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ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: NICKEL-CADMIUM BATTERY OPERATIONAL, MAINTENANCE, AND OVERHAUL PRACTICES

1. PURPOSE. This circular provides guidelines for more reliable nickel-cadmium battery operation through sound operational and maintenance practices.

2. BACKGROUND. An increasing number of potentially hazardous incidents involving nickel-cadmium (ni-cad) batteries, during flight and ground operations have been reported. The failures are more prevalent where the batteries are charged directly from the DC bus rather than by a separate battery charger. Although the ni-cad battery is capable of delivering large amounts of current, while maintaining its rated voltage to approximately 90 percent of its discharge life, the battery is inherently temperature sensitive, and a majority of the reported incidents can be attributed to overheating. The overheat conditions can be minimized or averted by following proper operational, maintenance, and overhaul practices.

3. TEMPERATURE EFFECTS ON NI-CAD BATTERIES. The nickel-cadmium battery is capable of performing to its rated capacity when the ambient temperature of the battery is in the range of approximately 70° to 90° F. An increase or decrease in temperature, from this range, results in reduced capacity. A combination of high battery temperature (in excess of 100° F.) and overcharging can lead to a condition called "thermal runaway." Some battery charging systems are designed to prevent overcharging and high battery temperatures by utilizing temperature sensors to reduce charging rate or thermal cutout protection which disconnects the battery from the charging source (DC bus or separate battery charger) at a predetermined temperature.

Basically, "thermal runaway" is an uncontrollable rise in battery temperature that will ultimately destroy the battery. This condition can occur when a ni-cad battery is operated at elevated temperature and subject to high charging currents associated with constant voltage charging. As the temperature of the battery increases, the effective internal resistance decreases and higher current is drawn from the constant voltage charging source. This increases the battery temperature which in turn results in ever increasing charging currents and temperatures.

4. CAUSES OF BATTERY OVERHEATING. Battery overheating can be caused or accelerated by the following factors which are related to operational and maintenance practices:

   a. Cells low on electrolyte.

   b. Excessive engine cranking.

   c. Frequent engine starts.

   d. Aircraft generator bus voltage too high.

   e. Aircraft generator bus voltage fluctuating.

   f. Ground operations using power units with voltage settings higher than the recommended aircraft bus voltage or power units with poor regulation.

   g. Poor ventilation of the battery compartment during hot weather particularly during ground operations.

   h. Loose cell-to-cell connections (commonly called links).

   i. Cell vents clogged or obstructed.

   j. Unnecessary use of aircraft batteries to run auxiliary equipment, such as lights, avionics equipment, ventilation systems, etc., during ground operations.

   k. Current leakage - cell to case.

5. OPERATING PRACTICES. To provide increased reliability it is recommended that the following operating practices be observed:

   a. Service batteries at the interval recommended by the aircraft and battery manufacturer; however, more frequent servicing may be necessary depending upon the following variables:

      (1) Hard or frequent engine starts.

      (2) Duty cycle for battery (useage hours).

(3) Outside ambient operating temperatures.

(4) Aircraft generator voltage regulator setting.

b. When experiencing hard engine starts, follow the manufacturer's recommended rest periods between starts. Prolonged engine cranking can cause excessive battery discharge current resulting in high battery temperatures.

c. When a series of short duration flights are planned, consider the use of well regulated external power of proper voltage for engine starts. Continued use of the battery for engine starts, during a series of short duration flights, results in the battery undergoing heavy discharge cycles accompanied by incomplete charge cycles. This can lead to cell imbalance, possible battery overheat, and loss of battery capacity. Proper battery conditioning and conservative use of the battery is important for all operations.

d. Careful observation of the aircraft bus voltage and load current will provide an indication of the charge voltage and current applied to the battery. A persistent increase, decrease, or fluctuation of the aircraft bus voltage or load current indicates an abnormal condition. Initiate corrective action as soon as possible as these conditions may result in either an overcharged or undercharged battery and possible failure. An increase in load or charge current as indicated on the aircraft load meter, especially during normal cruise, with no additional circuits being energized may be an indication of the battery overheat or failure.

e. It is recommended that ni-cad batteries not be charged in the aircraft by a ground power unit. If conditions warrant charging the battery in the aircraft, follow the precautions listed in item 7a. of this advisory circular, plus the recommendation of the aircraft and battery manufacturers.

f. During extended ground operation keep the battery loads to a minimum and ensure there is adequate battery compartment ventilation. When the outside ambient temperature is high, additional ventilation may be provided by opening the battery compartment access door.

6. SHOP MAINTENANCE. Follow the manufacturer's instructions regarding periodic servicing, capacity checks, and reconditioning to ensure a more reliable and properly conditioned nickel-cadmium battery. The following areas should be given special attention:

a. Battery facilities. Separate shops, equipment, and tools are recommended for servicing ni-cad and lead acid batteries. Anything associated with lead acid batteries (acid fumes included) that comes in contact with a ni-cad battery or its electrolyte can cause severe damage.

b. Make certain that cell links are secure. A loose cell link can generate heat and cause arcing which may ignite battery gases. Torque the cell links according to the manufacturer's specifications.

c. Keep battery and vents clear of obstruction by brushing with a non-metallic brush or cleaning cloth. Do not use solvents or wire brushes.

d. Adjust the electrolyte level, if necessary, after the battery has been fully charged using distilled or demineralized water. When a ni-cad battery is in a discharged condition, the electrolyte is absorbed into the plates and may not be visible from the tops of the cells. Immediately after charging the electrolyte is at its maximum height in the cell. Evidence of electrolyte being spewed out of the battery cell vents indicates an abnormal condition which requires corrective action. Under these conditions remove the battery for bench servicing, and check the aircraft electrical system for proper bus voltage and system regulation. A key point to remember is that the addition of too much water when the battery is discharged or in a partially discharged state will result in electrolyte spewing out during charging. This can result in the following:

(1) Corrosive effects on the cell links.

