Thoughts About Engine Conversions or Re-Power Options for Buses [Part 2]

Part One of this article appeared in the October issue. Topics included:

- **Should I modify my two-stroke engine for more power?**
- **If I do a conversion, should I stay with a two-stroke and use a bigger engine or go to a four-stroke engine?**
- **If I do a conversion, should I use a mechanical or electronic engine?**

Part Two continues this month with the following topics:

- **Will a conversion increase my mileage? Is there a reasonable payback with increased mileage?**
- **What are the costs involved in an engine conversion/power upgrade?**
- **Should I think about doing the conversion myself?**
- **What systems will have to be fabricated?**

Part Three of this article will run in our December issue. The topics will include:

- **Why will I need to change my gearing for a four-stroke conversion?**
- **What about cooling problems?**
- **Will I have to do any special structural modifications?**

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Will a conversion increase my mileage? Is there a reasonable payback with increased mileage?

A conversion from one two-stroke engine to a larger two-stoke engine (or a power upgrade on an existing engine) will generally result in reduced mileage. Part of the problem is the tendency to USE all of that power. There are some folks who will argue that an 8V92 will get better mileage than a 6V92 since it will not be working as hard. My opinion is that you should not count on an increase in mileage for this type of conversion.

However, the conversion to a four-stroke can result in an increase in mileage. This is especially true if you go to an electronic engine and gear the bus properly

The only factual data I can present is my own situation. Our bus and toad weigh over 46K pounds (large toad). I have driven the coach over 52K miles and have averaged 7.7 MPG as measured by the SilverLeaf (directly off the engine ECM). I did not have any experience with the bus at this weight with the 6V92, but my best guess is that I would have gotten less than 6 MPG (remember we travel over the mountains a lot and weigh more than many buses). If the 6 MPG is close to being correct, my mileage improvement is close to 30%. Over the 52K + miles, I have used about 6,800 gallons. If I had used 30% more fuel that would have been an extra 2,000 gallons. Even at a conservative $2.50 per gallon, that would amount to a $5000 savings. That all sounds great, but I have about $14K in the swap (parts only, I did all of the engine conversion work), so it will take a bunch more driving to pay off the swap.

As a side note, I cannot conceive what it would be like to drive this very heavy bus/toad combination with a 6V92 over the passes in Colorado. It would not be a lot of fun. The “fun factor” of the Series 60 is impossible to calculate. Rather, it is “priceless”.

The bottom line is that an engine swap will not be justified by fuel savings alone.

What are the costs involved in an engine conversion/power upgrade?

If the decision is made to simply increase the power of the existing two-stroke engine, the cost can vary drastically. When I upgraded my 6V92, it was a matter of injectors and a new turbo. That was about $2,000 as

I recall. A full rebuild with higher HP parts will run at least $12,000 at a certified Detroit dealer.

If a turbo is added to an non-turbo engine, the cost can be significant. The general consensus is that the engine should be rebuilt with components that are intended for the turbo application. There is quite a bit of controversy about whether to change to turbo pistons (lower compression) or stay with the original piston design. If you are thinking about going in this direction, you should consider adding a charge air cooler system. Tom Christman, one of the major contributors on the BCM board (TomC), did a turbo upgrade to his 8V71 in his AMGeneral. He has over $10K in the engine modifications and turbo upgrade (including the charge air cooler) and is very happy with the results.

If a two-stroke conversion to a larger engine is your choice, again the costs can vary considerably. For example, if a 6V92 is replaced with an 8V92, the costs involved will include the purchase of the engine, and possibly some rebuilding cost. There will be significant modification costs including engine mounts, water plumbing, exhaust plumbing, etc. Even if you do the work yourself, I would plan on a minimum cost of $8,000 and that cost could double or triple if you have someone do the work. As noted previously, installing a larger two-stroke will add a considerable heat load to the cooling system. At the least, the current radiator should be re-cored with the latest fin technology and include as big a core as possible.

If the conversion is to a four-stroke, the engine purchase and repair costs will be in the same ballpark as a two-stroke engine purchase. Four-stroke engines can be purchased for less than $10,000. Good shopping should result in finding a GOOD engine for about $7K-8K. Lots of re builder engines can be found in the $4k range. However, the modifications will be at least twice as extensive and expensive. If the larger four-stroke is chosen, the extensive structural modifications will greatly increase the cost.

