

Moses Ludel's 4WD Mechanics®

Issue Number 3: April 2010

"Monthly Technical News for Jeep® Enthusiasts and Four-Wheel Drive Shops"

**Inside the Mopar® Performance
4.7L 'Stroker Motor'
Long Block!**



**Also in
This Issue:
Six-Cylinder
Ignition Upgrades
for 4.2L Engines**

These Questions in This Month's Technical 'Q & A' Section!

Question: "...The XJ has a 242TC. Unless I blow it up, I am keeping it! I appreciate the full-time 4WD mode on marginal weather days—we get many around here in the winter...As for the SYE conversion, the 242 does not have a commercial kit solution like the popular 231 units. All of these 242 SYE kits are some sort of 'hack and tap' approach..."—Jim J.

Question: "I have a 1998 Jeep Cherokee Sport 4WD 4.0L, automatic with 121,000 miles. The vehicle has an 8.25" Chrysler rear axle without ABS. The transfer case is a New Process 231J...the Jeep has a DEEP DRONE that starts between 60 and 70 MPH..."—Joel Z.

'4x4 View' by Moses Ludel

The internet web is rife with information. Glowingly, Heidi and Alvin Toffler, authors of the classic book *Future Shock* and a currently bestselling take entitled *Revolutionary Wealth*, have proclaimed this the era of self-powered "prosumerism," rising from the ashes of dying consumerism.

Like many of my ivory tower colleagues, they weave together a reasonable case, citing that the American automotive aftermarket alone is a *\$37-billion per year 'do-it-yourself' market*. Safe to add, Jeep® owners contribute more than their fair share to this burgeoning growth!

The premise of the newest Toffler book is that a global movement has emerged, fueled by the information era and built upon the self-empowering notion of self-sufficiency. Striving for a more resourceful approach, many folks tackle tasks that they once left to others. The whole concept of "work," according to the Tofflers' findings, has shifted toward the sharing of information, shared technology and mastery of the skills needed to "survive" outside of a crumbling consumerist model.

Many Jeep® owners would argue that the Toffler thesis has been around for a very long time. Ask any trail running club or go-it-alone backcountry 'wheeler whether Jiffy Lube or a full-service gas station is available along the Rubicon Trail or at Moab...

On the other hand, technology has grown exponentially, too. The service department at a Five-Star Jeep® dealership might be just the place to diagnose an electronic powertrain issue or unearth that ABS gremlin. When it comes to Jeep® survival, *knowledge and pearls of wisdom come from any reliable source!*

As for things mechanical, like a trail running Jeep®, there's no such thing as having too much knowledge. Facing outback challenges provides a true incentive for advancing your skills! For forty-five years now, I've expanded my Jeep® awareness. As a professional mechanic and vocational shop instructor, my standards have always been governed by, "Can it do the Rubicon Trail—*trouble-free? How many times?*"

I first plied the Rubicon Trail behind the wheel of a CJ-5...Learning to drive in a Jeep®, owning numerous Jeep® 4x4s, modifying a Jeep®, Jeep® fabrication work, Jeep® magazine and book project vehicles, fixing my Jeep®, fixing others' Jeep® 4x4s, troubleshooting and Jeep® trail repairs, restoring Jeep® 4WDs, Jeep® consulting, conducting Jeep® workshops, writing Jeep® books, photographing Jeep® vehicles—and *Jeep® you name it*—have been woven into my lifestyle, work and family life since 1964!

Taking a hard look at the internet, consumer trends, the current 4WD publishing field and, most importantly, the needs of emerging Jeep® prosumers, one fact is clear: There has always been a place for sharing *useful* information! In the never ending quest for self-reliance, many Jeep® owners have turned to the internet, only to find, amidst a wealth of prized information, a heavy sprinkling of unfounded opinions.

One example of what to avoid was a recent forum in which some well-intentioned, owner-experts answered a fellow's question relating to a Dana 30 ARB Air Locker installation. *Not one of the answers was remotely accurate*. A few were just misleading, and several "tips" would lead to inevitable parts failure. I was flattered that one of the respondents mentioned my

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technique for using “dummy bearings” to trial fit a Dana-Spicer ring-and-pinion; of course, he had no idea where the idea originated. My magazine tech stories and three of my Jeep® books shared this approach, beginning as early as the mid-1980s. Good news: *Someone* read the books!

Looking around the office from my computer chair, I spy a framed ‘Automatic Transmission Specialist’ diploma—bearing a September 15, 1969 date. To me, that document is as meaningful as the 1980, College of Arts and Sciences, University of Oregon bachelor’s degree “with honors” that hangs next to it.

A string of General Motors “Certified Training” courses at truck chassis and powertrain areas, plus the California emission control licenses at “Qualified Test and Repair Mechanic” and “Licensed Installer,” has also proven as valuable as my university schooling. So did the years of apprenticeship training served as a heavy equipment operator-mechanic-welder with the Operating Engineers.

My prosumer path includes something akin to \$75,000 worth of education in today’s higher learning market. This does not include the investment in my wall-length bookcase full of reference texts or the major tool expenses that

have accompanied a professional practice of automotive/diesel mechanics plus stick, MIG and TIG welding. Unless I suffer senility or sustain a major head injury, this investment will remain a resource for others, like readers of *4WD Mechanix© Magazine*.

Yes, we’re all prosumers, and for us to be successful, we need to value *education and literacy*. Many Jeep® owners cleave toward individualism and self-sufficiency. *To safely and productively go the distance alone, however, requires professional insight and knowledge.*

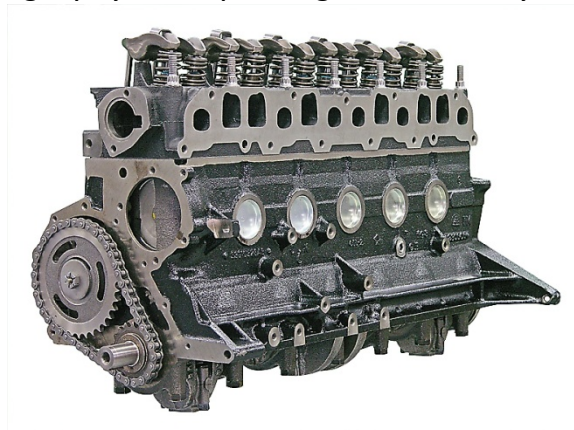
There’s no end to learning, and to be self-sufficient, you must invest in the right products and tools. I’m glad you’ve downloaded a copy of *4WD Mechanix© Magazine*, a good step toward furthering your prosumer technical skills!

As you will see in this issue, with its brand new cover design, my aim is to increase your Jeep® mechanical ability, welding skills and metals fabricating talent. Enjoy this month’s magazine. Next month, the focus is Moab, Utah, this year’s 2010 Easter Jeep® Safari. Watch for the vehicles, new technology, trail testing and innovation...I’ll see you folks at Moab—with my camera in hand!

A handwritten signature in black ink that reads "Moses Ludel". The script is fluid and cursive, with the first name "Moses" and last name "Ludel" clearly distinguishable.

Inside the Mopar® Performance 4.7L 'Stroker Motor' Inline-Six!

Text, Photography and Spinning Wrenches by Moses Ludel



4.7L Long-Block Photo Courtesy of Mopar® Performance

American Motors' most significant and enduring contribution to Jeep® was the seven main bearing inline six. While most associate this engine design with '72-up models, the architecture dates to 1964 and first appeared in 1965 Jeep J-trucks.

AMC introduced a variety of six-cylinder engine changes from the mid-'50s forward, offering four-main bearing inline sixes in L-head, iron OHV and even a short-lived aluminum block design that featured iron cylinder liners and an iron, OHV cylinder head. The aluminum-and-iron combination proved far less reliable than expected, and 1961-65 Rambler 196 cubic-inch, aluminum-block inline sixes required frequent head bolt re-torquing—or inevitable head gasket failure and block deck damage.

Lightweight Rambler six-cylinder models stood for economy, and AMC entered the

'sixties intent on elevating the status of inline six-cylinder performance. This feat was a significant challenge in an era of V-8 muscle power and cheap, readily available, high-octane pump gas.

Though Jeep® owners may wish to believe otherwise, AMC did not invent the seven-main bearing inline six. In fact, G.M. and Ford each abandoned four-main sixes, Chevrolet by 1963, Ford following in 1965.

G.M. introduced the 194 in the compact 1962 Chevy II, Rambler's direct competitor. The 1963 seven-main bearing 230 inline replaced the venerable 'Stovebolt' 235 four-main bearing engine in full-size cars and light trucks. A 250 followed in 1966. For stump-pulling truck power, the 292 inline six appeared in 1963 half-ton through 60-Series Chevrolet trucks.

Interestingly, the 230, 250 and 292 share the same bore as a stock Jeep 4.0L six. The 292's massive displacement and torque is the result of a 4.125" stroker crankshaft. *(Sorry, the 292 G.M. inline six crankshaft will not fit a Jeep® 4.0L block.)*

Ford waited until 1965 to introduce its seven-main bearing 240 and legendary 300 cubic inch truck inline six. The 300 six, a utility engine that survived well into the EFI era, enjoys a 4.00" bore with a 3.98" stroke.

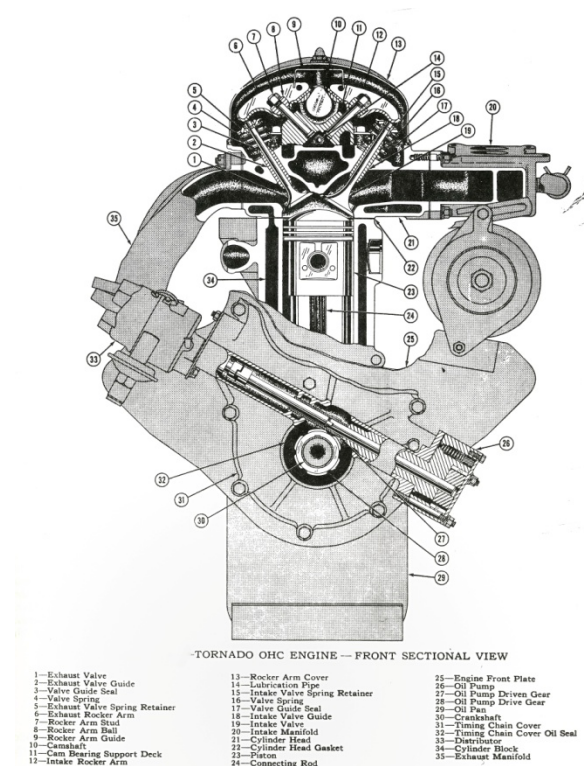
Note: Chrysler Corporation's advanced engineering produced the highly successful G-series, four-main bearing slant six design. Its crankshaft tucked well up in a 30-degree slanted block casting, the rugged inline came in 170 and 225 cubic inch versions produced between 1960 and 1987. The 225 slant six was a highly under-square design with a 3.40" bore and exceptional 4.125" stroke—ultimate truck power!

