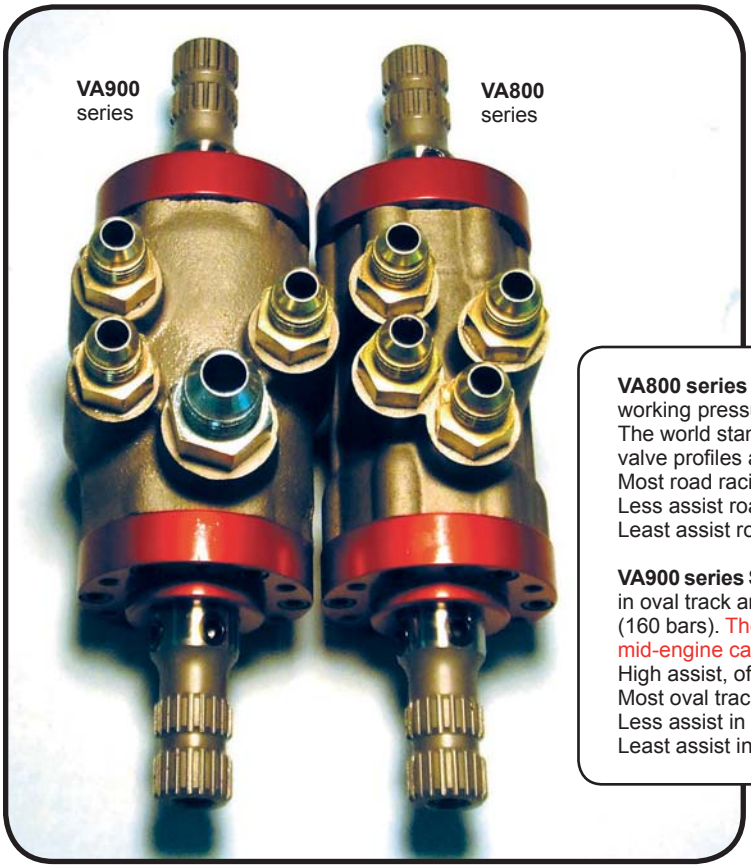
Power Steering Servo Valves

For inline installation or as part of HE and HL power steering racks

Made for installation at any convenient point in the steering column OR directly onto HE/HL series racks, the Woodward servo is the only type where the amount of power assist (light, medium, heavy, etc.) can be tuned to suit the driver's preference by means of a system of interchangeable torsion bars. The bars control the sensitivity of the power steering response and can be switched in the field without disassembly of the servo. A second revolutionary feature allows external adjustment of the left-to-right balance of the power steering. This is not possible with any other race car steering system. The Woodward servo allows it to be done right in the car, using nothing but a 5/32 or 4 mm Allen wrench in the two adjusting screws. Absolutely no OEM or salvage parts of any kind are used to make these servos; all components are made in our own plant.

NOTE: The servo used on a type MR or CF rack will have an integral pinion with a specific mounting flange instead of the round end cap and output spline shown here. In most cases it will also have different internal parts.



VA800 series SERVO is a light, compact valve for systems where the maximum working pressure will not exceed 1200 PSI (85 bars).Track proven since 1996. The world standard for the highest flow in the smallest space. Available in three valve profiles and all T-bar sizes; refer to the valve plots on next page.
Most road racing applications **VA850-1**
Less assist road racing applications **VA850-2**
Least assist road racing or street applications **VA850-2C**

VA900 series SERVO has a thicker case with revised porting for severe conditions in oval track and off-road racing. Designed for working pressure up to 2350 PSI (160 bars). The large -8 port reduces the back pressure from long return lines in mid-engine cars. Available in four valve profiles and all T-bar sizes.
High assist, off-road, heavy cars **VA955**
Most oval track applications **VA950-1**
Less assist in mid-engined cars **VA950-2**
Least assist in mid-engined cars **VA950-2C**

VALVE TORSION BARS can be changed out to adjust the response curve of your servo. Lighter bar=lighter feel; heavier bar=heavier feel. Made of spring tempered alloy steel. Using the set screws, the bar is anchored at one end and adjusted for centering or directional bias at the other end. Includes O-rings. ***NOTE: These T-bars fit servos mounted inline or on HE and HL racks. Servos on MR and CF power racks have T-bars specific to those designs.***

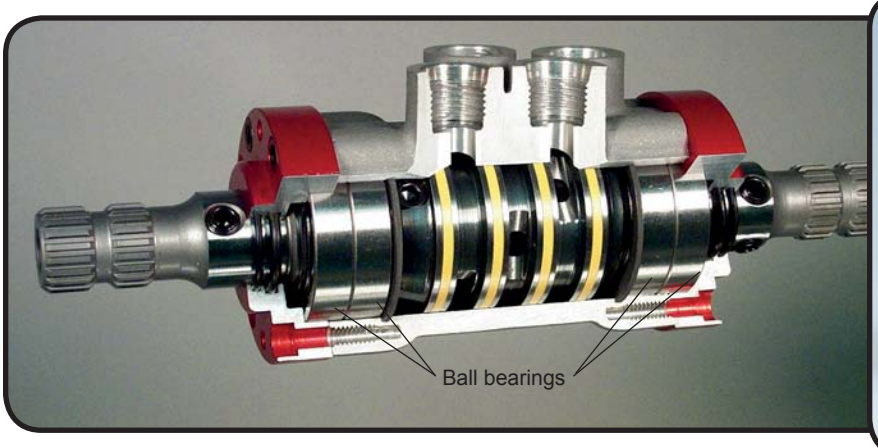
TB180
TB185
TB190
TB195
TB200
TB205
TB210
TB215
TB220
TB225
TB230
TB235
TB240

NEW!

STEEL LOCKING COLLAR has two set screws which bear against the T-bar adjusting screws on the servo input shaft and keeps them from vibrating loose.

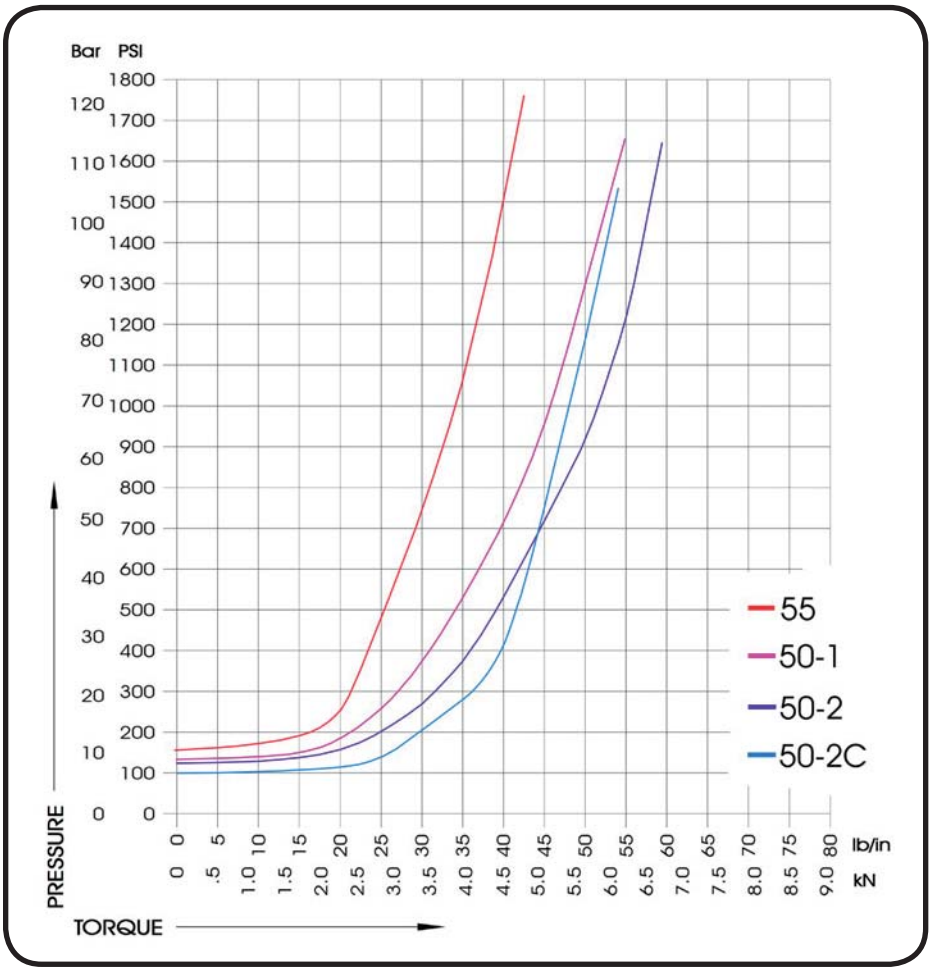
V591

The cutaway view below shows the four large ball bearings that support the valve and isolate it from mechanical steering loads. Large ducts within the Woodward distribution spool replace the series of small holes used in the OEM spools used by all other manufacturers. The Woodward design produces quicker response with lower restriction and lower operating temperature.



New Valve Profiles

Virtually all OEM steering responds solely according to the linear spring rate of its torsion bar. The Woodward valve features variable-area metering, which responds progressively at a rate dictated by the shape of the orifice. Combined with its range of torsion bars, a Woodward servo can be configured to match the tire load and steering resistance curve of any vehicle, from street-driven luxury supercars to AWD race cars with tons of aerodynamic downforce plus driving torque through the front wheels. The plot below shows the response curves of four valve profiles, all tested with the same torsion bar and the same pump. Changing the torsion bar changes the aspect ratio of these curves horizontally, while changing the flow from the pump displaces them vertically.

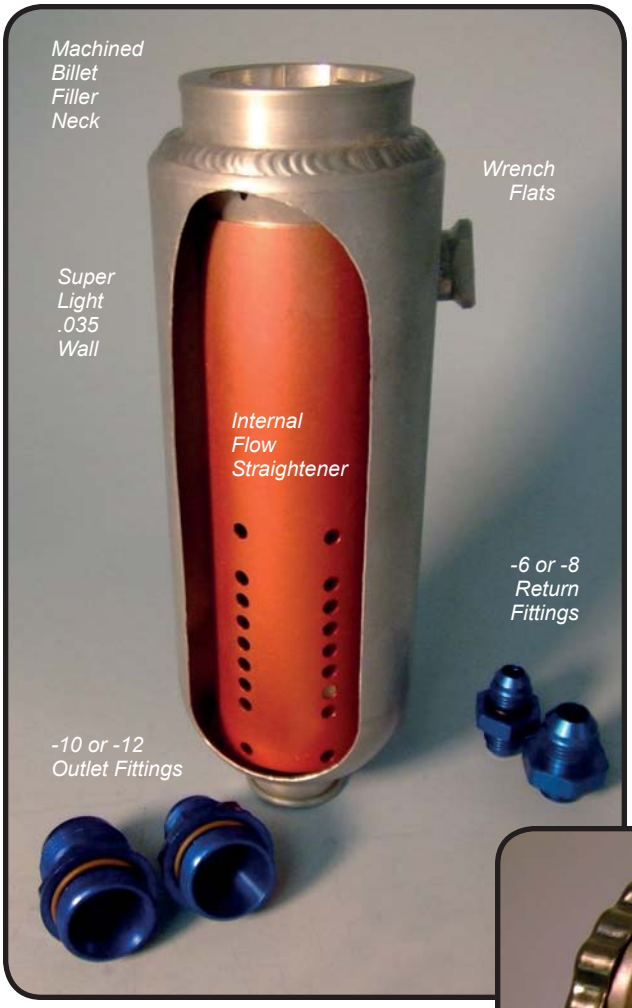


Recent Developments

The VA900 series servo incorporates several changes from the VA800. Most obvious are the large tapered ports shown above which increase its flow capacity by reducing turbulence. You can see that the fluid path is unobstructed all the way into the channels of the spool, *which is actually in place in this picture.* A 900 servo is capable of filling a large diameter cylinder at velocities well beyond the quickest race car steering and in most applications will allow 5W-40 engine oil to be used as the hydraulic medium.

The exhaust port of the 900 servo is enlarged to -8 hose size. This effectively relieves back pressure from the return side of the circuit (important on a mid-engine car with a relatively long distance between the rack and the pump), improving the sensitivity of the steering while reducing the buildup of waste heat. All existing Woodward reservoirs have removable hose adapters which can easily be swapped out to accommodate the large return hose from a 900 servo.

Originally developed to meet military requirements, the 900 series will handle the severe hydraulic shocks of off-road applications involving air time, collisions with boulders, etc., that would occasionally burst the case of an 800 servo.



Power Steering Reservoirs

High flow, de-aerating design

With a quick-steering rack, the performance of the reservoir is critically important in preventing fluid starvation and loss of power steering. In a typical aftermarket reservoir, returning fluid creates turbulence, which pulls air bubbles below the surface, which are then drawn into the pump intake. Air in the fluid makes it compressible, which causes hard or "surging" steering, hydraulic chatter, and overheating.

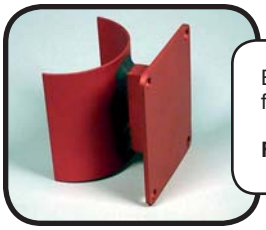
In the dual-chamber Woodward design, the return stream is tangent to the tank wall, creating a centrifuge effect to remove air bubbles. The freed air escapes at the top of the outer chamber through bleed holes leading to the inner chamber. The bleed holes point downward to prevent hot oil spray when the lid is removed. A -6 fitting is used with the 800 servo, and a -8 with the 900 servo. A -8 return is especially recommended for mid-engined race cars because of the long fluid circuit.

Farther down in the tank, the spin of the oil is arrested as it is drawn through a flow-straightening baffle by the pump suction. The pump draws from the inner chamber which is free of turbulence. In fact, the flow is so clean that the surface of the liquid cannot be seen to move with the engine running.

The outlet fitting is available for either -10 and -12 hose, and both are contoured for minimum flow restriction.

BRACKET
for 1.5 inch TUBE

FB35



BRACKET
for FIREWALL

FB36

BRACKET
for 1.75 inch TUBE

FB37

RESERVOIR with -6 return, -10 outlet and FB35 bracket **V100B**
RESERVOIR with -6 return, -10 outlet and FB36 bracket **V100C**
RESERVOIR with -6 return, -10 outlet and FB37 bracket **V100W**
RESERVOIR with -6 return, -10 outlet and FB38 bracket **V100J**

RESERVOIR with -8 return, -10 outlet and FB35 bracket **V101B**
RESERVOIR with -8 return, -10 outlet and FB36 bracket **V101C**
RESERVOIR with -8 return, -10 outlet and FB37 bracket **V101W**
RESERVOIR with -8 return, -10 outlet and FB38 bracket **V101J**

RESERVOIR with -8 return, -12 outlet and FB35 bracket **V102B**
RESERVOIR with -8 return, -12 outlet and FB36 bracket **V102C**
RESERVOIR with -8 return, -12 outlet and FB37 bracket **V102W**
RESERVOIR with -8 return, -12 outlet and FB38 bracket **V102J**

RESERVOIR ONLY, no bracket **V100X** *(specify fittings)*

High Pressure Hose

PTFE core, stainless braid, soft cover

Woodward power steering racks are now equipped with a new -6 hose rated for 2000 PSI working pressure. This hose replaces our former cloth-covered 1500 PSI hydraulic hose and its reusable type ends (shown at right for comparison). It also features a larger ID, which together with the low coefficient of friction of PTFE significantly improves the flow capacity.

IMPORTANT: There are many different brands of hose and reusable hose ends now in circulation, most of which are mutually incompatible. Because it can be difficult to tell them apart, racers in a hurry have been known to create mismatched hose assemblies from spare components. These may appear correct but can come apart under pressure. To prevent accidental mismatched field assemblies, WE USE ONLY PERMANENT CRIMP-TYPE ENDS ON OUR HPB6 PRESSURE HOSE, and we manufacture them in-house.

Although this hose conforms to the nominal standard dimensions of -6 stainless-braid PTFE hose, it also has an abrasion-reducing fabric cover. This cover adds slightly to the diameter of the hose and precludes the use of screw-on ends (the kind with a brass "olive") which are intended only for uncovered stainless braid. These steel permanent ends are the ONLY type approved for use with this hose. Crimp tooling data will be made available to qualified hose shops on request.

WOODWARD HOSE per foot **HPB6**

STRAIGHT end **HPB180**
BANJO end **HPB66**
90 end **HPB190**

Assembly labor (per hose)

Low Profile Banjo Fittings

Fit directly on -6 o-ring ports

Woodward has developed the first banjo fitting that utilizes the proven and convenient SAE/AN/JIC o-ring port. The banjo seals with o-rings top and bottom instead of metal compression washers, and they will seal hydraulic pressure with the same moderate torque as any other o-ring hose adapter. This prevents stripping the threads from aluminum ports. The banjo body and bolt are made from high-tensile steel to allow a thinner wall and greater flow cross-section.

The Woodward banjo fitting is available both as a permanent crimp type hose end or as a -6 male AN/JIC hose adapter. Note: a hose with two banjos should always have at least one of the adapter type to avoid twisting the hose.

As shown below, a banjo has the lowest profile of any right-angled fluid connection. These will clear any port boss which is flush with the surrounding surface, such as the ports on most servos. NOTE: The ports on GE150B and C cylinder castings are recessed and a banjo will not clear.

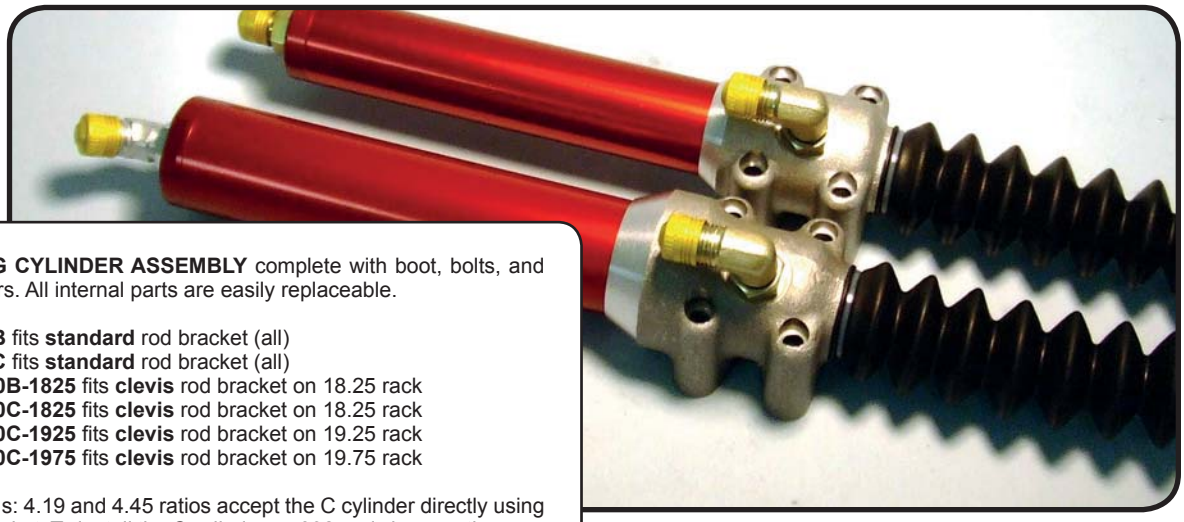
HOSE ADAPTERS, -6 O-ring to -6 AN/JIC male flare, showing relative heights

STRAIGHT **G180**
45 DEGREE **G145**
90 DEGREE **G190**
BANJO **HPB66MF**

Hydraulic Assist Cylinders

For GE/HE and GL/HL racks

Track proven since 1989 and continually improved since, these lightweight double-acting cylinders bolt rigidly to the rack housing with four symmetrically located socket head cap screws. The thrust is absorbed independently of the bolts by a 9/16 dowel. A thick nonmetallic piston prevents metal-to-metal contact in the bore and contributes to the very long useful life of these parts. These cylinders are tested to 1800 PSI in both directions.



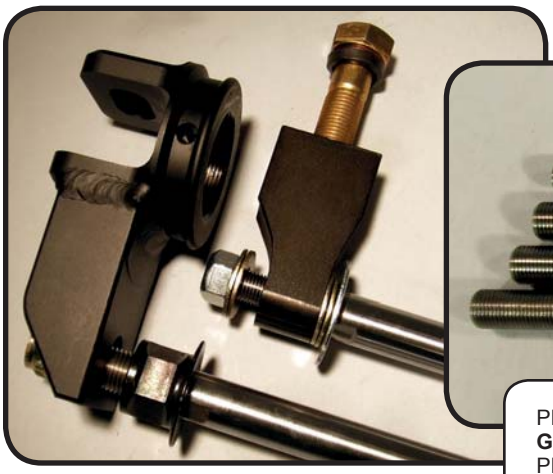
DOUBLE ACTING CYLINDER ASSEMBLY complete with boot, bolts, and steel hose adapters. All internal parts are easily replaceable.

1.13 bore **GE150B** fits **standard** rod bracket (all)
1.38 bore **GE150C** fits **standard** rod bracket (all)
1.13 bore **GEC150B-1825** fits **clevis** rod bracket on 18.25 rack
1.38 bore **GEC150C-1825** fits **clevis** rod bracket on 18.25 rack
1.38 bore **GEC150C-1925** fits **clevis** rod bracket on 19.25 rack
1.38 bore **GEC150C-1975** fits **clevis** rod bracket on 19.75 rack

Standard rack ends: 4.19 and 4.45 ratios accept the C cylinder directly using the GE264 rod bracket. To install the C cylinder on 392 and slower ratios, use the shim and the GE265 rod backet shown on the next page.
Clevis rack ends: work with or without a cylinder shim.

CYLINDER RESEAL KIT includes the piston with seal installed, both head and plug o-rings, rod bushing, rod seal and rod wiper.
Kit for all B cylinders (1.13 bore) **R150B**
Kit for all C cylinders (1.38 bore) **R150C**

NOTE: When disassembling a cylinder, always take the piston off the rod first and pull the rod OUTWARD. That way only the smooth, undamaged section of the rod will pass through the bushing and seals. Never remove a used rod by pulling its damaged end back through the seals.

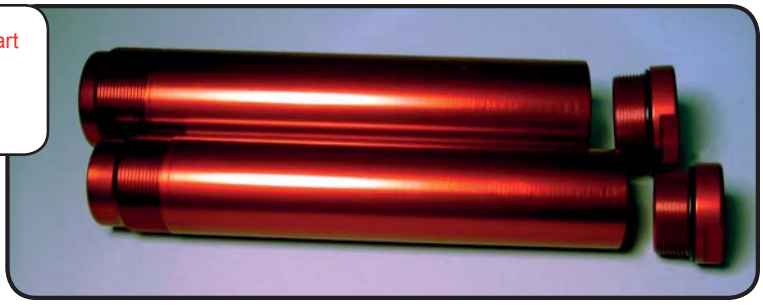


NOTE: The piston rods used on standard-end racks have a 3/8-24 thread with washers and a locknut. The piston rods used on clevis-end racks have a larger 1/2-20 thread with a one-piece flanged nut on the inner end and a locknut on the outer end. The two rod types are shown above inserted through their respective brackets.

PISTON ROD for STANDARD rack, includes nuts and washers
GE170B or GE170C
PISTON ROD for CLEVIS rack, includes nuts
GEC170C-1825, GEC170C-1925, GEC170C-1975

PISTON ROD assembly WITH PISTON for standard rack, includes nuts, washers and piston seal installed **GE170BA or GE170CA**
PISTON ROD assembly WITH PISTON for clevis rack, includes lock nut, flange nut and piston seal installed
GEC170C-1825A, GEC170C-1925A, GEC170C-1975A

CYLINDER TUBE is 6063-T8 aluminum with a polished ID; part includes plug and o-ring.
1.13 bore: **GE160B with GE161B**
1.38 bore: **GE160C with GE161C**



NOTE: Cylinder tubes ordinarily last for many years because they are free of metal-to-metal contact. However, dirt and debris can score the walls and cause internal leakage and overheating. Likewise, a dent can protrude into the bore and interfere with the piston travel. Always inspect the tube for rock damage.

ROD BOOT, computer-designed for an extreme ratio of extension to compression, protects the piston rod from rock hits and keeps dried mud from damaging the seals. **GE361**

Cylinder Installation Hardware

For GE/HE and GL/HL racks

The "B" cylinder can be installed directly on any GE/HE or GL/HL rack using the GE264 (or GEM264) rod bracket.

The "C" cylinder can be installed directly on any GL/HL rack, and on GE/HE racks in the 4.19 and 4.45 ratios, using the GE264 (or GEM264) rod bracket.

Installation of the "C" cylinder on GE/HE racks in 2.09 through 3.92 ratios requires a shim and a longer rod bracket in order to avoid physical interference with the pinion bearing cap. The kit for this installation consists of the GE151S shim, the GE108 longer housing dowel, the longer GE265 (or GEM265) rod bracket, and low-head screws for the two uppermost holes in the pinion bearing cap. The 265 brackets are shown below compared with the 264 brackets.

Shim GE151S shown in place

INSTALLATION HARDWARE and KITS

for GE/HE209-392 racks with B cylinder and GE/HE419-445 racks with C cylinder:
STANDARD ROD BRACKET includes bolt and washers **GE264**
MONOBALL ROD BRACKET includes bolt and washers **GEM264**
THRUST DOWEL (1/2 inch long, includes bolt) **GE107**

for GE/HE209-392 racks with C cylinder:
STANDARD ROD BRACKET includes bolt and washers **GE265**
MONOBALL ROD BRACKET includes bolt and washers **GEM265**
CYLINDER SHIM **GE151S**
THRUST DOWEL (5/8 inch long, includes bolt) **GE108**
LOW HEAD 10-24 SCREWS (pair) **GE153**

to install a C cylinder on a GE/HE209-392 standard rack originally equipped with a B cylinder:
RETROFIT KIT (includes GE150C, GE265, GE151S and GE108) **GE150CK**
MOUNTING HARDWARE ONLY, NO CYLINDER **GE150K**

to install a C cylinder on a GE/HE209-392 monoball rack originally equipped with a B cylinder:
RETROFIT KIT (includes GE150C, GEM265, GE151S and GE108) **GEM150CK**
MOUNTING HARDWARE ONLY, NO CYLINDER **GEM150K**

Service Kits

High quality components made by the USA's leading producers of elastomeric seals. Refer to the Power Steering System Tech section for seal replacement instuctions. Note that all Woodward component seals are MILITARY/INDUSTRIAL hydraulic seals, not OEM AUTOMOTIVE seals. The only fluid without destructive effect on industrial hydraulic seals is petroleum or "mineral oil." Power steering fluid of the straight oil type is available at auto parts stores and in this catalog. Caution: At one time we recommended red Ford Type F ATF. Originally an oil manufactured for use in transmisions made before 1980, Type F now has a different composition and is NOT compatible with Woodward seals.