(2) Creation of current leakage paths between cells and the battery case resulting in self-discharge of the battery.

(3) Dilution of the electrolyte density which reduces battery capacity.

(4) Possible blockage of the cell vents by potassium carbonate residue with a resultant pressure buildup and eventual cell rupture.

7. AIRCRAFT BATTERY MAINTENANCE. Give special attention to the following areas in conjunction with aircraft battery maintenance.

a. Charging ni-cad batteries with a constant voltage ground power unit is not recommended in as much as this eventually results in cell imbalance and gradual reduction in battery capacity. Observe the following criteria when charging a battery in the aircraft:

(1) Assure that the battery compartment is well ventilated.

(2) Establish, prior to charging, that the ground power unit voltage output is well regulated and its volt/ammeters are accurate.

(3) Remove the battery cover and check that cell links and caps are secure. Leave the battery cover off during charging to allow visual monitoring and to increase ventilation. It is recommended a battery not be charged in an aircraft when the battery temperature or battery compartment temperature is above approximately 100° F.

(4) Charging voltage does not exceed the recommended bus voltage setting for the particular aircraft.

(5) Battery does not spew out electrolyte.

b. It is not recommended that battery electrolyte specific gravity checks be performed in the aircraft. The specific gravity reading does not indicate the state of charge of a nickel-cadmium battery but only indicates the concentration of the potassium hydroxide in the electrolyte. Remember that if electrolyte is being boiled or spewed out of the battery, there is a need for corrective action, including bench servicing of the battery.

c. Visually inspect the battery and associated hardware on a periodic basis. Conduct a detailed investigation when any of the following discrepancies are noted:

(1) Cell case distorted.

(2) Cell link corrosion.

(3) Burn marks on battery terminals or cell links.

(4) Cell links show signs of overheating.

(5) Electrolyte has spewed or leaked from cells.

(6) Battery and cell vents are obstructed.

8. OVERHAUL PRACTICES. The construction and design of nickel-cadmium batteries allows easy overhauling of the individual cells, and the following guidelines are recommended to ensure meeting the original battery manufacturers specifications. Give special consideration to: frequency of the cell overhaul, mixing cells of different manufacturers, cell identification, battery identification, and quality control.

a. Frequency of cell overhaul. It is recommended cells be overhauled only once because of the following considerations:

(1) During the scrubbing or cleaning process, some of the plate material is lost, reducing cell capacity.

(2) Flexing of the plates during scrubbing may cause the tab-to-plate weld joints to crack. Heat can be generated at these joints and could result in premature cell failure.

It is the repair agencies responsibility to assure the repaired cell meets all the manufacturers specifications before it is released for return to service.

b. Mixing cells of different manufacturers. Manufacturers do not recommend mixing cells and indeed some manufacturers warranties become void when cells are mixed. The following illustrates why mixing of cells is not recommended:

(1) Cell materials establish the charging characteristics and charge retention properties for that cell. Since cell materials may differ between manufacturers, a battery made up of mixed cells is more susceptible to cell polarity reversal. The end result could be unreliable battery performance.

(2) Although some cells are the same physical size they have different current carrying characteristics. Therefore, batteries with mixed cells may not meet rated specifications, and be contrary to FAR 43.13. If the original manufacturer does not specify a compatible replacement cell, determine that the replacement cell is compatible in all essential respects including physical and electrical properties.

c. Identification of new and overhauled cells.

(1) New cells are usually identified by the manufacturer stamping the part number on the cell case.

(2) Manufacturers and repair stations use various methods to identify an overhauled cell, such as a stamped identification on the plastic case or color coding the cell cover.

(3) To preclude inadvertent mixing cells of different manufacturers, retain the original manufacturer's cell identity (manufacturer's part number) on the overhauled cell in addition to the repair agencies overhaul identification data.

d. Battery identification. Batteries are usually approved in conjunction with type certification (TC) procedures for that aircraft and can be identified by referring to the aircraft parts list and the battery manufacturer's name plate. Batteries not listed on the aircraft parts list may not meet original certification requirements for specific aircraft; however, it is necessary that replacement or overhauled batteries meet the requirements of FAR 43.13.

It is recommended that repair agencies mark an overhauled battery with their identity so as not to obliterate the original manufacturer's identification.

e. Quality control procedure. In addition to the standard quality control procedures utilized by a repair facility when overhauling ni-cad cells, give special consideration to the cell plate stacks. Inspect plates carefully for evidence of burned, crimped, or frayed edges, hot spots and other damage. Trimming damaged plate edges is not recommended as this practice reduces cell capacity. It is recommended that damaged cell plates or stacks be discarded. Ni-cad cells are not consistently identical with respect to their capacity, and this can be further applied to the plate stacks (positive and negative) of the individual cells. Procedures to retain positive and negative plate stack pairing is recommended for the following reasons:

(1) If one plate stack is found to be defective during cell overhaul, the other polarity stack will also be affected to some degree due to their close physical proximity. It is recommended that both stacks be discarded if one plate stack is found defective.

(2) If both polarity stacks are found satisfactory, retain them as a matched pair, as their electrical and physical characteristics are relatively the same.

9. SUMMARY. Optimum and reliable performance can be expected from nickel-cadmium batteries when they are operated, maintained, and overhauled in accordance with the battery and aircraft manufacturers' instructions. The degree of reliability is directly proportional to the quality of the practices followed in the operation, maintenance, and overhaul of nickel-cadmium batteries.

Acting Director
Flight Standards Service

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FEDERAL AVIATION ADMINISTRATION
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