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Diesel Engine Starting Batteries Guide and Worksheet

Energie-High power series

HOPPECKE Advanced Fiber NICKEL CADMIUM Technology
Designed for diesel engine starting applications

- **Ultra High Discharge Performance**
- **Reduced Space and Weight**
- **Extreme Low Temperature Operation**
- **Extensive Cycle Life**
- **High Recharge Efficiency**
- **Complete Engine Starting System Packages Available (Battery, Charger, Racks)**

SIZING METHODS AND SPECIFICATIONS

For the past few years a simplified method of battery sizing has been applied to alkaline batteries for engine starting. This method allows you to select a conservative battery which meets the parameters of the application without unwarranted expense.

SIZING TECHNIQUE:
The method of battery sizing applied here is based on the relationship between amperes at a given minimum voltage and engine cubic inch displacement. This relationship was established through the use of a formula where starting RPM, torque, and efficiency were calculated to the wattage required to start the engine. Additionally, coefficients have been developed for the various conditions which may exist in an application, such as battery electrolyte temperature, oil viscosity and cranking time.

POWER VS. CAPACITY:
Ampere hours, the general measurement of battery capacity over some number of hours, are irrelevant in power applications such as engine starting. Voltage stability at high currents varies greatly among the many different chemical and mechanical battery types. In cranking applications, the ability to supply amperes for 30 seconds is not guaranteed by a quantity of ampere hours at the 5, 8 or 20 hour rate. In addition, each battery type responds differently in terms of performance at various temperatures. The FNC battery, particularly the "X" series, provides more than twice the amperes for 30 seconds of any other alkaline system on the market, relative to its ampere hour capacity.

ITEMS TO SPECIFY:
In addition to the engine model, cubic inch displacement and starting system voltage, the battery manufacturer must know the following:

- The minimum battery electrolyte temperature
- The total cranking time (or number of 10 second attempts)
- The lowest engine temperature
- The engine oil viscosity

Battery electrolyte temperature is not necessarily as low as the minimum ambient temperature, since the electrolyte temperature changes at a slower rate. However, temperature has a large effect on battery performance, and must always be considered.
Engine oil viscosity and temperature are also major factors. As oil heaters are relatively inexpensive, they should be considered to reduce battery cost. Where multi-viscosity oil is used, it is taken at the lowest factor for the given temperature.
Cranking time, which is generally expressed as the number of 10 second start attempts, should be sufficient to allow for manual starting after difficulty with any automatic system employed. The manufacturer's listing in this guide, and the battery selection inTable E, when used without other factors, provides for 3 cranking cycles of 10 seconds as a minimum.
Battery life, in the case of the FNC, is expected to be 20 – 25 years, particularly in this application. Life is generally measured in capacity not performance, and the end of useful life is considered to be when the battery has 80% of its initial capacity. This measurement is based on tradition rather than fact, and developed since many lead acid batteries fail quickly once they reach 80% capacity. The same is not true of alkaline systems, where capacity loss is effectively linear well below the 80% level. You may wish to add a factor, in terms of performance not capacity, for the life expected of this particular system.

NOTE TO THE ENGINEER:
Frequently specifications for generator sets do not specify batteries by their type or construction, but in somewhat general terms of ampere hours, voltage and initial ability to crank the engine. As a resul, many crucial and expensive installations are started by automotive cranking batteries. There are applications where this is satisfactory, and relatively short life on float service for the battery is acceptable. However, in applications where an engine standby system expense is cost justified,it seems prudent to assure the starting capacity over the life of the system. A 1 – 3 year battery life, with intermittent periods of concern, may not meet the overall system requirements. This is even more obvious when translated to potentially life threatening situations of emergency power systems. Fire pumps, process controls, emergency lighting, to mention a few, always justify a system….and that system must be assured of starting power. **HOPPECKE**, of course, wants you to specify our **FNC product** for all critical applications, but what we ask is that you always specify a battery ***by type, construction, chemistry or classification***, to assure you receive a battery which meets your requirements and expectations.