SERVO SHAFT SEAL KIT includes two Hallite® loaded lip seals and two Viton® outer o-rings.
R581H

TORSION BAR SCREW KIT includes the two directional adjusting screws, the anchor set screw, the two plug screws and six o-rings.
R010

SERVO SPOOL SEAL KIT includes the four glass-reinforced Teflon® spool rings with Viton® preload o-rings. *Note: Use an installation mandrel to put the seals on the spool*
R800

SERVICE TOOLS for servo rebuilding:
The spool seals are a PTFE/glass composite which is semi-rigid. Expand the rings onto the spool with the mandrel and install the assembled spool into the housing through the compression sleeve. *NOTE: this operation requires considerable care; refer to the Tech Help section for step-by-step instructions.*
Mandrel **V598**
Sleeve **V599**

Power Steering Fluid

PETROLEUM TYPE (non-synthetic)

Because of the ever-increasing cost of petroleum, low-viscosity automotive hydraulic fluids formerly refined from the lighter grades of crude oil now utilize aggressive chemicals as diluting agents. These are generally described as "synthetics." Once reserved for products such as paint thinner, these chemicals render modern automotive fluids compatible *only* with the specific automotive seal and gasket materials under warranty by a particular car manufacturer. They are largely incompatible with military/industrial seal elastomers like those used in Woodward equipment. Some brands of fluid will shrink the shaft seals so rapidly that after three weeks the power steering will drip unless the engine is running. Note that there is no *functional* difference among various brands of hydraulic fluid; basically, like any liquid, it must (1) be practically incompressible, (2) flow rapidly enough to operate the steering, (3) lubricate the pump, and (4) not react with the seals.

Given the present uncertainty regarding (4), the only medium recommended for use in our systems is petroleum (i.e. *OIL*) which is still available at auto parts stores as well as in the automotive aisle of most discount stores and supermarkets in the USA. The fluid shown at right is completely benign with respect to the elastomers and nonmetallic materials used in our systems. It contains no silicones, no phosphate esters...and no purple dye. It does have a good combination of lubricity, chemical stability, thermal diffusion, and de-aerating properties which make it unsurpassed for use in Woodward-equipped race cars.

NOTE: So-called "anti-foaming" agents (usually just a thickener whose foam-suppressing action consists of keeping the air bubbles suspended in the oil—exactly where you don't want them) are another ingredient best avoided. Some other additives, such as those sold to "restore" power steering, will cause Buna N and many other seals to lose their durometer hardness and swell beyond their dimensional tolerances. While that may well stop a 1972 Buick from leaking, it is just about guaranteed to cause rough steering in a race car with a four-inch rack.

Quart **PSF-1**
Case of 6 **PSF-6**
NOTE: CANNOT SHIP BY AIR

Replacement Housings for Oval Track Steering

Type GE/HE racks are available in ten steering ratios. The housing is machined with the pinion bore at a set distance from the rack centerline, corresponding to its gear ratio. A GE/HE housing can only be used with the pinion for which it is machined, except for the 2.09, 2.36 and 2.62 ratios which share the same housing dimensions. Any rack built as a type GE with a separate servo can be converted to type HE by adding a servo adapter flange and splined coupler. NOTE: The GE/HE housing is a new design and will not work as a replacement housing for type E, F, G, or H racks manufactured from 1983-2008.

SERVO MOUNTING ADAPTER bolts to the housing and converts any inline servo to integral solid mount.
VHE584

SPLINED COUPLER connects the servo output to the pinion spline. NOTE: use of these parts requires a flat on the pinion spline.
VH201

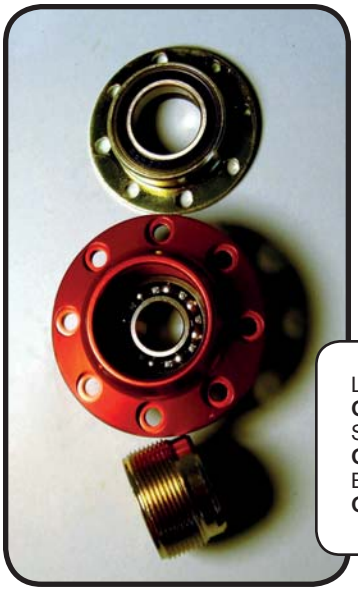
shown:
GE100-392

TYPE GE HOUSING (for inline servo) has rack bushings installed and pre-honed, and includes all the R100 kit parts.
GE100-209/236/262
GE100-288
GE100-314
GE100-340
GE100-366
GE100-392
GE100-419
GE100-445

TYPE HE HOUSING (for integral servo) also includes VHE584 and VH201.
HE100-209/236/262
HE100-288
HE100-314
HE100-340
HE100-366
HE100-392
HE100-419
HE100-445

REBUILD KIT (refer to the Technical Reference section) **RE100**

INDIVIDUAL PARTS:
Pinion thrust bearing (pair) **GE340**
Snubber adjusting screw **GE104**
Snubber **GE102**
Snubber o-ring **GE103**
Pinion radial bearing **GE321**
Rack bushing (pair) **GE101**
Set screw and cushion **GE105**
Pinion seal **GE323**



Pinion Bearing Caps

The pinion is adjusted against the rack with these eccentric bearing carriers. One set works with all ratios. The bearings are offset in the caps .015 which allows easy and precise adjustment of gear lash by simply indexing the caps in one-hole increments.

The presence of eight bolts per side effectively ties the housing together, reinforcing it against the separating force of the gears.

LARGE CAP w/ bearings
GE500
SMALL CAP w/bearing and seal
GE400
BEARING RETAINER PLUG
GE341

GE/HE Rack and Pinion Mechanical Parts

Pinions

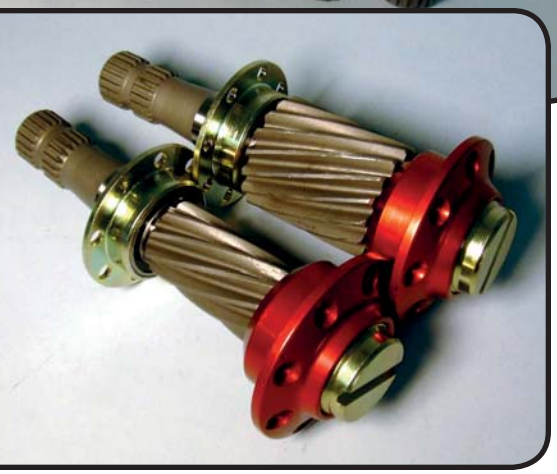
The ratio is determined by the pitch circumference of the pinion; the larger the pinion, the farther it will drive the rackshaft in one turn. This distance is the "gear ratio" of a rack and pinion set. The range of pinions in GE/HE racks is 2.09 (53 mm), 2.36 (60 mm), 2.62 (66 mm), 2.88 (73 mm), 3.14 (80 mm), 3.40 (86 mm), 3.66 (93 mm), 3.92 (100 mm), 4.19 (106 mm) and 4.45 (113 mm). You can figure "turns lock-to-lock" by dividing the total rack travel, which is nominally 6 inches (152 mm), by the ratio. For example, 6/2.36=2.5 turns (152/60=2.5 turns).

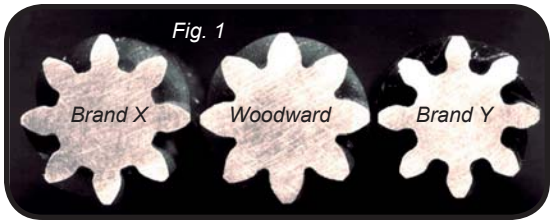
PINION (gear only)
2.09 ratio **GE308**
2.36 ratio **GE309**
2.62 ratio **GE310**
2.88 ratio **GE311**
3.14 ratio **GE312**
3.40 ratio **GE313**
3.66 ratio **GE314**
3.92 ratio **GE315**
4.19 ratio **GE316**
4.45 ratio **GE317**

PINION w/ flat for VH201
2.09 ratio **HE308**
2.36 ratio **HE309**
2.62 ratio **HE310**
2.88 ratio **HE311**
3.14 ratio **HE312**
3.40 ratio **HE313**
3.66 ratio **HE314**
3.92 ratio **HE315**
4.19 ratio **HE316**
4.45 ratio **HE317**

PINION ASSEMBLY
2.09 ratio **GEA308**
2.36 ratio **GEA309**
2.62 ratio **GEA310**
2.88 ratio **GEA311**
3.14 ratio **GEA312**
3.40 ratio **GEA313**
3.66 ratio **GEA314**
3.92 ratio **GEA315**
4.19 ratio **GEA316**
4.45 ratio **GEA317**

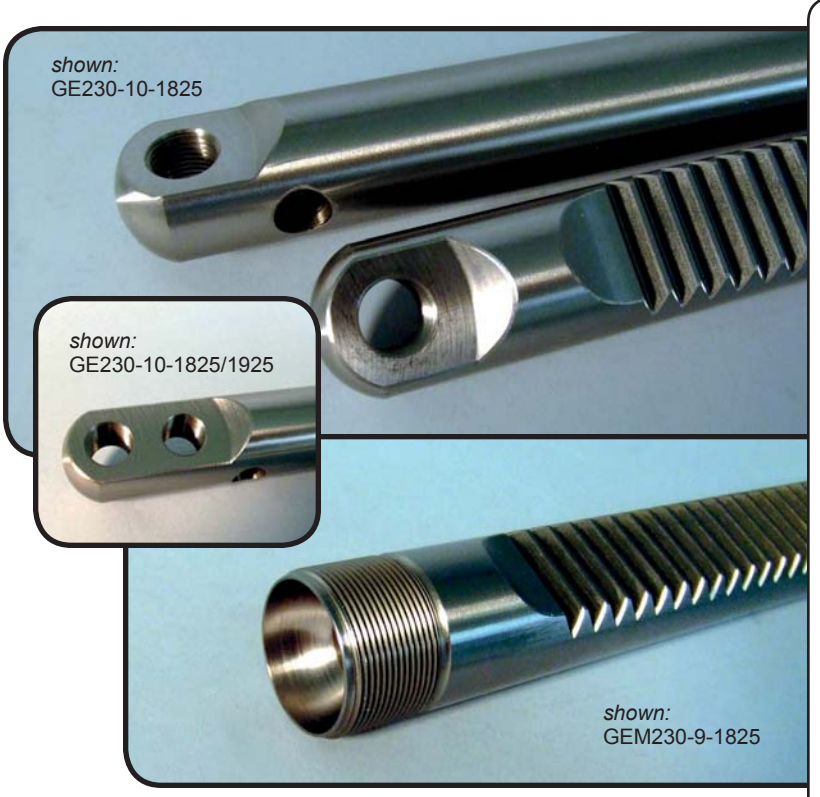
PINION ASSEMBLY w/ flat
2.09 ratio **HEA308**
2.36 ratio **HEA309**
2.62 ratio **HEA310**
2.88 ratio **HEA311**
3.14 ratio **HEA312**
3.40 ratio **HEA313**
3.66 ratio **HEA314**
3.92 ratio **HEA315**
4.19 ratio **HEA316**
4.45 ratio **HEA317**





Woodward Gear Design

The pinion is the single most highly stressed element in the steering. Because the teeth are formed around a circle, their profiles assume a curved shape whose base is always narrower than that of the basic rack tooth. In conventional gears this involute curve produces an undercut which weakens the teeth compared to those on the rack. Woodward pinions are made with a 30^0 pressure angle. Because this form allows the teeth to be generated without undercut, the gear has inherently stronger proportions and resistance to shear than a pinion of conventional form. In Figure 1, sections through some competitors' pinions appear on either side of a Woodward pinion of the same nominal ratio. You can easily see the strength advantage provided by the shape alone of the Woodward gear. In addition to their beefier profile, Woodward pinions have superior physical properties. Made of 4150 chrome-molybdenum alloy steel and heat treated to a minimum tensile strength level of 235,000 PSI, they are much stronger than the competition. In an revealing test of the four leading US brands, a Woodward pinion was simply hammered against each of the other pinions in Figure 2. Next, each pinion was used to hammer on the Woodward pinion. The results speak for themselves: the competition is beaten. Literally. With our equipment, you can do the same thing on the race track.



"STANDARD" RACKSHAFTS with 5/8-18 HOLES
GE230-8-1725 *(2.09 ratio only)*
GE230-9-1725 *(2.36 ratio only)*
GE230-10-1725 *(2.62 and quicker)*
GE230-8-1825 *(2.09 ratio only)*
GE230-9-1825 *(2.36 ratio only)*
GE230-10-1825 *(2.62 and quicker)*
GE230-10-1825/1925 *(2.62 and quicker)*
GE230-8-1925 *(2.09 ratio only)*
GE230-9-1925 *(2.36 ratio only)*
GE230-10-1925 *(2.62 and quicker)*
GE230-10-1975 *(2.62 and quicker)*

RACKSHAFTS for MONOBALL ENDS
GEM230-8-1625 *(2.09 ratio only)*
GEM230-9-1625 *(2.36 ratio only)*
GEM230-10-1625 *(2.62 and quicker)*
GEM230-8-1725 *(2.09 ratio only)*
GEM230-9-1725 *(2.36 ratio only)*
GEM230-10-1725 *(2.62 and quicker)*
GEM230-8-1825 *(2.09 ratio only)*
GEM230-9-1825 *(2.36 ratio only)*
GEM230-10-1825 *(2.62 and quicker)*

RACKSHAFTS for SLOTTED CLEVIS ENDS
GEC230-10-1825 *(2.62 and quicker)*
GEC230-10-1925 *(2.62 and quicker)*
GEC230-10-1975 *(2.62 and quicker)*

Rackshafts are now manufactured with 30 tooth spaces and, except for the clevis type, will fit Woodward racks back to 1983.

Rackshafts

The term "length" as applied to a rack refers to the distance between the pivot points of the rackshaft. This is a critical dimension which must conform to the car's suspension geometry. In the GE/HE series, any increase (or decrease) from a "basic" rack length of 18.25 inches is made at the right-hand (smooth) end of the shaft. Rackshafts are not extended from the toothed end; the distance from the left tie rod hole to the nearest rack tooth is constant. With racks 18.25 inches or shorter, both the pivots and the travel will be symmetrical with respect to the housing, whereas a rackshaft longer than 18.25 will extend farther from the housing on the right with the travel centered. Alternatively, this can be visualized as offsetting the pinion to the left relative to the pivot points, which provides improved clearance in an oval track chassis. To avoid excessive bushing wear, the maximum rack length used in the GE/HE housing is 19.75. Installations requiring racks longer than this are best served by the type GL/HL rack and pinion.

MONOBALL UNIT. Ball stud is threaded 5/8-18 RH. Install and adjust with 1-1/2 hook spanner. **M500**
BALL STUD **M512**
SWIVEL NUT **M510**
JAM NUT **M511**

SLOTTED CLEVIS installs with 1-1/2 hook spanner, includes 5/8 rod end.
RIGHT CLEVIS ASSEMBLY(with rod bracket) **F812**
LEFT CLEVIS ASSEMBLY **F712**
BOLT w/NUT **F510**
ROD END **FSR10**
ROD END HATS (pair) **F513**
JAM NUT **M511**

Clevis rack boots

BOOT for SLOTTED CLEVIS fits a groove machined in the shank of the clevis. The ID of any GE360 or GEM360 boot will fit the clevis the same way it fits the rack housing, just trim off the outer reduced end. This is an airtight installation and a 1/16 vent hole should be clipped in the bottom side. **GEF360**

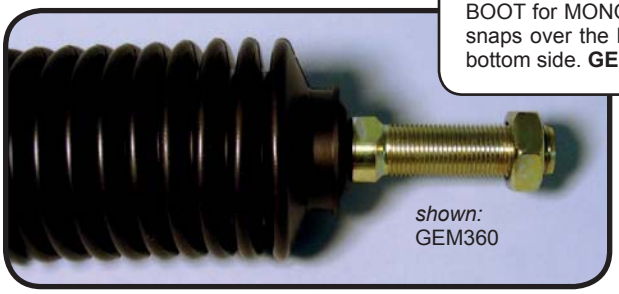
BETTER RUBBER for 2015!

WOODWARD RACK BOOTS are now supplied by one of Europe's premier auto parts manufacturers. These are very high quality precison-molded rubber, with the highest ratio of extension to compression we have ever seen. They are so flexible that an additional half inch of travel can now be obtained in those cases where the older, thicker boots would stack up and interfere. More pleats are now used for all three boot configurations shown on this page.

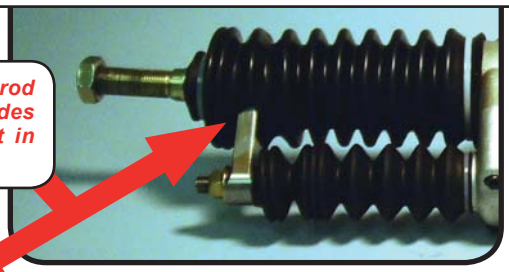
MEYLE Germany — MEYLE® Products

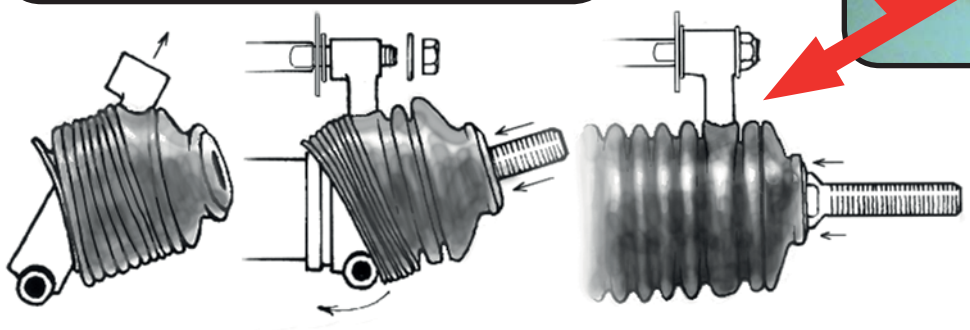
Monoball rack boots

BOOT for MONOBALL rack fits both ends of manual or power rack. Has a reduced end which snaps over the ball stud. The fit will be airtight and a 1/16 vent hole should be clipped in the bottom side. **GEM360**



The monoball rod bracket protrudes through a slot in the third pleat:

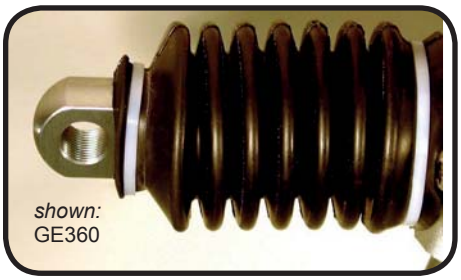


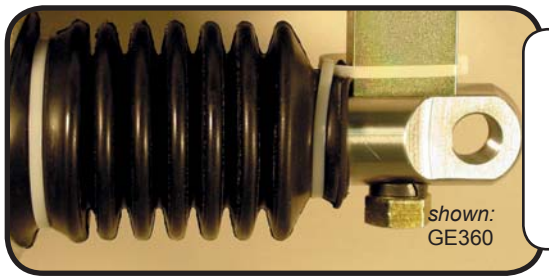


Installation tip for right Monoball Boot:

When installing the boot over a GEM264 or 265 rod bracket, coat the inside of the boot liberally with grease. After aligning and tightening the rod bracket, use a smooth pair of pliers to pull the boot the rest of the way on.

"Standard" rack boots





BOOT for STANDARD rack fits both ends of manual or power rack. When slid up on the shaft for use with the GE264 rod bracket (as at right) the fit will be airtight and a 1/16 vent hole should be clipped in the bottom side. **GE360**

MR series custom rack parts

MR, MRC and MC racks are essentially custom built and do not have "standard" rack shafts, cylinders, or housing tubes. Some models are proprietary, and spare parts for these are available only through ithe car manufacturer or authorized agent. Racks are identifiable by the model number on the rear bearing plate, or the serial numbers of the rack and/or servo.

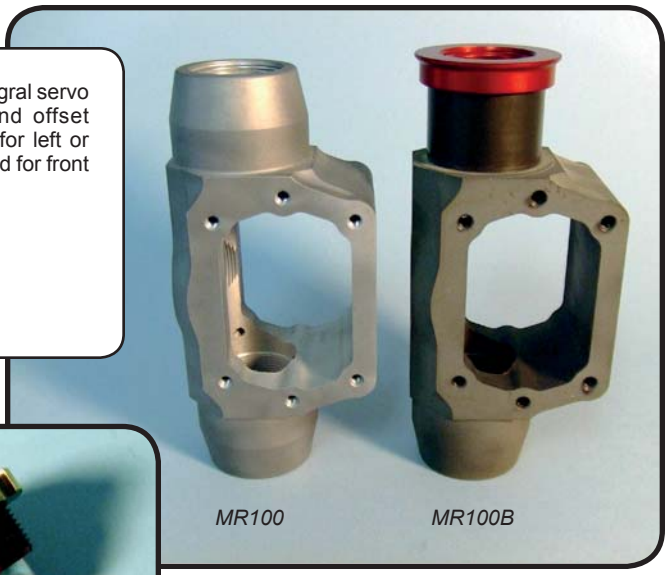
RACKSHAFTS are hard chromed (prices vary).

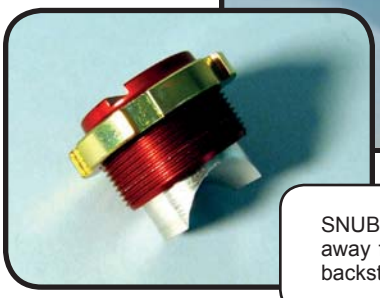
CLEVIS is threaded 5/8-18 UNF and includes the jam nut. Heat-treated 4142 alloy steel, made for two sizes of high-misalignment rod ends:

1/4 bolt x 3/8-24 **MR412**
5/16 bolt x 3/8-24 **MR413**

MR HOUSING is for integral servo only. Both centered and offset forms can be reversed for left or right steer and/or inverted for front or rear steer.

2.02 and 2.24 ratios
MR100A
2.02 and 2.24 ratios
MR100B





SNUBBER keeps the rack from being deflected away from the pinion. Also known as a yoke or backstop, this part is included with the housing.

MOUNTING BRACKETS for MR and MRC racks accept 5/16 or 8 mm socket head cap screws.

For 40 mm dia., each
MR35A
For 1-1/4" dia., each
MR35B

MC/MRC HOUSING is extremely light and compact. Power steering versions use remote servo. The centered type A can be reversed and/or inverted for left or right steer and front of rear steer. For offset type B specify left or right.

2.02 and 2.24 ratios
MC100-224
2.69 ratio
MC100-269
3.14 ratio
MC100-314
2.02 and 2.24 ratios
MC100B-224
2.69 ratio
MC100B-269
3.14 ratio
MC100B-314

MR, MRC and MC Rack Mechanical Parts

INTEGRAL CYLINDERS for type MR and MRC racks are available as complete units or as individual parts. Give model and serial number of rack when ordering.

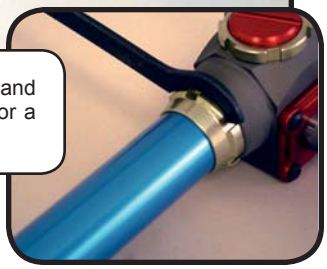
1.38 bore: **MR150 + Model number etched on rack**
1.50 bore: **MR150X + Model number etched on rack**

CYLINDER SEAL KIT includes Viton® o-rings and loaded lip seals for both ends of the cylinder
for 1.38 bore **MR150R**
for 1.50 bore **MR150RX**

PINION AND SERVO ASSEMBLY for MR racks mounts directly to the housing. Pinion backlash is set with an eccentric bushing. Specify servo valve, ratio, and size of Torsion bar in valve.
2.02 ratio **VA850-1MR-309 + Tbar + Rack model no.**
2.24 ratio **VA850-1MR-309 + Tbar + Rack model no.**
2.02 ratio **VA850-2MR-309 + Tbar + Rack model no.**
2.24 ratio **VA850-2MR-309 + Tbar + Rack model no.**

Note: Ratio set requires both pinion and rackshaft.

HOUSING TUBES on MR, MRC and MC racks are length-adjustable for a perfect fit in the chassis mounts.



PINION ASSEMBLY for MC and MRC racks includes the mounting flanges with bearings, locating eccentrics, and all cap screws.

2.02 ratio **MCA309**
2.24 ratio **MCA310**
2.69 ratio **MCA312**
3.14 ratio **MCA314**

PINION ONLY hardened alloy steel, hollow for weight reduction.
2.02 ratio **MC309**
2.24 ratio **MC310**
2.69 ratio **MC312**
3.14 ratio **MC314**

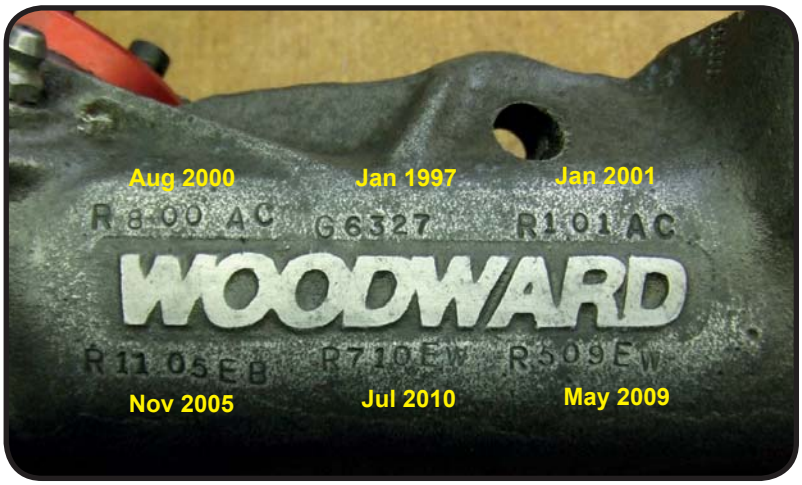
Note: Pinion and rackshaft are a set.

VALVE T-BARS for MR racks are designed for symmetrical road-race steering. They have a smaller directional adjustment band than T-bars meant for oval track racing and a greater resistance to loosening from v bration. **Specify Rack model no.**

Rack and Pinion Maintenance Products

Keep Your Gears Moving

Serial number G6327 shown below was issued in 1996/97 as a replacement housing to repair crash damage on an older rack. The subsequent dates stamped on the housing along with the initials of the technician who serviced it, show that this unit remained in continuous service through at least 2010. WEEKLY LUBRICATION OF THE MOVING PARTS by its owner and replacement of the rack bushings after every 50 races helped it survive what probably exceeded 15 years of competition. The newer GE/HE design with its all-ball-bearing pinion is expected to average an even longer useful life than the G/H, but regular and conscientious maintenance will always be the most important single factor in getting the most actual seat time per dollar spent.



ST-3 RACK GREASE is formulated to Woodward specs and is Lithium based with 3% Moly Disulfide, in a commercially unavailable ALGI 2.5 weight. Made from a very heavy base oil, it does not need silica gel as a thickening agent, so its combined properties of tack, lubricity, and high film strength are unsurpassed. Important: Keep in a separate, clearly labeled gun and use only in the rack. *NOT FOR USE IN WHEEL BEARINGS!* **ST-3**

Keep Your Seals Alive

Almost all automotive power steering and automatic transmission fluids in use today are synthetics of one kind or another and are incompatible with military/industrial seal elastomers like those used in Woodward equipment. Some brands of fluid are so chemically aggressive they will shrink the shaft seals within three weeks, and the power steering will drip thereafter unless the engine is running.

Note that there is no *functional* difference among various brands of hydraulic fluid; basically, like any liquid, it must (1) be practically incompressible, (2) flow rapidly enough to operate the steering, (3) lubricate the pump, and (4) not react with the seals.

