School Bus Application Guide

TSB-1025

Selecting the correct alternator for your school bus

We all know that the first and most important item to consider when it comes to any school bus is Safety. The second most important item would be Reliability, with minimal long term financial liability to its owner or operators.

Today's school buses have a very high amperage demand. The amperage requirements for the engine, transmission, high intensity lights, radios, door controls, wheel chair lifts, heaters, air conditioning, monitoring devices, drive line retarders, etc. are increasing year by year. The 160 amp alternator which performed well in 2002 was not adequate for buses made in 2005, and the 175 amp alternator that worked in 2006 will not be appropriate in for school buses manufactured in 2008.

It is important to note that ***many of the electrical accessories on your bus may have been installed after the chassis was originally manufactured***. The alternator and the cabling installed by the OEM may not be adequate to manage the additional amperage requirements for items which were added after the original manufacture date. Undersized alternators and wiring will force the batteries to be utilized for purposes other than for which they were intended, contributing to progressive damage of the batteries and all other components in the electrical system. In short, the alternator and cabling currently on your bus may not be adequate to ensure that it is both safe and reliable.

The purpose of this TSB (Technical Service Bulletin) is cover the topics necessary so that you can be sure that your school bus has both the correct alternator and the appropriate cabling connecting it to the electrical system. To do this we will review the purpose of the batteries, and then the sizing of both the alternator and the interconnecting cabling.

The Battery

The battery is a reservoir of chemical electrical power, whose primary purpose is to provide the electrical energy needed to crank the engine. Once the engine has been started the purpose of the battery is complete, and the bus amperage requirements should be managed by the alternator. This will ensure that batteries are charged properly and are healthy for the next time they are needed for engine cranking.

Many of today's school buses have an alternator which is undersized. The result is that the power that is required to manage the electrical accessories will be drawn from the batteries instead of the alternator, depleting the batteries' state of charge.

Did you know that a common flooded lead acid battery can absorb as much as 10 to 20% of its CCA rating in amperage at 75% state of capacity or below? In incorrectly configured systems the batteries may have enough energy to start the engine, but power is drawn from them during the operation of the bus to assist in maintaining the amperage demands of the system. In these configurations the batteries create additional demands on the alternator over and above the already heavy electrical accessory demands.

The Alternator

The typical work day for a school bus starts with the driver performing a visual inspection of the bus, which is usually done while heavy electrical loads are on and the engine is at idle. Then during normal operation the bus spends most of its time with either the engine idling or at very slow ground speeds. The maximum possible output of the alternator can be mostly irrelevant, as it may never reach the rpm's necessary to achieve that output. If the alternator on your school bus is undersized then power is being consumed from the batteries during operation. This will mean that at the end of the day the batteries have not been charged properly, contributing to premature alternator, starter and battery failures.

You can not determine the correct alternator for school bus applications by referencing its maximum output rating. ***The only important rating is the amount of power that the alternator can produce while the engine is idling***. For a school bus this is very important because of the typical low engine operating speeds.

Lets take a closer look at a typical school bus application. A bus equipped with standard D.O.T. requirements will typically have an electrical load of 80-105 amps, depending on the accessories that each individual operator may choose. However, this same school bus with basic air conditioning, or with 3 50,000 BTU or 2 80,000 BTU under-seat heaters has an average amperage requirement of 160-185 amps. The installation of lifts and/or electric drive line retarders will create much higher electrical demands.

\

An engine pre-heater also needs to be considered, as it is a load that may not be considered during load testing. These will draw approximately 100 amps or more for several minutes, until the time the air temperature entering the engine reaches a predetermined temperature. This demand will draw out of the batteries and must be replenished by the alternator.

Performance by application

A general rule when recommending an alternator for a specific application is to make sure that the total amperage demand of the vehicle does not exceed 80% of the alternator's maximum output capability. Thermal degradation (heat) will decrease the alternator output efficiency by as much as 15%. The remaining 5% is needed to maintain the batteries' state of charge when electrical demands at idle exceed that of the alternators output at that speed.

For example, the engine is idling and a wheel chair lift is in operation. During this time of operation power is being consumed from the batteries by the lift, reducing their state of charge. When lift operation is complete, the alternator must have the ability to replenish the batteries' state of charge without increasing the engine speed. The batteries are to be utilized for engine startup and subsequently only intermittently when optional loads exceed that of the alternator, and then only for a short period of time. By default the nominal speed of an alternator in the school bus vocation ranges from 1850 to 2400 rpm.

Determine amperage requirement

It is very important that you determine your typical amperage demands before choosing the alternator for your bus. To do this you should utilize an inductive DC clamp-on amperage instrument and follow the steps below.

