For stationary engine cranking applications, one of three different types of batteries is normally used. Since we offer all three types, we will attempt to fairly report the strengths and weaknesses of each type. They are listed in order of their initial capital equipment cost.

Lead Acid (SLI) Battery (Starting, Lighting and Ignition)

The SLI lead acid battery is commonly referred to as an "automobile battery". This may be exactly the same battery you have in your family car, or it may be a larger version of the same type of battery construction, i.e. "4D" or "8D".

SLI batteries are provided with three different ratings for comparison:

| | |
|---|---|
| Amp Hour | The (Amps)(Hours) available at the 20-hour discharge rate from a fully charged SLI battery to an end voltage of 1.75 v/c at an ambient temperature of 80°F. |
| Cold Cranking Amps (CCA) | The maximum discharge current in amperes which a new fully charged battery at 0°F (-17.8°C) can deliver for 30 seconds and maintain a voltage of 1.2 v/c or higher. |
| Reserve Capacity | The maximum number of minutes a new fully charged battery at 80°F (26.7°C) can be discharged at 25 amperes and maintain a voltage of 1.75 v/c or higher. |

As can be seen, none of these ratings relate very directly to the normal needs of cranking a gen set.

The battery was not designed for float service application. In such an application, it has a projected life of 1-3 years (for the better grades of SLI batteries).

10-Year Maintenance Free AGM Battery

The AGM battery is usually designed for 10 year float service and will probably provide this same service life in an engine cranking application assuming its charging and ambient specifications are adhered to. (See Section 14.) The AH capacity is normally rated at the 8-hour rate, however, some suppliers rate theirs at the 20-hour rate. The standard temperature and end voltage for rating is 77°F to 1.75 v/c.

25-Year Nickel Cadmium Battery

The nickel cadmium pocket plate battery is the longest life, most rugged and most abuse forgiving of all available engine cranking battery types. It really will have a useful life of over 20 years when connected to a properly sized and applied battery charger.

The AH capacity of the nickel cadmium pocket plate battery is rated at the 8-hour rate to 1.14 v/c at 77°F.

The battery recommendations for engines of various manufacturers are based on the standard generator set specifications of 3 each, 10-second cranks at 77°F, with SAE 30 oil in the crankcase. The electrical connection between the battery and load shall be configured to hold cable resistance to a minimum. A reasonable (total positive and negative) conductor resistance for engine cranking is:

.0015 Ohms for 12 V systems
.002 Ohms for 24 V systems
.0025 Ohms for 32 V systems

For copper cable at 77°F, the resistance is calculated by the formula:

$$R = \frac{10.37\ L}{A}$$

Where R = Conductor resistance in Ohms
L = Conductor length in feet (total for both the positive and negative conductors)
A = Conductor area in circular mils

Therefore, to determine the conductor size:

$$R = \frac{10.37\ L}{R}$$

Example: For a 24 V starter with the battery 8 ft. from the starter;

$$A = \frac{10.37\ (16)}{.002} = 82960 \text{ circular mils}$$

The minimum copper cable would be AWG 1.

| Wire Size AWG | A |
|---|---|
| 22 | 640 |
| 20 | 1020 |
| 18 | 1620 |
| 16 | 2580 |
| 14 | 4110 |
| 12 | 6530 |
| 10 | 10380 |
| 9 | 13090 |
| 8 | 16510 |
| 6 | 26240 |
| 4 | 41740 |
| 3 | 52620 |
| 2 | 66360 |
| 1 | 83690 |
| 1/0 | 105600 |
| 2/0 | 133100 |
| 3/0 | 167800 |
| 4/0 | 211600 |

| MCM | |
|---|---|
| 250 | 250000 |
| 300 | 300000 |
| 350 | 350000 |
| 400 | 400000 |
| 500 | 500000 |
| 550 | 550000 |
| 600 | 600000 |
| 700 | 700000 |
| 750 | 750000 |
| 900 | 900000 |
| 1000 | 1000000 |

To convert engine metric displacement in liters to cubic inches, multiply by 1000 to obtain cubic centimeters, and divide by 16.4.