The only medium recommended for use in our systems is petroleum (i.e. OIL) which is still sold at auto parts stores as well as in the automotive aisle of most discount stores and supermarkets in the USA. The fluid shown at right is completely benign with respect to the elastomers and nonmetallic materials used in our systems. It contains no silicones, no phosphate esters… and no dye. It does have a good combination of lubricity, chemical stability, thermal diffusion, and de-aerating properties which make it unsurpassed for use in Woodward-equipped race cars. It is not injurious to any known hydraulic hose, pump gaskets, or seal material

WOODWARD POWER STEERING FLUID
Quart **PSF-1**
Case of 6 **PSF-6**
NOTE: CANNOT SHIP BY AIR

SCA700 Safety Steering Column

NASCAR Approved for Sprint Cup competition since 1997

The SCA700 is a housed upper steering column used in Sprint Cup, the Australian V8 Supercars, the New Zealand Supertourers and other racing series around the world. A steel torque tube rotates inside a lightweight aluminum jacket, with a heavy-duty ball bearing and a splined shaft which can telescope inside the torque tube for a full nine inches (220mm), adding a large margin of safety for the driver during collapse of the forward crush zone in a high-speed crash. Available in many convenient length combinations and with optional quick releases shown on following pages.

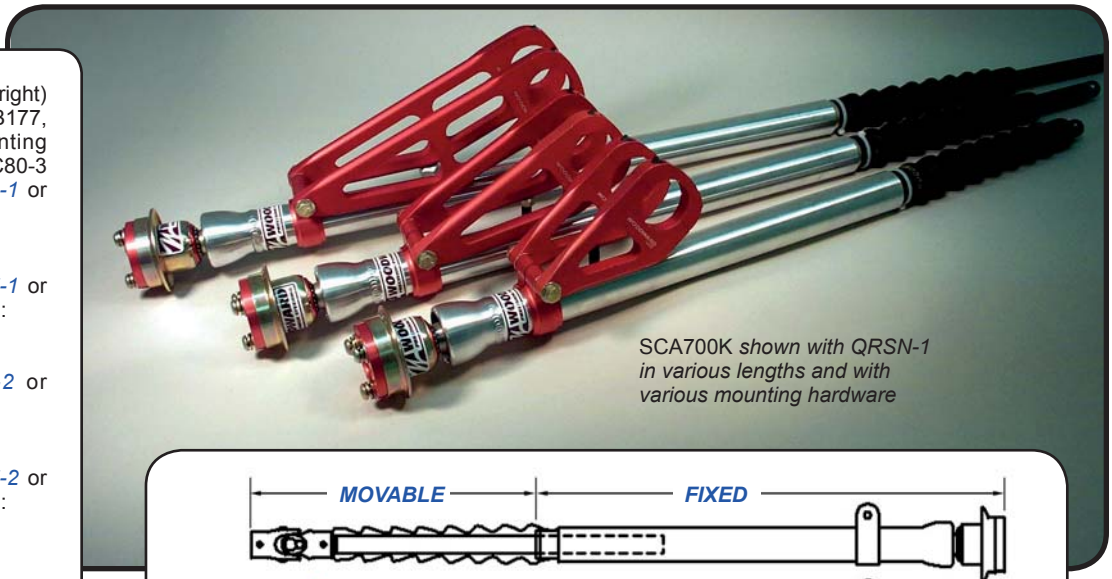
COLUMN KIT (shown at right) includes your choice of MB177, MB178, or MB179 mounting brackets, SBC80-1 or SBC80-3 jacket clamp, and *QRSN-1* or *QRAN-1* quick release.
SCA700K-A

Above kit with *QRSN697-1* or *QRAN697-1* quick release:
SCA700K-B

Above kit with *QRSN-2* or *QRAN-2* quick release:
SCA700K-C

Above kit with *QRSN697-2* or *QRAN697-2* quick release:
SCA700K-D

Column only **SCA700**



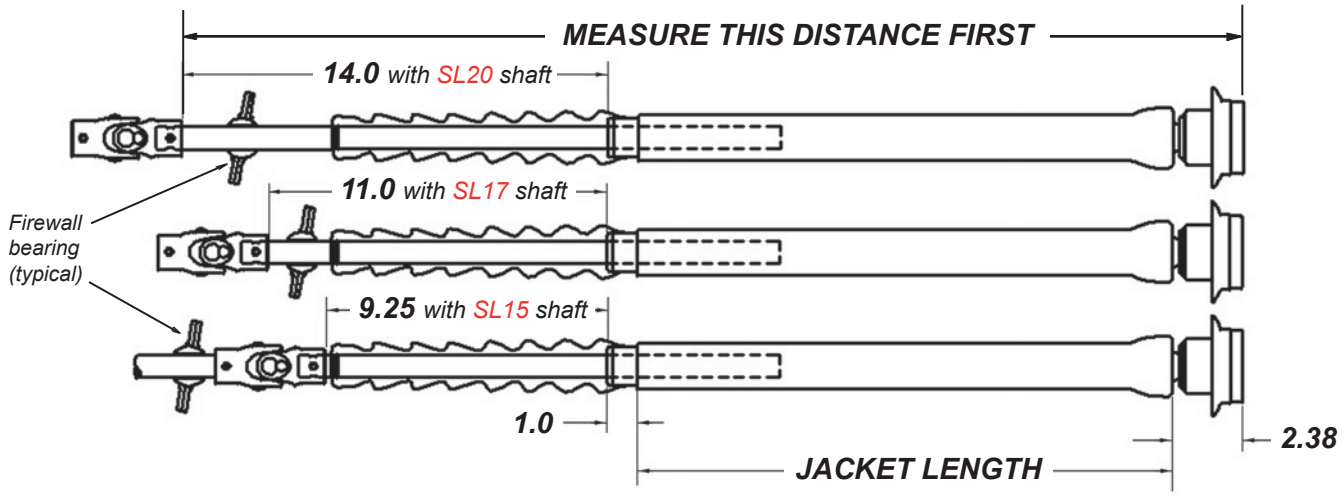
SCA700K *shown with QRSN-1 in various lengths and with various mounting hardware*

How to order:

1. Decide where the U-joint will go (usually just outside the firewall). Sit in the car and hold the steering wheel where you want it. Have a helper measure from the near end of the U-joint to the mounting surface of your steering wheel as shown in the drawing below.

2. Select the splined telescoping shaft (SL20, SL17 or SL15) that will best fit your installation. Note that the SL20 and SL17 can extend through a support bearing–as shown–and the SL15 cannot. If you use an SL15, the shaft to which it connects must be supported. Subtract the amount which corresponds to your splined shaft (14, 11, or 9.25 inches) from your overall measurement.

3. Subtract 1.0 inch for the boot cuff, 2.38 for the QR hub, and an additional .3 inch if you will be adapting a 6-bolt wheel. The remainder is the length of your column jacket. Select the closest jacket from the list. The ordering number for your safety column is made up of your *jacket* and *splined lower shaft,* e.g. **SCA700-1775-SL17**, **SCA700-2475-SL20**, etc.



Standard jackets are 13.75, 15.75, 17.75, 20.75, 22.75 and 24.75

Safety Steering Columns

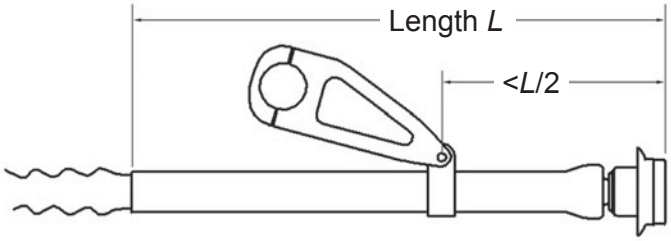
SCA700 Installation Hardware

JACKET CLAMP fits SCA700, for use with MB brackets below. Hardware included.
SBC80-1

JACKET CLAMP fits SCA700, 3-hole adjustable, for use with old style welded dash brackets. Hardware included. **SBC80-3**

Install your column for maximum stability

The SCA700 mounting hardware will provide a tight grip on the parts but stability depends on minimizing how far the steering wheel extends from the support point. Use brackets that will locate the support point toward the upper end of the column assembly, as at right.

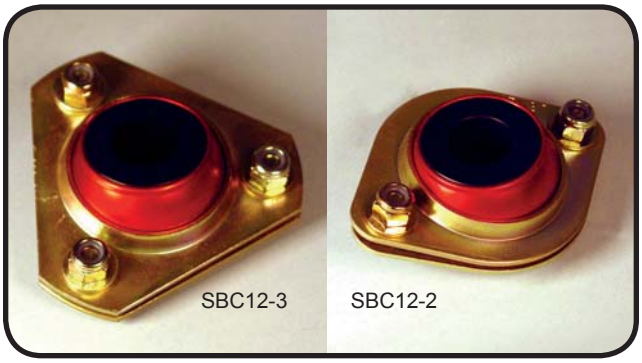


DASH BAR BRACKETS clamp onto roll cage tube and provide infinite adjustability to fit any driver position. Aluminum, very light, very rigid and secure.

BRACKET PAIR 6-1/2 centers
for 1-3/4 tube **MB178**
for 40mm tube **MB178-40**

BRACKET PAIR 9-1/2 centers
for 1-3/4 tube **MB179**
for 40mm tube **MB179-40**

BRACKET PAIR 4-1/2 centers
for 1-3/4 tube **MB177**
for 40mm tube **MB177-40**



FIREWALL BUSHINGS with steel flanges, aluminum ball and Delrin® sleeve are direct replacements for 3/4 inch industrial flange bearings.
with 3 bolts **SBC12-3**
with 2 bolts **SBC12-2**

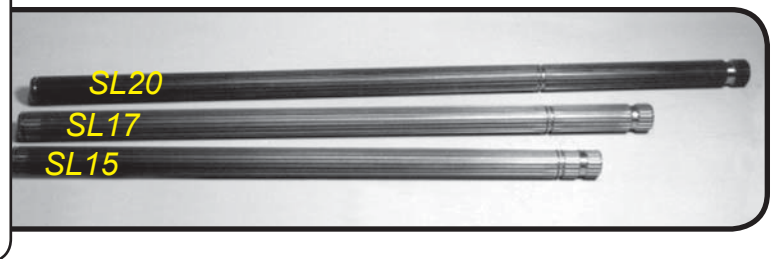
NEW LIGHTWEIGHT MINI-BUSHING is all aluminum with a Delrin® liner and a full-floating ball, sealed with o-rings. Very high operating angle; requires a 1.50 hole. **SBC6-2**

Bushing bores are sized for the SL17 and SL20 shafts below. Please specify if they will be used for 3/4 tubing. Install on one side only of the firewall sheet metal; do not sandwich.

SPLINED LOWER SHAFTS fit all Woodward columns. Retained by a spring clip, the shaft can be removed from the torque tube with a sharp pull.
SL20
SL17

Note: Cup rules require the u-joint to be outside the firewall. The SL17 and SL20 extend beyond the boot far enough to pass through the firewall bushings shown above; the SL15 does not (check your rules before ordering).

Applications *other than Sprint Cup* **SL15**

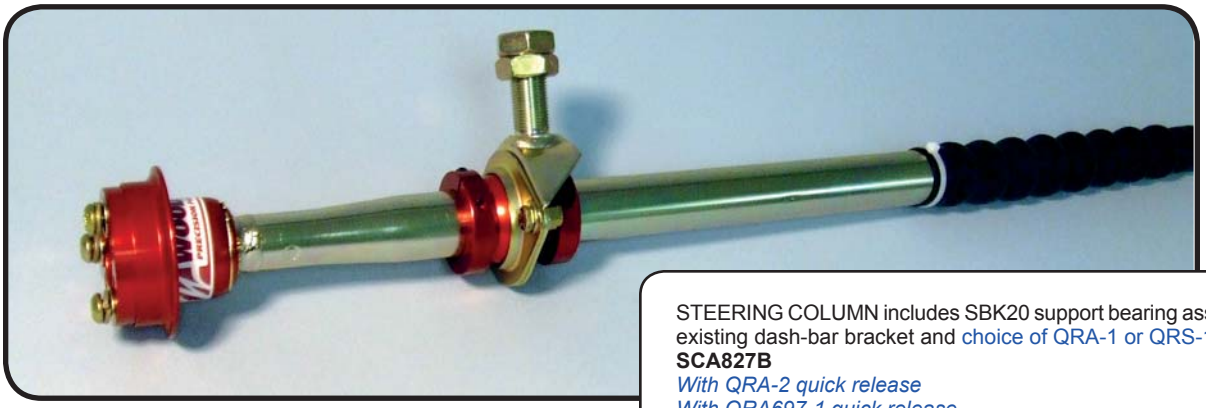


SCA827B

The standard for short track racing

The SCA827 features an open torque tube in a lightweight self-aligning Delrin sleeve bearing. Like the SCA700 the splined shaft can telescope inside the torque tube for a full nine inches. The SCA837B is intended to directly replace the simplest form of steering column: a 3/4 tube and Heim joint. The bearing hanger fits in the 3/4 hole or slot in a typical support bracket welded to the dash bar. Although light in weight, an 827 column is much stiffer than a 3/4 tube and provides a more stable and positive feel at the steering wheel. To reposition an SCA827 column: Back off the thrust collars and loosen the flange to free the bearing ball. After moving the torque tube, realign the bearing ball and retighten its flange, making sure the column turns freely. Last, reset the thrust collars, allowing .005 clearance. If you steam-clean the car's interior, blow the bearing dry and apply WD-40 to prevent rust; otherwise, no lubrication is necessary.

This column has an integral spline and includes the QRA-1 or QRS-1 steering wheel quick release. A QRA-2 or QRS-2 quick release, shown on the following pages, is available at extra cost.



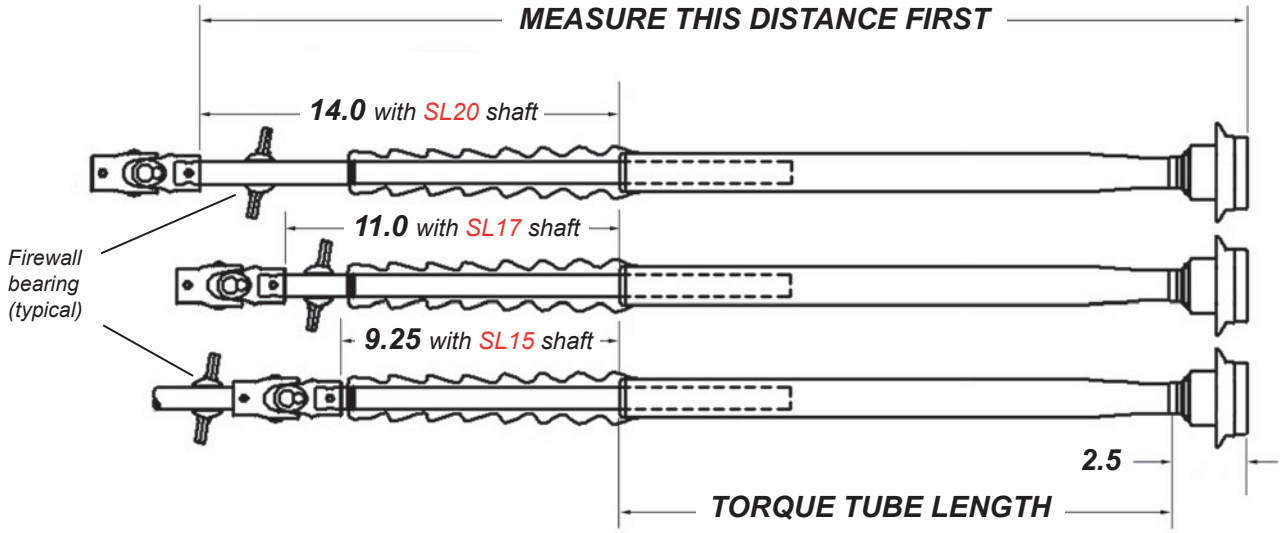
STEERING COLUMN includes SBK20 support bearing assembly to fit your existing dash-bar bracket and choice of QRA-1 or QRS-1 quick release.
SCA827B
With QRA-2 quick release
With QRA697-1 quick release
With QRA697-2 quick release

How to order:

1. Decide where the U-joint will go (usually just outside the firewall). Sit in the car and hold the steering wheel where you want it. Have a helper measure from the near end of the U-joint to the mounting surface of your steering wheel as shown in the drawing below.

2. Select the splined telescoping shaft (SL20, SL17 or SL15) that will best fit your installation. Note that the SL20 and SL17 can extend through a support bearing–as shown–and the SL15 cannot. If you use an SL15, the shaft to which it connects must be supported. Subtract the amount which corresponds to your splined shaft (14, 11, or 9.25 inches) from your overall measurement.

3. Subtract 2.5 from the upper end, and an additional .3 inch if you will be adapting a 6-bolt wheel. The remainder is the length of your torque tube. Select the closest one from the list. The ordering number for your safety column is made up of your *torque tube* and *splined lower shaft,* e.g. **SCA827B-2675-SL17**, **SCA827-1875-SL20**, etc.



Standard torque tubes are 13.75, 15.75, 17.75, 18.75, 20, 20.75, 22.75, 24.75, 26.75, 28.50 and 31.50

Steering Wheel Quick Releases

The Woodward steering wheel quick release features a square-contact spline with a two-inch engaged length. This low-profile form provides highly positive transmission of torque without the spreading effect of the common involute spline, and is the key to the hub's compact design and extremely light weight. Because the locking balls do not transmit torque, the unit will release from the steering column with very little effort. All Woodward quick releases are certified to SFI specification 42.1, and the QRSN-1 and QRSN-2 units meet the additional NASCAR requirement for a steel pull ring.

Weld-on QR Hubs for 3/4 inch tubing also fit SCA827 Safety Steering Column

QUICK RELEASE with 3-inch (75mm) ALUMINUM pull ring includes weld-on adapter for 3/4 inch tubing, bolts, washers and SFI 42.1 certification sticker *(this unit is supplied standard on SCA827 steering columns).*
QRA-1 *(standard red)*
Pull ring anodized yellow per FIA rules **QRA-1Y**
with weld-on adapter machined for other diameters, add

QUICK RELEASE with 3-inch (75mm) STEEL pull ring includes bolts, washers and SFI 42.1certification sticker. This unit is optional on SCA827 steering columns.
with weld-on adapter for 3/4 inch tubing **QRS-1**
with weld-on adapter machined for other diameters, add

QUICK RELEASE with 4-inch (100mm) ALUMINUM PULL RING includes bolts and SFI 42.1certification sticker. The aluminum pull ring is anodized yellow per FIA requirements. Same weight as the smaller 3 inch aluminum model, this can be supplied as an option on the SCA827 steering column.
with weld-on adapter for 3/4 inch tubing **QRA-2**
with weld-on adapter machined for other diameters,add

QUICK RELEASE with OVERSIZE STEEL PULL RING includes bolts and SFI 42.1certification sticker. Same weight as the smaller 3 inch steel model, this can be supplied as an option on the SCA827 steering column.

with weld-on adapter for 3/4 inch tubing **QRS-2**
with weld-on adapter machined for other diameters, add

WOODWARD PRECISION POWER STEERING

Steering Wheel Quick Releases

Bolt-on QR Hubs for SCA700 Column

QUICK RELEASE with 3-inch (75mm) STEEL pull ring and BOLT-ON adapter is approved for NASCAR Sprint Cup competition, includes bolts and washers and SFI 42.1certification sticker. For installation on SCA700 safety steering columns.
QRSN-1

The Woodward spline and taper design allows easy removal from the steering post without needing a puller. The cutaway shows how the QRSN adapter is installed on an SCA700 column using the recessed 12-point locknut. Secures with only 50 inch-pounds of torque.

QUICK RELEASE with 4-INCH (100mm) STEEL pull ring and BOLT-ON adapter is approved for NASCAR Sprint Cup competition, includes bolts and washers. The large pull ring gives better access behind the wheel pad as well as from the driver's window. Has SFI 42.1 certification sticker. For installation on SCA700 series safety steering columns. *SAME WEIGHT AS QRSN-1!*
QRSN-2

QUICK RELEASE with 3-inch (75mm) ALUMINUM pull ring and BOLT-ON adapter includes bolts and washers and SFI 42.1certification sticker. For installation on SCA700 safety steering columns.
QRAN-1 *(standard red)*
Pull ring anodized yellow per FIA rules **QRAN-1Y** *(shown)*

QUICK RELEASE with 4-inch (100mm) ALUMINUM pull ring and BOLT-ON adapter includes bolts and washers and SFI 42.1certification sticker. For installation on SCA700 safety steering columns.
QRAN-2 *(pull ring anodized yellow per FIA rules)*

QR Hubs for 6-BOLT Steering Wheels

QUICK RELEASES with QR697 flange installed, accept Momo, Sparco, OMB and other European steering wheels with 6 x 70mm bolt circle. All include Torx Plus® screws for both straight and countersunk holes. Adds approximately .34 inch (9mm) thickness.

WELD-ON style for 3/4 inch tubing (also fits SCA827 column)
3 inch STEEL **QRS697-1**
3 inch RED ALUMINUM pull ring **QRA697-1**
3 inch YELLOW ALUMINUM pull ring **QRA697-1**
4 inch STEEL pull ring **QRS697-2**
4 inch YELLOW ALUMINUM pull ring **QRA697-2**
with weld-on adapter machined for other than 3/4 dia. **add**

BOLT-ON style for SCA700 Column
3 inch STEEL pull ring **QRSN697-1**
3 inch RED ALUMINUM pull ring **QRAN697-1**
3 inch YELLOW ALUMINUM pull ring **QRAN697-1**
4 inch STEEL pull ring **QRSN697-2**
4 inch YELLOW ALUMINUM pull ring **QRAN697-2**

Steering Wheel Quick Releases

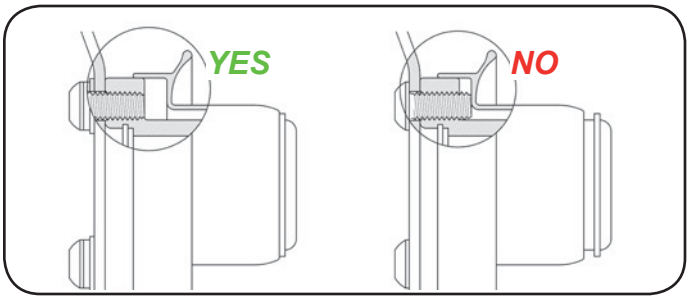
Steering Wheel Bolt Pattern Adapters

STEERING WHEEL ADAPTER for Momo, Sparco and other European steering wheels with 6 x 70 mm bolt pattern. Kit includes both standard and countersunk Torx Plus® screws. Less than 9 mm thick, this part is very strong and will fit any steering hub with the US pattern of 3 x 5/16 on a 1.75 bolt circle. **QR697**

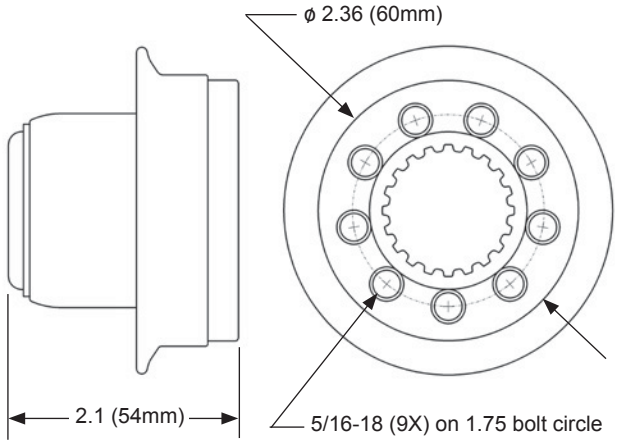
STEERING WHEEL ADAPTER for Moto-Lita custom steering wheels uses all nine bolts on the Woodward QR hub to match the Moto-Lita's nine bolts. Plain machined aluminum, suitable for polishing or anodizing. Supplied with Torx Plus® fasteners. **QR698**

Installing steering wheels on QR hubs

When bolting a steering wheel or bolt-pattern flange to the QR hub, use the appropriate number of washers to obtain correct engagement of the cap screws. The depth of the tapped holes in the hub is 7/16 inch (11,1mm). The button head Torx cap screws supplied with the standard hub include flat and lock washers which can be used in whatever combination necessary to obtain a minimum of 3/8 (9,5mm) thread engagement and a maximum of 7/16 (11,1mm) with a given thickness of steering wheel. *Failure to use the correct washer stack, especially on a thin steering wheel, may allow the screws to protrude far enough through the hub to stop the release travel short.* Always verify that the mechanism will still work properly after you have tightened all the bolts.



Always bolt the steering wheel directly to the quick release hub. If you have to bring the wheel closer to the driver, the best way is to adjust the column outward (provided you allowed an extra inch or two when ordering the column). Be careful never to pull the lower shaft out of its full engagement with both internal spline bushings. If it is at the limit, substitute a longer lower shaft (e.g. change out an SL15 for an SL17). Shim or extend the steering wheel from the hub only as a last resort. Excessive leverage acting on the quick release unit will eventually bell-mouth the splined bore and ruin the fit. If you have no choice but to extend the wheel, try using a more deeply dished wheel rather than a shim, as there will be less static weight acting to wear out the splines.



The hub is provided with three copies of the standard US bolt pattern to allow, where necessary, realignment of the steering wheel with respect to the 20 splines on the adapter. The extra bolt holes also enable continued use of the hub in case of stripped or worn holes. The splined hub is anodized for wear resistance, but is nevertheless aluminum and can be burred or otherwise damaged if not treated with reasonable care. Wipe off any obvious dirt from the shaft spline before you put the wheel on, and let the teeth get aligned and started with as little pressure as possible. The hub will slide onto the spline for a full half inch (13mm) before you need to actuate the pull ring; it doesn't need to be forced on.

Should you disassemble the unit for cleaning, repack it with a very light grease with minimum solid content such as Aeroshell 14. The spline contact surfaces themselves are normally left dry so as not to attract dirt.

SCA500

Engine-bay Collapsible Section

There are still some late model chassis in which a safety steering column cannot be installed correctly without refabricating the mounting points. An alternative for these cars (as well as for street stocks and other classes required to retain the OEM column) is to install an SCA500 splined telescoping section between the rack or steering box and the firewall bearing as a first line of defense in the "crush zone." Installation is fairly simple. Just shorten or extend the tube as necessary and weld the appropriate U-joint or splined adapter to the open end. See the Steering Universal Joints section for U-joints to connect the unit to most popular steering-gear splines.

COLLAPSIBLE section for installation between the steering gear and the firewall area. Cut or extend to fit. Unit is approx. 27 inches long fully extended. Instructions included. **SCA500**

NOTE: This component is designed to replace the intermediate steering shaft in the front or engine bay, NOT the steering wheel shaft. It should ONLY be used as an intermediate shaft with a universal joint at each end. Its torque tube has a reduced diameter for header clearance and a relatively thin wall, and is NOT intended to take side loads from the steering wheel of a full-size automobile. Although various mail-order houses sell adapters to attach a steering wheel to the SCA500, this is an unapproved and unsafe practice for anything heavier than a mini-sprint.

WELD-IN EXTENSIONS for SCA500 column sections are made to pilot in the ID of the swaged tube using 3 plug welds and a fillet weld as shown. Splined extensions are the preferred method of supporting the section against side loads, since the u-joint is removable and the rod end (or firewall bearing) is not captive.

