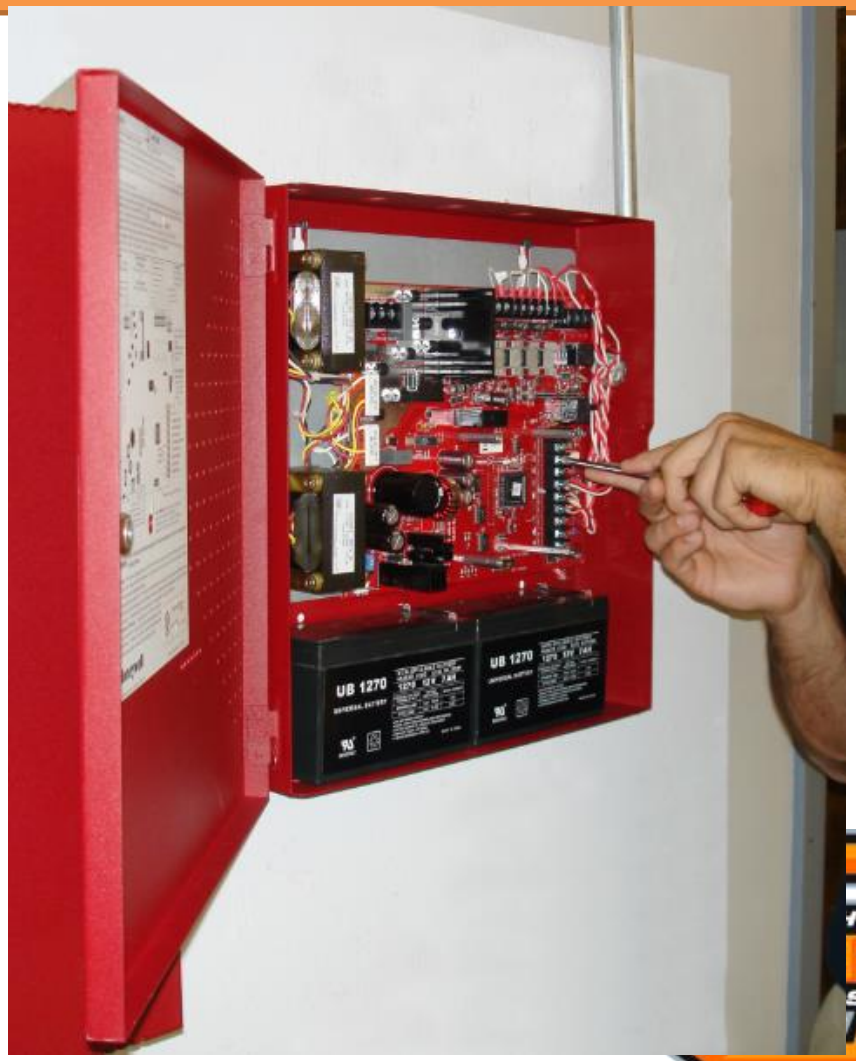
# Battery Capacity Calculations

- Identify information needed to perform battery capacity calculations.
- Identify requirements for voltage drop calculations.
- Select appropriate criteria for performing voltage drop calculations.

# Battery Capacity

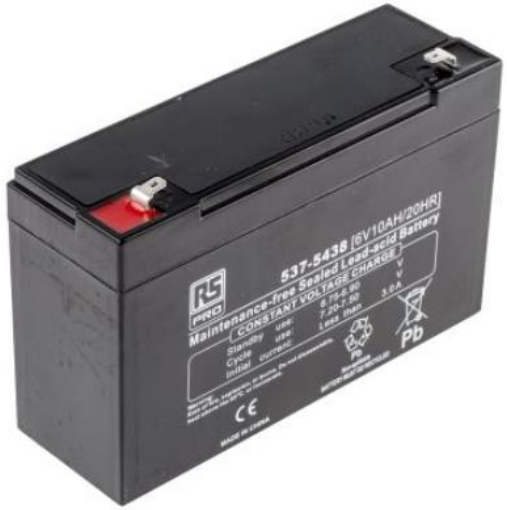
- Need to determine size of backup power supply
- Must be able to discharge at required rate during normal and emergency conditions