STANDARDS: The following standards require special consideration:

NFPA-20, CENTRIFICAL FIRE PUMPS

NFPA-76A, ESSENTIAL ELECTRIAL SYSTEMS FOR HEALTH CARE FACILITIES

SIZING METHODS AND SPECIFICATIONS

SAMPLE SPECIFICATION:

The engine starting battery supplied shall be nickel cadmium, alkaline electrolyte system, designed for extra high rate discharge and performance, and electrically sized to perform the below specified starting cycle for a period of at least 25 years. It is to have minimum internal resistance, welded construction, and be at least 80% efficient on recharge.

The battery must be designed for float / standby service without excessive maintenance such as electrolyte replacement, while being capable of 1500 or more full discharges with less than 10% loss of capacity.

Cells must be individual, translucent containers to facilitate simple observation of the electrolyte level and serviceability, with the electrolyte level minimum clearly marked. All inter cell connectors and inter-row connector cables must be sized for the maximum current draw of the engine to assure minimal voltge drop during the cranking cycle. The cells shall have the power and life characteristics of the **FNC – Xtra** high rate type, or be an approved equal.

SIZING REQUIREMENTS:

The following information should be supplied to aid in the sizing of the battery:

1. Engine Manufacturer & Model
2. Cubic Inch displacement of Engine
3. Battery System Voltage
4. Minimum battery electrolyte temperature.
5. Engine Oil Temperature (If block heaters are used, specify heater set temperature
6. Number of 10 second cranking cycles

BATTERY CHARGING

The most common cause of performance failure in batteries is improper adjustment or operation of the battery charger. The charger, representing about 5% of the system cost, must be specified in as much detail as the battery. It shouldbe as automatic as possible, with essential equipment and factory settings specified as well.

FNC Battery Recharge

All batteries recharge relative to time, current available, maximum voltage and battery efficiency. The **FNC** is 83% efficient, **13%** better than pocket plate nickel cadmium cells at 70%. The FNC requires less power, and given the same circumstances, recharges faster. **FNC** batteries may be charged at extremely high currents, up to **6 times** their ampere hour rating, while remaining very efficient on recharge. Effectively, **80%** of their capacity can be replaced in minutes when high current is available for recharge.

Recommended Charging:

We prefer and recommend a minimal charger ampere rating of 0.10C (10% of battery AH capacity), always in addition to any constant load. This will allow recharge in approximately 24 hours. Voltage settings on float should be between 1.42 volts per cell (vpc) and 1.45 vpc; on high rate from 1.52 vpc to 1.65 vpc as a practical limit. Within these limits long service intervals can be maintained.

Below are recommendations for typical applications:

1. **No Continuous Load – recharge time not critical**
   0.05C – 0.10C Ampere rating
2. **No Continuous Load – recharge in 24 hrs**
   0.10C – 0.20C Ampere rating
   Float = 1.45vpc; High rate = 1.65vpc
3. **Continuous Loads – recharge 8-24 hrs**
   0.20C – 0.25C Amperes plus constant load
   Float = 1.45vpc; High rate = Vmax / number of cells

HOPPECKE recommends a **two rate** charger to assure full and fast recharge after a battery discharge. Single rate charging requires factory recommended voltage settings and specification review. Fully **automatic transfer** to high rate charge (not to be confused with automatic voltage control) is highly recommended and available from most manufacturers. Voltage regulations should be better than 1% (1/2% is readily available). Other equipment, usually optional, such as low charger voltage, and high charger voltage alarms are suggested in installations where central monitoring exists.