ST2011 w/1" straight section
ST2012 w/2" straight section
ST2013 w/3" straight section
ST2014 w/4" straight section
ST2015 w/5" straight section
ST501 Plain splicer for weld-on u-joint

SLA200

Slide Yoke

A slide yoke allows a rack and pinion to be mounted on a straight axle. As the axle moves up and down, the distance from the chassis to the pinion changes, so the steering shaft must be capable of sliding in and out like a driveshaft. Note that the sliding travel required of a slide yoke depends on its mounting angle. Mounted horizontally it will need less than an inch of movement; inclined at 45 degrees it will require a stroke equaling almost three-quarters of the total suspension travel. In extreme cases it may be necessary to utilize an SCA500.

STANDARD SLIDE YOKE has 8 inch tube with about 3 inches of stroke. Shipped dry to make welding easier. Special grease for the spline is supplied in a separate container. **SLA200**

CUSTOM SLIDE YOKE same as above but with a longer tube for increased travel, built to order **SLA220**

Replacement splined shaft **SL10**

BOOT fits all Woodward columns. An absolutely essential part, to keep out dirt and water and maintain the collapsibility of your safety steering column. To use the boot on a slide yoke, just trim back the large end as necessary. For extra short units, the small end can be opened to fit onto the u-joint. Includes high-strength Panduit cable tie. **SCA360**

Parts for use with 3/4 inch tubular steering shafts

SPLINED INSERTS for welding into 3/4" steel tubing. Better than splined tube–the solid end can't be crushed by screws or clamps.

For 3/4 OD x .120 wall
ST201A
For 3/4 OD x .065 wall
ST201B
Oversize, machinable for up to .660 (16,75mm) diameter pilot
ST201C
Oversize, machinable for up to.875 (22,22mm) diameter pilot
ST201GM

SHAFT HANGER is a 3/4" RH male rod end with an oversize bore to pass tubing (unlike bar stock and bolts, which have clearance, tubing is slightly *oversize* and will not pass through a standard rod end).

Includes two jam nuts.
SB12

CLAMP COLLAR positively stops the steering shaft against a rod end or flange bearing. Part is specifically designed for this purpose, *not a hardware-store shaft collar.* Allows full angular misalignment of the rod end, and will withstand a tremendous blow without slipping.

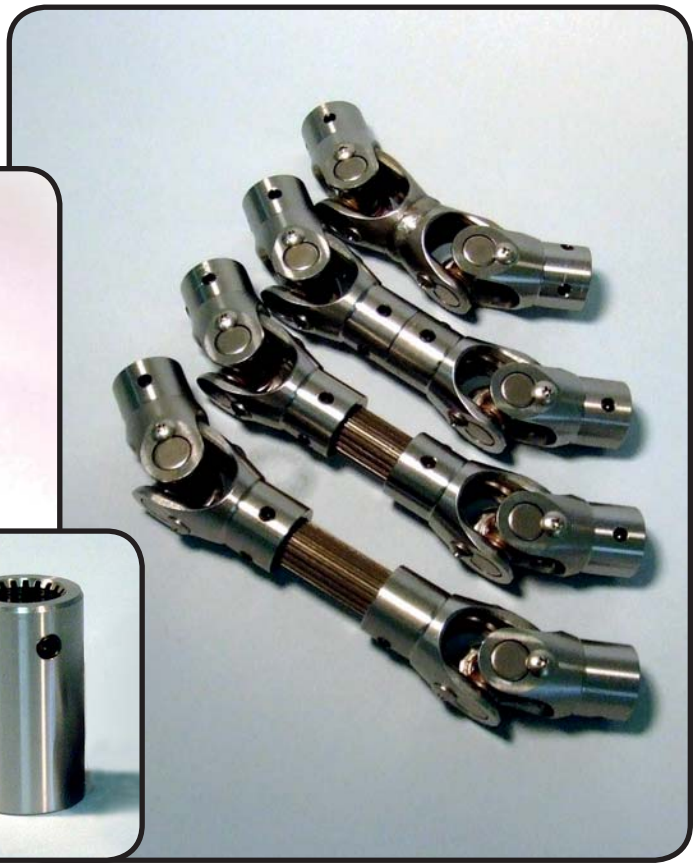
SCA175

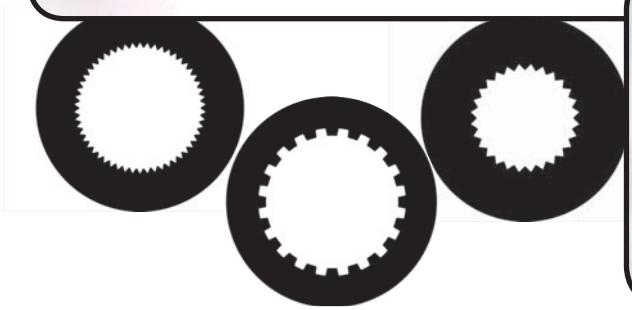
SPLINED SHAFT KIT is a 36 inch tube with one ST201A splined stub already welded in, and the other end loose to allow cutting to length.

WS201-36

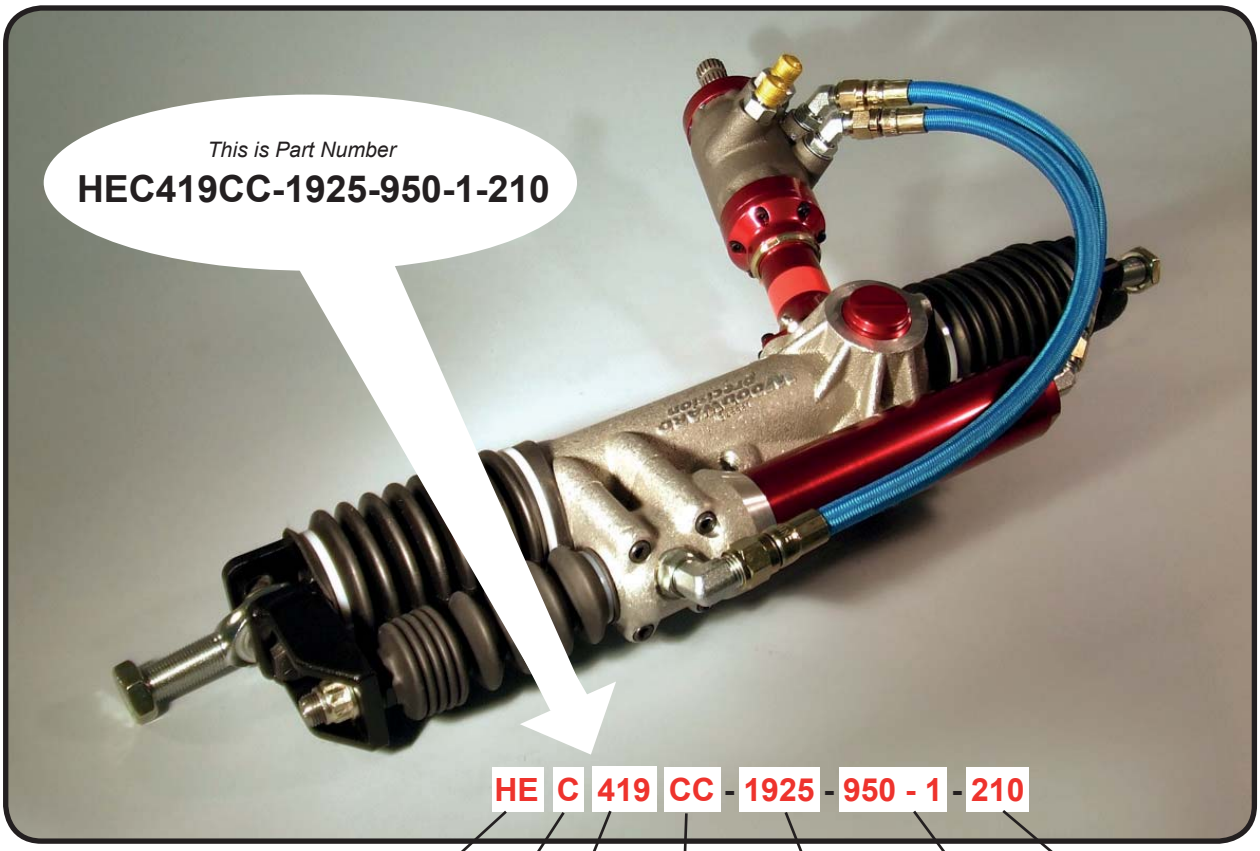
Steering Universal Joints

Woodward needle bearing U-joints are available to connect the safety steering column spline to plain tubular shafts as well as to most popular steering racks and gearboxes.





Guide to GE/HE/GL/HL Rack Part Numbers



HOUSING TYPE

GE–standard housing with remote servo (or manual steering without servo)
HE–standard housing with integral servo
GL–long housing with remote servo (or manual steering without servo)
HL–long housing with integral servo

RACK ENDS

M–monoball rack ends
C–clevis rack ends
no letter–5/8-18 hole

RATIO (inches per turn)

2.09
2.36
2.62
2.88
3.14
3.40
3.66
3.92
4.19
4.45

CYLINDER

CB–1.125 bore
CC–1.375 bore
X–no cylinder

RACKSHAFT (length in inches)

Standard lengths
for **GE/HE:**
1725 1825 1925 1975
for **GEM/HEM:**
1625 1725 1825
for **GEC/HEC:**
1825 1925 1975
for **GL/HL:**
2100 2150 2200 2250
2300 2350 2400 2450
2500 2550 2600 2700
2800 2900 3000 3100
3150

SERVO VALVE PROFILE

850-1
850-2
950-1
955

TORSION BAR IN SERVO

180 185 190
200 205 210
215 220 225
230 235 240

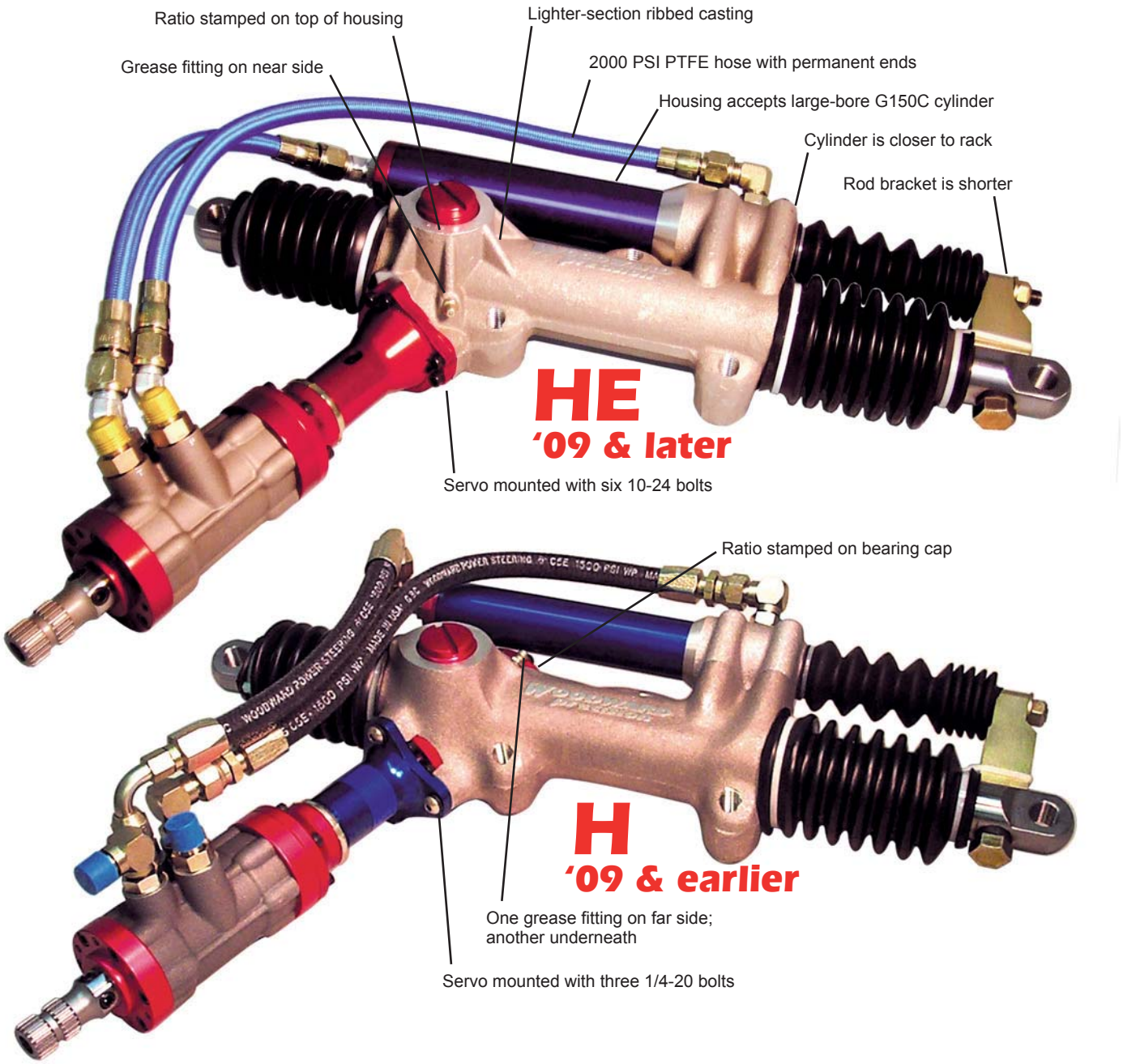
GE/HE/GL/HL rack part numbering system

Our part numbers include as many useful details as possible. Virtually any option can be specified using the codes shown above. Certain rack types are available with extra options, such as the GE/HE series which can be provided with a special rackshaft with two right-side tie rod holes for use on chassis with interchangeable mounting positions for the right-side upper and lower control arms. For example, part number GE366CC-1825/1925-955-210 would be an otherwise standard 18.25 rack but with an extra tie rod hole located one inch outboard on the right. Another combined number is used in the GL/HL series, where frequently the rack travel must be limited to less than the standard 6 inches. If, for example, a 25 inch rack must be limited to have 5 inches' travel, this is done by installing a 25 inch rackshaft in a housing ordinarily used for a 26 inch rackshaft. The part number for such a rack and pinion might be HLM209X-2500/2600-850-2-215.

Certain rack series (notably the GL/HL, MR, MRC, MC and the extensive family of CF racks) consist entirely of custom designs, and therefore have more possible part numbers than will fit on a catalog page. Although nominally built to order, GL/HL racks are offered in standard length increments and these part numbers are shown above. *All other rack types are subject to practically infinite dimensional variations and are assigned individual model numbers during the design stage.*

Rack type recognition

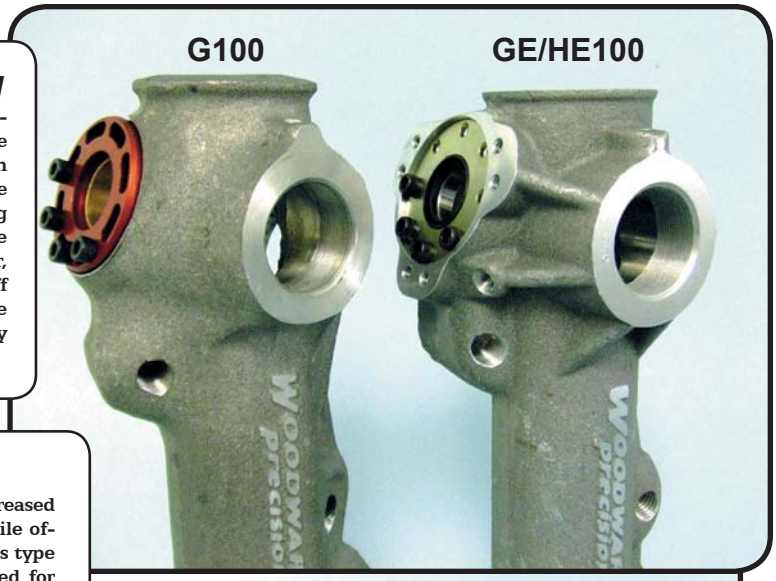
Beginning in 2008, some Woodward rack models underwent a comprehensive redesign. Because almost every detail of our racks was re-engineered and improved, almost none of the internal parts are interchangeable between the former types G and H, and the present type GE/HE. The following pages show the individual parts in their old and new versions. As of January 2013 replacement parts for the type G and H racks were no longer available, with the exception of rackshafts, rack bushings, and servo and cylinder components, which are current. As any type G or H rack still in service is now at least five yars old, it is recommended that it be replaced with one of the newer designs shown in the following pages. The illustration below points out the readily identifiable external features which distinguish the new HE rack from the old H rack:



Please note that improvements and new features are being introduced as time permits. Not all current features or options are shown in the above illustration, but most are. Other Woodward rack types have also been updated or superseded by new designs, and these changes are shown in their respective sections of the catalog.

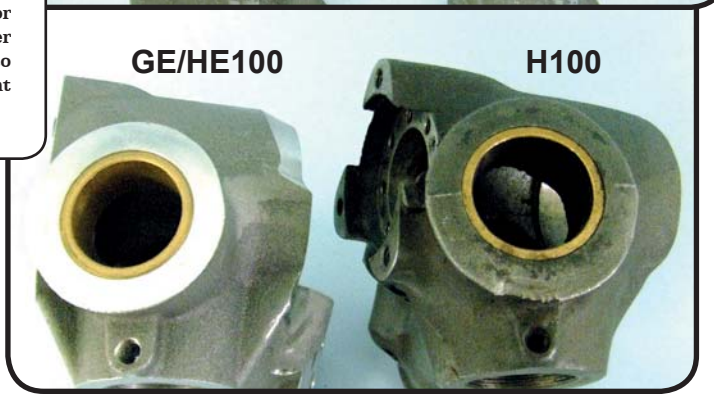
GE/HE housing replaces both G and H

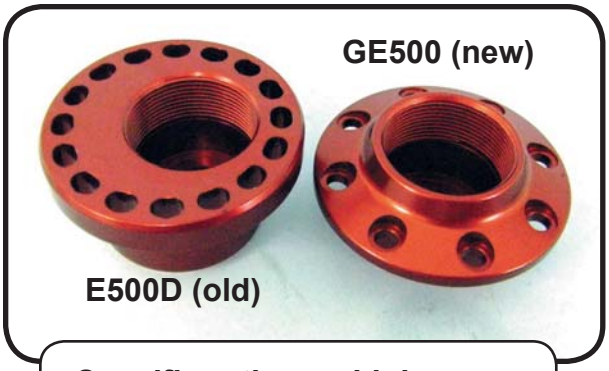
The former H rack, with its mounting provision for direct mounting of the servo, was distinct from the former type G which had no such provision and could be used only with an inline or remote servo. The new GE/HE rack housing can be used either way. When built as a type GE the servo mounting holes have bolts installed in them to exclude dirt. Except for the bolt hole at the upper left, which goes through to the interior, these bolts can be discarded and the cast boss cut or ground off if desired. However, leaving the mounting provision in place enables a GE rack to be converted to an HE at a later time by adding the servo adapter.



More compact design

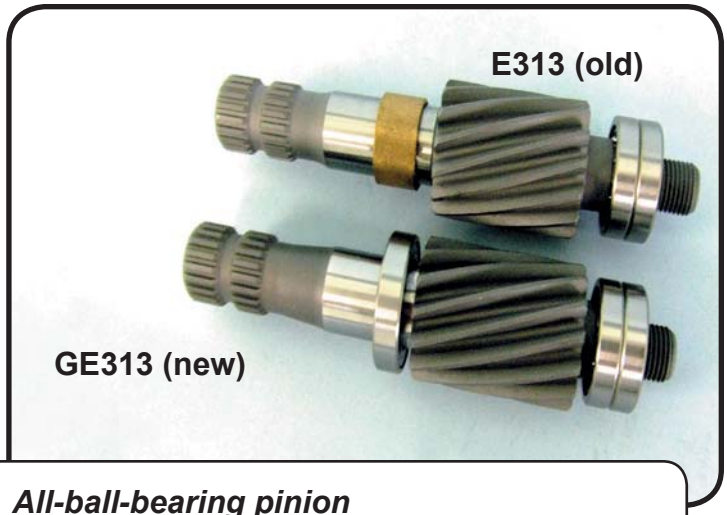
Computer-designed material distribution has greatly increased the stiffness and load-carrying ability of the new housing while offering an extra .25 inch of usable rack travel over the previous type G and H housings. The grease fitting has also been relocated for improved access in the car. The pinion area now packs 50% greater ball-bearing capacity into a shorter space and allows the cylinder to be mounted closer to the rack without compromising the alignment of the pinion with the steering shaft.





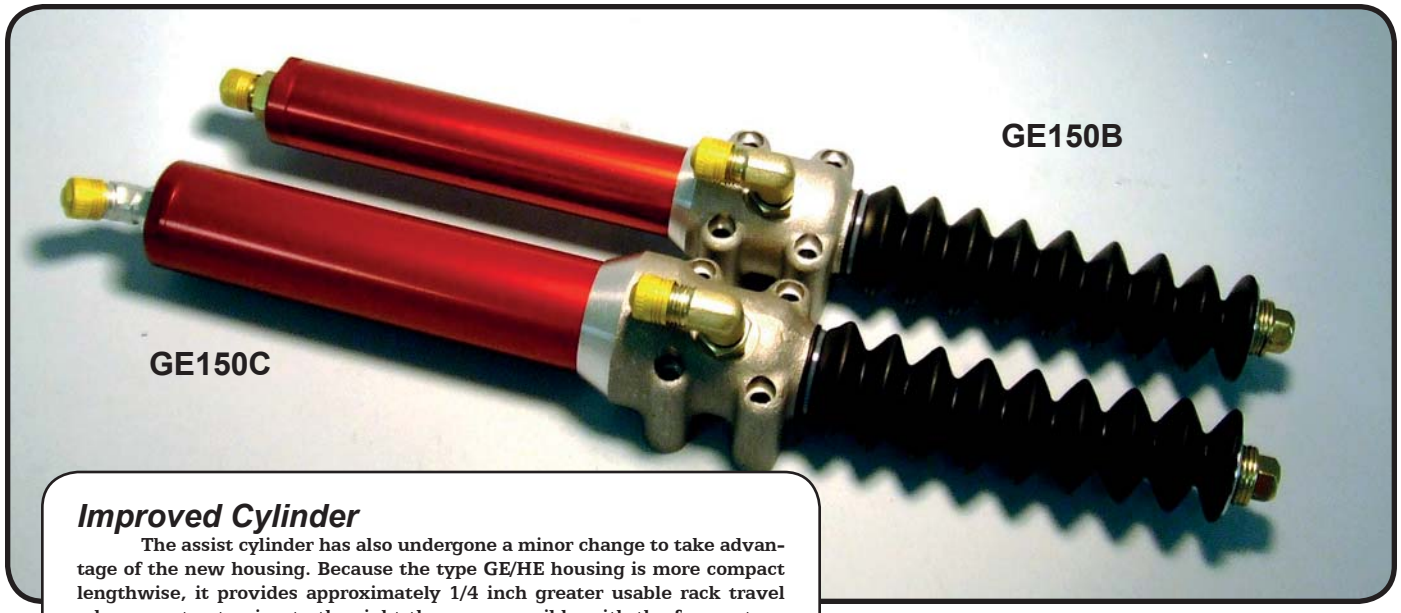
Specific-ratio machining

A five-axis machining process specifically locates the pinion bore for each ratio. The old design used a large assortment of eccentric bearing caps to accommodate different pinions, and was limited to a very coarse adjustment. The new caps have a very small eccentricity which allows the gear backlash to be set to virtually zero while preserving free conjugate action, and eliminating any need for drag-producing preload.



All-ball-bearing pinion

The new pinions are supported by THREE ball bearings for increased radial load capacity and reduced friction. This feature adds significantly to the useful life of the rack, since pinion bushing wear and eventual misalignment of the gear teeth is completely eliminated. The stacked pair of ball bearings used to resist thrust loads was proven effective over many years and has been retained in the new design. A new lip seal to exclude dirt and pressure-washer fluid replaces the o-ring formerly used .



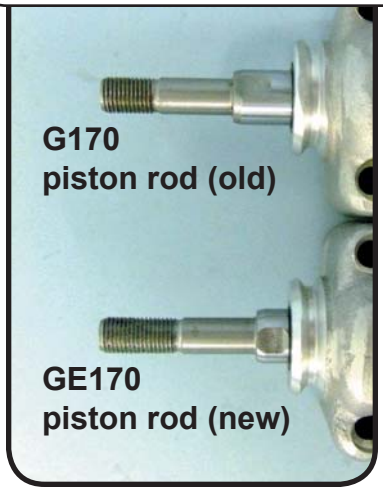
Improved Cylinder

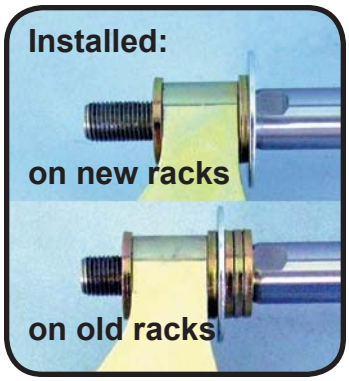
The assist cylinder has also undergone a minor change to take advantage of the new housing. Because the type GE/HE housing is more compact lengthwise, it provides approximately 1/4 inch greater usable rack travel when countersteering to the right than was possible with the former type G and H.

Installing an older G150B cylinder on a new design rack will interfere with rack travel to the left and should have its old design G170 piston rod changed out for a GE170.

The GE150B cylinder (or a G150B converted with a new piston rod) can be made backward-compatible with old racks by adding a .25 inch stack of washers between the rod and the bracket.

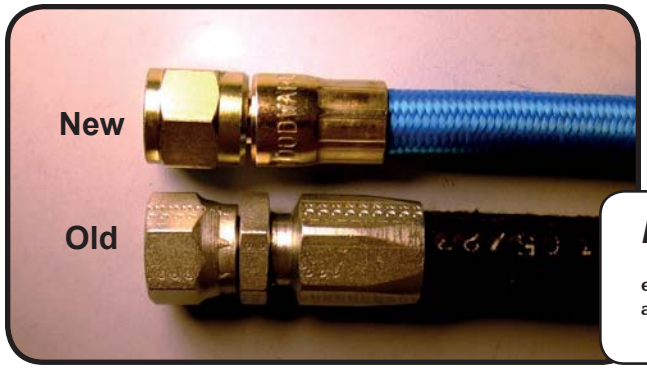
The GE150C large-bore cylinder is standard on the 4.19 and 4.45 racks and optional on slower ratios, but will NOT fit older G and H racks.





Shorter Rod Bracket

Moving the cylinder closer to the rack has resulted in a shorter and stiffer rod bracket capable of transferring the full force of the large-bore cylinder at maximum pump pressure without deflection. The twelve-point bolt shown above has been discontinued in favor of a grade 8 hex bolt manufactured by Lake Erie.