Modifying the drive train to provide decreased engine speed will also greatly add to the cost. We will discuss gearing issues later in this article.

Manufacturer	Model	Weight
DDC	6V92	2020
DDC	8V92	2420
DDC	Series 60	2610
Cummins	M11/ISM	2070
Cummins	N14	2805
Allison	HT 740	980
Allison	World	900
Eaton	10 Speed Truck	650

Table 1: Manufacturer's "Dry" Weight (lbs.)

If you decide to have a professional conversion done, plan on shop rates of $80-100/hour. Be sure to get references. Lots of shops are hungry for work right now and they will tell you they can do the work, but many are not equipped to do the job properly. I would expect a good shop would take between 100 and 300 hours to do a conversion. A more extensive conversion involving structural modifications can double the conversion time/cost. As noted earlier, a professional conversion to a mid-size four-stroke engine will generally exceed $30K for parts and labor. If the engine needs to be rebuilt, the cost will increase by $10-15K.

Should I think about doing the conversion myself?

An engine conversion requires many skills. I would liken the skills to that of a millwright, welder, and electrician and engineer. Perhaps not all of the skills of those professions, but at least first-level skills. Ingenuity has to be mixed in as well. However, many bus nuts possess those skills and can accomplish a good conversion.

In addition to skills, there will be special equipment/tools that will be required. You will need to have equipment capable of handling the engine/transmission weights of up to 4000 pounds. Table 1 shows some published weights of common engines and transmissions. When I unloaded the engine from the trailer, I used a boom on my rather large "classic" IHC truck. I kept wondering why the engine was not lifting. I checked, and the front wheels of the truck were off the ground! We are talking about big equipment!

As noted, you need all of the manuals for your engine including wiring diagrams. You should talk to folks who have done similar swaps. There are two websites that have quite a bit of detail about engine conversions in buses. I have listed my project pages several times in this article. A must-read project website is Brian Diehl's: http://home.earthlink.net/~diehls0792_1/BusSection10.html. Brian did an

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excellent job of documenting his Cummins ISM/Eaton AutoShift conversion in an MCI 96A3. In addition to the excellent documentation, Brian's description of picking up the engine and transmission, and transporting it is priceless!

What systems will have to be fabricated?

Any engine conversion, both two- and four-stroke, will generally require re-plumbing the cooling system, modifying/fabricating the following: exhaust system,

Figure 3: Pressure testing radiator tubing.

engine/transmission cooling lines, air intake plumbing, drive shaft, fan drive and engine mounts. Some will require fabrication and installation of a charge air cooler. In addition, there are a huge number of small details that will consume a huge amount of time.

For the air intake, charge air cooling, and engine coolant plumbing, I used exhaust tubing. It comes in the sizes needed and can be easily fabricated. I bought preformed bends and welded the tubing into shapes that only required short, straight hose connections. Each tube end has a rolled bead to prevent the hose from sliding off the tube when under pressure.

A word of caution here, be sure to pressure test all of the tubing if they involved welding pieces together. I thought I was a pretty fair welder, but quickly found out differently. I connected all of the pieces of fabricated tubing of a given system together with short pieces of hose and made two end caps from tubing and sheet steel. I welded an air fitting in one of the pieces so that I could apply air pressure (see Fig 3)

Engine mounts can be a debated subject, especially with four-stroke engines. Trucks have huge longitudinal frames that don't transmit vibration well. Conversely, our buses have either tubular or monocoque construction which can transmit vibration throughout the bus. The problem generally occurs at engine idle.

As I approached that part of my conversion project, I contacted Newell Coach whom I considered to be the premier coach manufacturer using Series 60 engines. They were kind enough to send me prints of their engine mounts. I was impressed with their design. It used a front motor mount for an IHC application that places the mounts in both compression and shear. Unfortunately, IHC no longer offered the Series 60 engine option and I gave up trying to find the Series 60 front engine bracket for that application. I ended up using the engine mounts from the Freightliner truck that my engine came out of. I did replace the rubber components.