AMC's Seven-Main Bearing Inline Six

AMC's 1964 launch of the 232 stands as a welcome milestone for three generations of loyal Jeep owners. Having annoyed Jeep® mechanics with an advanced, overhead cam 230 six, Kaiser sought a basic, durable OHV inline engine. The Jeep® 230 had only four main bearings, albeit large ones. Most inline six manufacturers had moved to the seven-main bearing platform.

Although the U.S. military would have some success with Kaiser's 230 OHC engines through the 1969 M715 and its variants, Jeep® dealership mechanics and civilian J-

truck (Gladiator) and Wagoneer customers applauded the Jeep® switch to AMC's 232 inline six in 1965.

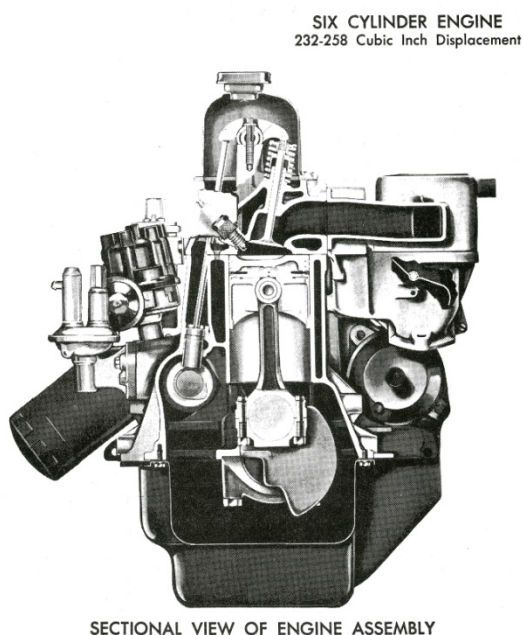


Kaiser's four-main bearing, OHC 230 inline six lacked performance and was hard to service. (Image courtesy of Jeep® Corporation. For detail, zoom to 300% in Adobe Reader™!)

Kaiser also turned to AMC for its 327 V-8. *(Do not confuse with the Chevrolet engine of similar displacement and bore/stroke sizing.)* A robust 327 V-8 gave the 1965-68 Jeep® Wagoneer and J-trucks a respectable power option to the 232 inline six.

In 1971, AMC introduced the 258 version of its inline six. This engine turned some J-truck owners' heads but did not reveal its true potential until the 258 (4.2L) became an AMC/Jeep CJ and I-H Scout option. The simple addition of more stroke

turned a 'Mobil Economy Run' Rambler 232 into a torque-twisting truck engine!



AMC's fix for CJ power was this 1972 232/258 engine. Seven-main bearings with pushrods and overhead valves, this simpler, more reliable engine has proven the best Jeep® design to date. (Image courtesy of 1972 AMC/Jeep® workshop manual. Try 300% in Adobe Reader® for maximum detail.)

Note: By design, inline sixes have inherent primary and secondary balance, contributing to their smooth performance and legendary longevity. My tow vehicle of choice is a Dodge Ram with Cummins six-cylinder diesel power!

Late night campfire stories often include the endless feats of 258/4.2L inline sixes. While the 232 in a CJ made reliable power, and certainly enough to climb over rocks in low range, it was the 258/4.2L that earned euphemisms like "stump puller," "torque monster" and "rock crawler."

Light weight, high in torque, extremely rugged, efficiently cooled, and capable of surviving the draconian emission controls of the 1980s, CJ and YJ Wrangler versions of the 258 hold top rankings as trail legends. (My *Jeep® Owner's Bible™* has sung praises for the 258/4.2L since 1992.) In rough terrain, 258/4.2L engines excel to this day.

Birth of the 4.0L/242 Six

The marketing coup of AMC/Jeep design was the 1984 XJ Cherokee. Having minor success with the all-wheel-drive Eagle car, AMC went back to the drawing board. Revisiting Jeep® utility truck successes, the XJ came forth with beam axles, a two-speed transfer case, a contemporary powertrain and a lightweight, unitized body. The result: a durable, stylish, utilitarian new product—the AMC/Jeep® compact Cherokee SUV.

Despite sensible axle and transfer case choices, AMC's 1984-86 V-6 engine option fell short. Amidst the industry trend toward downsized engines, AMC pushed aside its inline 258 six in favor of a throttle body injected (TBI), derivative 2.5L four as the base engine. The optional 2.8L metric V-6 was outsourced from Chevrolet.

The five-main bearing 2.5L AMC four-banger shares inline six features. Many parts interchange with the 4.0L six. Virtually bulletproof, 2.5L fours will often deliver 200-250,000 miles of service in lightweight CJ, XJ Cherokee or Wrangler models. The 2.5L four has become its own legend.



AMC's bulletproof, five-main bearing TBI 2.5L four shares architecture with the 4.0L inline six.

2.8L/173 cubic inch Chevrolet V-6s suffered the same problems in the XJ Cherokee chassis that they did in the early G.M. S-trucks and S/T Blazers. The "small-journal" 2.8L crankshaft was capable of breaking, and all 2.8L V-6s used in the XJ Cherokee had these crankshafts. A chronic rear main seal leak was endemic to these first-generation 2.8L engines.

Note: In fairness to Chevrolet, the 2.8L V-6 improved with the introduction of a large-journal crankshaft and final main seal upgrade. Unfortunately for the XJ Cherokee owners, none of these changes applied to '84-'86 XJ Cherokee engines.

AMC/Jeep® had a unique dilemma: The XJ Cherokee and an emerging MJ Comanche pickup were clearly sales successes. A quick powertrain fix was necessary. These chassis had room for an inline four or V-6, and with some squeezing of the fan spacing, an inline six would fit.

To this day, many question why the 258/4.2L was not the choice. Between EPA emission control constraints, CAFE fuel and

mileage standards, and an effort to satisfy crossover buyers from passenger cars to compact SUVs, a "truck engine" apparently was not acceptable. Better yet, the 2.5L four and a 4.0L six would share common bore sizing and parts. From a production standpoint, this was a compelling reason for the 4.0L configuration.



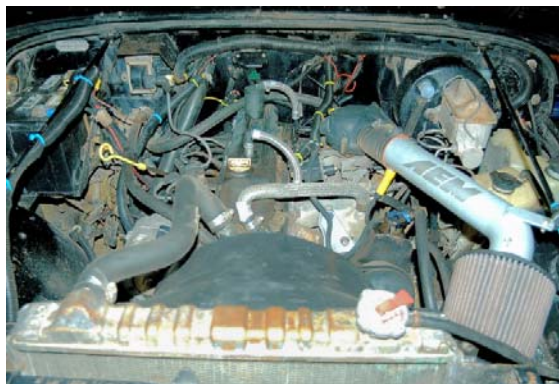
4.2L carbureted six found its last home in 1987-1990 YJ Wranglers. Can you find the engine?

The 258 still had carburetion in 1987, although many to this day wonder why. AMC and its partner Renault had launched a TBI system with the XJ's 2.5L four. Weighted with emission controls, a BBD carburetor and vacuum lines that ran in all directions, the new 1987 YJ Wrangler's 4.2L six looked archaic next to a base model's TBI 2.5L four.

AMC/Jeep took a bold initiative with the 1987 XJ Cherokee. Boasting a multi-port fuel injection system and an over-square, wholesome displacement inline six with seven main bearings, the 4.0L six arrived. The bigger bore, shorter stroke, higher speed engine claimed 177 horsepower.

That same year's carbureted 4.2L Wrangler struggled under severe emission

control detuning. Despite its useful torque output, the engine produced less peak horsepower than the TBI 2.5L four.



Pre-'91 XJ Cherokee and '87-'90 YJ Wrangler offered a 2.5L TBI base engine that delivered more horsepower than a carbureted 4.2L inline six. Many Wrangler drivers have enjoyed the 2.5L's smooth low-range power. Not this owner.

Note: Retrofitting Mopar's multi-point EFI Conversion Kit (essentially 1995 off-the-shelf 4.0L technology) to a 1981-90 258 or 4.2L six will unleash an immediate 50-plus horsepower over the stock carburetion.

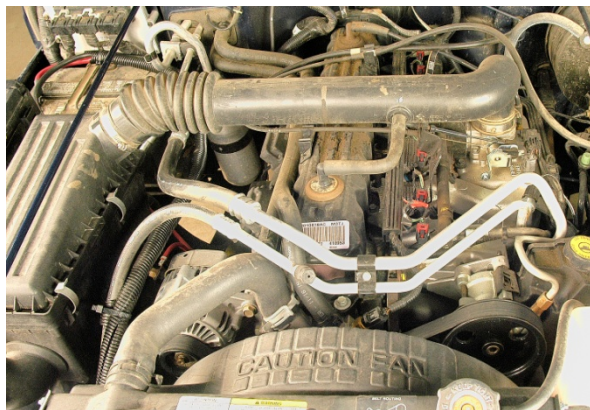
Doing the Math

As a new vehicle tester for *OFF-ROAD* magazine in 1987, I evaluated the first 4.0L XJ Cherokee models. That same year, Chuck Williams and I co-drove an XJ in the Jeep® Cup Rally's regional competition at the Sierra foothills near Placerville, California. We ran our rally vehicle up Interstate 5 from Southern California, providing a good opportunity to see what the new, 177-horsepower EFI engine could do.