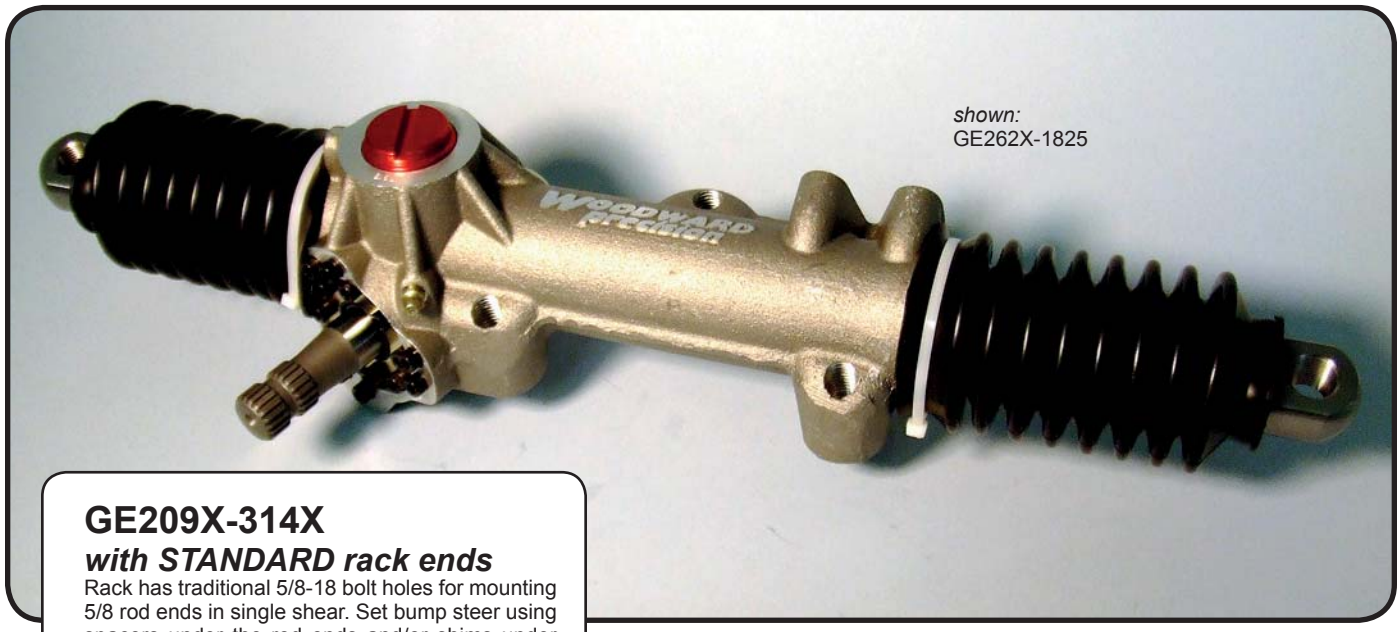
Lightweight Pressure Hose

We have replaced the previous 1500 PSI hydraulic hose and reusable ends with PTFE core 2000 PSI hose and permanent ends, for lighter weight and improved flow. All hose end fittings are manufactured by Woodward.

Type GE Manual Racks (ratios from 2.09 through 3.14 inches per turn)

General purpose manual steering applications

One-piece housing with heavy-duty rackshaft and all-ball-bearing pinion, available in three tie-rod styles.



shown:
GE262X-1825

GE209X-314X
with STANDARD rack ends

Rack has traditional 5/8-18 bolt holes for mounting 5/8 rod ends in single shear. Set bump steer using spacers under the rod ends and/or shims under the rack housing.

GE209X-1725, -1825
GE236X-1725, -1825
GE262X-1725, -1825
GE288X-1725, -1825
GE314X-1725, -1825

Ratios quicker than 3.14 inches per turn, although available on special order, are not listed here because they are not generally practical without power assist. The former extra-slow ratios of 1.83 and 1.57 have been discontinued.

The housing is machined for later conversion to power steering. Racks with standard or monoball rack ends can be equipped for power-assisted operation by bolting on a servo, a cylinder, and the appropriate rod bracket. Other parts required are pump, reservoir and hoses. See the Power Steering Components section for details.

GEM209X-314X
with MONOBALL rack ends

Heavy duty, externally adjustable monoball ends swivel through 52 degrees. Set bump steer using shims under the housing. Stroke is reduced on racks shorter than 18.25.

GEM209X-1625, -1725, -1825
GEM236X-1625, -1725, -1825
GEM262X-1625, -1725, -1825
GEM288X-1625, -1725, -1825
GEM314X-1625, -1725, -1825

GEC209X-314X *NEW!*
with SLOTTED CLEVIS rack ends

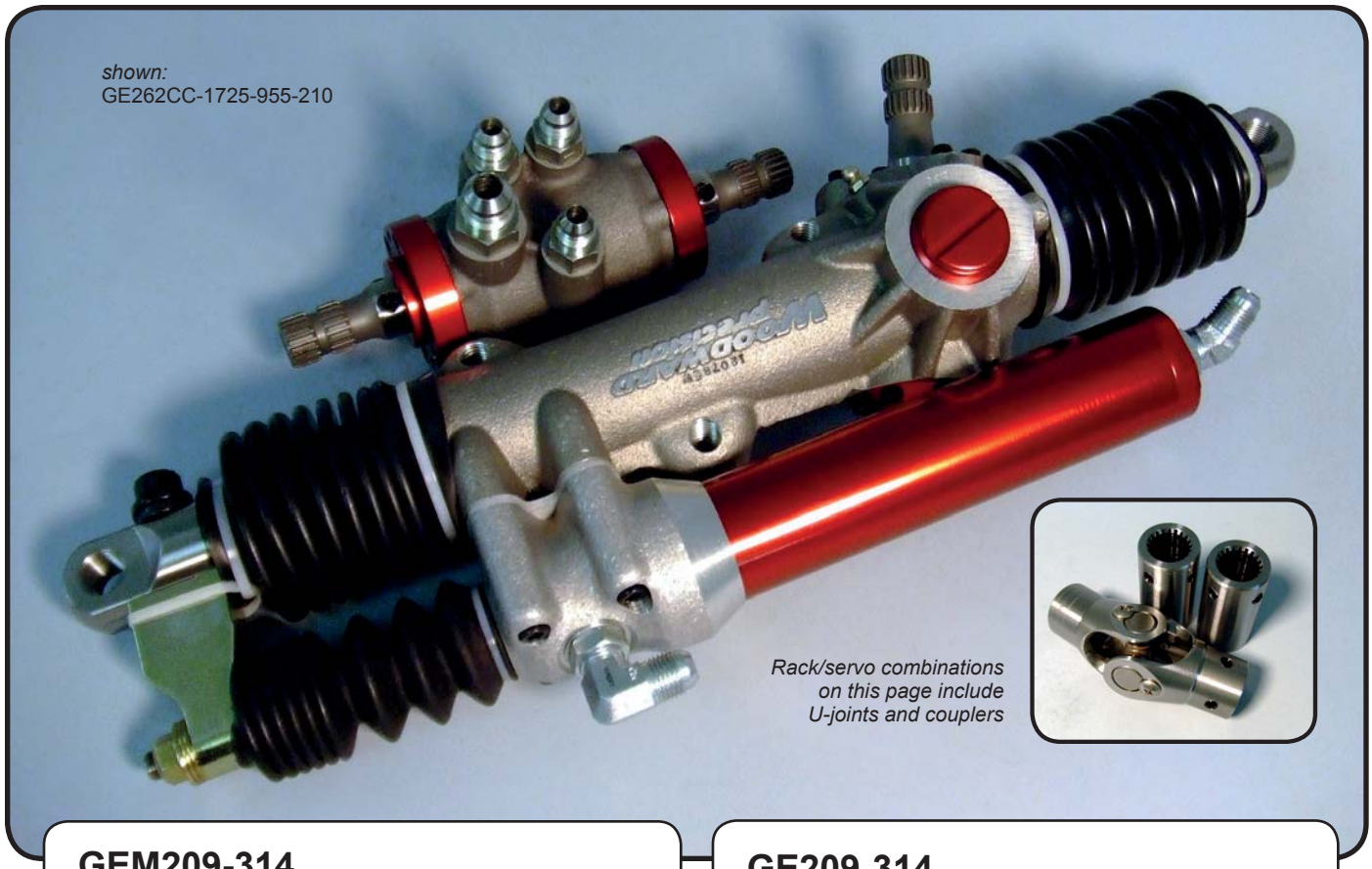
Includes 5/8 rod ends with 1/2 bolts in double shear. Set bump steer using shims under the housing and/or repositioning the rod ends in the slots.

GEC209X-1925, -1975
GEC236X-1925, -1975
GEC262X-1925, -1975
GEC288X-1925, -1975
GEC314X-1925, -1975

Type GE Power Racks (ratios from 2.09 through 3.14 inches per turn)

Power steering with inline servo, paved oval track applications

With power steering, the physical effort of steering is independent of the gear ratio; therefore, it is usually possible to use much quicker steering than with a plain manual unit. The servo has a splined input and output and can be installed anywhere in the steering column. The servo case does not have to be mounted to the chassis, provided at least one end is rigidly coupled into the steering shaft. The High Load Option is recommended for chassis setups using extreme anti-dive/caster gain or quicker steering ratios.



shown:
GE262CC-1725-955-210

Rack/servo combinations on this page include U-joints and couplers

GEM209-314

with MONOBALL rack ends

Rack has monoball ends. Set bump steer using shims under the housing.

With 800 series servo and B cylinder:
GEM209CB-1625, 1725, -1825
GEM236CB-1625, 1725, -1825
GEM262CB-1625, 1725, -1825
GEM288CB-1625, 1725, -1825
GEM314CB-1625, 1725, -1825

With High Load Option (900 series servo and C cylinder):
GEM209CC-1625, 1725, -1825
GEM236CC-1625, 1725, -1825
GEM262CC-1625, 1725, -1825
GEM288CC-1625, 1725, -1825
GEM314CC-1625, 1725, -1825

GE209-314

with STANDARD rack ends

Rack has vertical 5/8-18 bolt holes for mounting 5/8 spherical rod ends in single shear.

With 800 series servo and B cylinder:
GE209CB-1725, -1825
GE236CB-1725, -1825
GE262CB-1725, -1825
GE288CB-1725, -1825
GE314CB-1725, -1825

With High Load Option (900 series servo and C cylinder):
GE209CC-1725, -1825
GE236CC-1725, -1825
GE262CC-1725, -1825
GE288CC-1725, -1825
GE314CC-1725, -1825

GEC209X-314 *NEW!*

with SLOTTED CLEVIS rack ends

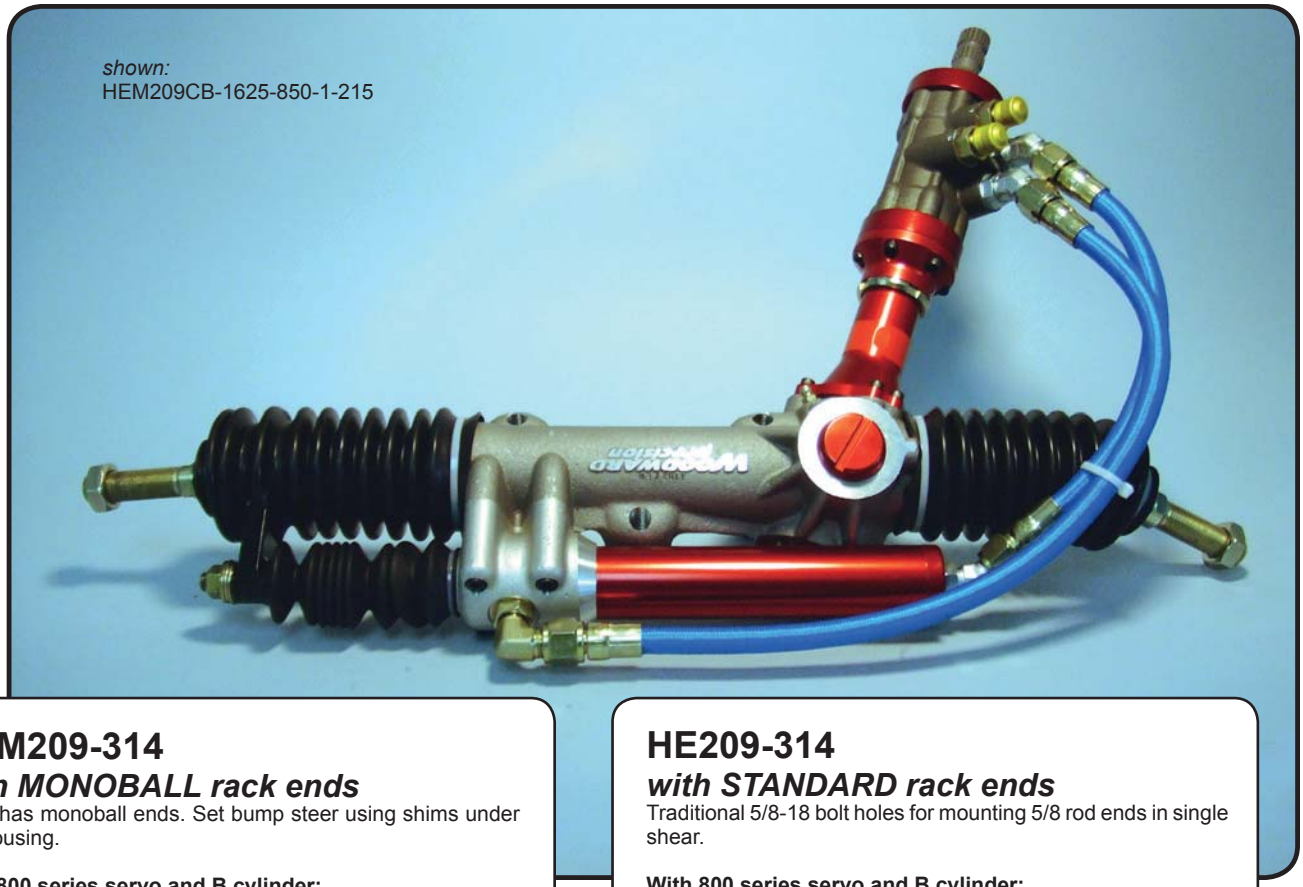
Includes 5/8 rod ends with 1/2 bolts in double shear. Set bump steer using shims under the housing and/or repositioning the rod ends in the slots.

GEC209CC-1825, -1925, -1975
GEC236CC-1825, -1925, -1975
GEC262CC-1825, -1925, -1975
GEC288CC-1825, -1925, -1975
GEC314CC-1825, -1925, -1975

Type HE Power Racks (ratios from 2.09 through 3.14 inches per turn)

Power steering with integral servo, paved oval track applications

These units have the servo mounted directly to the rack. This arrangement eliminates the extra u-joint and coupler used with an inline servo, and uses shorter hoses. The servo can be rotated for hose clearance. When ordering, specify the ratio and rack length (e.g. HE262CB-1825) and the servo valve and valve torsion bar (e.g. 855-205). The High Load Option is recommended for chassis setups using anti-dive/extreme caster gain or quick steering. Note: Many pavement race cars use a left-side block-mounted dry-sump pump which crowds the area of the servo. In cases of interference, the servo can be easily separated from the rack and mounted inline without any loss of function.



HEM209-314

with MONOBALL rack ends

Rack has monoball ends. Set bump steer using shims under the housing.

With 800 series servo and B cylinder:
HEM209CB-1625, -1725, -1825
HEM236CB-1625, -1725, -1825
HEM262CB-1625, -1725, -1825
HEM288CB-1625, -1725, -1825
HEM314CB-1625, -1725, -1825

With High Load Option (900 series servo and C cylinder):
HEM209CC-1625, 1725, -1825
HEM236CC-1625, 1725, -1825
HEM262CC-1625, 1725, -1825
HEM288CC-1625, 1725, -1825
HEM314CC-1625, 1725, -1825

HE209-314

with STANDARD rack ends

Traditional 5/8-18 bolt holes for mounting 5/8 rod ends in single shear.

With 800 series servo and B cylinder:
HE209CB-1725, -1825
HE236CB-1725, -1825
HE262CB-1725, -1825
HE288CB-1725, -1825
HE314CB-1725, -1825

With High Load Option (900 series servo and C cylinder):
HE209CC-1725, -1825
HE236CC-1725, -1825
HE262CC-1725, -1825
HE288CC-1725, -1825
HE314CC-1725, -1825

NEW! HEC209-314

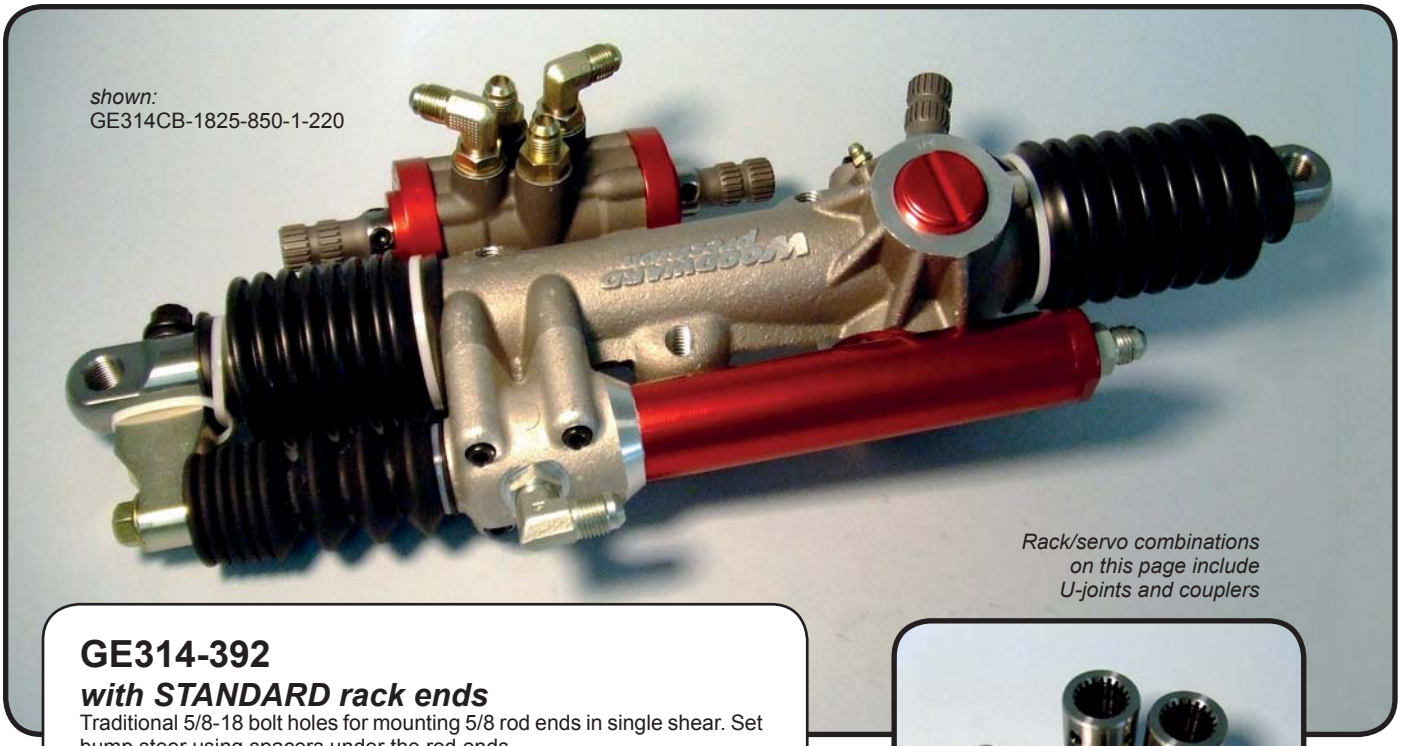
with CLEVIS rack ends with vertical slots providing 3/8 quick and precise bump steer adjustment with a 1/2 bolt in double shear. Includes 5/8 rod ends. Refer to technical description on subsequent pages. *NOTE SPECIFIC RACK LENGTHS* for clevis racks.

HEC209CC-1825, 1925, -1975
HEC236CC-1825, 1925, -1975
HEC262CC-1825, 1925, -1975
HEC288CC-1825, 1925, -1975
HEC314CC-1825, 1925, -1975

Type GE Power Racks (ratios from 3.14 through 3.92 inches per turn)

Power steering with inline servo, dirt oval track applications

The servo has a splined input and output and can be installed anywhere in the steering column. The servo case does not have to be mounted to the chassis, provided at least one end is rigidly coupled into the steering shaft. The High Load Option is recommended for chassis setups using extreme anti-dive/caster gain, or where mechanical leverage is lacking due to spindles with short steering arms. The most popular ratio in this group is the 3.66; the slower ratios were at one time used in late models practically everywhere but are now used mainly for limiteds or on cars running exclusively on larger race tracks.



shown:
GE314CB-1825-850-1-220

Rack/servo combinations on this page include U-joints and couplers

GE314-392

with STANDARD rack ends

Traditional 5/8-18 bolt holes for mounting 5/8 rod ends in single shear. Set bump steer using spacers under the rod ends.

With 800 series servo and B cylinder:
GE314CB-1825, -1925, -1975
GE340CB-1825, -1925, -1975
GE366CB-1825, -1925, -1975
GE392CB-1825, -1925, -1975

With High Load Option (900 series servo and C cylinder):
GE314CC-1825, -1925, -1975
GE340CC-1825, -1925, -1975
GE366CC-1825, -1925, -1975
GE392CC-1825, -1925, -1975

NEW! GEC314-392

with CLEVIS rack ends with vertical slots providing 3/8 quick and precise bump steer adjustment with a 1/2 bolt in double shear. Includes 5/8 rod ends. The 19.25 and 19.75 lengths feature a full usable 6 inches of rack travel for the maximum possible steering angle, with internal positive stops to prevent damage to the rubber boots. The 18.25 length has 5 inches travel. *NOTE: Clevis racks use a redesigned cylinder with a heavy duty piston rod and a larger nut; older style cylinders will not fit these racks.*

GEC314CC-1825, -1925, -1975
GEC340CC-1825, -1925, -1975
GEC366CC-1825, -1925, -1975
GEC392CC-1825, -1925, -1975

Type HE and HEC Power Racks (ratios from 3.14 through 3.92 inches per turn)

Power steering with integral servo, dirt oval track applications

Like their paved-track counterparts, hese units have the servo rigidly attached to the rack with six bolts. Note: The crossmembers on some existing dirt late models may interfere with these bolts. While a double-tube crossmember can easily be modified for the necessary clearance and reinforced with a backup gusset, it is generally not practical to do this on a single round tube. In such cases the rack and servo can be separated and installed as an inline setup, which is functionally identical. Some chassis are now being built with a crossmember specifically designed to accept this rack without interference; if you are considering a new car, call us for recommendations. Chassis setups using extreme front anti-dive (caster gain) and/or short steering arms may need the High Load Option.

shown:
HE366CB-1825-850-1-220

HE314-392

with STANDARD rack ends

Traditional 5/8-18 bolt holes for mounting 5/8 rod ends in single shear. Set bump steer using spacers under the rod ends.

With 800 series servo and B cylinder:
HE314CB-1825, -1925, -1975
HE340CB-1825, -1925, -1975
HE366CB-1825, -1925, -1975
HE392CB-1825, -1925, -1975

With High Load Option (900 series servo and C cylinder):
HE314CC-1825, -1925, -1975
HE340CC-1825, -1925, -1975
HE366CC-1825, -1925, -1975
HE392CC-1825, -1925, -1975

NEW! HEC314-392

with CLEVIS rack ends with vertical slots providing 3/8 quick and precise bump steer adjustment with a 1/2 bolt in double shear. Includes 5/8 rod ends. The 19.25 and 19.75 lengths feature a full usable 6 inches of rack travel for the maximum poss ble steering angle, with internal positive stops to prevent damage to the rubber boots. The 18.25 length has 5 inches travel. *NOTE: Clevis racks use a redesigned cylinder with a heavy duty piston rod and a larger nut; older style cylinders will not fit these racks.*

HEC314CC-1825, -1925, -1975
HEC340CC-1825, -1925, -1975
HEC366CC-1825, -1925, -1975
HEC392CC-1825, -1925, -1975

Type HEC and HE Power Racks (ratios 4.19 and 4.45 inches per turn)

Super-quick power steering with integral servo, dirt oval track applications

The 4.19 and 4.45 ratios are equipped standard with the High Load Option. The larger internal porting of the 900 series servo is designed specifically for the unrestricted flow needed to power the larger-bore cylinder at the higher velocities of these racks. Note: These racks require a constant pump volume of at least 3 GPM (12 liters/min). Also, because steering ratios of four inches per turn and up have a severely reduced mechanical advantage, pumps used with these racks should have a minimum pressure relief setting of 1450 PSI (100 bars). The recent chassis development of raising the rack for better ground clearance has permitted connecting the tie rods closer to the rack centerline, which greatly improves stability over tie rods connected above the rack. The new HEC and GEC series feature a double-shear tie rod attachment and a heavy-duty piston rod bracket.

NEW! HEC419-445

with CLEVIS rack ends with vertical slots providing 3/8 quick and precise bump steer adjustment with a 1/2 bolt in double shear. Includes 5/8 rod ends. The 19.25 and 19.75 lengths feature a full usable 6 inches of rack travel for the maximum poss ble steering angle, with internal positive stops to prevent damage to the rubber boots. The 18.25 length has 5 inches travel. *NOTE: Clevis racks use a redesigned cylinder with a heavy duty piston rod and a larger nut; older style cylinders will not fit these racks.*

HEC419CC-1825, -1925, -1975
HEC445CC-1825, -1925, -1975

shown:
HEC445CC-1925-950-1-205

Rod ends are semi-recessed into these massive steel clevises for more usable rack travel in a given rack length than any other brand. Positive travel stops prevent boot damage.

HE419-445

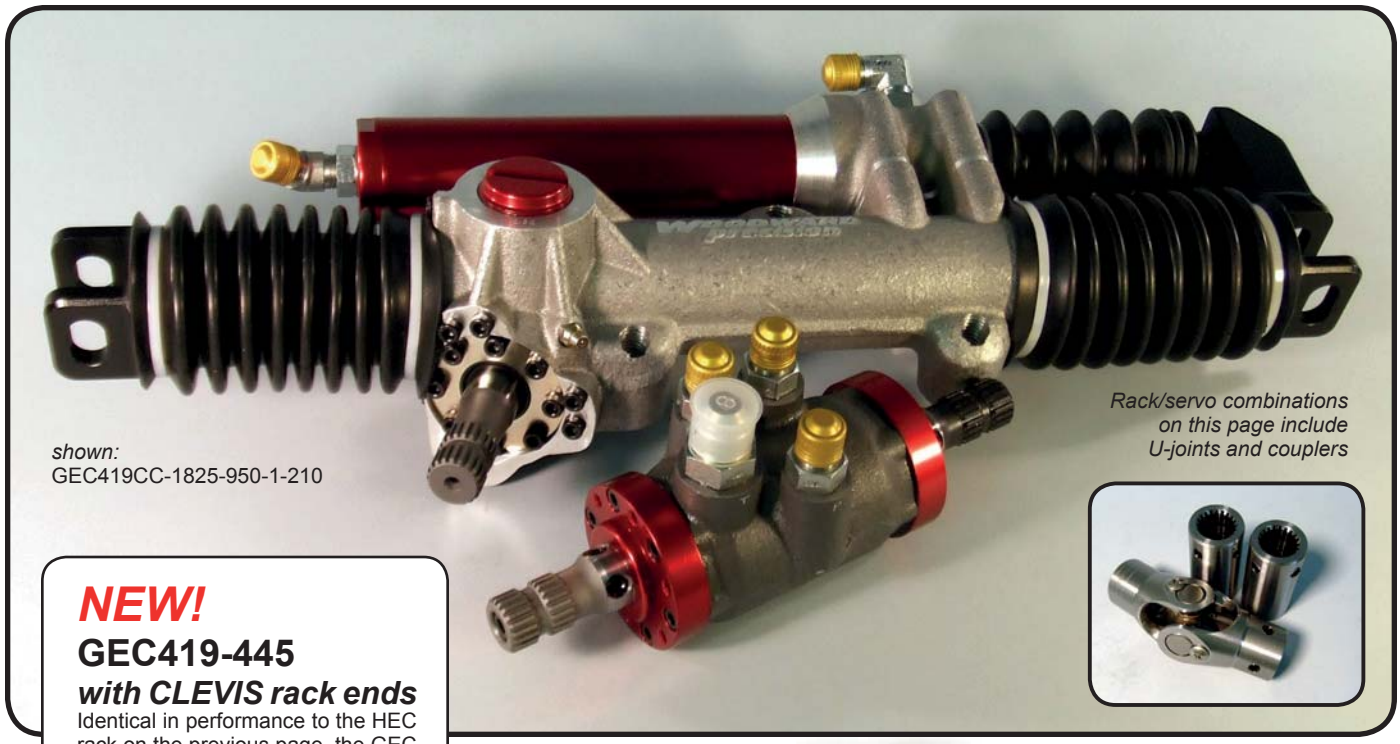
with STANDARD rack ends with traditional 5/8-18 bolt holes for mounting 5/8 rod ends in single shear. Set bump steer using spacers under the rod ends and/or shims under the rack housing.