Always ensure that the batteries state of charge is greater than 12.45 volts with a volt meter. If the batteries have been charged with a battery charger or the alternator within 24 hours of this test the batteries surface charge must be removed before proceeding with this test as it will be inaccurate. To remove the surface charge, simply turn the head lamps of the bus on and select "high beam" for 5 minutes. After 5 minutes turn the head lamps off, allow the batteries to recover for 1 minute and measure the true state of battery charge with a voltmeter. Remember the battery voltage must be greater than 12.45 volts for this test to be accurate. If necessary you should recharge the batteries with a battery charger before proceeding with this test.

Amperage requirement worksheet

A. Start the engine of the school bus and operate it at idle speed.
B. Simulate normal operation. Turn on electrical accessories that would normally be operated when the bus is en-route off loading or on loading passengers and record these items for future reference. (Do not consider the wheel chair lift or electric brake retarder at this point.)
C. Verify that voltage at the alternator is 13.8-14.2 volts. Record the alternator voltage output here ______. Values lower than this indicate that the alternator is not adequate to meet the electrical demands of this vehicle, and you should turn on the high idle to complete this test. Attach the inductive DC amp clamp onto the alternator positive output cable, ensuring arrow is pointing away from the alternator, and record the alternator's output amperage here ________.
D. At the battery location of the bus, locate all cables / wires attached to the (+) battery terminals. Clamp each cable/wire at the positive battery post individually, ensuring the arrow of the DC amperage clamp is pointing toward the (+) battery post.

1. If any cables/wires clamped indicate a positive amperage reading, total and record here. Also take a voltage reading at the battery and record that here for reference.	Positive amperage (D1) Voltage @ battery _________	
2. If any cables/wires clamped indicate a negative amperage reading, total and record here.	Negative amperage (D2)	
3. Subtract the negative amperage reading (D2), from the positive amperage reading (D1).	Battery demand (D3)	
Example:	*Positive amperage* *Negative amperage* *Battery demand*	*31* *47* *-16*

If the battery demand from step D3 is a positive number your alternator is supplying sufficient amperage to power your base system, and you can proceed to step F.

If the value from D3 is a negative number you are drawing power from your battery to power your base system. You must add that value to your alternator output to get your total system requirement, which you must calculate in step E below.

E. If the total battery demand from D3 is a negative number you will need calculate your total system demand. To do this you need to add the battery demand from D3 to the alternator output:

1. Enter the value from step C (alternator output)	Alternator output (C)	
2. Enter the negative value from D3, but enter it here ***as a positive number***	Battery demand (D3)	
3. Add the battery demand to the alternator output	Total requirement (E)	
Example:	*Alternator output* *Battery demand* *Total requirement*	*85* <u>*16*</u> *101*

F. If your school bus has any major intermittent electrical loads (electric drive line retarder, wheel chair lift, engine pre-heater, etc.) you will need to calculate the additional demands these will place on your system. You will need to measure the maximum amperage requirement of each component while operating it in the highest applied position. You should then use 25% of that total for calculating the additional requirement:

1. Electric drive line retarder		X .25	
2. Wheel chair lift		X .25	
3. Engine preheater (use 100 if not measurable)		X .25	
4. Other		X .25	
Total intermittent loads (F)			

G. You can now calculate your total system amperage requirement:

1. Enter your total system requirement. This is your alternator output from step C if your battery demand was positive, or the value from E if the battery demand was negative.	Total system requirement	
2. Enter the value from step F (if any)	Intermittent loads	
Total amperage requirement		
3. Allowance for thermal degradation	multiply * 1.20	

Minimum alternator output required at idle (2000 rpm alternator speed)	

You should perform this procedure once simulating summer conditions, then repeat the procedure simulating winter conditions. You must use the largest total amperage requirement when sizing the appropriate alternator for your school bus.

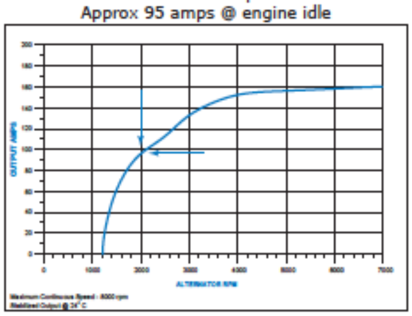
Sizing the alternator to your requirements

Now that we know the required amperage, let's take a look at a typical output curve for a school bus alternator. It is important to point out here that not all alternators are created equal. You must be cautious of claims that an alternator can be used on school bus applications simply because of the maximum output. Many manufacturers will build alternators to achieve a high output at maximum speed, but in doing so will sacrifice the output capabilities at lower speeds. As we've already seen, the maximum output of the alternator is often irrelevant. What you really need to look at is the amount of amperage that the alternator can produce at a much lower speed, when your engine is running at idle. The typical diesel engine will idle at approximately 625 to 800 rpm. Using a standard alternator-to-drive pulley ratio of approximately 3:1, we can estimate that your alternator speed at idle will usually be in the range 1850 to 2400 rpm. For simple comparisons we find it is useful to focus on the alternator output at 2000 rpm.