That horsepower was somewhat there. Immediately apparent to a veteran four-wheeler and driver of many truck-like Jeep® vehicles, I discovered the 4.0L engine had reasonable mid-range to redline power, *but it could barely get out from under itself in the lower rpm zone—off-idle to 2,200 rpm—the speed range vital to rock crawling.* This was AMC's gamble: an SUV engine that had enough power to maneuver in traffic or on the freeway, the XJ's likeliest venue. The all-season 4WD models, aided by a high-low range, two-speed transfer case, could move a boat up the ramp...*Flash forward a decade to lifted XJ Cherokees on the Rubicon Trail!*

Logic follows that transfer cases with a low enough low-range ratio can make any 4x4 a rock crawler. "In the day," the 75 horsepower, 134 F-head four could crawl up a hill and fire, *all under starter motor*

cranking power. In low-range, compound low gear, a T98 transmission and 40-50 available horsepower seemed like plenty at 9,000 feet elevation. In 4WD low range, the oxygen sensor-looped EFI system and a 4.0L inline six can certainly do far better.



EFI-equipped 4.0L inline sixes became a YJ and TJ Wrangler (shown) mainstay from 1991-2006.

When the Wrangler inherited the 4.0L six in 1991, blessings were mixed. Many owners celebrated the end of carburetion, flooded engines, hard starts on the trail and quirky performance at higher altitudes. Mopar's multi-point fuel injection instilled confidence both on- and off-pavement. Gone, though, was the 258's time-honored truck formula for torque and bottom end power—replaced by an over-square design.

AMC's 232 and 258 engines share a common bore size of 3.750". The 2.5L four and 4.0L six boast a stock bore of 3.875", 0.125" larger than these earlier sixes. Stroke on the 4.0L is 3.414". Stroke on the vintage 232 is 3.5". Both the 232 and 4.0L (242) have an "over-square" design, a bigger bore measurement than stroke length.

The most effective 258 feature is its longer 3.895" stroke. With a smaller bore diameter than stroke length, the 258/4.2L qualifies as "under-square."

Under-square engines have a long history in truck applications. Over-square engines were a product of the higher-compression, leaded fuel, OHV V-8 era that spawned the muscle car horsepower race. The 4.0L's bore/stroke dimensions provide the kind of performance that works well with lower (numerically higher) axle ratios. This contrasts directly with the EPA and CAFE standards, *which generally require taller axle ratios and overdrive gearing.*

What is lacking in the 4.0L is bottom end power. As early as 1987, it was apparent to many of us that the 4.0L has poor torque delivery, especially below 2,500 rpm. This is obvious by the engine's peak torque figure near 4,000 rpm. Add to that the typically taller axle gearing, and a problem exists.

By contrast, the low-end torque output of a 258 is exceptional. This engine, in its emission-laden, de-tuned, final years of use, could reach *maximum torque by 1600 rpm*. The closest comparison to that kind of torque rise is Cummins' 5.9L diesel—not surprisingly, a seven-main bearing inline six.

Despite the perils of unleaded fuel and stiff emission constraints, the carbureted 258 survived through 1990. With taller axle gearing for EPA and CAFE compliance, the final 258/4.2L engines still met 1990 YJ Wrangler emission requirements.

To build an engine that will meet both the low-end torque output of a 258 and the horsepower levels of a more contemporary, emission regulated EFI engine, the most sensible means is to meld the 242 (4.0L) bore size with the 258 (4.2L) six's stroke length...This creates a 4.5L stroker motor. Bore the block, and we have a 4.6L at 0.030" oversize or 4.7L at 0.060" oversize.

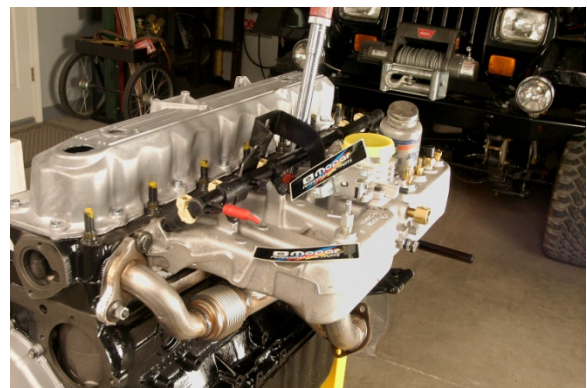
During the last two decades, innovative Jeep® owners and engine builders have retrofitted the 258/4.2L crankshaft into 4.0L engine blocks. AMC's common production methods and parts interchangeability make it possible to install the 258 crankshaft without 4.0L block modifications.

If you use an early, OEM 4.2L crankshaft with a later damper, an area that needs attention is the crankshaft snout length. For some pulley dampers, either 1) the longer 4.2L snout must be shortened or 2) the installer must use an aftermarket spacer with the OEM washer and a longer damper bolt. (HESCO sells this spacer as "Crankshaft Damper Spacer #HESBS.") New Mopar® stroker crankshafts come with the shorter, 4.0L-style snout length. For safety sake, use the correct length bolt for the damper.

Note: Think the 'stroker motor' is a new idea for AMC sixes? Consider the bore-and-stroke configurations built at AMC's 'VAM' plant in Mexico between 1969 and the '80s. There were 252 and 282 cubic inch engines, the latter closely resembling a modern 4.6L stroker. Using correct rods, pistons and crankshaft (stroke) with a thicker block

casting to tolerate the bigger bore sizing, these larger displacement inline sixes were popular in Mexican cars and trucks that ran on low-octane fuel. The 282 block's thicker casting accepted a 99.5mm/3.917" bore size. (U.S.-built 258 blocks will not tolerate this bore sizing.) According to several sources, VAM tested an XJ Cherokee prototype with the 282 engine as early as 1982. This allegedly inspired the 4.0L engine in 1987. (Perhaps 1984 would have been a wiser point—to avoid using the outsourced, troublesome G.M. 2.8L V-6!) Unfortunately, AMC did not fit the 'stroker' 258 or 282 crankshaft into the original 4.0L blocks.

This solution to the weak bottom-end performance of the 4.0L encouraged Mopar Performance® to offer its 4.7L stroker long-block. A clear gain is broad-range torque.



Here, a 4.7L stroker long-block accepts the Mopar® Performance EFI Conversion manifold. Template for EFI conversion is '95 4.0L engine.

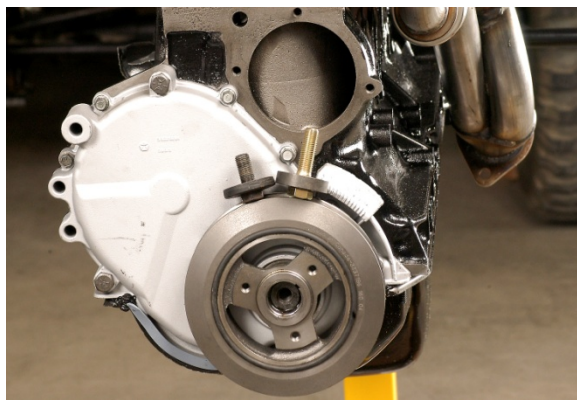
Mopar's 4.7L long block, designed for off-road performance, achieves its 0.2L added displacement from a 0.060" re-bore of the stock 4.0L block. Mathematically, this equates to a 3.935" (99.949mm) bore. With

a 3.895" (98.933mm) stroke, the new dimensions of this engine are 4.657L—for most purposes close enough to call 4.7L around the Rubicon Trail campfire!

Note: I took Pi out to 3.14159 to reach the 4.657L (4657cc) displacement figure. For bragging rights, the Mopar® Performance long-block can legitimately claim 4.7L by conventional "rounding off."

Inside the 4.7L Stroker Long Block

The stroker motor concept is not new. Decades ago, engine builders and designers melded the 4.0L's over-square attributes with the legendary 4.2L bottom end torque.

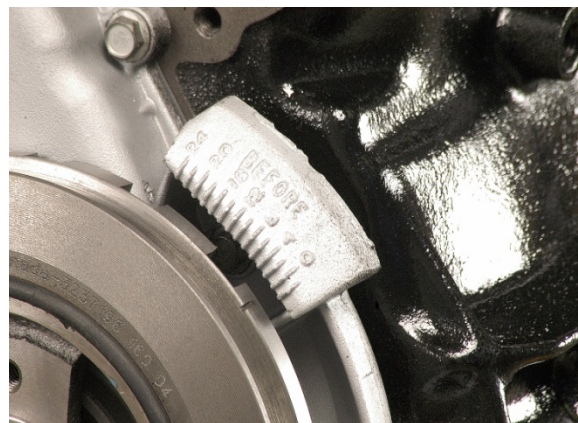


New Mopar® stroker 4.7L crankshaft has a short snout like the 4.0L design. Long bolt and correct washer are necessary for a V-belt style Mopar® EFI Conversion 4.2L/258 style damper.

Installation of a 4.2L crankshaft into a 4.0L block is so effective that users often claim more useful performance from this gesture than supercharging. Supercharging or turbocharging can produce exceptional results—in the mid- and high-rpm realms. For stump-pulling torque at idle and tip-in

rpm, however, *there is no change better than a stroker crankshaft.*

Note: One place where supercharging excels is at higher altitude. Supercharging will compress "thin air" and offset the lack of atmosphere. While oxygen-sensed EFI maintains the air/fuel ratio, supercharging compensates for the rarified atmospheric conditions and boosts manifold pressure.



Here, the 4.7L stroker long-block gets ready for installation in an '81-'90 4.2L chassis. Mopar EFI Conversion pulley with crankshaft sensor pickup bridges the 4.0L versus 4.2L gap. Oil pan, pump and pickup screen must match the chassis.

Mopar® Performance considered the basic formulas for a stroker long block. As the same engineers who design Jeep® vehicles, they set out to build a virtual turn-key installation. The 4.7L long block fits precisely like the original 4.0L long block in several popular model applications. Using select OEM and aftermarket parts to build these stroker motors, Mopar® has provided an optimal performance package.