# Nickel Cadmium Battery Sizing for Engine Starting

## How to select the right battery size(s) for your diesel engines.

### Basic sizing

The Basic sizing is very easy. You need to know:

- Total cylinder volume of engine in cubic inches
- System voltage

Use the Battery Selection Table to find the required battery. Your engine's cylinder volume must be equal to or smaller than the figure stated in the table.

The Nickel Cadmium Cell is nominally a 1.2 V electro-chemical couple. Therefore, use 10 cells for 12 VDC starters, and 20 cells for 24 VDC starters.

NOTE:
The battery chargers should be adjusted to float charge the batteries at 1.42 V/C and recharge at 1.6 V/C.

*Note: The sizing method is valid only for standard sizing conditions. If your conditions are different, see the correction factors on the next page.*

### Standard sizing conditions

The Battery Selection Table is based on the following conditions:

- Cylinder volume in cubic inches (to convert from liters to cubic inches, simply multiply by 61)
- Cranking time: 3 ea. 10 second cranks
- Engine temperature: 77°F
- Battery temperature: 77°F
- Oil: SAE 30 or multiviscosity oil
- Starting circuit efficiency: 60%
- Minimum cranking voltage: 70% of system voltage
- Fully charged battery

| | Engine Cubic Inch Displacement | |
|---|---|---|
| **CELL** | **12VDC** | **24 VDC** |
| TYPE | 10 CELL | 20 CELL |
| TSP 10 | | |
| 14 | 45 | 100 |
| 20 | 60 | 150 |
| 30 | 110 | 300 |
| 40 | 200 | 550 |
| 55 | 310 | 840 |
| 65 | 400 | 1100 |
| 80 | 510 | 1400 |
| 100 | 720 | 1950 |
| 125 | 880 | 2390 |
| 150 | 1220 | 3300 |
| 185 | 1600 | 4340 |
| 200 | 1900 | 5160 |
| 235 | 2420 | 6550 |

## Correction factor sizing

To select the appropriate battery for prevailing conditions other than those listed under Standard Sizing Conditions, simply use the following calculation:

- Record actual cylinder volume:
  Va = _____
- Use "Basic Sizing Method" and select a battery type from the "Battery Selection Table."
- Record the battery's TSP number:
  N = _____
- Record the maximum cylinder volume this battery can crank:
  VM = _____
- Calculate a total correction factor, Ct, by referring to the correction factor tables.

*Note: Sometimes the cranking battery has to supply current to other equipment than the starting system. This is especially common for vehicles and motor driven generators. Contact the CPMC sales office for this sizing.*

A. Battery temperature
B. Enging oil temperature
C. Cranking time
D. State of charge
E. Starting system efficiency
F. Battery end voltage

The total correction factor is the product of all relevant correction factors:

Ct = A x B x C x D x E x F = _____

Calculate the required baqttery size using this formula:

$$Nt = N \times Ct \times \frac{Va}{Vm}$$

Pick a battery with an TSP number equal to or higher than Nt.

## CORRECTIONS FACTOR TABLE

### A. Battery Temp.

| Temp. °F | Temp. °C | Battery temp. factor |
|---|---|---|
| 77 | 25 | 1.00 |
| 70 | 21 | 1.02 |
| 65 | 18 | 1.04 |
| 60 | 16 | 1.06 |
| 55 | 13 | 1.09 |
| 50 | 10 | 1.13 |
| 45 | 7 | 1.18 |
| 40 | 4 | 1.24 |
| 35 | 2 | 1.30 |
| 32 | 0 | 1.32 |
| 30 | -1 | 1.35 |
| 25 | -4 | 1.43 |
| 20 | -7 | 1.50 |
| 15 | -9 | 1.60 |
| 10 | -12 | 1.70 |
| 5 | -15 | 1.82 |
| 0 | -18 | 1.98 |
| -5 | -21 | 2.20 |
| -10 | -23 | 2.55 |