ENGINE STARTING BATTERY SELECTION GUIDE & WORKSHEET

Step 1: Find the Cubic Inch Displacement (CID): Of the Engine _____

Determine the Starting Voltage of the Engine (12VDC, 24VDC, 32VDC) _____

Step 2: Convert Engine Cubic Inch Displacement To Starting Amperes (standard conditions) **(TABLE A)** _____(Amps)

Step 3: Determine the Lowest Battery Electrolyte Temperature **(TABLE B – Factor F1)** _____

Step 4: Determine the Oil Viscosity Weight and Temperature **(TABLE C – Factor F2)** _____

Step 5: Determine the Total Cranking Time (minus rest periods) **(TABLE D – Factor F3)** _____

Step 6: Multiply Factors X Starting Amps **(Step 2 x F1 x F2 x F3)** _____(Amps)

Step 7: For dual starting motors increase Current by 10% (X 1.10) _____(Amps)

Step 8: Select Cell Type and Quantity based on Step 6**. (TABLE E)** _____

Step 9: Select Rack Type and Model **(TABLE F)** _____

Standard Starting Conditions:
30 Seconds total cranking time
70 deg F Battery electrolyte temperature
multi-weight oil at 70 deg F
0.65 vpc engine breakaway voltage
0.85 vpc engine rolling voltage

Some engine controls may require higher breakaway voltage (e.g., 1.00vpc). Please consult Hoppecke for sizing.

TABLE A

Displacement Cubic Inches	Amperes 12VDC	Amperes 24VDC	Amperes 32VDC
50	135	67	
100	200	100	
150	255	128	
200	322	161	
250	380	190	
300	422	211	
350	465	233	
400	516	258	
450	548	274	
500	587	294	
550	631	316	
600	674	337	
650	702	351	
700	729	365	
750	772	386	
800	814	407	
850	858	429	
900	901	452	
950	947	474	
1000	993	497	
1100		525	405
1200		553	425
1300		583	449
1400		613	471
1500		638	492
1600		662	509
1700		691	532
1800		719	553
1900		747	575
2000		775	596
2250		831	640
2500		886	682
2750		940	724
3000		994	765
3250		1065	820
3500		1135	873
3750		1186	913
4000		1237	952
4250		1299	1000
4500		1361	1047
4750		1417	1091
5000		1472	1132
5250		1523	1172
5500		1577	1215
5750		1668	1284
6000		1681	1293
6250		1750	1347
6500		1772	1365
6750		1823	1403
7000		1863	1433
7250		1900	1462
7500		1951	1502
7750		2015	1550
8000		2038	1568
8250		2063	1587
8500		2122	1634
8750		2188	1684
9000		2205	1696
9500		2288	1762
10000		2370	1823

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Diesel Engine Starting Battery Guide & Worksheet

TABLE B Battery Temp. (Factor F1)

Battery Temperature Degree C	Battery Temperature Degree F	Factor F1
21	70	1.00
16	60	1.00
10	50	1.00
4	40	1.00
0	32	1.00
-7	20	1.02
-12	10	1.07
-18	0	1.43
-23	-10	1.67
-26	-15	1.85
-29	-20	2.22

TABLE C Oil (SAE) at Temperature (Factor F2)

Oil Temp DegC	Oil Temp Deg F	40W	30W	20W	10W
21	70	1.08	1.00	1.00	1.00
16	60	1.14	1.06	1.00	1.00
10	50	1.25	1.15	1.02	1.00
4	40	1.38	1.25	1.11	1.00
0	32	1.60	1.41	1.24	1.05
-7	20	1.90	1.65	1.40	1.13
-12	10		2.40	1.60	1.25
-18	0			1.82	1.38
-23	-10				
-26	-15				
-29	-20				

TABLE D Cranking Time (Factor F3)

Seconds	Factor F3
30	1.00
40	1.04
50	1.07
60	1.11
90	1.19
120	1.28
150	1.35
180	1.45
210	1.54
240	1.61
300	1.72

TABLE E (Available Amperes by Cell Type)

