TECH TIME

Helpful tips for the Avionics Technician

BY AL INGLE

This month we continue our study of electrical load analysis, a subset of *wiring systems*. As was explained previously, an electrical load determination is required when installing new equipment into an aircraft or when questions arise as to the state of an electrical system. The British Civil Aviation Authority has already addressed many, if not all of these deficiencies through an *Airworthiness Information Leaflet* titled *AIL/0194, Issue 1, 25 March 2004*. This is a well written and thorough document and will be used as a guide in this series. It may be found at www.caa.co.uk.

Last month we touched upon the industry's lack of knowledge of an electrical system's capacity and consumption under Emergency conditions. This is the condition whereby the aircraft is operating with an auxiliary power unit (APU) or Ram Air Turbine, in the case of some airline transport category aircraft, or in the case of most general aviation and business aircraft, the battery. Therefore, it is the battery that will be the focus of this article. Let us review the FARs regarding Emergency (battery) operation.

§23.1351 (g) states in part: *It must be shown by analysis, tests, or both, that the airplane can be operated safely in VFR conditions, for a period of not less than five minutes, with the normal electrical power (electrical power sources excluding the battery and any other standby electrical sources) inoperative, with critical type fuel (from the standpoint of flameout and restart capability), and with the airplane at the maximum certificated altitude…*

§23.1353 (h) states: *In the event of the complete loss of the primary electrical power generating system, the battery must be capable of providing at least 30 minutes of electrical power to those loads that are essential to continued safe flight and landing. The 30 minute time period includes the time needed for the pilots to recognize the loss of generated power and take appropriate load shedding action.*

For our analysis, we are going to invoke the requirements of §23.1351(c)(4) that states: *There must be a means to give immediate warning to the flight crew of a failure of any generator/alternator.* Following the loss of a generator/alternator, it is assumed a 5-minute period will elapse prior to any manual load shedding by the flight crew. Any automatic load shedding is assumed to take place immediately. For aircraft that do not provide a flashing warning to the flight crew, 10 minutes will be assumed to elapse before manual load shedding.

Part 91 or 135 operators flying under IFR conditions should have the following equipment operational:

- One airspeed indicator and altimeter with a heated pitot tube and heated static pressure source;
- Magnetic compass, and any display necessary for continued safe flight and landing, sufficiently lighted for night operation;
- One navigation system installation appropriate to the ground facilities to be used;
- One communication installation system;
- One gyroscopic pitch, directional and bank indicator;
- One clock;
- Any display for the powerplant parameter necessary for continued safe flight and landing;
- Any electrical loads unique for the airplane characteristics and needed for continued safe flight and landing for the intended operations.

We must determine the rated operating capacity of the battery, the normal service life, and the continued airworthiness requirements of §23.1529. For the published operating capacity we are interested in the discharge rate, temperature, end-point voltage, etc. For the airworthiness requirements we must review the inspection schedule, useful battery life, end-of-life, etc. Some assumptions regarding battery terms and conditions have briefly been discussed in previous articles. For the load analysis the capacity of the battery is expressed in ampere-minutes (ampere-hours x 60) to discharge to a specified voltage level. We know that the voltage decay is not linear over time or discharge rate and that heavier currents reduce the overall capacity of the battery. Figure 1 below shows the typical discharge curve for Ni-Cad and lead Acid batteries.

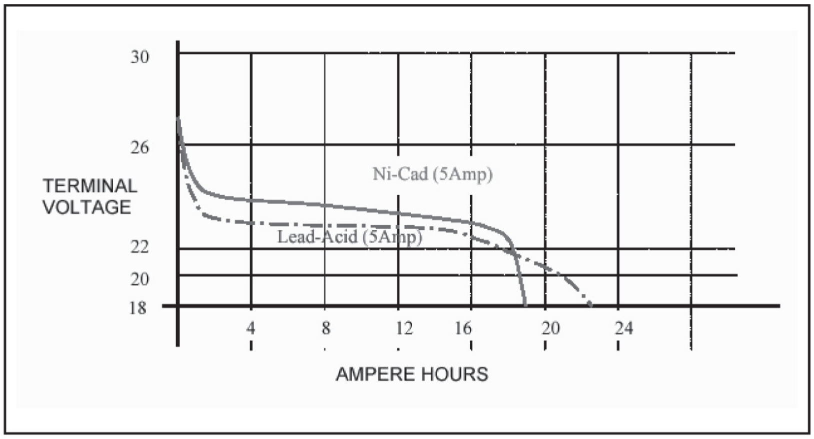

Figure 1 Typical discharge rates of lead-acid and nickel-cadmium batteries

For our Emergency operation, we are going to assume the battery capacity, at room temperature, to be 80% of the data sheet rated capacity, at the one hour rate, and a 90% state of charge. This results in a capacity of approximately 72% (90% of 80%) of nominal data sheet rated capacity at +20º C. This may be rounded up to 75% for calculations. The allowance for battery endurance presumes that adequate requirements for periodic battery maintenance have been met.

A Battery-Charging Current Analysis should be included in this study. The charging current for any aircraft battery is based on the total elapsed time from the beginning of the charge, and is calculated using the following formula**: I = A x C** where: **I** is the average charging current in amperes, **A** is the Ampere-hour capacity of the battery, based on the one-hour rate and **C** is the battery charging factor taken from the battery charging curve supplied with the battery (graphical data). This calculation will tell us the state of the battery's charge.

An example of how to calculate the battery duration is given below:
a) Check the nameplate capacity of the battery and assume 75% is available e.g. 12 amp-hour = 720 amp –min. Therefore, 75% is equal to 540 amp-mins.
b) Estimate the normal or pre-load shed cruise consumption (assume worst-case cruise at night). For example, 15 amps (15 amps x 5 mins = 75 amp-mins). Automatic load shedding need not be considered.
c) Estimate the minimum cruise load necessary to maintain flight after the generator/alternator has failed e.g. 10 amps.
d) Estimate the consumption during the landing approach e.g. 20 amps for 5 minutes (100 amp-mins).

The cruise duration is therefore:

$$\frac{\text{Battery Capacity} - (\text{Pre-Load Shed} + \text{Landing Load})}{\text{Cruise Load}} = \frac{(a) - (b + d)}{(c)}$$

$$= \frac{540 - (75 + 100)}{10} = \frac{365}{10} = 36.5 \text{ minutes.}$$

Total duration = Pre-Load Shed Cruise Time + Cruise Duration + Landing Time = 5 + 36.5 + 5 minutes = **46.5 minutes**. This meets the FAR requirements.

Next Month: A simple Electrical Load Analysis