# Thoughts About Engine Conversions or Re-Power Options for Buses [Part 3]

**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 of this article appeared in the November issue. Topics included:**
- **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, our last installment of this article follows below. The topics 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?**

JIM SHEPHERD

## Why will I need to change my gearing for a four-stroke conversion?

As noted earlier, most four-stroke engines obtain the best mileage and power in the 1300-1600 range. Many of today's four-stroke engines are governed at 1800 RPM (can be changed to 2100 RPM in most cases). All modern trucks are geared to operate at what seems like very low RPM.

By comparison, most two-stroke buses are geared to run all day at 2100 RPM. Typical rear end gear ratio options for large buses with two-stroke engines are 3.36 and 3.73. With 11x24.5 tires a 3.73 ratio will have a top speed of about 70 MPH at 2100 RPM.

Table 2 shows various MPH values for various engine RPM and gearing options. That table is calculated based on a tire rating of 480 revolutions per mile which is typical of many bus tires.

The first thing we will do with Table 2 is to look at the 3.73 column with no overdrive. This is typical gearing for Eagle/MCI/Prevost. You can see that to stay within the "sweet" range of a four-stroke engine (less than 1600 RPM) you would need to stay under 55 MPH! If you change the ratio to 3.36, the top of the "sweet spot" range would be 60 MPH.

| Axle Ratio | 3.36 | 3.73 | 3.73 | 3.73 |
|---|---|---|---|---|
| Overdrive Ratio | 1.00 | 1.00 | .074 | .061 |
| RPM | | | | |
| 1300 | 48 | 44 | 59 | 71 |
| 1400 | 52 | 47 | 63 | 77 |
| 1500 | 56 | 60 | 68 | 82 |
| 1600 | 60 | 54 | 72 | 88 |
| 1700 | 63 | 57 | 77 | 93 |
| 1800 | 67 | 60 | 82 | 99 |
| 1900 | 71 | 64 | 86 | 104 |
| 2000 | 74 | 67 | 91 | 110 |
| 2100 | 78 | 70 | 95 | 115 |
| Note: Based on 480 tire revolutions per mile. | | | | |

**Table 2: Miles per hour calculator.**

Lots of folks with engine conversions stay with the stock gearing and run the engine at higher speeds. That will do two things: reduce the MPG and shorten the engine life. For most of us, the reduction in engine life is not a huge factor. However, the goal of switching to a four-stroke to gain MPG will be nullified.

For those wanting to optimize their bus gearing, rear end gear ratio options are quite limited. The best option to properly gear a four-stroke conversion is to select a transmission with an overdrive. About the only options are the Allison World automatic transmission (double overdrives) and a truck transmission. Most truck transmissions are available with a .74 overdrive which yields almost optimum gearing when combined with a 3.73 rear end ratio. Truck transmissions can be swapped into a bus equipped with a standard transmission fairly easily. In my case, I chose an Eaton AutoShift because it does not require shifting linkage. It does require a clutch, but the engine and transmission communicate with each other and the gear changes are made automatically.

When you look at the 3.73 column with the .74 overdrive, you will see that the "sweet spot" is in the perfect driving speed range for most folks. That overdrive is the ratio for my Eaton AutoShift. It is also the first overdrive for the Allison World transmission. The second overdrive for the World is .61. You can see from the last column, that ratio is a bit "tall" for most applications. Indeed, the programming of the World is such that it might not get into sixth gear with a 3.73. At least one engine conversion in an Eagle used a 4.11 rear end ratio (fairly rare) and can just get the World transmission into 6th gear at his cruising speed (65 MPH as I recall).

The rear end housings for Eagles/MCI/Prevost do not have gear sets "taller" than 3.36. Sonnie Gray took matters into his own hands and reconfigured his bus so that the drive axle was in front of the tag axle and installed a truck rear end. He has 2.93 gears and cruises with the engine in the ideal range (1650 RPM at 70 MPH). He uses an Allison HT740 which has the 1.0 high gear ratio.