FNC Cell Type	Amp Hour	12VDC 9 Cells	12VDC 10 Cells	24VDC 19 Cells	24VDC 20 Cells	32VDC 25 Cells	32VDC 26 Cells
257EH	14	205	257	238	257	238	257
297EH	22	238	297	278	297	278	297
501EH	28	401	501	464	501	464	501
582EH	44	469	582	544	582	544	582
808EH	47	646	808	749	808	749	808
938EH	73	745	938	872	938	872	938
1092EH	66	853	1092	997	1092	997	1092
1296EH	103	1040	1296	1200	1296	1200	1296
1353EH	85	1044	1353	1228	1353	1228	1353
1573EH	132	1284	1573	1502	1573	1502	1573
1859EH	144	1487	1859	1710	1859	1710	1859
1983EH	156	1586	1983	1824	1983	1824	1983
2103EH	168	1682	2103	1935	2103	1935	2103
2217EH	180	1774	2217	2040	2217	2040	2217
2327EH	192	1862	2327	2141	2327	2141	2327
2431EH	204	1945	2431	2237	2431	2237	2431

TABLE F (Rack Selection Table)

FNC Cell Type	12VDC Rack	24VDC Rack	32VDC Rack
257EH	PGL 1-06	PGL 1-06	PGL 1-08
297EH	PGL 1-06	PGL 1-06	PGL 1-08
501EH	PGL 1-06	PGL 1-12	SGL 2-08
582EH	PGL 1-06	PGL 1-12	SGL 2-08
808EH	PGL 1-08	SGL 2-08	SGL 2-12
938EH	PGL 1-08	SGL 2-08	SGL 2-12
1092EH	PGL 1-12	SGL 2-12	SGL 2-12
1296EH	PGL 1-12	SGL 2-12	SGL 2-12
1353EH	PGL 1-12	SGL 2-12	SGL 2-15
1573EH	PGL 1-12	SGL 2-12	SGL 2-15
1859EH	PGL 1-12	SGL 2-12	SGL 2-12
1983EH	PGL 1-12	SGL 2-12	SGL 2-12
2103EH	PGL 1-12	SGL 2-12	SGL 2-12
2217EH	PGL 1-12	SGL 2-12	SGL 2-15
2327EH	PGL 1-12	SGL 2-12	SGL 2-15
2431EH	PGL 1-12	SGL 2-12	SGL 2-15

RACK DIMENSIONS:

Rack Model	Length (inches)	Width (Inches)	Height (Inches)	Shipping Weight (lbs)
PGL 1-06 – 1 step rack	23.62	8.46	19.48	13.78
PGL 1-08 – 1 step rack	29.53	8.46	19.48	14.88
PGL 1-12 – 1 step rack	47.24	8.46	19.49	20.94
SGL 2-08 – 2 step rack	29.53	16.93	23.42	29.76
SGL 2-12 – 2 step rack	47.24	16.93	23.42	41.89
SGL 2-15 – 2 step rack	59.06	16.93	23.42	46.30

Diesel Engine Data and Battery Recommendations

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ALLIS CHALMERS

Model	CID	12V cell type	24V cell type
D175	175	297EH	257EH
D262	262	501EH	501EH
2200	200	501EH	257EH
2800	301	501EH	257EH
2900	301	501EH	257EH
3400	426	582EH	297EH
3500	426	582EH	297EH
3700	426	582EH	297EH
3750	426	582EH	297EH
6000	344	501EH	257EH
7000	344	501EH	257EH
10000	516	808EH	297EH
11000	516	808EH	297EH
13000	516	808EH	297EH
16000	844	938EH	501EH
17000	844	938EH	501EH
21000	844	938EH	501EH
25000	844	865EH	501EH
61000	2035		808EH
65000	2035		808EH

CUMMINS ENGINE

Model	CID	12V cell type	24V cell type
N,NT,NTA,	855	938EH	501EH
NTTA	855	938EH	501EH
Kt, KTA19	1150	1092EH	582EH
VT,VTA28	1710		808EH
KT,KTA38	2300		938EH
KTA50	3067		1092EH
4B3.9	239	501EH	257EH
4BT3.9	239	501EH	257EH
6BT5.9	360	582EH	257EH
NT,	495	808EH	297EH
NTA495	495	808EH	297EH