### B. Engine Oil Temp.

| Temp. °F | Temp. °C | Oil temperature factor SAE 30 | SAE 10W | SAE 2C | SAE 40 |
|---|---|---|---|---|---|
| 77 | 25 | 1.00 | | 0.89 | 1.05 |
| 70 | 21 | 1.04 | | 0.92 | 1.11 |
| 65 | 18 | 1.08 | | 0.96 | 1.14 |
| 60 | 16 | 1.12 | | 0.99 | 1.20 |
| 55 | 13 | 1.17 | 0.90 | 1.02 | 1.25 |
| 50 | 10 | 1.21 | 0.94 | 1.05 | 1.31 |
| 45 | 7 | 1.27 | 0.98 | 1.10 | 1.38 |
| 40 | 4 | 1.33 | 1.01 | 1.15 | 1.46 |
| 35 | 2 | 1.40 | 1.05 | 1.21 | 1.54 |
| 32 | 0 | 1.45 | 1.09 | 1.24 | 1.60 |
| 30 | -1 | 1.48 | 1.10 | 1.26 | 1.65 |
| 25 | -4 | 1.58 | 1.15 | 1.31 | 1.80 |
| 20 | -7 | 1.70 | 1.20 | 1.39 | 1.98 |
| 15 | -9 | 1.86 | 1.26 | 1.48 | 2.18 |
| 10 | -12 | 2.04 | 1.33 | 1.59 | |
| 5 | -15 | 2.23 | 1.40 | 1.72 | |
| 0 | -18 | 2.42 | 1.48 | 1.93 | |
| -5 | -21 | | 1.61 | 2.10 | |
| -10 | -23 | | 1.76 | 2.27 | |

### C. Cranking Time

| Cranking time | Corr. factor |
|---|---|
| 10 | .92 |
| 30 | 1.00 |
| 40 | 1.05 |
| 50 | 1.09 |
| 60 | 1.13 |
| 70 | 1.17 |
| 80 | 1.22 |
| 90 | 1.25 |
| 100 | 1.29 |
| 110 | 1.34 |
| 120 | 1.37 |
| 180 | 1.58 |
| 240 | 1.72 |
| 300 | |

### D. State of Charge

| State of charge % | Corr. factor |
|---|---|
| 100 | 1.00 |
| 95 | 1.03 |
| 90 | 1.06 |
| 85 | 1.10 |
| 80 | 1.14 |
| 75 | 1.18 |
| 70 | 1.22 |
| 65 | 1.26 |
| 60 | 1.31 |
| 55 | 1.37 |
| 50 | 1.43 |
| 45 | 1.49 |

### E. Starting Circuit Efficiency

| Efficiency | Correction factor |
|---|---|
| 55 | 1.09 |
| 56 | 1.07 |
| 57 | 1.05 |
| 58 | 1.03 |
| 59 | 1.02 |
| 60 | 1.00 |
| 61 | 0.98 |
| 62 | 0.97 |
| 63 | 0.95 |
| 64 | 0.94 |
| 65 | 0.92 |
| 66 | 0.91 |
| 67 | 0.90 |
| 68 | 0.88 |
| 69 | 0.87 |
| 70 | 0.86 |
| 71 | 0.85 |
| 72 | 0.83 |
| 73 | 0.82 |
| 74 | 0.81 |
| 75 | 0.80 |

### F. Battery End Voltages

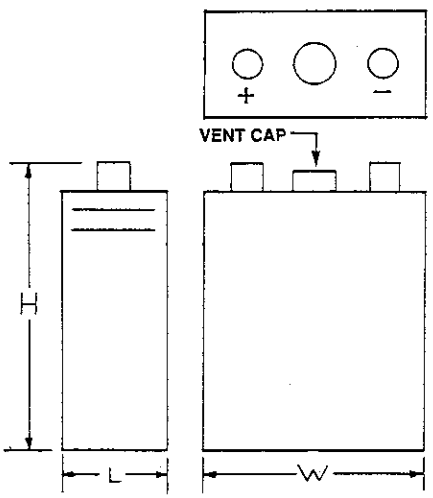
| Battery end volt in % of system volt | 12 volts 30 cells | 30 cells | 24 volts 60 cells | 30 cells | 32 volts 80 cells | 40 cells |
|---|---|---|---|---|---|---|
| 66 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 |
| 68 | 0.955 | 0.955 | 0.955 | 0.955 | 0.955 | 0.955 |
| 70 | 1 | 1 | 1 | 1 | 1 | 1 |
| 72 | 1.02 | 1.005 | 1.01 | 1.005 | 1.01 | 1.005 |
| 74 | 1.155 | 1.11 | 1.13 | 1.11 | 1.13 | 1.11 |
| 76 | 1.25 | 1.175 | 1.205 | 1.175 | 1.205 | 1.175 |
| 78 | 1.36 | 1.25 | 1.28 | 1.25 | 1.28 | 1.25 |
| 80 | 1.485 | 1.34 | 1.385 | 1.34 | 1.385 | 1.34 |