I have heard of other conversions that installed truck rear ends so that they could obtain better gearing. A word of caution on the use of tall gears: "startability" should be considered. Sonnie has no starting issues on even the worst slopes. He attributes this to the Caterpillar torque, but I suspect any of the large four-stroke engines will not have startability issues when coupled with an HT740. The torque converter on the HT740, coupled with a strong engine will generally not have issues if the rear end ratio is not taller than 2.9.

## What about cooling problems?

As noted earlier, upgrading a two-stroke engine (either increasing HP on an existing engine or converting to a larger two-stroke), often results in cooling problems. Bus cooling systems are notoriously marginal from the factory. Cooling-system capacity degrades with age due to buildup of deposits on the inside of the core. Another factor that occurs is "decoupling" of the fins from the tubes after many years of service.

Radiator technology had changed significantly since most of our buses were built. The latest technology is "dimpled tubes". Re-coring a radiator with new technology can increase cooling capacity by up to 30% over original capacity. Additional rows can be added to the radiator. Often times this will be sufficient to solve cooling problems.

For the MCI group, some buses can be upgraded to larger radiators. In addition, fan speed can be increased. Other conversions utilize modern fan technology to move more air through the radiator.

In all cases, care should be taken to maximize the air flow through the radiator. This involves using a good fan shroud and blocking off the area around the radiator to make sure that the fan does not pull air from around the radiator.

For installations that only have cooling problems under extreme conditions, a misting system can be considered. This is a controversial subject on the bulletin boards. My opinion is that misters are appropriate if they are used sparingly. They should not be used as a band-aid for bad cooling system. One of the issues with misters is that they can result in calcium buildup on the surface of the radiator. That can be addressed with the application of vinegar or commercial calcium removal products.

Four-stroke engines require considerably less cooling capacity. Oftentimes, the stock bus radiator, if it is in good condition, will be sufficient.

## Will I have to do any special structural modifications?

There are two structural issues to consider. The first is to make sure that the existing engine compartment has sufficient strength to support the engine when a conversion is made. The second issue is modification of the bus to provide space for the new engine.

Lets' talk about making sure the engine compartment has good structural integrity. Table 1 shows the weights of various engines and transmissions. When converting from a 6V92 to a Series 60, the engine weight increases about 600 pounds. That does not sound like much, but consider that the Series 60 is longer and that places the added weight further from the axles. Is that enough to require beefing up the engine compartment structure? Probably not from a calculation standpoint, but in the real world, the structure has endured lots of miles of flexing (reduced fatigue

| 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.)**

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strength) and corrosion. For Eagles, this can be a real issue, but it is present in all coaches.

For my conversion, I beefed up the engine rails and "double tubed" most of the structure. Double tubing the area is quite easy. You simply place a second tube next to each existing tube and weld the tubes together (see Fig. 7). In my opinion doubling the tubing is far superior to splicing new tubing into the old tubes. This requires butt welds and it is very hard to produce butt welds that have the same strength as the tube.

**Figure 7: Double tubing frame.**

Modifying the bus to make room for a new engine can range from adding a few inches in length (adding a "bustle") to a complete rebuild of the rear structure. I have seen several buses where up to two feet were added to the rear of the bus. It can also include raising the floor to accommodate the taller large four-stroke engines (see Fig. 8)

**Figure 8: Floor raise for tall engine.**

Adding a bustle does not present design issues other than the aforementioned added engine weight and longer engine issue. In general, the issue is one of aesthetics.

Adding length to the bus to accommodate a engine conversion involves modification of the structural design of the bus. As an engineer, I become very concerned about modifying the structure of a bus. The structure of many buses are monocoque construction. This kind of structure is very complex and modifications can significantly alter both the longitudinal and torsional stiffness. It would be pretty easy for me to "prove in my mind" that this kind of modification will result in disaster. Having said that, many folks have successfully made modification to their bus structure with apparent success. Some have had a structural engineer review their design, and I highly recommend that review.

**So there you have it. My thoughts on engine modifications and engine conversions. I would like to think that this is the first "go around." I encourage the readers to contact me with their thoughts and questions and we will write a follow-up article in a future issue of BCM.**

**You can contact me via Email: jim@rvsafetysystems.com.**