HE419CC-1825, -1925, -1975
HE445CC-1825, -1925, -1975
HE419CC-1825/1925 (two holes on right)*
**Double-hole rackshaft is machined from a single piece, does not use screw-on ends*

Type GEC and GE Power Racks (ratios 4.19 and 4.45 inches per turn)

Super-quick power steering with inline servo, dirt oval track applications

Functionally identical to the HE Super-Quick rack, the GE Super-quick has a separate servo intended for installion at any convenient point along the steering column. The servo case does not have to be mounted to the chassis, provided at least one end is rigidly coupled into the steering shaft. The High Load Option is standard on the 4.19 and 4.45 ratios. Because steering this quick has a severely reduced mechanical advantage, pumps used with these racks must be capable of supplying at least 3 GPM and should be equipped with a 1450 PSI relief setting. The oversize -12 pump intake kit is also recommended.



shown:
GEC419CC-1825-950-1-210

Rack/servo combinations on this page include U-joints and couplers

NEW!

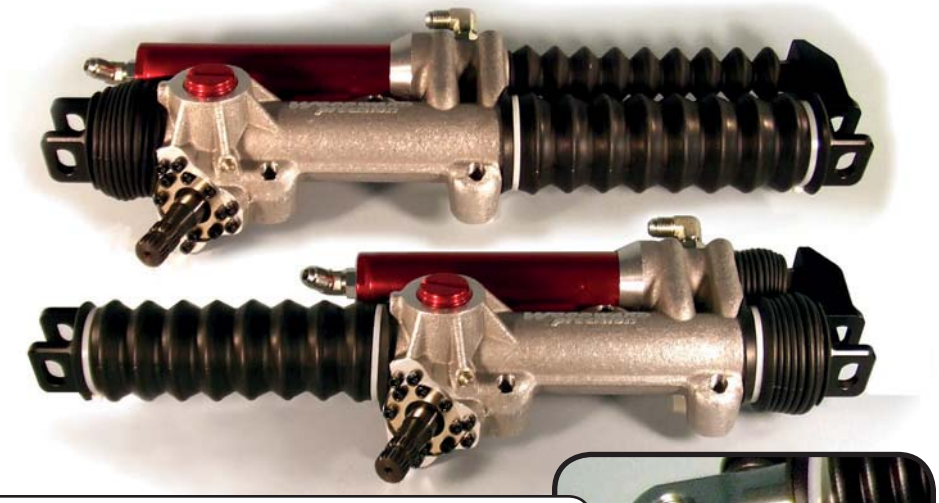
GEC419-445

with CLEVIS rack ends

Identical in performance to the HEC rack on the previous page, the GEC servo mounts inline for clearance. Includes 5/8 rod ends. The 19.25 and 19.75 lengths feature a full usable 6 inches of rack travel for the maximum possible steering angle (see photo at right). Internal positive stops prevent damage to the rubber boots. The 18.25 length has 5 inches travel.

NOTE: Clevis racks use a redesigned cylinder with a heavy duty piston rod and a larger nut; older style cylinders cannot be used on these racks.

GEC419CC-1825, -1925, -1975
1305.15
GEC445CC-1825, -1925, -1975
1305.15



GE419-445

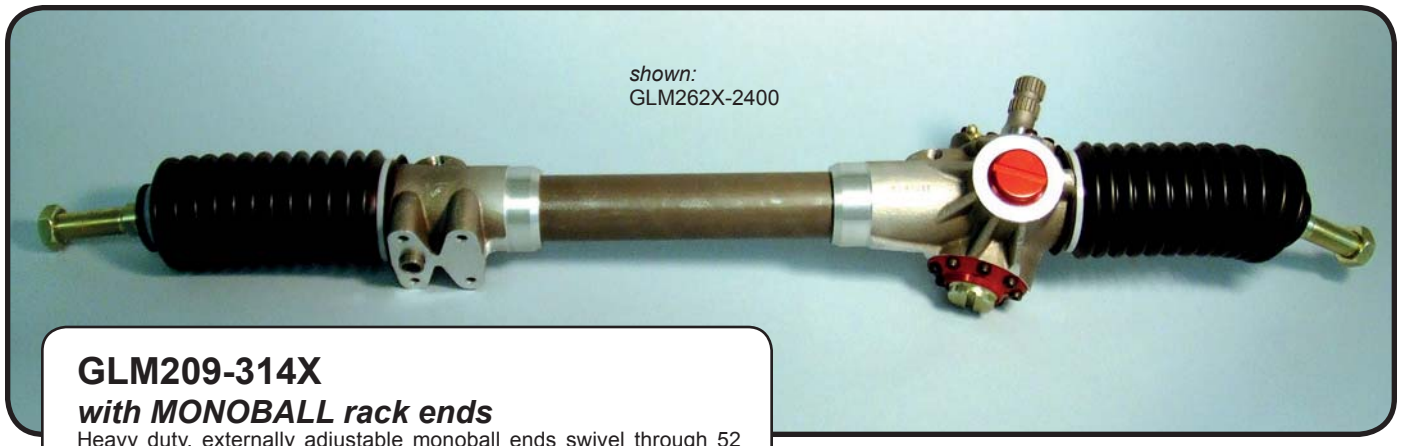
with STANDARD rack ends and traditional 5/8-18 bolt holes for mounting 5/8 rod ends in single shear. Set bump steer using spacers under the rod ends and/or shims under the rack housing.

GE419CC-1825, -1925, -1975
GE445CC-1825, -1925, -1975
GE419CC-1825/1925 (two holes on right)*
**Double-hole rackshaft is machined from a single piece, does not use screw-on ends*

Type GLM, GLC and GL Manual Racks (ratios 2.09 to 3.14 inches per turn)

Longer length manual steering applications

Designed to accommodate the longer rack lengths typical of GT race cars, the housing is made to support the rackshaft proportional to its length, with no more overhang than necessary for the required rack travel. The GL/HL series are built to customer length and stroke requirements, with installation drawings available via return e-mail. The type GL uses the newer internal parts of the GE/HE, such as the all-ball-bearing pinion, and has replaced the former plain-bearing type K. Although they can be supplied on special order, ratios quicker than 3.14 are not listed since these are generally not practical to use without power assist, and the former extra-slow ratios of 1.38 and 1.57 have been discontinued. Available in all three tie-rod styles, GLM (monoball), GLC (slotted clevis) and GL ("standard" vertical bolt).



GLM209-314X

with MONOBALL rack ends

Heavy duty, externally adjustable monoball ends swivel through 52 degrees. Set bump steer using shims under the rack housing. *This is the preferred design for all manual steering applications but the rack mounting height should be established within fairly close limits.*

GLM209X-2100 thru -3150
GLM236X-2100 thru -3150
GLM262X-2100 thru -3150
GLM288X-2100 thru -3150
GLM314X-2100 thru -3150

For manual steering purposes, monoball rack ends are by far the preferred style. They promote easier steering because they do not impose offset loads.

GL series racks can be upgraded to power assisted operation by bolting on a servo, a cylinder and the appropriate rod bracket. Direct servo attachment was not possible with the K series. The two-bolt rack mounting method, besides providing clearance for an integral servo, is much more fabricator-friendly than the former type K with its vertical bulkhead mount. With a GL, chassis bracketry can be as simple as a pair of tabs with 1/2 inch holes.

GLC209-314X *NEW!*

with CLEVIS rack ends

Rack has 5/8 spherical rod ends with 1/2 bolts in double shear, using the new slotted clevises. Set bump steer using shims under the housing and by adjusting the rod ends vertically in the slots.

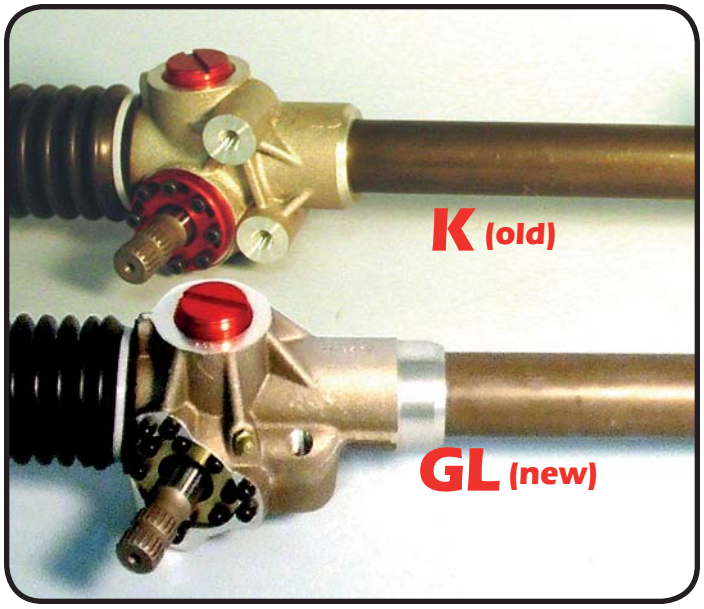
GLF209X-2100 thru -3150
GLF236X-2100 thru -3150
GLF262X-2100 thru -3150
GLF288X-2100 thru -3150
GLF314X-2100 thru -3150

GL209-314X

with STANDARD rack ends

Rack has the traditional vertical 5/8-18 bolt holes for mounting 5/8 spherical rod ends in single shear. Bump steer is set using spacers under the rod ends and/or shims under the rack housing.

GL209X-2100 thru -3150
GL236X-2100 thru -3150
GL262X-2100 thru -3150
GL288X-2100 thru -3150
GL314X-2100 thru -3150



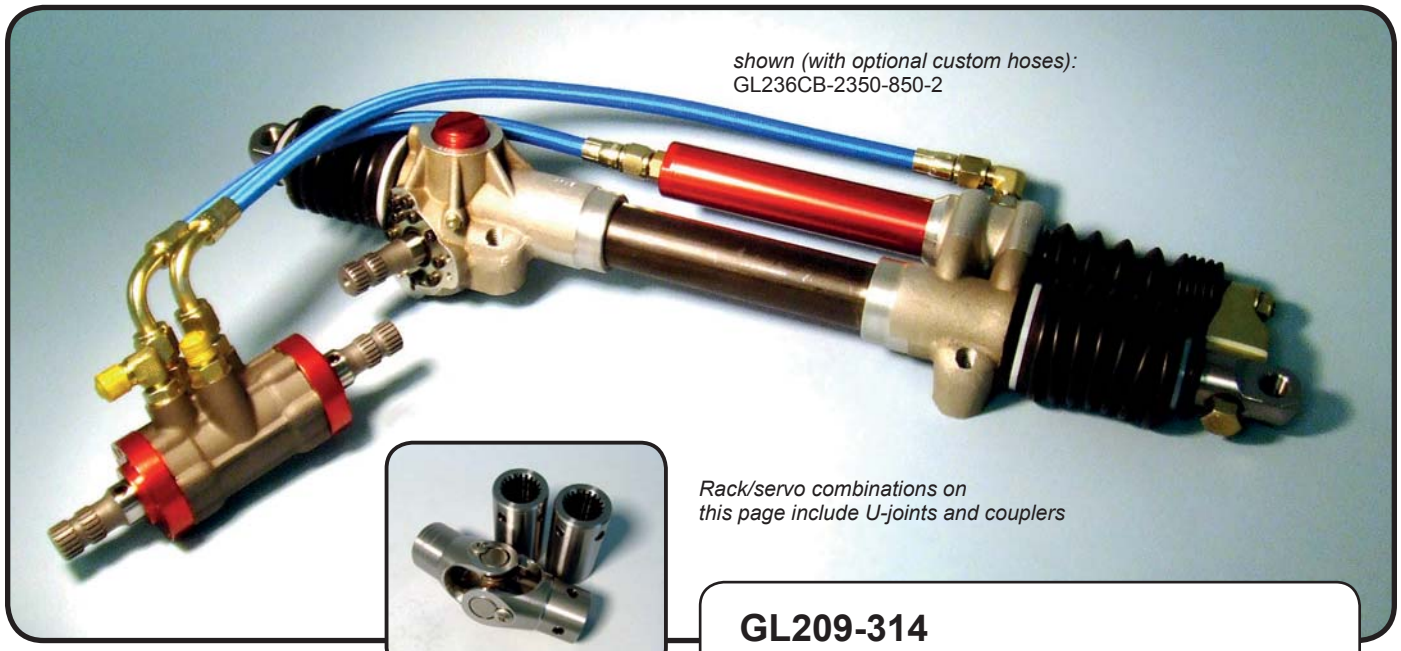
Improvements over the former type K rack

The four 3/8 holes of the type K are replaced with two 1/2 holes with the pinion angled upward 15 degrees from the mounting plane. Viewed from above, the pinion is angled away from center at 20 degrees instead of 12.

Type GL, GLM and GLC Power Racks (ratios 2.09 to 3.14 inches per turn)

Power steering with inline servo, road racing and custom car applications

As with the manual GL racks, the housing is made to support the rackshaft proportional to its length, with no more overhang than necessary for the required rack travel. These racks are built to customer specifications for length and stroke; installation drawings are available by return e-mail. Note that ratios quicker than 3.14 are not commonly used in most applications of these racks; however, quicker ratios are practical for special applications such as autocross. The High Load Option is recommended for the quicker ratios and/or heavier cars.



shown (with optional custom hoses):
GL236CB-2350-850-2

Rack/servo combinations on this page include U-joints and couplers

NOTE: GL and HL racks can exert over a ton of axial force and have been known to flex a thinwall crossmember and elongate the bolt holes in individual welded tabs. If not restrained by the structure of the chassis it can actually force itself apart. It is best to think of the rack as a Porta-Power jack lying horizontally and to reinforce the mounting provisions accordingly. The best practice is to put both bolt holes in a single piece of cold-rolled steel at least 3/8 thick.

GL209-314

with STANDARD rack ends

With 800 series servo and B cylinder:
GL209CB-2100 thru -3150
GL236CB-2100 thru -3150
GL262CB-2100 thru -3150

With High Load Option (900 series servo and C cylinder):
GL209CC-2100 thru -3150
GL236CC-2100 thru -3150
GL262CC-2100 thru -3150
GL288CC-2100 thru -3150
GL314CC-2100 thru -3150

GLM209-314

with MONOBALL rack ends

With 800 series servo and B cylinder:
GLM209CB-2100 thru -3150
GLM236CB-2100 thru -3150
GLM262CB-2100 thru -3150

With High Load Option (900 series servo and C cylinder):
GLM209CC-2100 thru -3150
GLM236CC-2100 thru -3150
GLM262CC-2100 thru -3150
GLM288CC-2100 thru -3150
GLM314CC-2100 thru -3150

NEW! GLC262-445

with CLEVIS rack ends

"Autocross Special"

Highly aggressive steering, especially suitable for throwing a car sideways around cones in a parking lot. With High Load Option only; uses clevises at left with heavy-duty piston rod (see description of dirt track racks on previous pages):

GLC262CC-2100 thru -3150
GLC288CC-2100 thru -3150
GLC314CC-2100 thru -3150
GLC340CC-2100 thru -3150
GLC366CC-2100 thru -3150
GLC392CC-2100 thru -3150
GLC419CC-2100 thru -3150
GLC445CC-2100 thru -3150

Type HLM and HL Power Racks (ratios 2.09 to 3.14 inches per turn)

Power steering with integral servo, road racing and custom car applications

These units have the servo mounted directly to the rack. The servo can be rotated for hose clearance. The High Load Option is recommended for heavier cars (above 2400 lb/1100kg) or for special-order quicker ratios. In cases of component interference, the servo can be easily separated from the rack and mounted inline. The HL rack is functionally identical to the GL, but the integral-servo configuration eliminates the extra u-joint and coupler needed with an inline servo.

shown:
HLM262CC-2500-950-1

HLM209-314
with MONOBALL rack ends

With 800 series servo and B cylinder:
HLM209CB-2100 thru -3150
HLM236CB-2100 thru -3150
HLM262CB-2100 thru -3150
HLM288CB-2100 thru -3150
HLM314CB-2100 thru -3150

With High Load Option (900 series servo and C cylinder):
HLM209CC-2100 thru -3150
HLM236CC-2100 thru -3150
HLM262CC-2100 thru -3150
HLM288CC-2100 thru -3150
HLM314CC-2100 thru -3150

Installation of GL/HL Power Racks:

Type GL/HL power steering racks feature highly convenient mounting with two 1/2-13 bolts screwed directly into the housing from underneath. Unlike their manual counterparts, however, these racks are capable of applying tremendous force in the axial direction, much like a body and frame straightening jack. In any application requiring high-powered steering, the chassis attachment points should be carefully inspected for elongation of the bolt holes. Reinforcing the individual mounting tabs may not be enough, as these racks have been known to stretch a lightweight crossmember. If this happens, the rack will be free to literally jack itself apart like a hydraulic press. To prevent the power assist from overpowering its own chassis attachment, use a single thick bracket with two holes rather than a pair of tabs.

NEW! HLC262-445
with CLEVIS rack ends
"Autocross Special"

Highly aggressive steering, especially suitable for throwing a car sideways around cones in a parking lot. With High Load Option only; uses clevises at left with heavy-duty piston rod (see description of dirt track racks on previous pages):

HLC262CC-2100 thru -3150
HLC288CC-2100 thru -3150
HLC314CC-2100 thru -3150
HLC340CC-2100 thru -3150
HLC366CC-2100 thru -3150
HLC392CC-2100 thru -3150
HLC419CC-2100 thru -3150
HLC445CC-2100 thru -3150

HL209-314
with STANDARD rack ends

With 800 series servo and B cylinder:
HL209CB-2100 thru -3150
HL236CB-2100 thru -3150
HL262CB-2100 thru -3150
HL288CB-2100 thru -3150
HL314CB-2100 thru -3150

With High Load Option (900 series servo and C cylinder):
HL209CC-2100 thru -3150
HL236CC-2100 thru -3150
HL262CC-2100 thru -3150
HL288CC-2100 thru -3150
HL314CC-2100 thru -3150

Type MR Power Racks

Power steering with integral cylinder and servo, for road racing and proprietary supercars

For installations requiring relatively long pivot centers. Vastly lighter in weight than any production-car power rack, the minimum length possible to build depends on the rack stroke and the pinion location. MR racks can be built as left or right hand, front or rear steer, offset or centered, in two ratios—2.02 and 2.24 inches/rev (51 and 57 mm/rev) and with a maximum stroke of 5.38 inches. In most MR applications the steering arms on the hub carriers are fairly short, and the rack travel will rarely exceed 4.5 inches. The MR mounts in clamp brackets and can be oriented to any angle.

A tapped bolt circle on the end of the servo provides a rigid and convenient third mounting point. In most cases the rack velocity is low enough that an electric power steering pump can be used. Options include mounting provisions for data acquisition equipment and additional weight reduction by gundrilling the rack shaft. Many variations are possible, a few of which are shown at left.

MR rack prototypes typically cost US$3500 with a 4 week lead time following customer approval of the 3D CAD model. To obtain a design proposal and a quote please specify the following details so we can determine how one can be manufactured to fit your application:

(1) Pivot center distance
(2) Total rack travel required L to R
(3) Ratio (rack travel per revolution)
(4) Pinion location relative to center
(5) Front or rear steer (i.e. whether the rack is to be located ahead of or behind the front wheels)

Other information about the car can be very helpful in determining the required level of power assist. If the vehicle is an early-stage prototype and its characteristics are unknown, we suggest the prototype rack be ordered with a range of servo valve components to allow substitution during track testing.

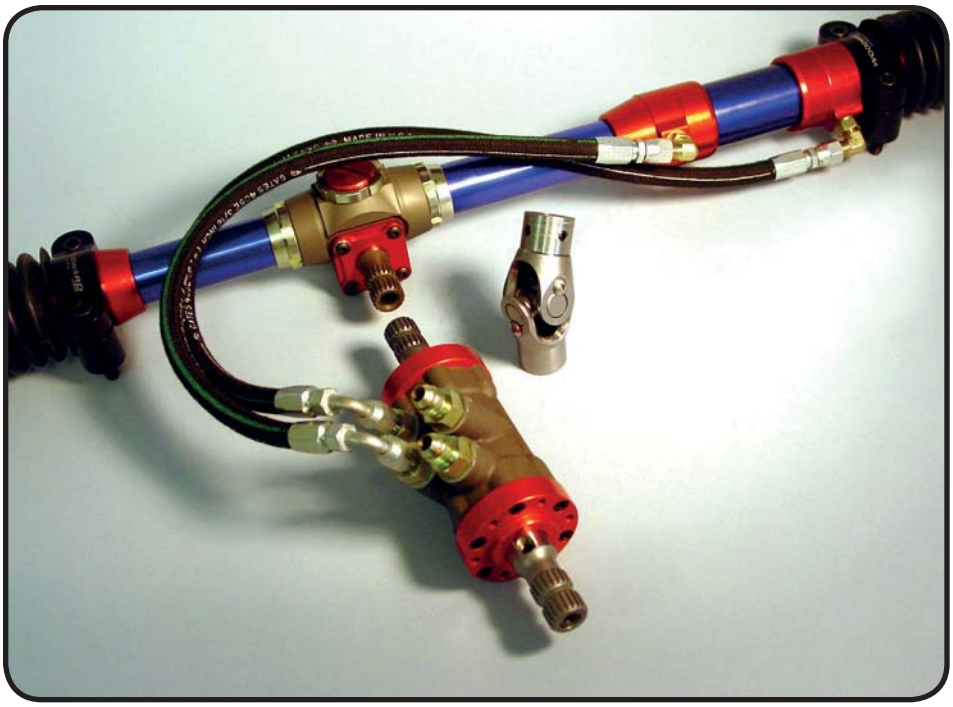
Please bear in mind that not all dimensional combinations are possible. For example, the MR rack has an integral hydraulic cylinder which obviously cannot occupy the same space as the rack teeth. What is often overlooked is that both of these elements must move the full length of the rack travel without mutual interference. This fact imposes a definite minimum on the length of the rack housing, which dictates a minimum length for the rackshaft, which in turn must protrude from the housing at each end by a distance equal to half the travel.

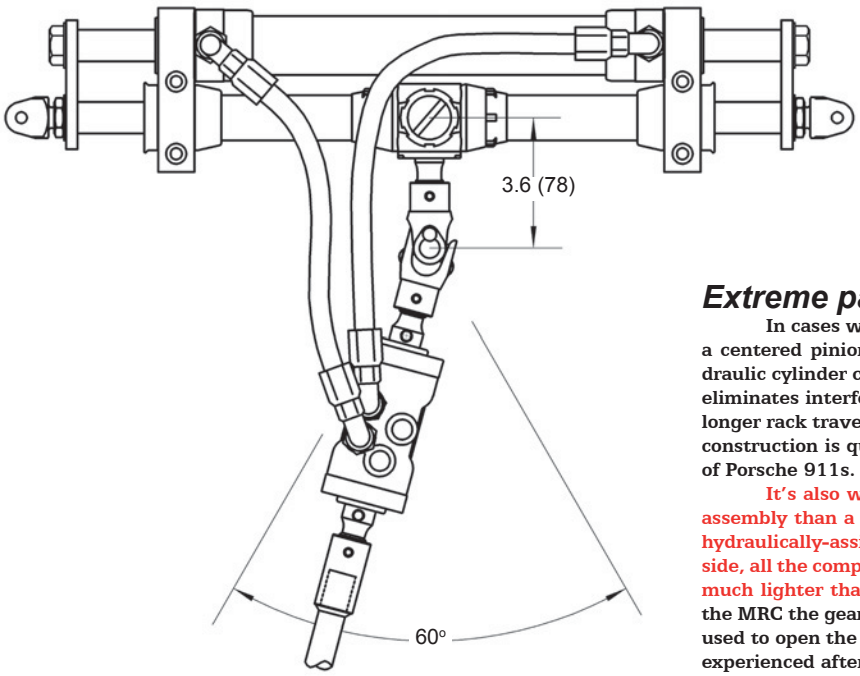
It will be seen that the mounting points on MR racks are located at the extreme ends of the housing tubes so as to obtain the minimum possible rack shaft overhang and the maximum stability. This feature is essential in extracting the maximum efficiency from such an extremely lightweight unit. In cases where a power rack must be made especially short, it is sometimes possible to mount an external cylinder parallel to the rack, as shown at left.

Type MRC Power Racks

Power steering with integral cylinder and inline servo, same applications as MR series

For type MR applications where severe space conflicts exist in the area of the pinion housing such as in front-engined race cars. MRC racks use the much smaller housing of the MC manual rack. With this setup the servo is mounted independently and is connected to the pinion through an intermediate shaft and/or universal joints. Like the MR, these racks can be made left or right hand, front or rear steer, offset or centered, with a maximum stroke of 5.38 inches (136mm) depending on pinion location. While functionally identical to the integral-servo MR, separating the servo from the pinion removes some dimensional constraints and incidentally enables the use of some additional gear ratios. The hollow straight pinion is extremely light. Its straight rolling contact with the rack develops only radial loads which are taken by three ball bearings. The absence of end thrust enables the housing to be miniaturized. It has been described as *"a scale model rack and pinion, but with an output of 1800 lb-force (8,2kN)."* Although there are no functional limitations on its distance from the rack, the servo should not be mounted within the driver's compartment in a way that could directly expose the driver to the radiant heat of operation or to hot fluid.





Steering Ratios

MRC racks are available in ratios of 2.02 (51mm), 2.24 (57mm), 2.69 (68mm), and 3.14 (80mm) per turn.

Clevis Rack Ends

MR, and MRC racks are equipped with heat treated allow steel clevises which accept high-misalignment rod ends in 1/4 inch, 5/16 and 8 mm bolt sizes.

Cost and Lead Time

The typical cost of a prototype MRC rack is UDS$3500 with 4-5 week delivery after approval of a 3D CAD model. In order to quote an MRC we must have the following information:

(1) Pivot center distance
(2) Total rack travel required L to R
(3) Ratio (rack travel per revolution)
(4) Pinion location relative to center
(5) Front or rear steer (i.e. whether the rack is to be located ahead of or behind the front wheels)

When considering the MRC design, please bear in mind that some dimensional combinations may be impossible. Like the MR, the MRC is normally built with an integral hydraulic cylinder. The part of the shaft which slides in the cylinder obviously cannot occupy the same space as the rack teeth. In most cases, the smaller pinion housing of the MRC rack will permit offsetting the pinion somewhat farther to one side than is possible with the MR, making it possible to package a shorter rack.