Starting with premium remanufacturing processes and well-matched components, Mopar® Performance has targeted off-road

Jeep® users. The process begins with a complete remanufacturing of the block assembly and, when cores offer the right cylinder head design, careful rebuilding of a tested, OEM cylinder head casting. Head work includes three-angle valve seats, premium valves, renewed guides, springs, keepers, rocker arms and sized pushrods. Any reused parts receive reconditioning.

For later generation 4.0L engines with the less desirable, smaller port head, Mopar retrofits a new, earlier design cylinder head assembly. *All Mopar® Performance 4.7L long blocks have a cylinder head that flows properly for the increased displacement.*

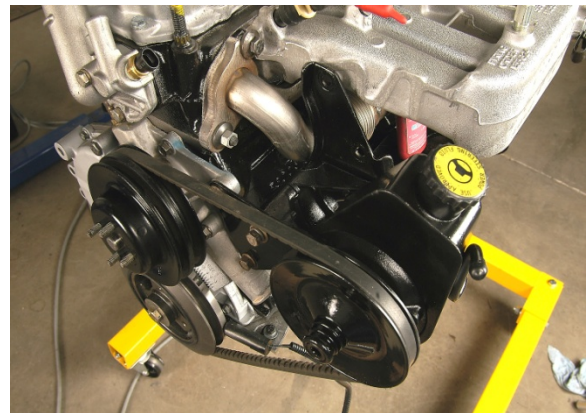
Precisely bored and honed cylinders finish at 0.060" over stock, creating the 4.7L displacement. Forged pistons readily bump compression to 9.6:1 with the longer piston stroke filling the combustion chambers.

Rods are production type, machined to exact tolerances. The crankshaft is a brand new, cast-type design, providing the 3.895" stroke dimension that made the 258 six famous. A four-counterweight, balanced and fitted assembly, the crankshaft matches the rod and piston choice. All new bearings are premium quality.

Blending traditional Jeep® reliability with high performance objectives, the camshaft adds just enough lift and duration to support the compression ratio and "square" bore/stroke configuration of the engine. The tested profile selected by Mopar® Performance provides a wider

torque band and better breathing in the mid- to high-rpm ranges.

The goal with this engine is maximizing horsepower and torque without sacrificing smooth off-idle performance—the key to rock-crawling success. For valve timing accuracy, a new roller chain and sprockets spin the flat tappet, hydraulic lifter camshaft. No detail left to chance, the oil pump is a new, high volume design with a new pickup screen.



Parts interchangeability between 4.2L, 2.5L and 4.0L engines enable fitment of the Mopar® 4.7L long block into a pre-1991 chassis. Mopar® Performance does not endorse or assist with these retrofits; however, a perceptive engine swapper can find the commonality in many parts. Here, slightly modified, 1987 V-belt 2.5L brackets fit neatly onto front of 4.7L long block.

The long-block ships without a valve cover, timing cover, manifolds, distributor or oil pan. Installers must match up the oil pan type. For a retrofit into Jeep® models not directly targeted by Mopar's program, the oil pan, pump and pickup screen must match the original engine and its chassis configuration. If a 1991-2006 Jeep® model

is specifically listed for a Mopar 4.7L long-block part number, the installer simply cleans and transfers parts from the original long-block to the new one.

4.7L Long-Block Applications

At this point, Mopar® Performance offers three part numbers for the 4.7L long-block. Each number correlates to a model and chassis application. If your model is not listed here, check with your nearest Mopar® Performance dealer. The current list omits a few vehicles—like the '99 XJ Cherokee or a '99 TJ Wrangler. Assuredly, Mopar® will update these listings:

- 1) P5155209—1991-97 all models plus the '98 Cherokee and '98 Wrangler—not for 1998 Grand Cherokees
- 2) P5155210—2000-2001 Cherokee only
- 3) P5155627—1999-04 Grand Cherokee, 2000-06 Wrangler

The Mopar® Performance long-block program aims at simplifying installation. With such a large cohort of Jeep® vehicles in each part number category, Mopar® Performance demystifies the applications and installation requirements. This is long overdue for 4.5L to 4.8L inline six buildups.

Are you searching for a virtual turn-key approach? If your Jeep® fits one of the part number categories, transferring peripheral pieces from your current engine directly onto the Mopar® 4.7L long-block will be a straightforward task. Of course, you'll want to clean transfer parts thoroughly and make sure they are in top condition. Approach

this installation as you would any new engine, following factory guidelines for the transfer of parts.



Starter motor and alternator must be in top condition. Mopar® remanufactured, 4.0L starter motor, available through your local Jeep® dealership, assures reliable cranking torque for the fresh, 9.6:1 compression engine.

You'll also want to change the fuel injectors. To fuel the new, nearly square (3.935" bore with 3.895" stroke), 4.7L engine, Mopar® Performance has done the homework. Furnished with the long-block are installation details, including the Mopar® Performance part numbers for the injectors that will properly fuel this potent powerplant. The intent, as one might expect from a factory effort, is to make this installation as trouble-free as possible.

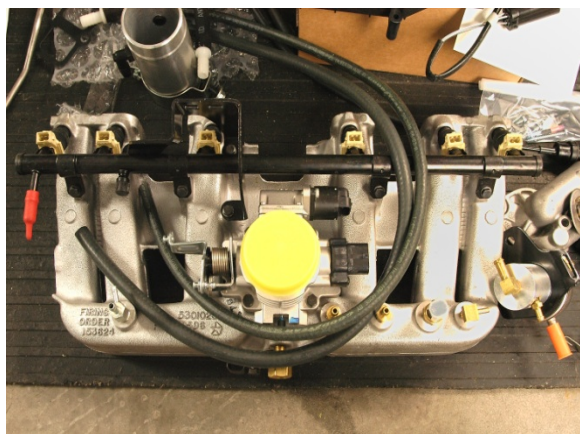
What Do I Think of This Approach?

As a four-wheeler who values torque at lower speeds, *I wholly endorse the stroker approach. In fact, I would not rebuild a 4.0L inline six without installing, at the bare minimum, a 4.2L stroker crankshaft with appropriate pistons and an 'H.O.' cylinder*

head. For any year Jeep® chassis, I would use factory MPI or a Mopar® EFI Conversion.



Optimal induction system is a 4.0L multi-point injection system. Installers using the 4.7L stroker long-block will find the Mopar® Performance EFI Conversion very practical for 1990-back chassis.

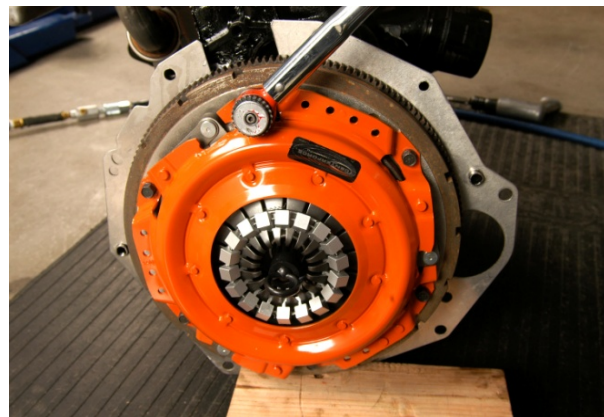


One modification for the long-block is use of Mopar® Performance's recommended injectors. The 4.7L engine requires more flow than stock. An adjustable, aftermarket pressure regulator is popular for systems with return fuel rails.

The '99 XJ Cherokee that graces 4WD Mechanix© Magazine pages, a vehicle at ease on rock piles or making time across a washboard road in the high desert, is a great candidate for a stroker long-block. A Mopar® Performance long-block provides

the research, attention to detail and quality workmanship that could clinch the deal.

Are you looking for a broad power band, torque to satisfy bottom end rock crawling or horsepower for making tracks over a desert playa with a tent trailer in tow? Do you prefer a compression ratio below the engine's detonation threshold? Or matched components like a fresh crankshaft, rods, pistons, camshaft and cylinder head? If your expectations coincide with the Mopar® Performance 4.7L design intent, by all means, consider this turnkey long-block!



Commonality between 4.2L, 2.5L and 4.0L engines makes flywheel and clutch fit-up easier. Use the correct pilot bearing for your manual transmission. Mopar's 4.7L crankshaft comes balanced. I also balance the damper, flywheel and clutch cover. An upgrade Centerforce II clutch (shown) assures maximum performance.

Specifically, the Mopar® Performance research has targeted off-road enthusiasts who expect better performance across the board. The combination of a longer stroke and 9.6:1 compression, coupled with a tested camshaft profile and free-breathing cylinder head, will yield more horsepower

and torque from lower speeds all the way to redline. This manageable kind of power can compensate for additional equipment and accessories weight, oversized tires and multi-use axle gearing.

Mopar® Performance offers a flexible, all-around performance engine that serves a wide cross-section of off-road users. The 4.7L long-block's engineering reflects a feel for Jeep® driving environments and an awareness of those areas where the 4.0L engine needed improvement. This product is thoroughly tested and endorsed by the same folks who design and develop Jeep® off-road vehicles!

If you want a properly built, quality engine package that can be fitted to your Jeep in as little as a weekend—or a few hours at a Jeepspeed Cup or VORRA racing pit—this is a program to consider!



Here is the complete 4.7L stroker ready for installation in an '87 YJ Wrangler chassis. I did a "blueprint" rebuild of an AX-15 five-speed (overdrive) transmission to meet torque and horsepower demands of the high output engine. A new, tubular steel Mopar® "factory" exhaust manifold fits up well with the 50-State legal Mopar® Performance EFI Conversion—impressive!