Several people have strongly recommended Metalastik motor mounts. Their Metacone product (http://www.missionsupplyonline.com/trelleborg/parts/metacone.php) is said to be a very good vibration isolating product. Eagle bus used them for the short period that they installed Series 60 engines.

Figure 4: Engine mount alignment.

Engine mount geometry needs to be based on proper alignment of the engine in relationship to the rear end. I took a great deal of time measuring the old 6V92 engine geometry and replicated that with the new engine. Fig. 4 shows the jig I made to perform the measurements. I did have to modify the geometry "replication" a bit to allow for the added length of the new engine.

Design of the engine

Figure 5: Installation using dolly.

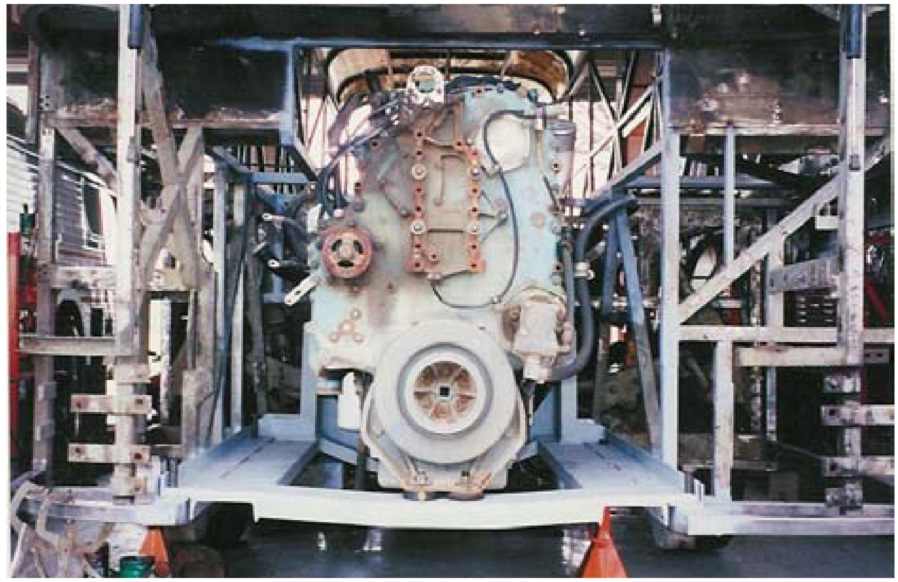

Figure 6: Engine mount system for fork lift installation.

mount should also consider how the engine will be "moved" into the engine compartment. Most installers will use a dolly (see Fig 5) or pallet jack. At least one person designed the mount system for use with a fork lift (see Fig 6).

If the conversion is from a mechanical engine to an electronic engine, multi-wire cables must be constructed. The construction of these cables was discussed earlier. This sounds like a formidable project. Constructing your own cable is not that difficult (once you have studied the wiring diagrams and fully understand what is required). There are companies that specialize in making cables and can easily make a custom one for your application.

Drive shaft fabrication/modification will almost always be a part of the conversion process. I was able to use my existing rebuilt drive shaft, but most conversions will require a length change. This work should be done by a professional shop.

One major system that will require fabrication is the cooling fan drive. If a hydraulic fan is used, the fabrication will be minimal. If a belt drive is used, and a side radiator is involved, the design and fabrication will be significant. In general, a side radiator will require two belt drives and a right angle gear box. The selection of the belts is a bit complicated, since there can be a mixture of automotive and industrial pulleys. Belts will generally be industrial cross sections and care must be taken to make sure they mate well with the automotive grooves in the crankshaft. The engine will move slightly on the engine mounts and I strongly recommend installing a spring loaded idler in the engine-to-gearbox drive. This whole system is a bit complicated and I have quite a bit more detail on my project pages.

This concludes Part 2 of our three part series: "Thoughts About Engine Conversions or Re-Power Options For Buses." The next installment will appear in our December issue.

Jim Shepherd and Sonnie Gray have conducted several engine conversion presentations at various bus rallies. These presentations are typically split into two sections:
a. Presentation of their thoughts
b. Round table discussion

We would like to treat these articles in much the same way. Consider this series of articles, the presentation. After you have read this month's article, think about the opportunity for a round table discussion. Once you have reflected and digested, share your thoughts with Jim. He plans to consolidate the feedback received into a follow up article.
Thank you.

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