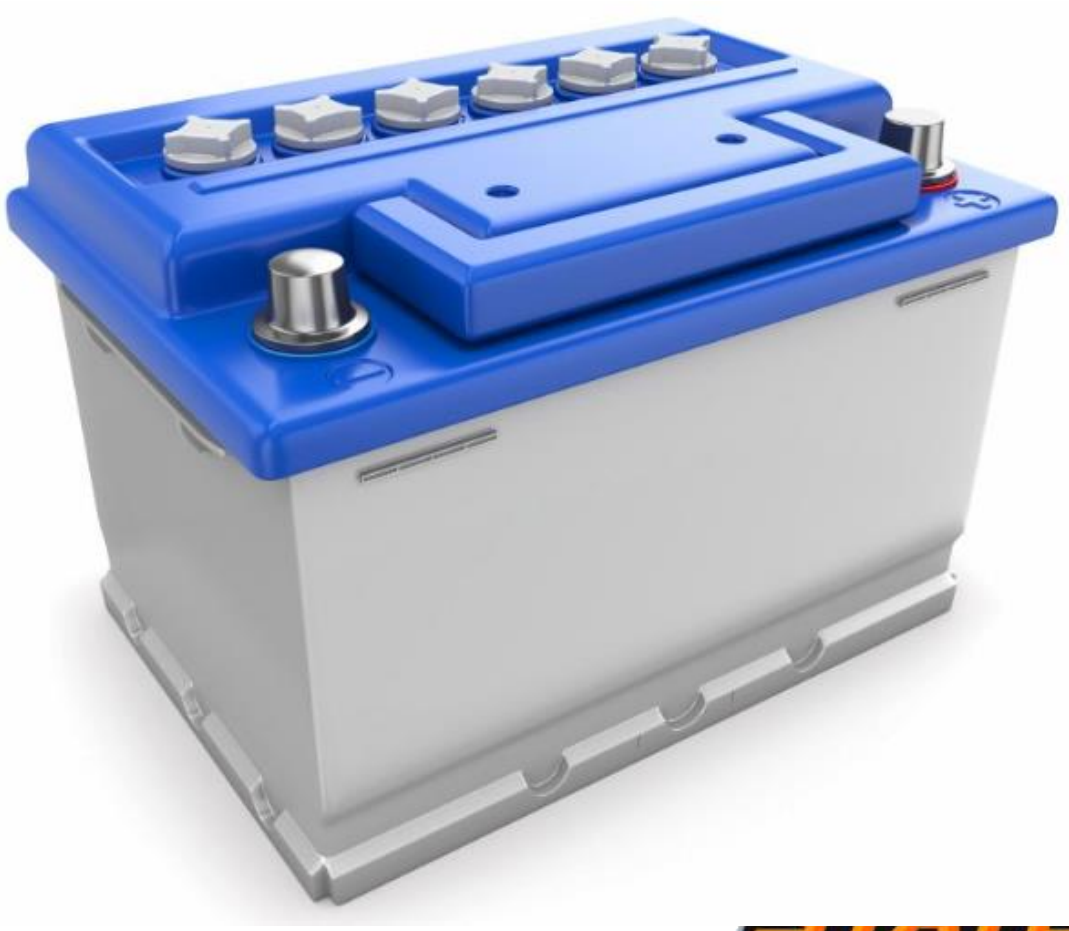


# Battery Capacity

- Capacity represents specific energy in ampere-hours (Ah)
  - Ah is the discharge current a battery can deliver over time
  - As a battery ages, its rated capacity will decrease to 80% which is considered the end of the battery's service life
    - For lead-acid batteries, capacity drops off rapidly after the 80% point
  - NFPA 72 requires adding 20% of the calculated battery capacity to the result as a safety factor

# Lead-acid battery



# NFPA 72 Table 14.4.3.2

- “Replace battery or conduct load capacity test…record test information and calculate battery capacity…replace battery if capacity is ≤80%...”
- Battery Load Test
  - A controlled discharge of a battery at a specified rate for a given period of time until the final voltage is achieved to determine battery capacity
- Battery life can be calculated
  - Capacity / circuit draw = hours of life
    - mAh / mA = h
    - Ah / A = h