Pre-EFI Jeep® Inline Six-Cylinder Ignition Upgrades

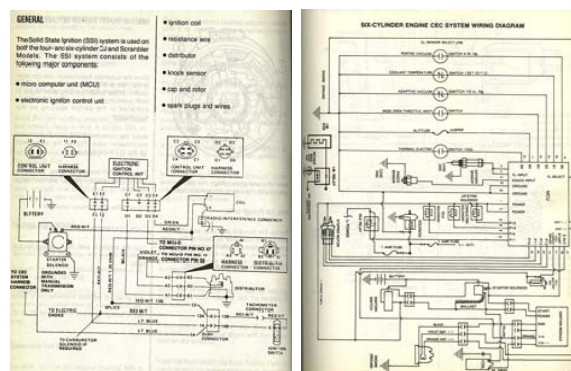
Kaiser's Jeep® Corporation dropped civilian use of the OHC 230 six-cylinder engine in 1965 and opted for American Motors' engines. AMC had redesigned its inline OHV engines for its 1964 cars, shifting to a 7-main bearing design. The platform would last longer than any other engine design in U.S. automotive history.

The last AMC six was the 4.0L Jeep engine, which served through the 2006 TJ Wrangler. In all, the 232, 258/4.2L and 4.0L inline sixes would span over four decades of use in Jeep trucks and SUVs. 1983-up 2.5L four-cylinder, OHV pushrod engines use this architecture as well.

While the inline sixes and 2.5L four evolved into EFI/MPI engines, AMC's engines began as conventional fuel-and-spark systems, a basic carburetor with an ignition distributor. 1965-74 sixes used a breaker point ignition. From 1975-up, all Jeep sixes use electronic distributors.

The 232/258 electronic distributors used traditional vacuum-and-centrifugal advance mechanisms through the end of the carbureted era. 1990 was the last year for a carbureted inline six, the YJ Wrangler's 4.2L powerplant.

AMC did not manufacture ignition distributors or carburetors. During the breaker point era, Jeep outsourced 232/258 distributors from Delco-Remy. For the electronic era, AMC/Jeep® turned first to Prestolite then Ford-Motorcraft.



At left, a wiring diagram for the micro-computer unit (MCU) ignition override found on mid-'80s Jeep CJs and YJs through 1990. The wiring diagram (right) for MCU-driven components of the carburetor circuit shows the complexity of the fuel system, too. (A vacuum diagram is even busier!) With the service and replacement parts unavailable, these systems often fail visual and tailpipe emissions tests. (Courtesy of AMC/Jeep® workshop manual.)

Delco-Remy distributors were reliable and simple to service. Ford's Motorcraft Duraspark II design was durable; however, the bulky, fender-mounted box module could fail unexpectedly. Prestolite units were marginal in quality and used for only a brief period (1975-77). Parts have become difficult to source due to low-volume sales of these distributors.

Each of these electronic distributors were emissions era designs, and by the 'eighties, add-on modules further limited the spark timing functions of AMC engines. The priority, compliant emissions readings, was at the expense of engine horsepower, which hit an all-time low for the 258/4.2L six. A primitive "feedback" induction system struggled to meet standards. By 1987, introduction of AMC Renix's

MPI-EFI on the new XJ Cherokee 4.0L inline sixes seemed long overdue!

For 1991, the XJ Cherokee's updated Mopar MPI 4.0L replaced the 4.2L 258 in the YJ Wrangler. The 2.5L four went from throttle body injection to full MPI, which kept the inline six in the lineup for another *fifteen model years*. Although sixes through 1999 still have distributors, their spark timing management is fully controlled by the powertrain control module (PCM). In 2000, the 4.0L went to a high-efficiency distributorless ignition with contemporary coil-on-plug design.

Pre-EFI 232/258 Six-Cylinder Spark Deficiency

The goal of pre-EFI smog equipment was to reduce tailpipe emissions, specifically NOx, O2, CO, HC and CO2. The same year that AMC switched to electronic distributors on its 232 and 258 sixes, vehicles in the Jeep® CJ utility, Cherokee (full-size) and Wagoneer or J-10 categories also gained catalytic converters. An electronic distributor, EGR valve plus the emission-calibrated carburetor each focused on a thorough combustion process.

The catalytic converter and other devices reduced pollutants in the exhaust stream. Leaner fuel mixtures were a carburetor chore. Exhaust gas recirculation (EGR) dilution lowered combustion temperatures to reduce NOx emissions. Hotter spark helped the combustion process for more complete fuel burn. The catalytic converter reduced the primary pollutants by burning them in a catalyzing process...A few catalytic converters have also set wild lands on fire when 4x4s get parked in tall, dry grass!

By the 1980s, stricter emissions standards drove AMC and other manufacturers to the use of "feedback" carburetors and electronic overrides for spark timing. The most glaring change in AMC's 4.2L/258 carburetors was the Carter BBD two-barrel's stepper motor and fuel enrichment solenoid.

The ignition changes included a module that received sensor signals and altered spark timing beyond the distributor's conventional means. In addition to using the traditional mechanical (centrifugal) advance and vacuum controlled mechanisms, the module creates various spark timing changes under different engine loads and operating conditions.

Any owner of a 1981-90 Jeep with a 4.2L six knows the limitations of these systems. They consist of failure-prone components: feedback carburetors and quasi-electronic spark timing control overrides that were half-baked steps toward EFI engineering. Factory shop manuals of the period contain lengthy chapters of troubleshooting flow charts and details for servicing these systems.

Over the years, Jeep® abandoned the needed replacement parts for these emissions systems, carburetors and distributors. Restoring a stock 232 or 4.2L engine for emission compliance can be daunting.

Note: The 50-State emission legal Mopar Performance EFI Conversion for 1981-90 4.2L engines has been a great contribution to owners of these Jeep models. Thanks, Jeep®/Mopar™ for offering this system!

Righting Ignition Wrongs

Whether you want to restore a defective, unreliable '65-'90 Jeep inline six-cylinder ignition or upgrade to more efficient spark output and wider spark plug gaps, there are solutions. Depending upon your Jeep vehicle's emission requirements and the state or local inspection demands, you have options. Since most of the components to restore the system are no longer available, a reliable upgrade may qualify as a repair in some states.

Canadian sixes began using the Motorcraft distributor in '77, U.S. models in '78. This was a great improvement over the short-lived '75-'77 Prestolite electronic units. The Motorcraft

Duraspark II is actually a good system, and I have converted '81-up versions of these distributors to non-feedback use with a common Chrysler 5-pin module. You can also use the broader distributor cap, spacer and large rotor with these housings. (See my *Jeep® Owner's Bible™* (Bentley Publishers) for details or submit a Q&A question if you would like clarification on this upgrade. I am happy to illustrate upgrades for a stock 4.2L Motorcraft distributor.)



Infamous Prestolite electronic distributor was a 232/258 six item from 1975-77. If your Jeep engine has this distributor, consider options available. Prestolite, once a highly reputable product, was unreliable and failure-prone by the late 'sixties. Just ask a 225 V-6 CJ owner!

A homespun alternative that gained some popularity in the '90s was an HEI distributor from a Chevrolet inline 250 or 292 six. The claim is that a 1978-up HEI unit will work. These distributors have become rarer and, yes, they do wear out. '78-up is also the emissions era, and the distributor will need a spark timing re-curve for reasonable performance. The swap requires a new drive gear. The story goes that an '83-up AMC V-8 item will do the trick. (I looked this up as Mopar P/N J3208615 gear with J8128462 pin.)

Before performing this swap 1) make sure the I.D. of the new gear and drive pin's diameter fit the G.M. HEI drive-shaft properly; 2) the HEI housing must fit the block's bore correctly; 3) check the G.M. HEI driveshaft's end

tang-to-housing-base measurement; be certain tang engagement at the oil pump is correct, and 4) make sure that the new drive gear's tooth diameter, tooth angle and engagement point with the camshaft is a precise match for the OE six-cylinder distributor.

Warning: If any of these measurements are incorrect, camshaft or oil pump failure will result! Voltage to the distributor should be full 12-volt ignition and not ballast resisted.



In the mid-'70s, Delco-Remy introduced the HEI distributor. Broad at the cap base of the housing, the distributor contains the module, centrifugal and vacuum advance systems, a coil that mounts in the cap and easy service access. Shown is a six-cylinder version similar to the unit some have retrofitted to Jeep® inline sixes. The design is noted for its hot 50KV spark plus easy service and spark re-curving.

If checking out all of these dimensions with a caliper and micrometer does not sound like fun, a practical, time saving approach is the new, 'brand-X' billet aluminum distributor from 4WD Hardware. This assembly has the cap, rotor, coil, vacuum canister, drive gear and module all in place. At its low price, the unit must be a 'knock off' of the G.M. HEI design with 232/258 dimensions. Currently, \$122.99 plus freight will get you into this ready-to-run assembly—with a set of new plug wires! A harness is available.



This has to be the best price in the 'Free World!' 4WD Hardware offers the unit, as of this printing, for \$122 with new plug cables! You can barely buy the tune parts (new coil, module and vacuum canister) for this price. Looks like typical G.M. HEI dimensions and comes with a drive gear. [Click here for details.](#)

Note: I have not tested this distributor. The shaft bushing design and quality is not specified. 4WD Hardware and others offer upscale HEI-type distributors like the D.U.I., Mallory and MSD units, each popular for Jeep® inline sixes.



D.U.I. focused on the G.M. HEI distributor design. This is an AMC Jeep® application for 232/258 sixes. An easy to follow wire hookup, provision for a tach lead, double shaft bushings and 50K-plus volt output make this popular!

D.U.I. units come curved properly for typical use. Retailing around \$379, they hook up

easily and use off-the-shelf G.M. HEI replacement parts. D.U.I. distributors work well for daily driver, trail or competition use. Like other G.M. designs, these units can be serviced readily in the field and feature a simpler approach to spark timing and curving—an excellent distributor pick.

Note: Components suggested in this article represent performance improvements. If your Jeep still requires annual or biennial state or local inspection for emissions equipment, make sure any replacement parts comply with these standards. I strongly advocate a clean tailpipe reading. A passive device like the EGR should be kept and maintained. EGR can increase engine life, by cooling upper cylinders, without degrading performance...Keep a clean tailpipe!



MSD ball-bearing shaft support is simply the best. If you use your Jeep 232/258 CJ, 4.2L YJ, J-truck/Cherokee or 4.0L engine competitively, go MSD. The MSD billet distributor is built to a racing standard. This premium ignition must be run with an MSD box (6, 7, 8, 9 or 10 series) and Blaster coil. CARB approved for use in all 50-States. [Click here for details.](#)

Race proven for decades, MSD delivers quality and spark accuracy. This 50-State legal

design requires the MSD "box" or an upgrade coil, making this the more costly alternative.

