals. The autopilot would continue to guide the airplane according to previously established crew inputs, and the GPWS would not sound an alarm due to glideslope deviation or descent below a safe altitude. This could also occur if the VOR localizer or glideslope signals to the autopilot were interrupted by an open circuit.

To cross-check the system, the pilot and copilot normally use two separate VOR/ILS receivers for navigation information that would be displayed on their respective instruments. However, without warning flags indicating system failure, the pilots might accept as accurate centered indications and then use the "NAV" switching function to select the malfunctioning VOR/ILS receiver on both panels.

According to the airframe manufacturer, some VOR/ILS receivers have an expanded self-monitoring capability to detect this kind of failure. Receivers that do not have this feature are:

Collins model 51RV-1
Collins model 51RV-4
Wilcox model 806
King model KNR6030
Bendix model RNA 26C (some versions)

The airframe manufacturer of the accident airplane issued alert notices to all affected operators that described the potentially hazardous failure mode, as long ago as 1984 and again in 1991. These receivers are, however, installed on many aircraft of various types and models, and some users may not have been notified about the problem.

A U.S. National Transportation Safety Board (NTSB) safety recommendation suggests that operators who have these receivers include a procedure in the pilot operating manuals for detecting malfunctions. Also, it was suggested that the affected operators include this potential failure scenario in flight crew training curricula. ♦

Posilock Hydraulic Pullers Enhance Operator Safety

The Steelgrip Tools Inc. recently introduced a line of hydraulic puller fixtures with a special lock-on feature intended to reduce the risk of coming detached under pressure. The device includes a cage that keeps the two or three jaws in place while applying hydraulic pressure to effect the pulling pressure. The company claims that simply turning the T-handle to engage the caging device increases the safety of pulling operations while easing the work of the technician. For more information, contact: Steelgrip Tools Inc., 5252 W. Armstrong Ave., Chicago, IL 60646 U.S. Telephone (312) 763-6500.

Photograph not available.

Flexible Polyurethane Primes Aluminum

The Lord Corp., Industrial Coatings Division, recently introduced a highly flexible primer for aluminum, which is available in two versions.

Aeroglaze K3607 is a high-solids, two-component polyurethane primer, intended for use over clean, alodine- and anodized-treated aluminum. This primer is designed for conventional spray equipment.

Aerogaze K3605 is a quick-dry formulation intended for high volume production use and can be applied using plural component spray equipment. This product has a 15-minute pot life and cures in 30 minutes.

The manufacturer states that a key feature of both products is flexibility of the coating after application, plus its environmental resistance. The maker claims that both primers pass testing of 40 inch pounds of direct impact when tested by the Gardner impact tester. No cracking or adhesion failure is exhibited under the standard high temperature baking test or at the minus 70 degrees F. cold temperature testing. Lord further states that both primers have passed durability testing of 3,000 hours of salt-fog corrosion, 60-days filiform corrosion and 30-day room temperature testing with synthetic hydraulic fluids.

For further information, contact: Lord Corp., 845 Olive Avenue, Suite 207, Novato, CA 94945 U.S. Telephone (415) 898-1995.

Photograph not available.

Safety Matting Absorbs Spills

Foss Manufacturing Co. has developed a non-absorbent, non-penetrating matting product designed to provide a cleaner and safer work environment by absorbing up to 10 times its own weight in oil, water or chemical spills. This non-woven matting, called Enviro-Mat, is said to eliminate slipping on virtually any type of flooring and can prevent absorbed fluids from seeping and spreading under the mat.

The non-skid backing is said to prevent slipping and its use eliminates the need for messy granular products that can be tracked into or contaminate other work areas. The material is available in rolls or in three-by-five-foot mats. For further information, contact: Foss Manufacturing Co., 380 Lafayette Road, Hampton, NH 03842 U.S. Telephone (603) 929-2111.

WD-40 Has Many Uses

“WD” stands for water displacement, and the familiar WD-40 product is formulated to penetrate into the pores of metal surfaces and creates a continuous molecular film. This film acts as a lubricant, rust preventive and cleaner.

Originally developed to prevent corrosion on U.S. Atlas missiles, the manufacturer of WD-40 claims that this product has many applications in all types of aircraft.

As a cleaner containing no silicone, the maker states that it will not become gummy or attract dirt and dust.

Photograph not available.

When used as a moisture displacer, the manufacturer states that WD-40 creates a moisture barrier that is electrically non-conductive and prevents water from wetting the surface. This characteristic is useful in applications on battery terminals, wiring and electrical connectors.

As a lubricant, the manufacturer claims that the product can prevent sticking and jamming of door latches, hinges, cowl hold-open devices or other devices without causing messy build-ups of grease or oil.

For more information, contact: WD-40 Co., 1061 Cudahy Place, San Diego, CA 92110 U.S. Telephone (619) 275-1400. ♦