# Spreadsheet

http://www.afaa.org/PDF/battcalc.xls

| ITEM | DESCRIPTION | STANDBY CURRENT PER UNIT (AMPS) | | QTY | | TOTAL STANDBY CURRENT PER ITEM | ALARM CURRENT PER UNIT (AMPS) | | QTY | | TOTAL ALARM CURRENT PER ITEM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FACU | Fire Alarm Control Unit | 0.1000 | X | 1 | = | 0.1000 | 0.2000 | X | 1 | = | 0.2000 |
| SD | Smoke Detector | 0.0010 | X | 30 | = | 0.0300 | 0.0500 | X | 15 | = | 0.7500 |
| HD | Heat Detector (mech) | 0.0000 | X | 5 | = | 0.0000 | 0.0000 | X | 0 | = | 0.0000 |
| RLY | Relay (failsafe) | 0.0500 | X | 0 | = | 0.0000 | 0.0000 | X | 3 | = | 0.0000 |
| RLY | Relay (not failsafe) | 0.0000 | X | 4 | = | 0.0000 | 0.0500 | X | 3 | = | 0.1500 |
| HS | Horn-Strobe | 0.0000 | X | 18 | = | 0.0000 | 0.0750 | X | 10 | = | 0.7500 |
| DH | Door Holder | 0.0650 | X | 4 | = | 0.2600 | 0.0000 | X | 0 | = | 0.0000 |
| ANN | Annunciator | 0.1000 | X | 1 | = | 0.1000 | 0.2000 | X | 1 | = | 0.2000 |
| MS | Manual Station | 0.0000 | X | 8 | = | 0.0000 | 0.0000 | X | 5 | = | 0.0000 |
| WF | Waterflow Switch | 0.0000 | X | 6 | = | 0.0000 | 0.0000 | X | 4 | = | 0.0000 |
| TS | Tamper Switch | 0.0000 | X | 6 | = | 0.0000 | 0.0000 | X | 4 | = | 0.0000 |
| 0 | 0 | 0.0000 | X | 0 | = | 0.0000 | 0.0000 | X | 0 | = | 0.0000 |
| 0 | 0 | 0.0000 | X | 0 | = | 0.0000 | 0.0000 | X | 0 | = | 0.0000 |
| | | | | | TOTAL SYSTEM STANDBY CURRENT (AMPS) | 0.4900 | | | | TOTAL SYSTEM ALARM CURRENT (AMPS) | 2.0500 |

| Prepared for: | REQUIRED STANDBY TIME (HRS) NFPA 72-2002 4.4.1.5.3.1 | | TOTAL SYSTEM STANDBY CURRENT (AMPS) | | REQUIRED STANDBY CAPACITY (AMP-HOURS) | REQUIRED ALARM TIME (HOURS) NFPA 72-2002 4.4.1.5.3.1 | | TOTAL SYSTEM ALARM CURRENT (AMPS) | | REQUIRED ALARM CAPACITY (AMP-HOURS) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 24 | X | 0.4900 | = | 11.7600 | 0.083 | X | 2.0500 | = | 0.1702 |

| Prepared by: | REQUIRED STANDBY CAPACITY (AMP-HOURS) | | REQUIRED ALARM CAPACITY (AMP-HOURS) | | TOTAL CAPACITY (AMP-HOURS) | TOTAL CAPACITY (AMP-HOURS) | | SAFETY FACTOR | | ADJUSTED BATTERY CAPACITY (AMP-HOURS) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 11.76 | + | 0.1702 | = | 11.9302 | 11.9302 | X | 120% | = | 14 |

# Voltage Drop

- Need system to continue to function
- Worst case
  - End of secondary power
  - All NAC zones in alarm

# Battery Viability

- Most systems 24 V
  - Designed to run 16 V to 33 V
- Effective battery life 80 %
  - 20.4 V
  - 16 V at last device

# Resistance

- Depends on:
  - Material – specific resistivity (ρ)
  - Cross-section area (A)
  - Length (*l*)
  - Temperature (T)
- R Increases if:
  - Length of wire ↑
  - Diameter of wire ↓
  - Temperature of wire ↑

$$R = \frac{\rho l}{A}$$

$$\rho = \rho(T)$$

# Methods

- End of line
  - Most simple
- Point-to-point
  - More math
  - Often done with spreadsheet
- Load Centering
  - Less common
  - Conservative

# EOL Calculation

- Add up current draw for all devices
- Add up total length of wire
  - Multiply by wire resistance per foot (NFPA 70 Chapter 9, Table 8)
  - Multiply by total current
- Subtract off voltage for panel

# Spreadsheet

http://www.afaa.org/PDF/AZ%20AFAA%20NAC%20Circuit%20Calculator.xls

This calculator provided voltage drop calculations in three formats (Point to Point, End of Line, and Load Centering).