The earlier breaker point 232 or 258 engines can also benefit from any of these distributor upgrades. There are breakerless conversion kits available for older Delco-Remy breaker point distributors, clearly the least expensive route to breakerless performance. An upgrade to the HEI coil and module distributor would offer superior spark output and reliability. Considering the cost of 4WD Hardware's HEI distributor, HEI

would be smarter than a breakerless conversion on an ancient breaker point distributor. Frankly, it's hard to imagine an original breaker point distributor without shaft and bushing wear.

If you plan an extensive backcountry trip, play it safe. In the breaker point era, we carried a spare point set, condenser, rotor and even a coil. Although a quality HEI distributor should be very reliable, bring along a spare module, rotor, cap and coil.

A handwritten signature in black ink that reads "Moses Ludel". The script is fluid and cursive, with the first letter of "Moses" being a large capital and "Ludel" following in a similar style.

4WD Tech 'Q&A'

XJ Cherokee with Continuous Vibes

Hi, Moses...I just downloaded the magazine and need your advice. I have a 1998 Jeep Cherokee Sport 4WD 4.0L, automatic with 121,000 miles. The vehicle has an 8.25" Chrysler rear axle without ABS. The transfer case is a New Process 231J. I purchased the Jeep in 2004 at 91,000 miles. Since the beginning, the Jeep has a DEEP DRONE that starts between 60 and 70 MPH. It is VERY annoying to say the least! I have had the rear drive shaft replaced with the upgraded Mopar shaft with rubber damper. I had the spacer kit installed per Mopar TSB 980327 to drop the transfer case and change the rear driveshaft angle. I have had the front and rear differentials rebuilt, replaced the front hub assemblies and replaced the engine mounts with genuine Mopar units. I changed the tires to a set of Michelin 'LTX' P225/75-15 and Goodyear Forteras. None of this makes a difference...I have replaced the rims with brand new Jeep 5-spokes. I had the front Cardan joint replaced by a local machine shop, replaced the ATF fluid in the transfer case with synthetic ATF, and the drone continues. I have not had any work done to the automatic transmission or the transfer case beyond fluid and filters.

The Jeep is 100% stock except for the drive shaft and spacer kit. The noise/drone was present prior to all the work listed and prior to the tire brand changes. The vehicle currently has Hercules P225/75-15 Terra Trac SUV tires because of their very non-aggressive tread. My Jeep has never been drone or vibration free in the four years I have owned it. If your shop can help, I can

drive the Jeep to your facility for repairs if advised. Thanks!—Joel Z.

Wow, you have incredible commitment to this XJ, Joel! As you know, I have a '99 XJ project vehicle that appears throughout the website and this magazine. The XJ provides an ongoing test-bed for the XJ Cherokee owners' issues...To begin, any tire balance issues usually occur between 45-55 mph, normally not pronounced below that speed or above 65 mph unless there is a belt separation or more severe out-of-round condition. Driveline vibrations generally occur gradually, increasing in intensity with driveline rpm (equivalent to road speed). Since driveline angles are usually correct from the factory, it's interesting that Jeep issued this TSB request for a transfer case drop on a stock-height vehicle—without a lift kit or even the 'Up Country' factory off-road package.

With the part-time 4WD, '231' transfer case, you can disconnect torque to the front driveline in 2WD high range. Your vibration sounds prominent in 2WD and presumably 4WD high range as well, although you may not have tested 4WD high range on a loose traction surface at 65-70 mph speed. There is the possibility of a transfer case shaft, sprocket or planetary assembly imbalance, perhaps there's an engine or powertrain harmonic imbalance.



At top is stock '99 XJ Cherokee 231 transfer case with original rear driveline that Joel describes. U-joints are single Cardan at each end of the driveshaft. Illustration at bottom is a heavy-duty, aftermarket Advance Adapters' slip yoke eliminator ("SYE") output with a CV conversion joint, commonly used with suspension lift kits.

However, these would be long shots, the last items to consider. I would start with driveline issues. To isolate the front driveline, try removing the front driveshaft assembly and driving the vehicle in 2WD mode to speed. If the drone disappears, there is a clear relationship between the front driveline and the problem. If the drone continues, since you have tried two rear drivelines, I would carefully measure the rear driveshaft joint angles to see if they meet specification.

The joint angle at the front (slip yoke) and rear (pinion) should cancel each other on a single Cardan, cross-type U-joint arrangement. At the front driveline, the transfer case end uses a self-cancelling double Cardan joint. The single Cardan front joint angle is relative to the front axle's caster angle. By self-cancelling, the double-Cardan "CV" (constant velocity) joint helps eliminate a variety of vibration issues.

Measured angles at each joint of a double Cardan CV are approximately half those of a single Cardan joint. CVs are popular and work well on long front drivelines with a gradual slope and considerable front axle caster angle. If the rear driveline's joint angles do not cancel at 1-degree or less—the less, the better—you have a problem.

Maximum driveshaft joint operating angle should be less than 3-degrees. Minimum operating angles should be ½-degree. If the driveline U-joint angles are less than ½-degree (essentially straight), the needle roller bearings in the joint will not move sufficiently. Premature bearing failure will take place from this lack of movement and poor distribution of lubricant.

Caution: A U-joint often fails when the pinion has been rotated upward on a lifted truck with a CV rear driveline. If the single Cardan rear joint has a zero-degree operating angle, the needle bearings will wear rapidly. I like to see approximately 1-1/2 degrees of angle on that single joint—with the vehicle loaded normally and each loaded axle perched on safety stands.

The factory TSB (service bulletin) assumes that the transfer case needs to be dropped to reduce driveline angle and change the U-joint cancellation pattern. On your XJ, the rear driveline's front joint now has less

angle than before the drop. It is still possible that the angles are not correctly cancelling each other. If so, the next move would be to place correction wedge shims between the rear axle's spring pads and the leaf spring stack. This will rotate the pinion upward or downward to set the correct U-joint angle.

When taking measurements of the U-joints, I like the vehicle to be at simulated road height. This means that the vehicle is either on four stands placed squarely at the front and rear axles, or the vehicle sets level on a drive-on ramp lift. Our old shop had an asymmetrical side arm lift, so I placed a pair of 2-ton tripod stands at each axle, as directly beneath each spring point as possible. I rested the vehicle on stands to simulate an on-the-ground load.



For driveline angle checks and lift kit installations, I raised the vehicle on our side-arm lift and set 2-ton (each) tripod stands carefully beneath each axle. I then lowered the hoist enough to fully load the stands, leaving the lift arms in place for safety. A drive-on ramp hoist will also work well for driveline checks.

If you have no hoist and can get safely beneath the vehicle on the ground, that works, too—or four high-quality chassis jack stands can be used, a pair at each axle, if you can safely get beneath the vehicle while

it sets on these stands. With the vehicle level and its normal highway or trail running load on each spring, you can now measure the driveline angles.

The Jeep factory manuals prioritize proper driveline angle over caster. Here, I disagree. Since the front driveline is a CV type and long, and since your vehicle is stock height and not lifted, I believe that it is wiser to concentrate on adequate caster angle. Lacking sufficient 'positive' caster angle, XJ Cherokees often experience the so-called "death wobble," a lay term for the time-honored, classic kingpin shimmy.

Having operated the alignment rack at a GMC truck dealership during the beam axle era, I draw attention to the XJ Cherokee's factory-recommended front axle caster angle: 6.5-degrees of positive caster for manual transmission models and a full 8.0-degrees of positive caster for automatic transmission models. This is considerable caster and *necessary* to prevent shimmy.

From my experience around new truck warranty vibration issues, *I would not drop below the XJ's recommended 6.5 degrees positive caster to adjust a front driveline U-joint angle.* With a CV joint at one end of the front driveline and a relatively long driveshaft, *the correct caster angle should provide an acceptable driveline angle.*

Note: If the vehicle were dramatically lifted, that would be a different situation.

Jeep engineering attempted to counter both driveline vibration and caster issues like kingpin shimmy. (The steering damper helps some.) Angles were apparently a delicate balance with the XJ Cherokee's vehicle dynamics. Early on, the aftermarket

suspension lift kit manufacturers discovered that changing the driveline angles creates problems. Their solution was the slip-yoke eliminator and a CV-driveline that could reduce joint angles and help counter the driveline vibration.

Note: The XJ Cherokee has a unitized body with an inherently high sensitivity to NVH: noise, vibration and harshness.

Slip Yoke Eliminator (SYE) kits have become a mainstay for Jeep aftermarket suspension lifts. Two major changes occur here: 1) the shorter transfer case tailshaft allows for a longer rear driveline and 2) the aftermarket CV-type rear driveline has two joints that self-cancel. The axle pinion end of the rear driveshaft uses a single Cardan U-joint. That joint's angle can be radically reduced by rotating the axle's pinion flange upward.

Comment: When a driveline is lengthened with no change to the transfer case, chassis height or joint design (visualize the side view), the shaft can handle higher torque loads. This is due to the reduction in U-joint angles. Less angle, less load, less tendency to vibrate!

Joel, if everything checks okay, including the joint angles and the balance on your rear driveline, you might consider an SYE kit with a custom CV rear driveline. Given that your XJ is at stock height, this would surely lend itself to smoother driveline operation. Use my formula for the rear, single Cardan joint's angle when tilting the pinion: 1.5 degrees or so, no less than 0.5 degrees—at loaded, curb vehicle height.

As a final note, with a CV driveline and fixed yoke at the back of the transfer case, you could remove the rear driveline (without

any oil pouring out) for testing the vehicle. With the transfer case in 4WD High and the rear driveline removed, you could drive in front-wheel drive to speed (on a straight road) and see if any driveline harmonic vibration or droning remains.