The MRC is as close to a pure racing component as has ever been produced, and is rapidly becoming the go-to solution for all kinds of prototype race car projects.

Extreme packaging solutions

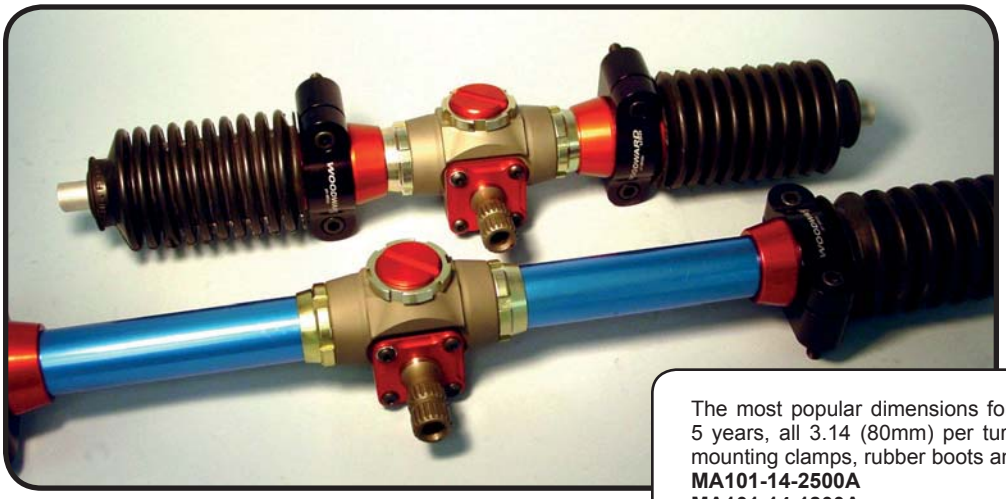
In cases where a very short rack needs power assist (or one with a centered pinion as in many single- or two-seater race cars) the hydraulic cylinder can be fixed ahead of the rack as illustrated at left. This eliminates interference with the rack teeth and opens the possibility of longer rack travel than might be possible with an integral cylinder. This construction is quite robust and in fact has been retrofit into a number of Porsche 911s.

It's also worth mentioning that the MRC is a much lighter total assembly than a manual rack driven by an electric gearmotor. Since in hydraulically-assisted steering the power is amplified on the OUTPUT side, all the components (gear teeth, housing structure, etc) can be made much lighter than if they had to transmit amplified INPUT. Because in the MRC the gears are essentially relieved of all but the very low torque used to open the servovalve, it tends not to develop the play commonly experienced after a few laps with an electric column drive.

Type MC Manual Racks

Manual steering for FSAE and F/Student projects and lightweight formula cars

The MC rack uses the same mounting clamps as the power racks as well as the same clevises. Like the power racks, the mounting points are located a fixed distance from the ends of the housing, which is calculated to result in the minimum possible shaft overhang and the greatest tie-rod stability. Like all Woodward racks these units have the .750-20 pinion spline, which provides a substantially more positive engagement than the .562-36 usually found on small steering racks. To achieve equivalent light weight, the pinion is hollow. The MC incorporates the same level of engineering as the steering racks we make for high-end race cars, and delivers the most function per dollar of anything offered for Formula SAE and Formula Student projects. Now available in a selection of standard dimensions for quick delivery at reasonable cost, the MC series can also be built in custom lengths.



Custom MC Racks

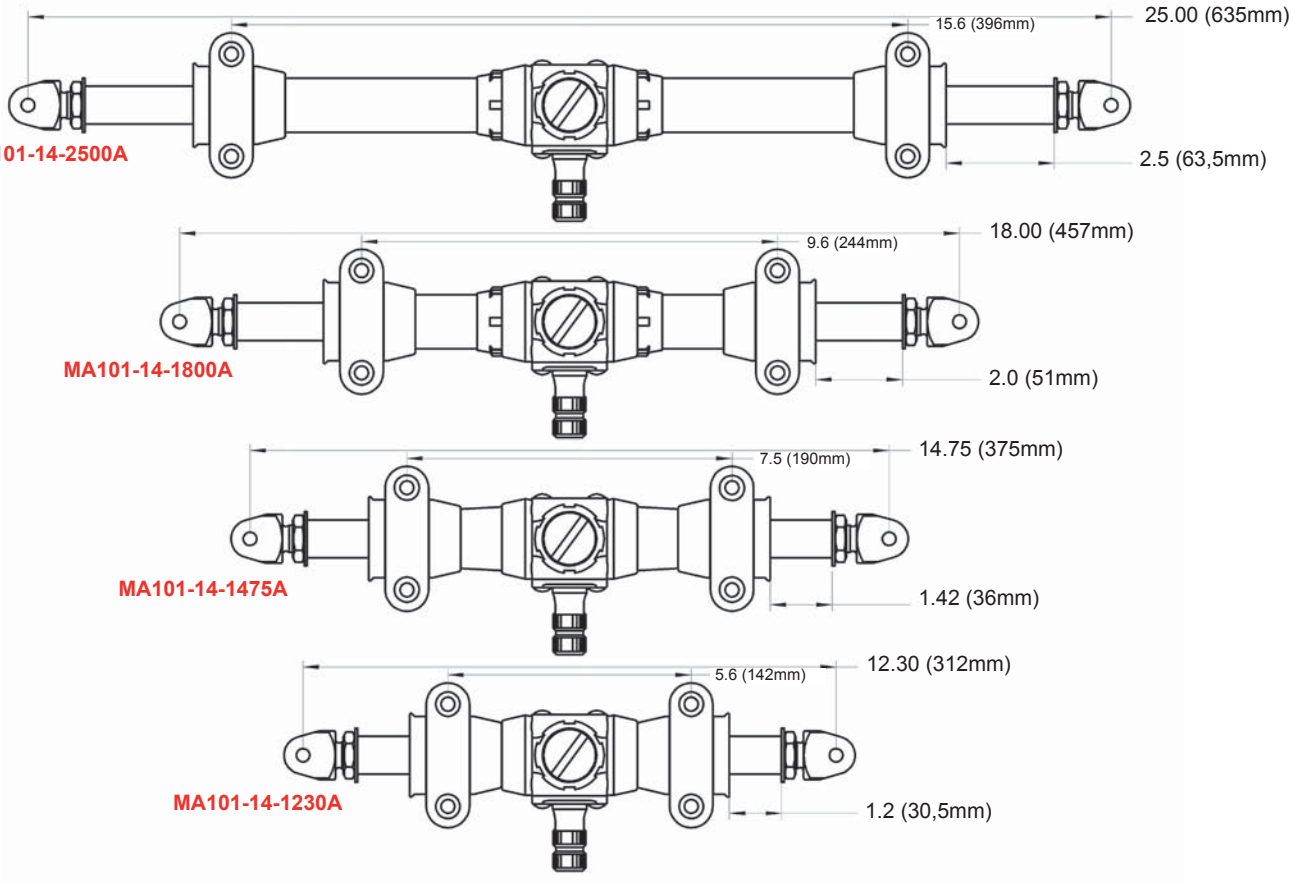
To obtain a quote for a custom MC rack to fit your project, please provide the following data:

(1) Pivot center distance
(2) Total rack travel required L to R
(3) Ratio (rack travel per revolution)
(4) Pinion location relative to center
(5) Front or rear steer (i.e. whether the rack is to be located ahead of or behind the front wheels)

Standard MC Racks

The most popular dimensions for FSAE and F/Student over the past 5 years, all 3.14 (80mm) per turn. Includes weld-on splined coupler, mounting clamps, rubber boots and clevises for 5/16 (8mm) rod ends
MA101-14-2500A
MA101-14-1800A
MA101-14-1475A
MA101-14-1230A

Note: Rack ends adjust +.275 /-.120 (+7/-3mm) at each end

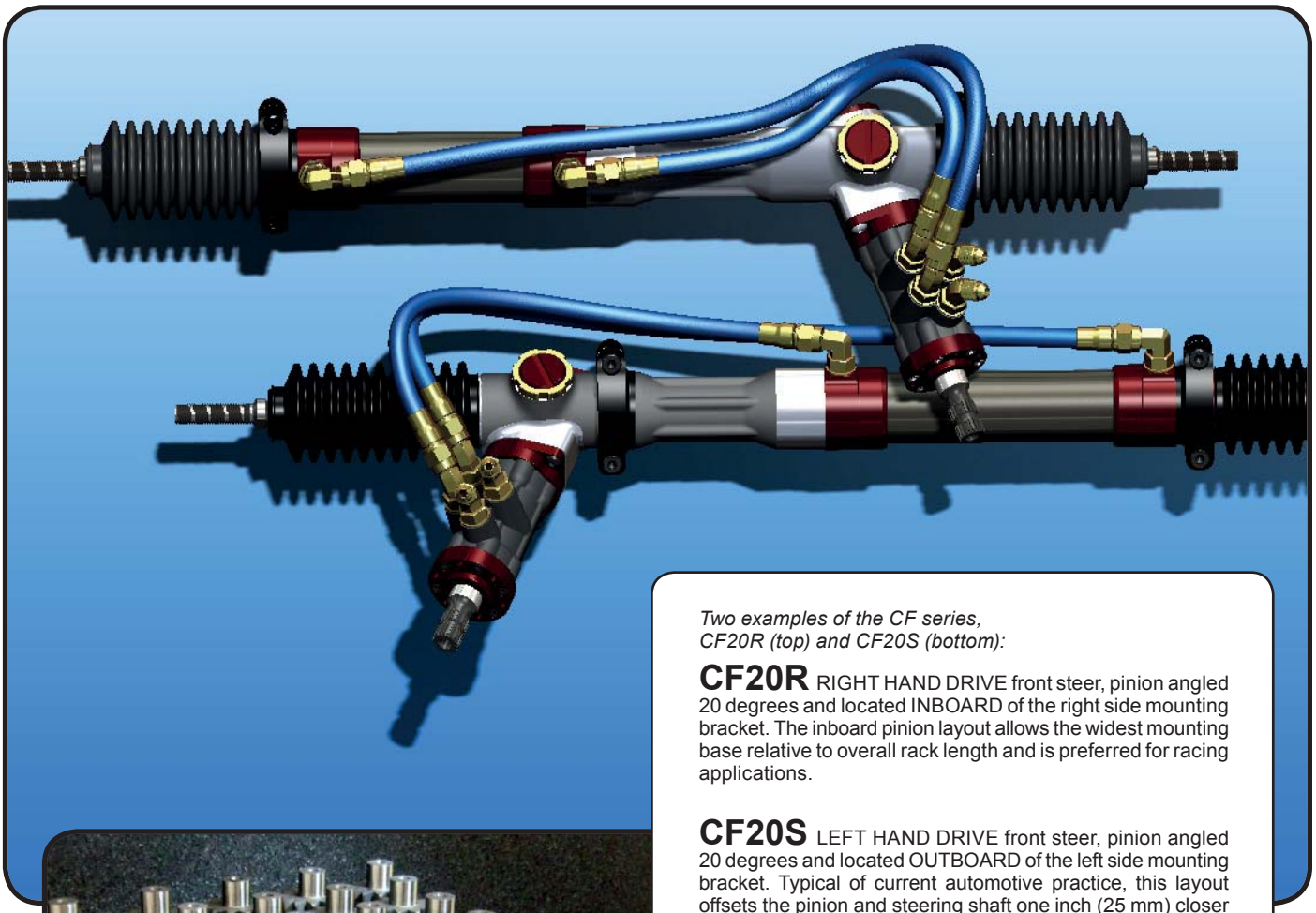


Type CF Power Racks (ratios from 1.57 through 3.14 inches per turn)

Power steering with integral cylinder and servo, for all types of race cars

The Woodward CF series is the revolutionary answer for racing applications where packaging restrictions have traditionally dictated a reliance on power racks of the passenger-car type, with their limited potential for performance at the level required in professionally built race cars. A pure racing design based on our more than 30 years experience *and manufactured entirely in our own plant,* the CF group constitutes the broadest selection of racing power steering racks offered anywhere in the world.

The CF design platform encompasses three pinion angles and seven gear ratios. All these are available in both left and right hand drive, and in both front steer (rack *ahead* of the front wheels) and rear steer (rack *behind* the front wheels). All utilize the high-capacity, hyper-responsive Woodward servovalve, proven for decades in winning cars all over the world from Eldora to Le Mans. CF power racks are built in custom lengths to match your chassis geometry.



Two examples of the CF series, CF20R (top) and CF20S (bottom):

CF20R RIGHT HAND DRIVE front steer, pinion angled 20 degrees and located INBOARD of the right side mounting bracket. The inboard pinion layout allows the widest mounting base relative to overall rack length and is preferred for racing applications.

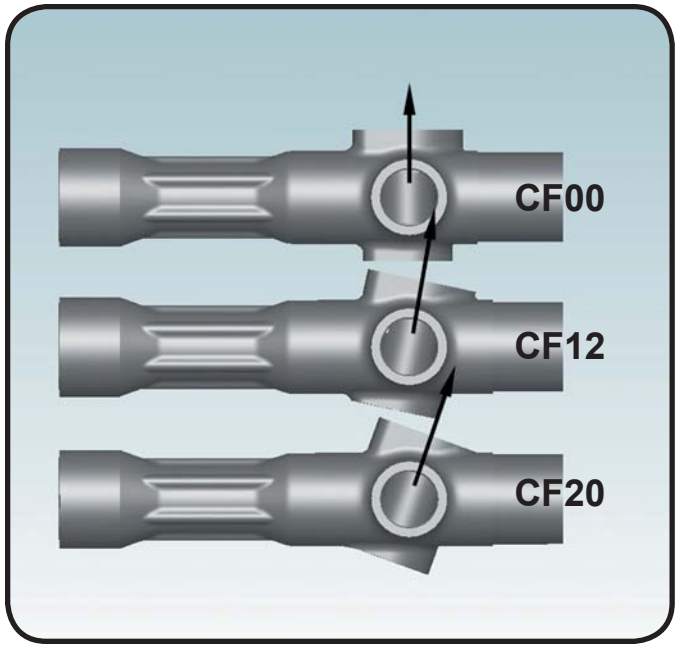
CF20S LEFT HAND DRIVE front steer, pinion angled 20 degrees and located OUTBOARD of the left side mounting bracket. Typical of current automotive practice, this layout offsets the pinion and steering shaft one inch (25 mm) closer to the end of the rack for tight packaging situations.

Custom rack length

Racks in the CF series can be built in any length from 24 inch centers (610 mm) and up; racks shorter than this will have correspondingly shorter travel.

Huge choice of steering ratios

Each model in the CF series can be machined for one of seven pinions, to provide a wide choice of steering ratios. Expressed in inches (mm) per turn, these are: 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80). The entire range of pinions is available in 20 degree, 12 degree and straight, in both left and right hand.



Three pinion angles available

As a general rule, the pinion is angled toward the steering wheel so as to achieve the lowest total angular and parallel misalignment. The smaller the operating angles of the universal joints, the more constant the velocity of steering input. The ideal–seldom achieved–is for the steering column to be connected directly to the pinion spline, as in a single-seater formula car. The straighter the pinion, the lower the frictional and thrust losses (which is, incidentally, why today's racing transmissions are mostly equipped with straight spur gears). Cars with no engine in the front bay should be able to fit one of the CF00 models with a straight pinion. As obstructions (such as an engine) are introduced into the front of the race car it becomes more difficult to align the steering column and pinion, and so the pinion must point to one side. A straight-bank engine may only need a minimally angled pinion such as the CF12, while a forward-mounted V8 or front drive differential may require a CF20 for clearance. The width of the rack plays a part as well; the wider the rack, the farther the pinion is from center.

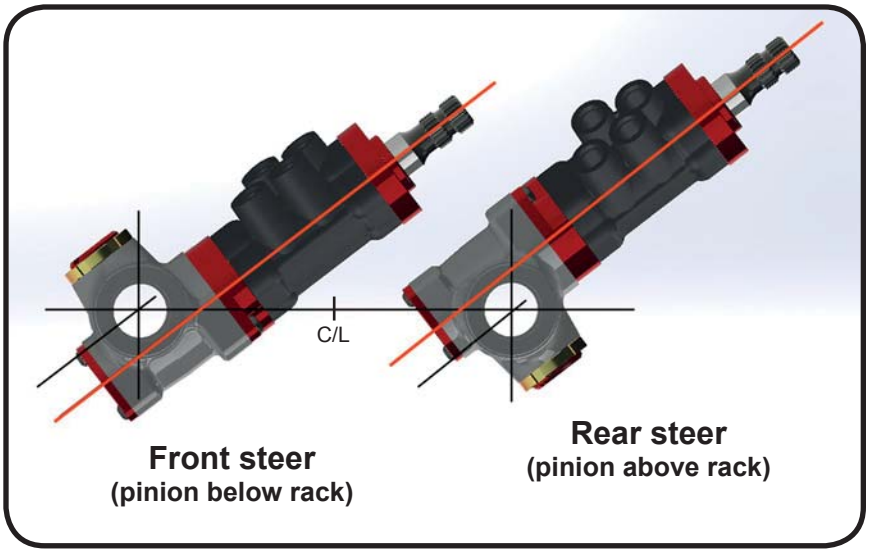
In cases where the race car is to be based a production automobile, it is sometimes possible to improve the routing of the steering column by using a straighter pinion angle, especially if the engine is being set back and/or obstructions such as antiroll bars and air conditioning will be relocated or removed. Much of what is possible in this area will depend on the extent of refabrication planned. A kit is available to simplify the welding of rigid brackets to the chassis to replace the usual OEM rubber mounts, after which the rack can be rotated into optimum alignment with the steering shaft and clamped in place.

Front steer or Rear steer

With the steering positioned ahead of the centerline of the front wheels, the pinion engages the rack from beneath. With the steering positioned behind the centerline of the front wheels, the pinion engages the rack from above. If these conditions are not met, the steering will operate in reverse.

In a front steer layout, the outer ends of the tie rods are located outboard of the kingpin axis to obtain positive Ackerman, or steering toe. In a rear steer layout they are inboard. In this case, rear steer has a packaging advantage because the outer tie rod ends tend not to interfere with the wheels or brakes. However, under severe braking front steer tie rods are loaded in tension whereas in rear steer they are loaded in compression. Because of this, tie rods used for rear steer applications should generally be of stiffer construction.

The principal factor in designing for front or rear steer is engine clearance, which is why the vast majority of purpose-built front-engined race cars are front steer.



Low-drag preloaded tie rod ends

Woodward CF racks are equipped with adjustable monoball rack ends machined from billet. They have much lower "stiction" (break-away torque) than ordinary automotive rack ends, almost completely eliminating the drag of suspension movement and delivering enhanced steering response.

Woodward monoball units are all metal, completely disassemblable and regreasable, with no plastic inserts. The high tensile alloy ball studs are recessed into the ends of the rackshaft for maximum stability and feature 52 degrees angular misalignment. The studs are threaded 14 mm x 1,5 RH with large 19 mm external wrench flats.

Easy, precise adjustment

To set, tighten the adjusting nut until the ball stud is locked solid and then back off one wrench slot. For the maximum recommended preload back off half a slot, for minimum preload back off 1-1/2 slots. Both nuts take a standard hook spanner. One nut has 6 slots and the other 7, allowing two wrenches to be positioned for a powerful "squeeze" without applying any turning force to the rack itself.

The CF series consists of the 24 basic layouts listed below. We can configure these in any of 7 different ratios, 2 piston sizes, and a large number of rack lengths and servovalve characteristics. To obtain a quote and lead time for a steering rack to fit your chassis design, please provide as many details as possible about the application. We regret that at present we are unable to respond to requests for something to fit a certain make and year; we need engineering dimensions.

Part numbers for the CF series are composed like our other rack part numbers, e.g. "**CF12-236-2750**" would be a LHD front steer unit with an inboard pinion angled **12** degrees to the left, a ratio of **2.36** inches per turn, and a rack **27.50** inches on centers.

Left Hand Drive
20 degree angled pinion

CF20-209-2544

CF20
LHD front steer, pinion angle 20 degrees left
Pinion INBOARD of the left side mounting bracket. An INSET pinion allows the widest mounting of the rack relative to its overall length and is preferred for racing applications wherever poss ble. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF20S
LHD front steer, pinion angle 20 degrees left
Pinion OUTBOARD of the left side mounting bracket. Consistent with production automotive practice, an OFFSET pinion provides increased clearance around the pinion and steering shaft for tight packaging situations. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF20E
LHD rear steer, pinion angle 20 degrees left
Pinion INBOARD of the left side mounting bracket. An INSET pinion allows the widest mounting of the rack relative to its overall length and is preferred for racing applications wherever poss ble. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF20SE
LHD rear steer, pinion angle 20 degrees left
Pinion OUTBOARD of the left side mounting bracket. Consistent with production automotive practice, an OFFSET pinion provides increased clearance around the pinion and steering shaft for tight packaging situations. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

Left Hand Drive
12 degree angled pinion

CF12
LHD front steer, pinion angle 12 degrees left
Pinion INBOARD of the left side mounting bracket. An INSET pinion allows the widest mounting of the rack relative to its overall length and is preferred for racing applications wherever poss ble. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF12S
LHD front steer, pinion angle 12 degrees left
Pinion OUTBOARD of the left side mounting bracket. Consistent with production automotive practice, an OFFSET pinion provides increased clearance around the pinion and steering shaft for tight packaging situations. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF12E

LHD rear steer, pinion angle 12 degrees left

Pinion INBOARD of the left side mounting bracket. An INSET pinion allows the widest mounting of the rack relative to its overall length and is preferred for racing applications wherever poss ble. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF12SE

LHD rear steer, pinion angle 12 degrees left

Pinion OUTBOARD of the left side mounting bracket. Consistent with production automotive practice, an OFFSET pinion provides increased clearance around the pinion and steering shaft for tight packaging situations. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF12E-209-3412

Left Hand Drive

Straight pinion

CF00

LHD front steer, straight pinion

Pinion INBOARD of the left side mounting bracket. An INSET pinion allows the widest mounting of the rack relative to its overall length and is preferred for racing applications wherever poss ble. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF00S

LHD front steer, straight pinion

Pinion OUTBOARD of the left side mounting bracket. Consistent with production automotive practice, an OFFSET pinion provides increased clearance around the pinion and steering shaft for tight packaging situations. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF00E

LHD rear steer, straight pinion

Pinion INBOARD of the left side mounting bracket. An INSET pinion allows the widest mounting of the rack relative to its overall length and is preferred for racing applications wherever poss ble. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF00SE

LHD rear steer, straight pinion

Pinion OUTBOARD of the left side mounting bracket. Consistent with production automotive practice, an OFFSET pinion provides increased clearance around the pinion and steering shaft for tight packaging situations. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF20RS-209-2480

CF20R-236-2651

Right Hand Drive

20 degree angled pinion

CF20R

RHD front steer, pinion angle 20 degrees right

Pinion INBOARD of the right side mounting bracket. An INSET pinion allows the widest mounting relative to overall length and is the preferred style for racing applications wherever poss ble. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF20RS

RHD front steer, pinion angle 20 degrees right

Pinion OUTBOARD of the right side mounting bracket. Consistent with production automotive practice, an OFFSET pinion provides increased clearance around the pinion and steering shaft for tight packaging situations. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF20RE

RHD rear steer, pinion angle 20 degrees right

Pinion INBOARD of the right side mounting bracket. An inset pinion allows the widest mounting relative to overall length and is the preferred style for racing applications wherever possible. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF20RSE

RHD rear steer, pinion angle 20 degrees right

Pinion OUTBOARD of the right side mounting bracket. Consistent with production automotive practice, an OFFSET pinion provides increased clearance around the pinion and steering shaft for tight packaging situations. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

Right Hand Drive

12 degree angled pinion

CF12R

RHD front steer, pinion angle 12 degrees right

Pinion INBOARD of the right side mounting bracket. An INSET pinion allows the widest mounting relative to overall length and is the preferred style for racing applications wherever possible. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF12RS

RHD front steer, pinion angle 12 degrees right

Pinion OUTBOARD of the right side mounting bracket. Consistent with production automotive practice, an OFFSET pinion provides increased clearance around the pinion and steering shaft for tight packaging situations. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF12RE

RHD rear steer, pinion angle 12 degrees right

Pinion INBOARD of the right side mounting bracket. An INSET pinion allows the widest mounting relative to overall length and is the preferred style for racing applications wherever possible. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF12RSE

RHD rear steer, pinion angle 12 degrees right

Pinion OUTBOARD of the right side mounting bracket. Consistent with production automotive practice, an OFFSET pinion provides increased clearance around the pinion and steering shaft for tight packaging situations. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

Right Hand Drive

Straight pinion

CF00R

RHD front steer, straight pinion

Pinion INBOARD of the right side mounting bracket. An INSET pinion allows the widest mounting relative to overall length and is the preferred style for racing applications wherever possible. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF00RS

RHD front steer, straight pinion

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Pinion INBOARD of the right side mounting bracket. An INSET pinion allows the widest mounting relative to overall length and is the preferred style for racing applications wherever possible. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

CF00RSE

RHD rear steer, straight pinion

Pinion OUTBOARD of the right side mounting bracket. Consistent with production automotive practice, an OFFSET pinion provides increased clearance around the pinion and steering shaft for tight packaging situations. Can be built in any rack length from 24 inches (610 mm) up and with speeds of 1.57 (40), 1.83 (46,5), 2.09 (53), 2.36 (60), 2.62 (67), 2.88 (73), and 3.14 (80).

A huge range of steering ratios

A rack and pinion gear ratio is defined as linear rack movement in 360 degrees of pinion rotation. In the CF rack these are available in increments of approximately .26 inch (6,65 mm), from 1.57 inches (40 mm) per turn through 3.14 inches (80 mm) per turn. The slow end of this range is equivalent to most road-vehicle steering, while the quick end is suggested where violent changes in direction are intended, as in autocrossing.

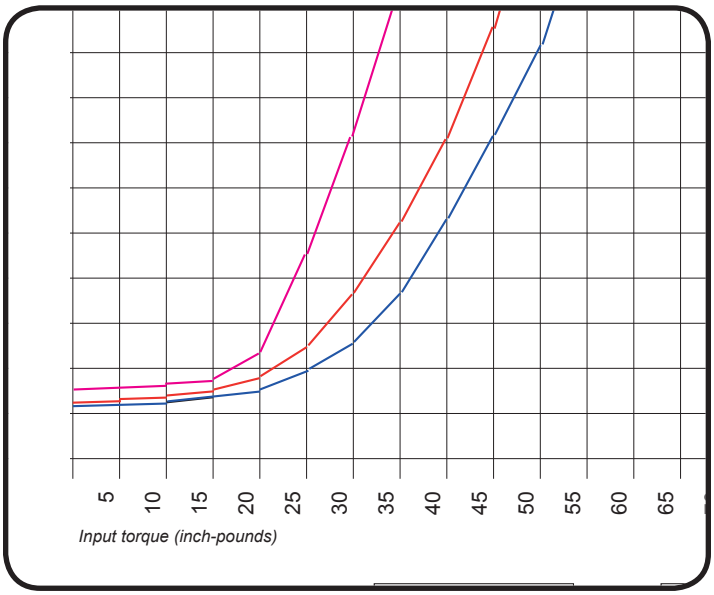
Across the various configurations of CF racks (straight pinion, 12 degree angled pinion and 20 degree angled pinion) there are 35 pinion part numbers. *This is by far the largest selection of steering gears manufactured as standardized race car parts anywhere in the world.* This degree of commitment enables Woodward to respond rapidly with a well-engineered bespoke design for virtually any motorsport application, with steering performance far superior to what can be achieved by modifying an OEM rack.