**Make sure that you know what method is accepted by, and the results do not exceed the limits set by the respective jurisdiction**

| | Point to Point Method | End of Line Method | Load Centering Method |
|---|---|---|---|
| | CIRCUIT IS WITHIN LIMITS | EXCEEDS DEVICE LIMITS | CIRCUIT IS WITHIN LIMITS |

| Project Name | Company XYZ | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | | | | | | Totals | | Voltage | Totals | | Voltage | Totals | | Voltage |
| Circuit Number | | | | | | Current | Distance | Drop | Current | Distance | Drop | Current | Distance | Drop |
| Area Covered | | | | | | 0.873 | 290 | **1.32** | 0.873 | 290 | **3.934** | 0.873 | 290 | **1.967** |
| Nominal System Voltage | | | 20.4 | | | End of Line Voltage | | **19.08** | End of Line Voltage | | **16.47** | End of Line Voltage | | **18.43** |
| Minimum Device Voltage | | | 18.2 | | | Percent Drop | | 6.48% | Percent Drop | | 19.29% | Percent Drop | | 9.64% |
| Total Circuit Current | 0.873 | | | Wire | Ohm's | End of Line and Load Centering Methods use only the wire guage for the first device to source | | | | | | | | |
| | | | | Gauge | Per 1000 | Standard Wire Resistance in Ohms per 1000 feet. | | | | | | | | |
| Distance from source to 1st device | | 50 | 18 | 7.77 | | | | 18=7.77 | 16=4.89 | 14=3.07 | 12=1.98 | 10=1.24 | | |
| Wire Gauge for balance of circuit | | | 14 | 3.07 | | 18-14 Awg = Solid Conductors 12-10 Awg = Stranded Conductors | | | | | | | | |

| Enter current in amps. | | Distance | | Voltage | |
|---|---|---|---|---|---|
| .150 = 150 ma | | from | | | |
| Device Number | Device Current | previous device | At Device | Drop from source | Percent Drop |
| Device 1 | 0.097 | 50 | 19.72 | 0.678 | 3.33% |
| Device 2 | 0.097 | 30 | 19.58 | 0.821 | 4.03% |
| Device 3 | 0.097 | 30 | 19.45 | 0.946 | 4.64% |
| Device 4 | 0.097 | 30 | 19.35 | 1.054 | 5.16% |
| Device 5 | 0.097 | 30 | 19.26 | 1.143 | 5.60% |
| Device 6 | 0.097 | 30 | 19.19 | 1.214 | 5.95% |
| Device 7 | 0.097 | 30 | 19.13 | 1.268 | 6.22% |
| Device 8 | 0.097 | 30 | 19.10 | 1.304 | 6.39% |
| Device 9 | 0.097 | 30 | 19.08 | 1.322 | 6.48% |
| END | | | 19.08 | 1.322 | 6.48% |
| END | | | 19.08 | 1.322 | 6.48% |
| END | | | 19.08 | 1.322 | 6.48% |
| END | | | 19.08 | 1.322 | 6.48% |
| END | | | 19.08 | 1.322 | 6.48% |
| END | | | 19.08 | 1.322 | 6.48% |
| END | | | 19.08 | 1.322 | 6.48% |
| END | | | 19.08 | 1.322 | 6.48% |
| END | | | 19.08 | 1.322 | 6.48% |
| END | | | 19.08 | 1.322 | 6.48% |
| END | | | 19.08 | 1.322 | 6.48% |
| Totals | 0.873 | 290 | End of Line Voltage | | **19.08** |

Notes:
Wire resistance is doubled in the calculations for two wires (Positive and Negative)
The voltage calculated to the last device in any method must not be lower then the manufactures listed minimum operating voltage (IE: rated operating voltage 20-32 VDC).

| Device Manufacturer | Honeywell | |
|---|---|---|
| | | Current |
| Horn Strobes | | @Rated |
| Model # | Candela | Voltage |
| SpectrAler P2R | 30 | 0.097 |

| Device Manufacturer | Gentex | |
|---|---|---|
| | | Current |
| Strobe Only | | @Rated |
| Model # | Candela | Voltage |