This is a CV driveline conversion on an XJ Cherokee. The SYE kit has been fitted to transfer case output. A SYE uses a longer driveline with a self-cancelling, double-Cardan CV joint at the front. The rear, single U-joint's angle is controlled by the tilt of the rear axle pinion. Note that this axle is at full suspension drop, not at loaded, static curb height. The pinion/U-joint angle is greater than at curb height.

If droning still persists, final possibilities would be the internal components of the transfer case, an engine and powertrain harmonic imbalance or an axle differential carrier and ring gear that run out-of-center. Each of these would be less likely prospects, although strange things do occur—like an imbalanced flexplate, defective crankshaft or damper, or a flawed torque converter.

TJ Wrangler: Lifted and Leaning Rightward

Moses, I just had my TJ Wrangler lifted as you shared in the magazine's premier issue. After driving for a short period, I noticed that the Rubicon is setting down approx 0.5"-1" inch on the passenger right front side

when measured from the ground to the bumper and ground to the fender. She is exactly the same when measured from the ground to the axle, and there is no difference in measurement when checking the suspension from different locations. While I hate to think of torque twist or anything like that, it is only ½-inch or so, and the installation shop was pretty blunt: they cannot figure it out. They assure me the suspension is rock solid dead on, and the vehicle does ride and drive fantastic!

The lean may have been there before, and I didn't or could not see it because of the closer frame to axles spacing with the OEM suspension. Maybe that is the way she was from the factory? The shop checked out the 'crookedness,' and they think the problem lies in the sway bar links and mounts on the axle. They switched the coil springs side to side and thought the vehicle was level with the sway bar still disconnected. Hooking it up again, the truck leans to one side. They think the best solution is to use a different style sway bar disconnect that's adjustable to get the lengths perfect on each side and level the truck correctly.

What has caused the sway bar to line up or mount with a lean to one side? I do not see the correlation. Thanks for your response, Moses, I need some insight here...Joe M.

Joe, this is interesting...If the vehicle sets level without the sway bar connected and not when the bar is attached, the front axle may be offset in one direction or the other. Full-Traction Suspension systems have a provision for adjusting the front track bar to center and align the axle. This track "arm" in engineering terms is supposed to rise and drop on a radius that will keep the axle aligned as it moves up and down. The shape of the track bar, its mounting points and the

alignment of the axle are critical to your issue. To begin, make sure the lift kit's track bar drop-bracket is in the proper position at the left side of the frame. Check the sway bar's lower disconnect link locations at the front axle. These FTS kits use weld-on relocation brackets; the attachment points for the brackets must match positions shown in the instructions.

If I were addressing your problem, the first thing to check would be the axle's *lateral position* with the vehicle at its normal, weighted curb height. If the track bar has been adjusted with the axle at full drop, which some shops do in error, the track bar may force the axle toward the right side when vehicle weight is on the ground and the springs compress. With the sway bar connected, the sway bar and disconnects will try to center the axle. In doing so, there would be bind that could cause the right side spring to load and compress.

The clue here would be a cocking or binding of the disconnect links. The sway bar is a torsion bar, essentially, and this creates force. In a static, curb height mode, there should be no bind or loading on either disconnect link. Here, the tip-off would be links that are very difficult to disconnect or a sway bar that either rises or sets when one link is disconnected. My bet is that the sway bar is binding when the TJ is at static height. The fix would be to adjust the track bar with the axles loaded.

Like my discussion of Joel Z.'s driveline issue, the proper alignment of the axles should be done with the axles bearing weight. When I install a lift kit on TJ or XJ models, I start by setting the axles in their centered positions on tripod stands with full vehicle weight on the springs. *I note the*

frame/body and axle lateral (side-to-side) alignment before removing any suspension parts or the springs. With new springs in place, I compress the suspension under vehicle weight, then set up the track bar length in this mode to assure that the axle is both in alignment laterally and unbound—at the vehicle's static, weighted curb height.



I align the axles on tripod stands, lowering the frame to place full vehicle weight on the stands. This determines the static height, loaded position for the axle. The axle is precisely aligned laterally, and I then raise the frame straight upward to unload all spring tension before removing the coil springs. With the axle housing in lateral, side-to-side alignment with the frame/chassis, I remove the track bar, steering linkage and sway bar (top) before loosening suspension link arms. With new suspension and springs installed safely (bottom), the new dropped track bar is adjusted with the axle laterally aligned and the vehicle's weight bearing on the axles (at static, loaded height).

After installation of any kit, I do a four-wheel alignment check. On the stands, a diamond check is useful for a ballpark test. With heavy string, check the right front axle to left rear axle distance, using a clear reference point like the center of a front knuckle joint to a common position on the rear axle backing plate or dust shield flange. With this measurement taken, you can do the same thing from left front axle to right rear axle. If these lengths are equal, the axles should be reasonably parallel *and* in track alignment. *By choosing identical front axle, rear axle and side to side reference points, you can increase this test's accuracy.*



FTS long-arm lifts include a new disconnect link relocation bracket. This modification requires welding the brackets at a precise location on each side of the front axle. Follow instructions closely. I have MIG welded the new bracket in place. Painted and finished, it looks "factory." This is the only welding modification necessary.

At this point, the vehicle should go on a four-wheel alignment rack. Full-Traction's long-arm kits have provision for adjusting caster, pinion angle, axle parallel, axle square-to-frame centerline plus the lateral axle positions. Given this much adjustment, there is plenty of room for correction—or error. I have installed these kits with the vehicle on a side arm hoist and tripod stands. During the installation, I keep the axles in the same lateral position as when I detach them from the chassis. Again, I adjust the track bar length with the vehicle's weight on the axles. In the

process, I've had great success with axle alignment...On one TJ, I installed an FTS Ultimate kit that resulted in nothing more than a 1/3-turn adjustment of *one* out of the six adjustable suspension arms to bring the entire chassis into square and track—the four-wheel alignment was verified on a \$40,000 beam alignment machine!

The main objective is that the four wheels remain square (axles parallel) and track properly with each other (lateral position of each axle is correct). A four-wheel alignment rack is the final test. My guess is that your TJ's axles are not in lateral alignment. The front axle is bound and loading the right side springs. If that were not the case, the sag issue would be due to coil spring lengths.

You say that the springs were switched left to right, and that should have adjusted for any length issue. Frame straightness could be an issue, but that would be a very remote prospect. Responding to the long shot troubles, torque twist would be to the *left side* of the vehicle in terms of drop. So rule that out.

Then there's the possibility of an aggressive tie-down when the Jeep was on the transport trailer or that the vehicle may be within spec for acceptable factory frame error. On the four-wheel alignment rack, axle bowing will show up when checking front axle camber angles. I've discovered that side-to-side camber seldom matches due to factory beam axle welding methods and tolerances; the right and left side camber angles should be within factory specification, however.

The overall concern is that the axles are square with each other and track in the correct path fore-and-aft. If the issue were

as simple as spring height, torque twist might actually level your vehicle over time. (Your TJ's low side is now the passenger side.) I'd be looking for track bar offset and bind or an out-of-square installation. Verify square with the string method in diamond-cross. The chassis should be at curb height.

Lift Kits and Bigger Brakes

I've been thinking about lifting my YJ Wrangler Jeep. When you lift the truck and add weight like the suspension kit, a winch and so forth, do you need to change or enlarge your braking system?—Phil K.

Oversized tires with a larger diameter would have only a marginal effect on the braking. Mass of the wheel and tire are considerations but not enough to warrant a great increase in braking size. Some convert to disc rear brakes on disc/drum systems just to improve braking overall. This is a gain but not necessary for moderately oversized tires. In any case, your brakes should be in premium condition. The need for bigger brakes has more to do with a dramatic increase in overall vehicle weight or when setting up for towing use.

One overlooked aspect of "braking" is that a lift kit goes together with bigger diameter tires. Unless you install lower (numerically higher) ratio axle gears, your vehicle will lose its *engine compression braking ability*. It will take more effort to stop the vehicle, and you will be using the brakes more often. Off-road control, especially on steep downgrades and on the rocks, will be compromised. The clutch on a manual transmission model will have a greater load, too. If you mount bigger diameter tires, you need to restore *engine braking, typically with the installation of new, lower and*

matching ratio ring-and-pinion gears in the front and rear axles. At least re-gear low enough (numerically higher) to compensate for the larger diameter tires.

Diesel JK Rubicon Unlimited Tow Vehicle?

If Chrysler/Jeep installs a 3.0 diesel in the JK Unlimited, I would consider trading in my Tahoe for one of them. The JK would be a daily driver and tow our trail Jeep. Would this be a good tow vehicle for a 4,500-pound load? Is the JK Unlimited beefy enough to withstand the rigors of being used as a daily driver and weekend tow truck for my trail Jeep?—Bill S.

Bill, the towing capability has more to do with torque ratings of front and rear axles, transmission and transfer case. Brakes would be an issue that applies to the combined vehicle weight and tow load (the gross combination weight or GCW). A weightier diesel engine with typical diesel torque would require a beefy front and rear axle, transmission and transfer case to handle the torque. The final consideration is frame modular section stamina. All of this applies to the 3.8L gas V-6, too, including the brake capacity for a given GCW.

In my view, the biggest concern for towing is wheelbase length and track width. The JK has a very rugged frame, and Rubicon models use Dana 44 axles. All of these parts are impressive. The JK has a 5" wider track than a TJ, a big step in the right direction for towing. If the vehicle's GCW rating would cover the heft of your trail Jeep on a lightweight aluminum trailer, this might be a way to go—but currently, maximum towing capacity for a JK is officially 2,000 pounds. Optional Trailer Sway Control or TSC is recommended for that tow weight.

(TSC works in conjunction with Electronic Stability Control or ESC.)



My tow package: '05 Dodge Cummins 5.9L diesel 3500 Quad-Cab 4x4 and 7,500-pound capacity trailer. Trailer has electric brakes at each wheel. Onboard this trip is our '55 CJ-5 Jeep, loaded via a Warn utility winch.