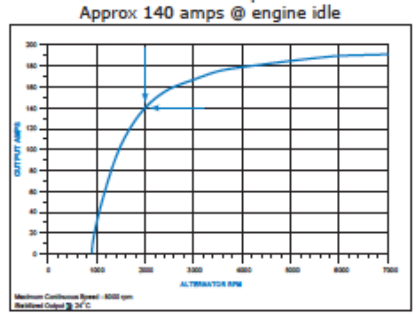
A Leece-Neville 160 amp alternator *(graph A, below left)* can produce approximately 95 amps at idle. While this is considerably more power than most similarly-rated alternators can produce, it is well below what would be required for the typical school bus today. As a general rule of thumb you should use these alternators only on buses manufactured prior to 2003, when load requirements were less.

Our testing has determined that you will need an alternator with the ability to produce a ***minimum*** of 140 amps at idle in order to supply the necessary power for school buses manufactured in 2003 or later. In order to achieve this you will need a Leece-Neville alternator with a rating of 185 amps *(graph B, below right)*. It is important to note that ***there are alternators being used in school bus applications today with ratings of 200 amps that produce less than 120 amps at idle***. These units may run at a low voltage during times of high amperage demand, which will cause the premature failure of other parts of the electrical system.

Graph A
Leece-Neville 160 amp alternator
Approx 95 amps @ engine idle



Graph B
Leece-Neville 185 amp alternator
Approx 140 amps @ engine idle



It is important to consider the complete interdependent ***charging system*** consisting of the alternator, batteries and cabling when diagnosing electrical problems. Making sure that you have a properly sized alternator is just one step of the process. All components within that system are dependent on each other to maintain the health of the entire system, and all must be considered when trying to determine the true root cause of any problem.

We have included a chart on the final page of this TSB that gives additional information on correctly sizing alternators for school bus applications with additional electrical loads.

School bus wiring requirement

Alternator output cable size

Just as the alternator may be undersized for the additional electrical loads that have been installed on your school bus, the same holds true for the size of the cabling attached to that alternator.

Imagine a fire hose that is pumping the maximum amount of water that it can accommodate. Now increase the size of the pumps that are supplying the water to that hose. The fire hose can not pump any additional water, as it is already at maximum. Instead of pumping more water what you will see will be an increase in the pressure of the entire system.

This same phenomenon applies to the electrical system on your school bus. Increasing the size of the alternator without also increasing the size of the connected cabling will increase the electrical *pressure* (known as resistance) within your system. Technically speaking, you should not have more than 1/4 volt of resistance in each output circuit in your system with the alternator supplying 75% of its rated capacity.

The net effect of undersizing the wiring on your bus is the same as undersizing the alternator. Every component within the electrical system will be stressed, making them more likely to fail prematurely and ultimately creating a system which is less reliable

Please refer to the chart below for general guidelines regarding recommended cable sizes.

Alternator Output	***Total Circuit Length***	***Recommended Minimum Wire Size***
60-75 Amps	15 Feet or Less 16-25 Feet 26-40 Feet	#6 #4 #2
80-125 Amps	15 Feet or Less 16-25 Feet 26-40 Feet	#4 #2 #0
130-250 Amps	15 Feet or Less 16-25 Feet 26-40 Feet	#0 #2/0 #4/0
250-325 Amps	12 Feet or Less 13-20 Feet	#2/0 #4/0

There are times when a chassis manufacturer will use cabling of a different construction, allowing for smaller outside diameters than what are shown here. For instructions on the proper procedure to validate alternator wire size please refer to Section 3.4 of our Technical Training Manual, available online at www.prestolite.com/pgs_training/training_3.php#sec3_4.

Negative circuit

Leece-Neville alternators that have an output of 185 amps and larger are *case ground*, meaning they are designed so that the alternator housing must be adequately grounded to the chassis. In addition, these units have a negative terminal on the rear wiring plate that must also be grounded. When replacing a typical alternator with a heavy duty Leece-Neville alternator you can use the existing ground wire from the old alternator to attach to this negative terminal on the Leece-Neville alternator. However, it is imperative that you locate and check (and most likely replace) the ground wire which leads from the cranking motor or the engine block to the chassis frame rail. This must be a minimum 1/0 or 1 gauge wire and have clean, un-corroded connections.