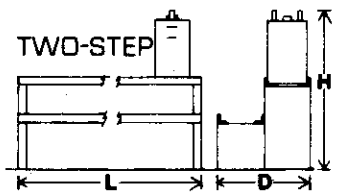
## Final discharge voltage 0.65 V per cell

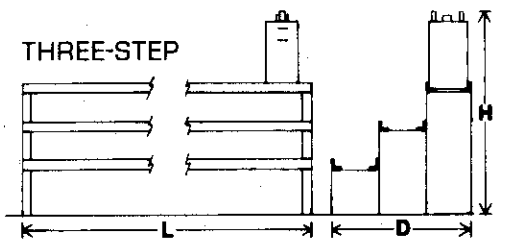
| Type of Cell | Nominal capacity - $C_5$ - down to 1.1 V per cell [Ah] | Times of discharge | | | | | |
|---|---|---|---|---|---|---|---|
| | | Seconds | | | | | |
| | | 1 | 5 | 10 | 20 | 30 | 60 |
| | | Discharge currents [A] - constant | | | | | |
| TSP 10 | 10 | 190 | 170 | 152 | 143 | 135 | 122 |
| TSP 14 | 14 | 266 | 238 | 213 | 200 | 189 | 171 |
| TSP 20 | 20 | 380 | 340 | 204 | 286 | 270 | 244 |
| TSP 30 | 30 | 570 | 510 | 456 | 429 | 405 | 366 |
| TSP 40 | 40 | 760 | 680 | 606 | 572 | 540 | 488 |
| TSP 55 | 55 | 830 | 731 | 687 | 660 | 632 | 577 |
| TSP 65 | 65 | 981 | 864 | 812 | 780 | 747 | 682 |
| TSP 80 | 80 | 1208 | 1064 | 1000 | 960 | 920 | 840 |
| TSP 100 | 100 | 1510 | 1330 | 1250 | 1200 | 1150 | 1050 |
| TSP 125 | 125 | 1888 | 1662 | 1562 | 1500 | 1437 | 1312 |
| TSP 150 | 150 | 2205 | 1950 | 1830 | 1710 | 1635 | 1515 |
| TSP 185 | 185 | 2720 | 2405 | 2257 | 2105 | 2016 | 1868 |
| TSP 200 | 200 | 2940 | 2600 | 2440 | 2280 | 2180 | 2020 |
| TSP 235 | 235 | 3455 | 3055 | 2867 | 2675 | 2561 | 2373 |

## Final discharge voltage 0.85 V per cell

| Type of Cell | Nominal capacity - $C_5$ - down to 1.1 V per cell [Ah] | Times of discharge | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Seconds | | | | | Minutes | | | | |
| | | 1 | 5 | 10 | 20 | 30 | 1 | 3 | 5 | 10 | 15 |
| | | Discharge currents [A] - constant | | | | | | | | | |
| TSP 10 | 10 | 139 | 122 | 110 | 103 | 96 | 87 | 70 | 60 | 41 | 27 |
| TSP 14 | 14 | 195 | 171 | 154 | 144 | 134 | 122 | 98 | 84 | 57 | 37 |
| TSP 20 | 20 | 278 | 244 | 220 | 206 | 192 | 174 | 140 | 120 | 82 | 54 |
| TSP 30 | 30 | 417 | 366 | 330 | 309 | 288 | 261 | 210 | 180 | 123 | 81 |
| TSP 40 | 40 | 556 | 488 | 440 | 412 | 384 | 348 | 280 | 240 | 164 | 108 |
| TSP 55 | 40 | 605 | 533 | 495 | 473 | 451 | 413 | 346 | 302 | 231 | 176 |
| TSP 65 | 65 | 715 | 630 | 585 | 559 | 533 | 488 | 409 | 357 | 273 | 208 |
| TSP 80 | 80 | 880 | 776 | 720 | 688 | 656 | 600 | 504 | 440 | 336 | 256 |
| TSP 100 | 100 | 1100 | 970 | 900 | 860 | 820 | 750 | 630 | 550 | 420 | 320 |
| TSP 125 | 125 | 1375 | 1213 | 1125 | 1075 | 1025 | 938 | 787 | 687 | 525 | 400 |
| TSP 150 | 150 | 1605 | 1425 | 1335 | 1230 | 1140 | 1110 | 1020 | 915 | 660 | 480 |
| TSP 185 | 185 | 1980 | 1758 | 1647 | 1517 | 1406 | 1369 | 1258 | 1128 | 814 | 480 |
| TSP 200 | 200 | 2140 | 1900 | 1780 | 1614 | 1520 | 1480 | 1360 | 1220 | 880 | 640 |
| TSP 235 | 235 | 2515 | 2233 | 2092 | 1927 | 1786 | 1739 | 1598 | 1433 | 1034 | 752 |