For more serious towing, I opt for the Cummins 5.9L or 6.7L diesel in a Ram 2500 or 3500 Dodge truck. Our '05 Ram 3500 Quad-Cab 4WD Cummins truck *consistently* averages 23.8 mpg without a trailer and 18 mpg at legal speeds while towing our XJ Cherokee (approximately 3,800 pounds) on a car hauling trailer (additional 1,500 pounds). The 142" wheelbase is very stable with a trailer in tow.

Note: If you'd like to know how I get that kind of fuel mileage from a stone stock Ram diesel truck that has a 7,800-pound curb weight, I'd be pleased to share. It's all about driving technique.

Much to its credit, the current WUL is the *very best tow profile of any CJ/Wrangler class vehicle to date*. The WUL has a 116" wheelbase, similar to traditional ½-ton SWB pickups, so that certainly does qualify for lighter towing. That said, I personally will not tow anything of size with less than a 110"-142" wheelbase. The 110" figure is from the Grand Wagoneer days, when the Grand Wagoneer boasted a hefty chassis and a wide, J-truck track width.

As for the 3.0L diesel, I'd buy a JK 2-door in a heartbeat if Jeep offers the diesel in that

chassis—for a trail runner, not tow vehicle. My guess would be that Chrysler would use the current Grand Cherokee diesel and not a Cummins. In the Grand Cherokee, the V-6 turbo-diesel delivers 376 lb-ft of torque at 1600-2800 rpm! This is true diesel power at a slightly higher speed than the Cummins inline sixes, yet still capable of some serious fuel efficiency—especially in a JK chassis.



Our car hauling trailer has tandem axles with electric brakes at each of four wheels. For toting the XJ Cherokee to events, I use a load distributing equalizer hitch. The heavy trailer coupler has a 2-5/16" ball size. This equipment adds an extra margin of safety within the factory tow rating.

As a tower, though, compare a turbo V-6 JK WUL prospect to the Dodge Ram 2500 or 3500. Our Ram 3500 has Dana 60/70 axles, a 600-plus lb-ft rated transmission and a massive transfer case. At a 142" wheelbase, this truck has huge, four-wheel disc brakes and a full-floating rear axle design. Wife Donna and I towed our XJ Cherokee to Moab for a Jeep Safari and Four-Wheeler TV shoot. I used the car-hauling trailer and pulled at any speed we desired—governed strictly by the amount of fuel we were willing to burn. The tow was safe in crosswinds, up and down steep grades and in urban traffic through Salt Lake City. Our GCW was around 13,500 pounds on that

trip. Best of all, Donna really likes the visibility, stance and performance of the Ram truck. She is very comfortable driving and riding in the Dodge, a big point with us since we put up to 18,000 miles per year on the vehicle. We each drive this truck, primarily for business chores.

My pure guess would have the trailer tow limit of a JK Unlimited diesel in the range of 3,500 to 5,000 pounds. Track width would likely be the same as non-WUL JKs. In my view, the WUL wheelbase length and track dimensions do not make this the ultimate trailer puller any more than an XJ or Grand Cherokee has been suited for heavy towing. Despite the 7,400-pound towing limit of the Grand Cherokee 3.0L V-6 diesel model, I would still opt for a longer wheelbase Dodge Ram 2500 or 3500 4WD truck.

Fuel mileage with a 3.0L diesel would offset current fuel cost extremes. For that reason, I would target the JK Wrangler 2-door diesel (if offered) as the ultimate multi-purpose, trail-running Jeep®. With the current wave of 4.7L V-8 and 5.7L hemi swaps into the JK, the 3.0L turbo diesel deserves some serious consideration. I'd be game for a project...

XJ Cherokee Undergoing Serious Changes!

My wife and I purchased our XJ Cherokee new. At 100K miles, after years of patiently waiting, I have "inherited" the XJ and am about to make some changes. The right front axle shaft U-joint is now squeaking rhythmically, the front axle pinion seal is leaking, and the other U-joint at 100K miles can't be in great shape. I have ordered the Superior Axle Dana 30 upgrade that you did on the project XJ Cherokee. I stayed with the 27-spline shafts, opting to forego a locker in the front. The Chromoly axles and the beefy

760X U-joints should be plenty strong for planned 31" tires and a mild lift. Of course, I had to get a pair of those cool looking red aluminum axle tube seals! The ARB diff cover will complete the front axle upgrade.

I know that the 30-spline differentials are all the rage; the demand for the 27-spline unit may drop to unacceptable levels. It would be nice to safeguard my investment in these lifetime guaranteed Superior axle shafts. I'll keep tab on the availability of the 27-spline ARB front locker. For now, though, I'm just installing a 30-spline ARB Air Locker in the Dana 35 rear axle.

The XJ has a 242TC. Unless I blow it up, I am keeping it! I appreciate the full-time 4WD mode on marginal weather days—we get many around here in the winter. My plan is to install the lift kit and take note of changes in driveline angles. With the adjustable lower control arms on the mild Skyjacker lift kit, I have some independent control of the caster angle and front pinion angle. I am confident that I can make these angles acceptable. That leaves the rear driveline angles in play.

The rear lift is only 2.5" over stock, according to Skyjacker. Maybe that works out to be okay or maybe the transfer case drop will bring the driveline angles back to an okay level. If it doesn't work out, I will go with an SYE kit. As for the SYE conversion, the 242 does not have a commercial kit solution like the popular 231 units. All of these 242 SYE kits are some sort of 'hack and tap' approach. The MIT and Tom Woods solutions are the same: Cut off the existing tail shaft splines, re-spline for a standard Dana yoke, and enlarge the tail housing for a new seal around the new yoke flange. The much maligned Rubicon Express

'hack and tap' takes a different course: Shorten the tail shaft but leave an inch or so of existing splines to accept a stainless steel flange they sell for \$90. The problem with this kit is that they advertise you can do the cutting and tapping on the vehicle—maybe, but crudely. I would take the tail shaft out and have a machine shop do that cutting professionally. That leaves the shaft cutoff perfectly square.

I can get a Spicer built C-V driveshaft for about \$300, or I can get a custom-built from Action Machine using American DOM tubing, all Spicer parts and balanced to 50% tighter tolerances than Spicer for \$250. Action Machine would do the tail shaft machining for \$60—so total cost for the mod is about \$400. What do you think about this approach?—Jim J.

Jim, the biggest concern I have is heat treating. Actually, cutting off the original shaft (if the existing splines match the splines of the replacement yoke) could be okay. If done right, the cutting should not impact the heat treating. Keep in mind that shafts are typically 8620, 4130, 4340 or similar metallurgy plus case hardening. That hardening can vary in depth, tensile and Rockwell, depending upon the heat-treating process. Below the case hardening, you're dealing with softer and more machinable metal. If you were cutting new splines, heat-treating would be essential.

Even in cutting off the OE shaft, there could be a HAZ (heat-affected zone) that will denigrate the original heat-treating, tensile and Rockwell (HRC). When the cut-off is with the heat of a chop saw, that affected area would be *considerable*, and the spline hardening would deteriorate accordingly.



Stock 231 output shaft (left) compared to high quality new and heat treated Advance Adapters' SYE replacement shaft for CV yoke. Retrofit SYE shaft (right) requires a virtual transfer case rebuild to install.

At the very least, cut the shaft to length with the least amount of sustained heat. (A liquid cooled band saw or lathe would be advisable if the shaft were out of the transfer case.) Drill the hole for the threads on center. Run a Rockwell test at the bottom of the drilled hole. If the tensile is sufficient for the threads to hold, tap the threads and use a premium Grade 8 bolt and a high tensile, thick hard washer to hold the yoke in place. Use a lock washer and apply Loctite 271 to clean threads. Tighten new hardware to recommended torque.

A recap of issues: If you do this hack and tap, keep heat to an absolute minimum; use a liquid-cooled band saw or lathe with slower cutting speeds...As for threads, again beware that you're drilling and tapping into softer metal, and the tensile strength of that threaded area is considerably lower than the hardened surfaces of the shaft and splines. Although the flange bolt should not have a great amount of end thrust (the rear CV drivelines have a splined coupler), the yoke does need to attach firmly. Tensile of the tapped threads is still a concern.

My approach would begin with normalizing the shaft (similar to annealing but not as intensive or costly). Then the cutting and machining could take place before re-heat treating the shaft to proper depth and match with the original Rockwell hardness. I always test the Rc before normalizing and after final heat treat.

To illustrate the differences between a hardened and non-hardened alloy material, consider 4340 steel: the annealed (non-hardened) 4340 is typically only 20 Rockwell C hardness; hardened, this same metal can be in the 55-60-plus Rc range for gear or shaft purposes. Even hardened, the tensile can range from 130-200,000-plus psi for 4340, depending upon the kind of heat-treating method employed.

In an annealed state (similar to the material beneath the surface case hardening of a heat-treated shaft), these metals have relatively low tensile. My concern is the tensile within the shaft at the drill-and-tap threads. To increase tensile at the threads, you would need to case-harden (heat treat) the shaft after machining.

I understand your appreciation for the full-time 4x4 mode in the 242 design. The 242 is common enough. There should be an aftermarket interest in an SYE conversion for these transfer cases.

Let me know what you do with your '242' transfer case and the SYE approach if you go that route! I would like to know the Rockwell C (HRC) reading of the drilled thread bore in the stock shaft—prior to normalizing or additional heat treating.



Installed SYE kit shows shorter output length and yoke installed for CV joint on new rear driveline. This has become a popular conversion for lifted Jeep vehicles. Advance Adapters builds a high quality SYE kit that comes with all necessary parts, including a new housing, shaft, yoke and all related hardware. At this point, there is not a kit like this for the 242 transfer case.

As for the ARB 27-spline differential for the Dana 30, it would be smart to watch ARB's level of interest in continuing the 27-spline front locker unit. 30-spline is the buzz, and most installers now change to a 30-spline and upgrade the axle shafts when doing the ARB installation. The application is usually for 33" or larger diameter tires.

Worth noting, you may never need a locked front axle with an ARB at the rear axle. You'll find it very difficult to spin one front wheel when in 4WD low range with the torque bias being even front-to-rear. The Dana 30 at the front only receives 50% of the torque, so 27 splines with Superior's axle shafts should be plenty—especially with 31" tires.

Moses Ludel

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