WHITE

Model	CID	12V cell type	24V cell type
D198	198	501EH	257EH
D298	298	501EH	257EH
D2000	200	501EH	257EH
D2300	226	501EH	257EH
D3000	298	501EH	257EH
D3300	339	501EH	257EH
D3400	339	501EH	257EH
D4800	478	582EH	297EH

CATERPILLER

Model	CID	12V cell type	24V cell type
3304	425		297EH
3306	638		501EH
3406	893		501EH
3408	1099		582EH
3412	1649		808EH
3508	2105		938EH
3512	3158		1092EH
3516	4210		1353EH
D343	893		501EH
D346	1191		582EH
D348	1786		808EH
D349	2382		938EH
D353	1473		808EH
D379	1964		808EH
D398	2946		1092EH
D399	3928		1296EH

DETROIT DIESEL

Model	CID	12V cell type	24V cell type
2.53	106	257EH	257EH
3.53	159	297EH	257EH
4.53	212	501EH	257EH
6V-53	318	501EH	257EH
8V-53	424	582EH	297EH
2-71	142	257EH	257EH
3-71	213	501EH	257EH
4-71	284	501EH	257EH
6-71	426	582EH	297EH
6V-71	426	582EH	297EH
8V-71	568	808EH	501EH
12V-71	852	938EH	501EH
16V-71	1136		582EH
6V-92	552	808EH	501EH
8V-92	736	808EH	501EH
12V-92	1104		582EH
16V-92	1472		808EH
12V-149	1788		808EH
16V-149	2384		938EH

KOHLER

Model	CID	12V cell type	24V cell type
4-108	108	257EH	257EH
4-154	154	297EH	257EH
4B3.9	239	501EH	257EH
4BT3.9	239	501EH	257EH
6BT5.9	360	582EH	257EH
NT,NTA495	495	808EH	297EH
NT, NTA855	855	938EH	501EH
KT,KTA1150	1150	1092EH	582EH
VT,VTA1710	1710		808EH
KT,KTA2300	2300		938EH
KT,KTA3067	3067		1092EH

WAUKESHA

Model	CID	12V cell type	24V cell type	32V cell type
VRD155	155	501EH	257EH	
VRD232	232	501EH	257EH	
VRD283	283	501EH	257EH	
VRD310	310		257EH	
H1077D	1077		582EH	
F1197D	1197		582EH	
L1616D	1616		808EH	
F1905D	1905		808EH	
P2154D	2154		938EH	
F2896D	2894		938EH	808EH
L5100D	5100		1573EH	1296EH
L5792D	5788		1983EH	1296EH
L6670D	6670		1983EH	1353EH
P8894DSI	8894			1983EH

JOHN DEERE

Model	CID	12V cell type	24V cell type
3164D	164	297EH	257EH
4219D	219	501EH	257EH
4276D,T	276	501EH	257EH
6329D	329	501EH	257EH
6414D,T	414	582EH	297EH
6404D,T,A	404	582EH	297EH
6531D,T,A	531	808EH	297EH
6466A	466	582EH	297EH
6619A	619	808EH	501EH

ONAN

Model	CID	12V cell type	24V cell type
JC Types	120	257EH	257EH
RDJF	140	257EH	257EH
DL4.8	140	257EH	257EH
DL6,DLG	210	501EH	257EH
DDA, B	219	501EH	257EH
EK	240	501EH	257EH
DVA,DVB	298	501EH	257EH
EM	300	501EH	257EH
DVC	396	582EH	297EH
DVD,DVE	435	582EH	297EH
DVF,DVG	674	808EH	501EH
DVH,DVJ,2	930	938EH	582EH
DFN,S	1150	1092EH	582EH
DFY	1710		808EH
DFZ	2300		938EH
DHH	2389		938EH

- 12V Batteries consist of 10 cells each
- 24V Batteries consist of 20 cells each

Batteries are Sized for Standard Conditions:

- Battery Temperature 77 deg F
- Oil Temperature 77 deg F
- Engine Oil viscosity 30W (SAE)
- 30 second cranking time total

* For all other conditions refer to the previous pages of this guide.