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Battery installations – some considerations.

Starter batteries and battery cables are a major consideration for engine starting systems. Incorrect selection of both battery and cables is a major cause of starting failure.

Batteries:

1) Battery sizes: These should never be of less capacity than the makers recommendation. If in doubt – ask.
2) In extreme conditions, low temperatures, battery capacity needs to be increased as performance will decrease. This needs to be allowed for during selection of a battery.
3) Battery terminals and connections must always be kept clean, in good condition and tight. Faulty connections can lead to poor performance and even (in extreme conditions) explosion.
4) Batteries must be in good condition and must hold voltage. An idle standing battery would be expected to be at least 12.6 volts and we would like to see at least 12v on the starter motor terminals.
5) Charging circuits must be sufficient for the battery system used. In other words make sure you have enough battery capacity but bear in mind the recharge capability. Depending upon the battery type the recharge voltage will be in the region of 14.7 volts.

Battery cables:

1) Starter batteries should be as close to the engine as practically possible. The reason for this is to ensure that the maximum voltage from the battery is available to the starter motor. The longer the cable run - the more will be the voltage drop. This is due to the resistance of the cables.
2) Generally speaking for smaller engines we recommend battery cables of 25mm^2 conductor cross sectional area with length up to 1.5m per cable. That equals a cable run of 3m total which would have a voltage drop in the region of 0.8v if the starter motor was using 160 amps when motoring. Battery cables that are too small will overheat and their insulation could catch fire.
3) When the supply is switched on to the starter motor there will be a massive inrush of power in the region of 5 times the motoring current. The battery will be expected to supply this inrush and then recover sufficiently to give the motoring current (often called the ‘rolling’ or ‘cranking’ current). If the correct battery is selected but the engine will not crank at sufficient speed after the inrush then (assuming battery cables are the correct size) the battery is either discharged or faulty.
4) If the voltage at the starter motor terminals after the inrush is not at least 10.5 volts it is likely that the motor will either crawl at insufficient speed or not turn at all. Battery cables could overheat.

5) Battery cables are sized on the motoring or rolling current of the starter motor and the length of battery cable run. This length is the total distance of both the positive and negative cables added together. Under normal circumstances the voltage drop in the starter battery cable circuit should not exceed 0.8 volt and in any circuit should not exceed 1.2 volts.
6) Please note that cranking time should be no longer than 10 seconds with at least a 10 second rest between attempts.

Typically, Voltage drop per metre of pvc insulated cable:

Engine Model	Cranking Amps (Rolling current)	25mm^2 Cable Volt drop*	Max length, both cables added together.
Up to Beta38	100	0.0017V	4.7m
Up to Beta50	120	0.0017V	3.9m
Up to Beta60	170	0.0017V	2.8m
Up to Beta105	210 / 250**	0.0017V	Not suitable
Beta 150	333	0.0017V	Not suitable

Engine Model	Cranking Amps (Rolling current)	35mm^2 Cable Volt drop*	Max length, both cables added together.
Up to Beta38	100	0.0013V	6.2m
Up to Beta50	120	0.0013V	5.2m
Up to Beta60	170	0.0013V	3.6m
Up to Beta105	210 / 250**	0.0013V	2.5m
Beta 150	333	0.0013V	1.8m (not preferred)

Engine Model	Cranking Amps (Rolling current)	70mm^2 Cable Volt drop*	Max length, both cables added together.
Up to Beta38	100	0.00063V	12.7m
Up to Beta50	120	0.00063V	10.5m
Up to Beta60	170	0.00063V	7.5m
Up to Beta105	210 / 250**	0.00063V	5.0m
Beta 150	333	0.00063V	3.8m

*Voltage drops for pvc insulated cables are ex table 9D1 of the IEE Wiring Regulations.

** Varies between models and builds.

The above are based on a maximum conductor temperature of 70°C in an ambient temperature of 30°C.

Superior insulations such as Cross-linked Polyolefin coupled with superior cable construction allow increased conductor temperatures enabling higher current flows. Here it is necessary to know the actual voltage drop usually based on the resistance of the cable at 20°C.

For example: find the CSA required if the load is 210 amps and the total run (positive + negative) is 22m. Max voltage drop is 0.8V.
Firstly find the allowable voltage drop per metre. Divide (the total voltage drop 0.8v) by (the length of run 22m x the rolling amps 210A) = 0.00017v or 0.17mV/m.

Using a catalogue for Cross-linked Polyolefin insulated cable we see that 120mm^2 has a resistance of 0.164mV per meter.

Similar results can be achieved by using the formula in Annex A of ISO directives ISO10133 and 13297. Here a constant is used for expressing an approximation of volts drop. By re-arranging this we can find a minimum cable size for various runs. It is based on a factor of 0.0164 which gives a reasonable approximation for extra low voltage DC systems.

Cross sectional area of cable = 0.0164 x load current in amps x total length of run in metres / all divided by maximum allowable voltage drop.

Using the previous example: CSA = 0.0164 x 210 x 22 / 0.8 = 95mm^2. However we see from the catalogue that 95mm^2 has a volt drop of 0.21mV/m which gives a total voltage drop of 0.00021v x 22m x 210A = 0.97V, so we must again select the 120mm^2 cable which is the next standard size up.

Please note that it is not practical to use table 9D1 of the IEE Wiring Regulations for larger sizes. We are after all talking about short duration power flow not continuous ratings for the starter motor. At the end of the day what matters is the voltage at the starter motor terminals before starting and whilst cranking all without destroying the insulation on the cables.

This document is based on 12 volt start systems.

Paul Grigg.
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