Positive circuit

As previously stated, you should not be surprised if the wiring used on your school bus is undersized. This will be most certainly true if you are upgrading the bus to a new, larger alternator. In these cases the entire positive circuit must be upgraded, which is not only the wire but also any protective fusible devices which are in that circuit. These include fusible wire/cable links, mega fuses and circuit breakers of both thermal and reset type.

At a minimum you should have a 1/0 or 1 gauge wire and a fused device that exceeds the maximum output of the alternator by 5% but by not more that 25%. In all applications the fused device must be installed and incorporate a protective coating on all connection points.

You may want to consider obtaining the appropriate ‘complete circuit components’ from the chassis manufacturer, which would incorporate the necessary fusible device(s) that will be required for your application.

Helpful tips

Specification

Utilize a high-idle device that will increase the engine speed to approximately 1100 rpm if the school bus will be required to operate for long periods of time at idle or during operations that require excessive electrical draw from the system. These operations would include pre-delivery inspections, wheel chair lift operation or pre-heating or cooling of the bus interior. Running at high idle during these times will ensure longer life for the alternator and the electrical components on your bus.

Specification

Consider the effects that additional electrical components will have on your specification when purchasing a new school bus. Write down these additional requirements and make sure that the alternator and all associated electrical components that will be supplied with the chassis are capable of handling the entire system load of the finished bus. This will save you the trouble and expense of upgrading these components later on.

Alternator specification guide

Please note that 175 amp alternators have been superseded by 185 amp units for school bus applications. You can get additional details by downloading the 'School Bus Alternators Update', FL-1083 from our website at www.prestolite.com/literature/alts/FL1083_175Amp_to_185Amp.pd

Minimum Amperage	Application	Sales Number	Description	Mount
185	Any school bus without A/C. Can be with or without a wheelchair lift.	4833LGH	Self excite, positive on right, 5/16" output term	J180
		4836LGH	Self excite, no 'R' term, positive on left, 5/16" output term	J180
		4836AAH	Remote reg, no 'R' term, positive on left	J180
		4846AAH	Remote reg, positive on right	J180
		4939AAH	Remote reg, positive on left	PAD
		4939PGH	Self excite, positive on right	PAD
		4943PGH	Self excite, positive on left	PAD
		4945AAH	Remote reg, positive on right	PAD
40	Any school bus with one A/C unit. Can be with or without a wheelchair lift. Any school bus without A/C but that does have an electromagnetic brake retarder.	4860JB	Ignition excite	J180
		4863JB	Self excite	J180
		4940PA	Ignition excite	PAD
		4951PA	Self excite	PAD
270	Any school bus with two A/C units. Can be with or without a wheelchair lift. Any school bus with one A/C and an electromagnetic brake retarder.	4867JB	Self excite	J180
		4870JB	Ignition excite	J180
		4942PA	Ignition excite	PAD
		4944PA	Self excite	PAD
		4947PA	Ignition excite	PAD
		4949PA	Self excite	PAD

320	Any school bus with two A/C units and either a dash A/C unit or a third A/C unit. Can be with or without a wheelchair lift. Any school bus with two A/C units and an electromagnetic brake retarder.	4890JB	Self excite	J180
		4962PA	Self excite	PAD

1. These are our minimum recommendations for these applications.
2. Remote regulators are recommended for all forward engine transit type buses. Any bus outfitted for CNG or LNG (compressed or liquid natural gas) should also use remote regulators. OEM's may supply configurations other than this. Please contact Leece-Neville Tech Service at 866-288-9853 for details on changing to remote regulators.
3. An A/C unit is defined as having one evaporator and one condenser. A bus with a main rear evaporator and a slave dash A/C unit would be considered a two A/C system, even though they share the same condenser.

About Prestolite Electric, Inc.

The Prestolite and Leece-Neville product line includes high-output alternators and gear reduction starter motors for on- and off-highway trucks, military applications, mining vehicles, school and city buses, motor coaches and other uses. The company has received certificates of registration to the ISO/TS 16949:2009 Quality Management and ISO 14001:2004 Environmental Management systems.

Prestolite is a division of Broad-Ocean Motors, a global supplier of high-tech, high-quality motors, alternators, and starters to multiple markets, including appliance, air handling and commercial transportation.

Global Headquarters
30120 Hudson Drive
Novi, Michigan 48377
USA
Phone: +1 866-463-7078
Fax: +1 248-863-2341
Email: corpinfo@prestolite.com

Manufacturing, OE Sales
400 Main Street
Arcade, NY 14009
USA
Phone: +1 585-492-1700
Fax: +1 585-492-1660
Email: info@prestolite.com

Distribution, Aftermarket Sales
7585 Empire Drive
Florence, Kentucky 41042
USA
Toll Free: +1 800-354-0560
Toll Free Fax: +1 800-997-6202
Phone: +1 859-525-8801
Fax: +1 859-525-8814
Email: info@prestolite.com