| Cell Type | Cell Data | | | | | Rack Data 12 VDC | | | | Rack Data 24 VDC | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L Inches | W Inches | H Inches | LBS/ Cell | Electro-lyte Gal./Cell | NO. STEPS | L | D | H | NO. STEPS | L | D | H |
| TSP 10 | 1.9 | 3.4 | 10.3 | 2.9 | .1 | 1 | 20 | 6 | 17 | 2 | 20 | 12 | 23 |
| TSP 14 | 1.9 | 3.4 | 10.3 | 3.6 | .09 | 1 | 20 | 6 | 17 | 2 | 20 | 12 | 23 |
| TSP 20 | 1.9 | 3.4 | 10.3 | 4.7 | .07 | 1 | 20 | 6 | 17 | 2 | 20 | 12 | 23 |
| TSP 30 | 3.4 | 3.4 | 10.3 | 6.6 | .16 | 1 | 36 | 6 | 17 | 2 | 36 | 12 | 23 |
| TSP 40 | 3.4 | 3.4 | 10.3 | 8.6 | .14 | 1 | 36 | 6 | 17 | 2 | 36 | 12 | 23 |
| TSP 55 | 2.2 | 5.3 | 14.2 | 11.9 | .21 | 1 | 24 | 6 | 21 | 2 | 36 | 12 | 27 |
| TSP 65 | 2.2 | 5.3 | 14.2 | 13.2 | .18 | 1 | 34 | 6 | 21 | 2 | 36 | 12 | 27 |
| TSP 80 | 2.8 | 5.3 | 14.2 | 15.4 | .27 | 1 | 30 | 6 | 21 | 2 | 36 | 12 | 27 |
| TSP 100 | 4.2 | 5.4 | 14.2 | 18.3 | .49 | 2 | 24 | 14 | 27 | 3 | 30 | 21 | 33 |
| TSP 65 | 2.2 | 5.3 | 14.2 | 13.2 | .18 | 1 | 24 | 6 | 21 | 2 | 36 | 12 | 27 |
| TSP 80 | 2.8 | 5.3 | 14.2 | 15.4 | .27 | 1 | 30 | 6 | 21 | 2 | 36 | 12 | 27 |
| TSP 100 | 4.2 | 5.4 | 14.2 | 18.3 | .49 | 2 | 24 | 14 | 27 | 3 | 30 | 21 | 33 |
| TSP 125 | 4.2 | 5.4 | 14.2 | 26.2 | .45 | 2 | 24 | 14 | 27 | 3 | 30 | 21 | 33 |
| TSP 150 | 4.3 | 6.5 | 15.6 | 31.5 | .80 | 2 | 24 | 14 | 28 | 3 | 36 | 23 | 34 |
| TSP 185 | 6.3 | 6.5 | 15.6 | 36.3 | 1.16 | 2 | 36 | 15 | 28 | 4 | 36 | 30 | 40 |
| TSP 200 | 6.3 | 6.5 | 15.6 | 39.6 | 1.11 | 2 | 36 | 15 | 28 | 4 | 36 | 30 | 40 |
| TSP 235 | 6.3 | 6.5 | 15.6 | 46.9 | 1.06 | 2 | 36 | 15 | 28 | 4 | 36 | 30 | 40 |