Woodward pinions are hardened alloy steel with a minimum tensile strength of 235,000 PSI (1,620 MPa).

Optional piston sizes

A useful tool for the vehicle designer, the CF is available in two different cylinder diameters, the standard 1.63 bore with an effective piston area of 1.30 square inches (839 mm^2) and an optional 1.75 bore with 1.63 square inches (1052 mm^2). As a rule of thumb, the maximum theoretical axial force available from the steering is equal to its piston area multiplied by the maximum fluid pressure produced by the pump just below its relief point.

In general, lighter car weight and/or conservative geometry requires less assist, and a smaller piston is more efficient because it displaces a lower volume. Heavier cars, or those with aggressive geometry (high positive caster, large scrub radius, etc), may need a larger piston to lessen the load on the pump. The special problem of a mid-engined car with an engine-driven pump is nicely solved with the larger piston, coupled with the larger return porting of the optional 900 series servo. In a mid-engined car the fluid circuit can be long enough to cause a lag in the power steering. In such cases, the larger piston will allow the required steering force to be obtained at an earlier point on the response curve, reducing the load on the pump and eliminating the lag.



Perfectly Matched Power Assist

The Woodward servovalve is manufactured entirely in our plant and, unlike our competitors, does not utilize any OEM components. It is designed with a combination of torsion-bar-controlled resistance and progressive orifices, making possible the most sensitive and precise power steering available anywhere in the world. Several basic valve profiles plus a range of torsion bars in small stiffness increments, can be matched to any steering ratio, in any type of race car of any weight, and under any conditions of tire loading due to suspension geometry or aerodynamic downforce.

Extremely large internal porting and low turbulence eliminates the sensitivity-robbing hydraulic damping encountered when OEM-based power steering is adapted to race cars. The Woodward servovalve will maintain a very close connection between the driver's hands and the tire contact patch, even while overcoming impulsive loads from rough track surfaces and responding to rapid steering inputs.

For the race car builder wishing to optimize the power assist during the testing phase of a new race car, the entire servo assembly can be switched out in the field, saving expensive development time for other uses.

WOODWARD Needle Bearing U-Joints

Since 1989, Woodward steering universal joints have been the preferred choice of race car builders everywhere, and have won every major race and series championship in North America many times over, including the NASCAR championship. Woodward pioneered the use of caged needle rollers with a slight preload to create a joint without backlash and with noticeably lower reversing inertia than conventional automotive designs. That means enhanced sensitivity at the steering wheel, and makes even the smallest steering input more effective—whether on a superspeedway at 200MPH or sideways on a dirt bull ring.

The bearing trunnion used in these u-joints is a single piece of hardened chrome-vanadium tool steel. The grease seals are high-durometer fluorocarbon o-rings in compression against the end surfaces of the needle bearing cups. These seals will resist sustained oven-level heat and will retain the bearing grease under severe conditions, including welding. Other design details include stainless steel truss-head screws overlapping the bearing cups, and a pair of fine-thread knurled set screws located at 90°, for highly positive and reliable retention on a splined shaft or steering gear.

Please note that the intended application of these u-joints and couplers is automobile racing, where low frictional resistance and low mass are the primary goals. Their dimensions are Woodward standards, shown in the drawing on the following page. Except for the spline sizes, which fit steering racks and gearboxes adapted from OEM automobiles, they do not conform to any automotive manufacturer's dimensions and are not OEM replacement parts.

PLATING: Splined Woodward U-joints are now available gold zinc plated in several of the most popular sizes. Plated joints are baked immediately after plating to prevent hydrogen embrittlement, and all dimensionally critical surfaces are corrected prior to final assembly. For gold zinc where available, add G to the part number. *To avoid possible contamination of the weld zone, plain-bore joints intended for welding are not plated.*

shown:
UAD1-20201

DOUBLE UNIVERSAL JOINTS: Double U-joints neatly solve problems of angular misalignment by providing a more constant rotational velocity than a single joint used at the same operating angle. These joints are available as short permanent-center units as shown, or assembled onto splined shafts at various center distances. On assembled units the Woodward "201" spline is timed with respect to the bearing axis to provide correct phasing and smooth and reliable operation.

INDUSTRIAL APPLICATIONS: Woodward can manufacture long or short runs for industrial uses such as machine tools, printing presses and assembly and packaging equipment.

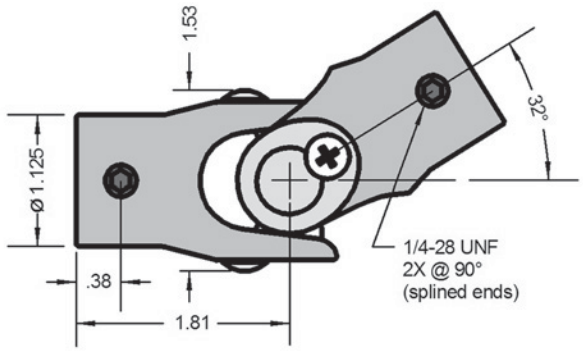
MILITARY APPLICATIONS: As part of the defense procurement chain, Woodward supplies steering u-joints for combat vehicles in current production, as well as prototypes.

CUSTOM U-JOINTS: We can produce one-off splines for rare auto restorations, vintage race cars and retrofits. Alternatively, joints can be supplied unassembled for machining of special profiles by the customer.

Steering Universal Joints

Mechanical Specifications

Weight 310g
(smaller hole=heavier part; larger hole=lighter part)
Rotational clearance circle 1.75 (44 mm) diameter
Maximum possible angular misalignment 32 degrees
Recommended operating angle <20 degrees
Torque resulting in bearing damage >250 lb/ft (>339 Nm)
Torque resulting in plastic deformation >275 b/ft (>372 Nm)
Ultimate breaking torque >300 lb/ft (>406 Nm)



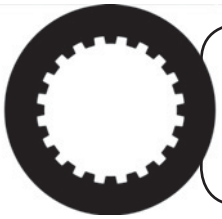
Operating Angle

Although the ears of the joint are contoured to prevent it from jamming, it will not operate beyond a 32 degree angle. Any universal joint will transmit rotary motion at constant velocity when straight, but when rotating through an angle it will develop a twice-per-revolution acceleration/deceleration cycle whose amplitude increases with the angle. To avoid variable velocity effects in the steering we strongly recommend that the total angular misalignment between steering column and pinion not exceed 20 degrees. Smoothness of operation can be further improved by subdividing the angle between two joints.

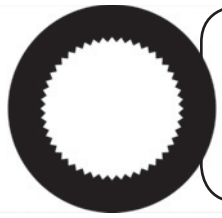
Spline Identification

The diameter shown after the three-digit identifying code is the nominal outside diameter of the male spline the u-joint is intended to fit, in decimal inches, and in millimeters where the profile was originally a metric design. In production, a spline is measured over wires of specified diameter which fit into the vees. Since it's seldom practical to do this in the field, we suggest you simply measure over the crests of the teeth. That measurement will usually correspond closely enough to one of the listed diameters to identify it. Keep in mind that splines fit on the flanks of the teeth, not the crests. Like screw threads, the crests of spline teeth can be truncated without affecting the fit, so an actual measurement of any of these examples might well be .005 (or more) under the nominal sizes shown here. To aid identification, the vehicle origins of the various automotive splines are also listed below where known.

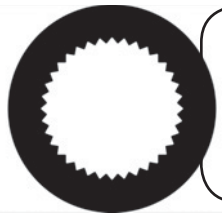
The number of spline teeth refers to the number of equally spaced divisions of the circle, whether or not they are used in the spline pattern. Flats or interruptions are ignored (e.g., a shaft with 36 teeth, 6 of which are missing, is NOT a 30-tooth spline). If interruptions make it impossible to get a reliable count all the way around the shaft, count halfway around and double it.



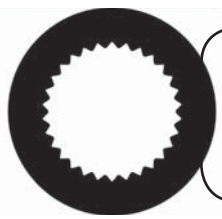
201 .750 diameter; 20 teeth
Used on all Woodward products since 1992; fits Woodward integral power racks, Woodward remote power racks, Woodward servos, and Woodward safety steering columns, weld-in stubs, and double u-joints. Also used on copies of Woodward columns. Not an automotive industry profile. The shaft spline OD is cylindrical and can run in a bearing.



101 .750 diameter; 48 teeth
Fits most US stock-car racks past and present (Sweet, Appleton, Speedway, SWS, Quick-trac, Wilwood, Coleman, BRT, RCP, and pre-1992 Woodward) and the output end of large style Sweet servos. Note: Over the years this profile has been used by many aftermarket manufacturers without reference to the original dimensional standard; a proper fit cannot be guaranteed on parts made by companies no longer in business.



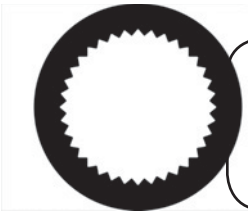
102 .735 diameter; 36 teeth
Fits Mustang power rack, Chrysler power steering box, old Chevy and Ford manual boxes and most steering quickeners. Note: This is an automotive industry profile whose production tolerances varied during the half century it was in use. Aftermarket versions vary even more. Some aftermarket shafts and steering quickeners with a "3/4-36 spline" do not conform to this profile and may not work with this joint.



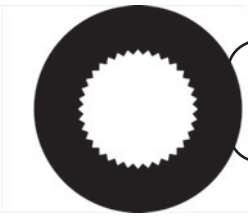
103 .720 diameter; 30 teeth
Introduced on 1980s GM power steering boxes and racks. Used on current Delphi 600 series boxes and on aftermarket servos using the Delphi 600 input shaft (Appleton, small style Sweet, etc.). Interchangeability of this profile is fairly reliable. Usually has a large flat on one side.

WOODWARD
PRECISION POWER STEERING

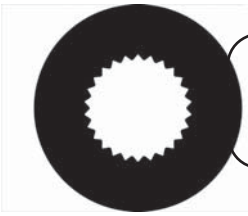
Steering Universal Joints



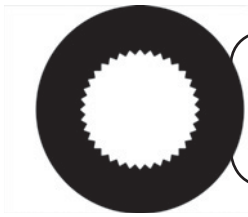
104 .820 diameter; 36 teeth
Used on older GM power steering (700 series boxes) and on aftermarket servos using the Delphi 700 input shaft (large style Sweet). The measured diameter varied considerably during the years of production of the steering box, from .812 as originally produced, to .820 on later units. Usually has a large flat on one side.



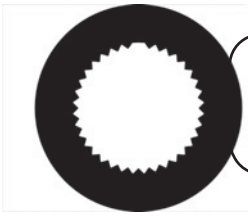
105 .620 diameter; 36 teeth
OEM Chevrolet Vega steering box (NOTE: may not fit “5/8-36” aftermarket copies of the Vega box).



106 .565 diameter; 26 teeth
Fits Ford Pinto manual rack and pinion and most aftermarket copies.

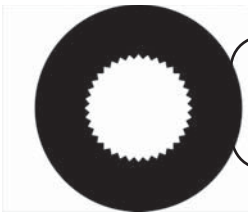


107 .625 diameter; 36 teeth
Made specifically for the Stiletto manual rack. A special profile; not an automotive standard, and NOT for Vega steering boxes.



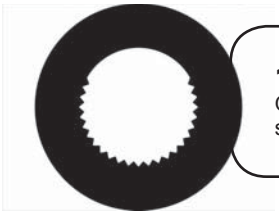
108 .688/17,5 mm diameter; 34 of 36 teeth)
Fits Toyota truck power steering with one filled spline for orientation, also other 17,5 x 36 splined shafts.

109 .750 diameter with two flats (“double D” shape)
Fits Ford style DD shaft and street-rod aftermarket DD shafting measuring .550 across the flats. Does NOT fit the smaller GM DD shaft.

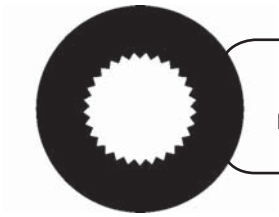


110 .563 diameter; 36 teeth
Fits Jack Knight and Titan racks, Ariel Atom steering shaft, also some dragster steering.

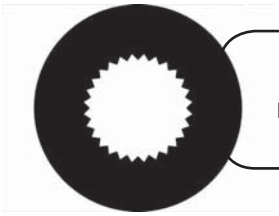
Steering Universal Joints



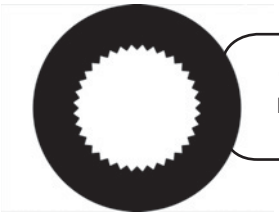
111 .625/16 mm diameter; 23 of 36 teeth
Originally made to fit the Australian TRW power rack with 13 blocked or filled splines, this also fits the 16 mm x 36 spline shaft used on various Japanese cars.



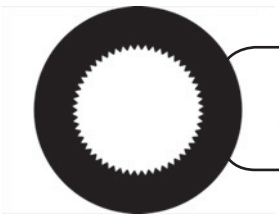
112 .590/15 mm diameter; 29 teeth
Fits Honda rack and pinion and steering column and some aftermarket midget racks.



113 .570/14,5 mm diameter; 28 teeth
Fits Datsun 240/260/280Z. The other end of this u-joint can be sized for welding onto the original steering shaft.



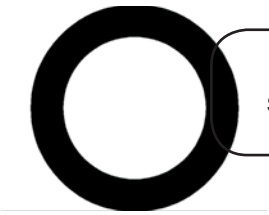
114 .669/17 mm diameter; 36 teeth
Fits Mitsubishi Starion, Chrysler Conquest and various electric gearmotor-powered steering columns.



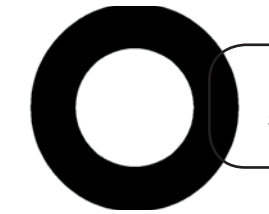
115 .688/17,5 mm diameter; 54 teeth
Fits ZF steering rack and splined shafts used on many European cars such as BMW, Mercedes, Ferrari, Maserati.

Plain bore sizes for welding onto steering shafts

Note that U-joints can undergo distortion if they are heat-soaked during a time-consuming welding process, and excessive heat will draw the temper of the needle bearings. The recommended procedure is MIG using ER80S-D2 wire and 25%CO2/75%Ar shielding gas. The joints are designed with sufficient mass and length to allow a full-circumference fillet weld without disassembly. DO NOT add plug or rosette welds, as the additional contraction stresses will tend to misalign the bearing axes and/or distort the bearing bores (see discussion below).



100 .755/753 diameter
Sized for a close slip fit on 3/4 inch cold finished TUBING. Mills normally produce tubing to a PLUS tolerance.



150 .625 diameter
Sized for a close slip fit on 5/8 cold finished BAR STOCK. Mills normally produce round bar to a MINUS tolerance.

Welding U-joints

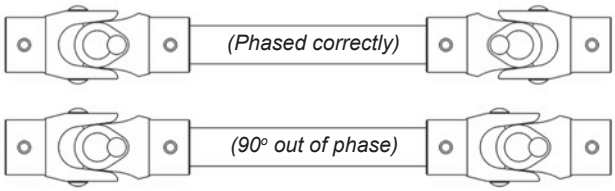
While it has become obvious over many years that universal joints can be welded to shafts with a high degree of reliability, some procedures are detrimental to the u-joint and must be avoided.

(1) Plug or rosette welds on universal joints are virtually guaranteed to shorten the life of the bearings from both direct heat and the distortion resulting from weld contraction in proximity to the bearing bores. Even if the bearings are removed first, this distortion will cause enough ovality and misalignment to damage both the bearings and the trunnion journals when reinstalling. In any case, the cross section of a circumferential weld joint is comfortably larger than that of a tubular steering shaft, and any additional welding in the form of plugs or rosettes would be entirely superfluous.

(2) Any welding procedure which consumes enough time to discolor the ears of the u-joint should be assumed to have drawn the temper of the bearings. This does not necessarily disqualify the TIG process, but TIG does tend to be fairly slow. To avoid heat-soaking the joint when TIG welding, use a high-strength, non-cracking filler rod such as 309 stainless and keep the cross-section small. The most practical method is MIG, as a comfortably large weld can be made in a few seconds. ER80S-D2 wire using 25%CO2/75%Ar shielding gas will give excellent results for both strength and appearance.

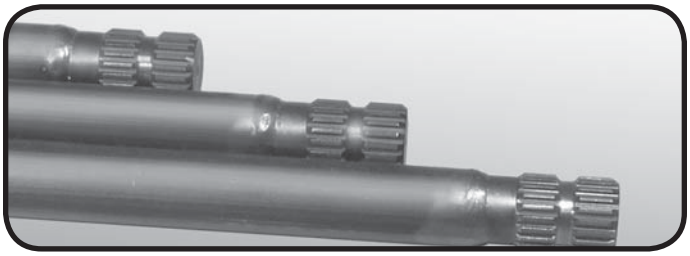
Phasing and Clocking of U-joints

Phasing or "clocking" of universal joints for smooth operation is especially critical when welding u-joints directly to the shaft, since it will be impossible to reposition them once you've done it. Assuming all sections of the steering shaft lie approximately in the same plane so that the only misalignment is angular (the most common condition), any back-to-back pair should be aligned like the ends of a driveshaft, as in the illustration at right. Please study it closely; the difference is not obvious unless you are looking for it. The greater the angular misalignment of the steering shaft, the more critical the phasing of the u-joints. For reference, most stock car steering layouts will tolerate joints 20 degrees out of phase, but 45 degrees out will cause a noticeable change in rotational velocity–the steering will actually speed up and slow down within half a turn of the steering wheel. Shafts with both angular and parallel misalignment may require special u-joint phasing which can only be found by trial and error. In the case of weld-on u-joints, this can be done by temporarily holding one of the joints onto the shaft or tube with a small tack weld, and welding it permanently in place only after you have determined its optimal position. The obvious disadvantage of welding u-joints directly to the shaft or tube is, of course, that once you've welded them they cannot be removed without resorting to a torch, saw, or angle grinder.



Weld-in Splined Stubs

Welding a splined stub into the steering tube is no more work than welding a u-joint to it, and by confining the welding to the tube, potential heat damage to the u-joint bearings is eliminated. A full-penetration circumferential weld of the stub to the tube will transmit steering torque as effectively as the tube itself, and is not difficult.



.750-20 SPLINE
WELD-IN STUB

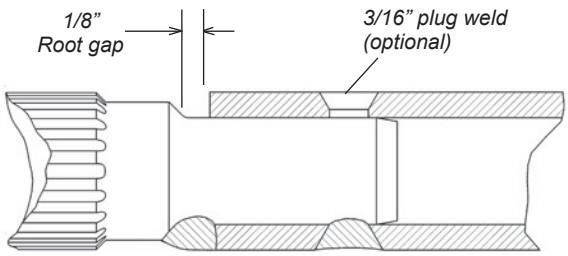
For 3/4 OD x .120 wall
ST201A
For 3/4 OD x .065 wall
ST201B
Custom (up to .660 pilot)
ST201X
Custom (up to .875 pilot)
ST201GM

Weld-in stubs contain no moving parts and are virtually immune to damage other than spatter. They are solid, and unlike a splined piece of tubing cannot be crushed by the set screws. The slight extra cost of stubs and double-splined joints is almost insignificant compared with the time and effort which must otherwise be invested in welding u-joints, removing welded u-joints with a torch or hand grinder, or trying to modify a steering shaft whose joints have been welded.

Installation Technique for Stubs

With a weld-in stub, plug or rosette welds can be added if desired. If so, use two; these should be as directly opposite each other as possible to equalize the inevitable distortion. The pilot of the splined stub is made a few thousandths oversize to ensure a tight fit in the expected ID of a .120 wall tube. File the pilot if necessary until it fits the tube snugly. A heavy driven fit is unnecessary and will restrain the weld joint. Leave a 1/8" gap at the root of the weld to ensure penetration. For the circumferential weld, a couple of hot MIG passes (use a rolling fixture if you can) will get the job done before any significant distortion can set in.

Although a steering shaft is not a high-speed rotating assembly, straightness is still a practical goal. If you prefer TIG welding, excellent results will be obtained using 309 stainless steel filler rod as above. However, keep in mind that TIG is relatively slow; the slower the welding process, the more your finished job is likely to deviate from straight. Postheat to a faint red and let cool in air (Note: don't postheat a universal joint).



New simplified U-joint Part Numbers

The new six-digit numbers are made up of the spline codes for each end. The numerically higher code appears first, e.g. UA201109, UA109102, UA110100 etc.

In addition to the common ones shown on the following pages, any combination of ends can be specified by composing an appropriate part number as above. All joints with splines at both ends (or bores other than the standard diameters) are priced the same; all joints with splines at one end are priced the same, etc.

Example:

UA201115

.750-20 SPLINE (201) x
3/4 WELD-ON (100)

Woodward spline one end; other end sized .755/.753 for welding onto 3/4 OD tubing

UA201100

.750-20 SPLINE (201) x
.750-20 SPLINE (201)

Connects Woodward parts to any other Woodward parts (telescoping column, either end of the servo, splined shaft sections, and all Woodward rack types).
UA201201

.750-48 SPLINE (101) x
3/4 WELD-ON (100)

Fine-pitch serration used on various makes of R&P steering; 3/4-48 was also used on pre-1992 Woodward racks.

UA101100

.750-20 SPLINE (201) x
.750-48 SPLINE (101)

Adapts Wooodward shaft to the fine-pitch serration used on various makes of R&P steering; 3/4-48 was also used on pre-1992 Woodward racks.
UA201101

.735-36 SPLINE (102) x
3/4 WELD-ON (100)

Fits Mustang power rack and aftermarket copies, old manual Chevy box, Dodge truck power steering box, and most steering quickeners.

UA102100

.750-20 SPLINE (201) x
.735-36 SPLINE (102)

Adapts Woodward shaft to Mustang power rack and aftermarket copies, old manual Chevy box, Dodge truck power steering box, and most steering quickeners.

UA201102

WOODWARD
PRECISION POWER STEERING

Steering Universal Joints

.720-30 SPLINE (103) x
3/4 WELD-ON (100)

Fits current-model GM power steering including the 600 series box and all servos using 600 series parts (Appleton, small style Sweet, etc.).

UA103100

.750-20 SPLINE (201) x
.720-30 SPLINE (103)

Adapts Woodward shaft to current-model GM power steering including the 600 series box and all servos using 600 series parts (Appleton, small style Sweet, etc.).

UA201103

.820-36 SPLINE (104) x
3/4 WELD-ON (100)

Fits older-model GM power steering (700 series box) and large style Sweet servo.

UA104100

.750-20 SPLINE (201) x
.820-36 SPLINE (104)

Adapts Woodward shaft to older-model GM power steering (700 series box) and large style Sweet servo.

UA201104

.620-36 SPLINE (105) x
3/4 WELD-ON (100)

Fits OEM Vega steering box; may not fit aftermarket copies

UA105100

.750-20 SPLINE (201) x
.620-36 SPLINE (105)

Adapts Wooodward shaft to OEM Vega steering box; may not fit aftermarket copies

UA201105

.565-26 SPLINE (106) x
3/4 WELD-ON (100)

Fits Pinto manual rack and most aftermarket copies.

UA106100

.750-20 SPLINE (201) x
.565-26 SPLINE (106)

Adapts Woodward shaft to Pinto manual rack and most aftermarket copies.

UA201106

Steering Universal Joints

.625-36 SPLINE (107) x
3/4 WELD-ON (100)

Fits Stilletto rack and pinion.

UA107100

.750-20 SPLINE (201) x
.625-36 SPLINE (107)

Adapts Woodward shaft or slide yoke to Stilletto rack and pinion.

UA201107

.688-34/36 SPLINE (108) x
3/4 WELD-ON (100)

Fits Delphi 600 series box used on Toyota truck. Has one filled or "block" spline; not indexable on the steering box.

UA108100

.750-20 SPLINE (201) x
.688-34/36 SPLINE (108)

Adapts Woodward shaft to the Toyota 600 box. Has one filled or "block" spline; not indexable on the steering box.

UA201108

3/4-DD (109) x
3/4 WELD-ON (100)

Fits Ford type DD and aftermarket DD shaft measuring .550 across the flats.

UA109100

.750-20 SPLINE (201) x
3/4-DD (109)

Adapts Woooodward shaft to Ford type DD and aftermarket DD shaft measuring .550 across the flats.

UA201109

.563-36 SPLINE (110) x
3/4 WELD-ON (100)

Fits Jack Knight, Titan racks.

UA110100

.563-36 SPLINE (110) x
.563-36 SPLINE (110)

UA110110

.750-20 SPLINE (201) x
.563-36 SPLINE (110)

Adapts Woodward shaft to Jack Knight, Titan, etc., Formula One and Indy racks.

UA201110

WOODWARD
PRECISION POWER STEERING

Steering Universal Joints

.625-23/36 SPLINE (111) x
3/4 WELD-ON (100)

Fits TRW power rack and pinion used in Australia and other right hand drive markets.
Uses 23 spaces out of 36; not indexable on the rack.

UA111100

.750-20 SPLINE (201) x
.625-23/36 SPLINE (111)

Adapts Woodward shaft to Australian TRW power rack. *Uses 23 spaces out of 36; not indexable on the rack.*

UA201111

.585-29 SPLINE (112) x
3/4 WELD-ON (100)

Fits Honda and aftermarket racks using Honda spline.

UA112100

.750-20 SPLINE (201) x
.585-29 SPLINE (112)

Adapts Woodward shaft to Honda and aftermarket racks using Honda spline.

UA201112

.570-28 SPLINE (113) x
3/4 WELD-ON (100)

Fits Datsun 240/260/280Z
UA113100

.570-28 SPLINE x
14 mm (OEM shaft) WELD-ON
UA113100Z

.750-20 SPLINE (202) x
.570-28 SPLINE (113)

Adapts Woodward shaft to Datsun 240/260/280Z

UA201113

17 mm-36 SPLINE (114) x
3/4 WELD-ON (100)

Mitsubishi Starion, Chrysler Conquest steering rack

UA114100

.750-20 SPLINE (202) x
17 mm-36 SPLINE (114)

Adapts Woodward shaft to Mitsubishi Starion or Chrysler Concept steering rack

UA201114

Steering Universal Joints

17,5 mm-54 SPLINE (115) x
3/4 WELD-ON (100)

ZF rack spline used on BMW
UA115100

17,5 mm-54 SPLINE (115) x
3/4 DD shaft (109)
UA115109

.750-20 SPLINE (201) x
17,5 mm-54 SPLINE (115)

Adapts Woodward shaft to ZF rack spline used on BMW, Mercedes, Ferrari, Maserati and other European cars

UA201115

3/4 WELD-ON (100) x
3/4 WELD-ON (100)

Plain weld-on style steering joint; the actual bore diameter is .755/.753 so as to admit 3/4" OD tubing, which is typically oversize.

UA100100

5/8 WELD-ON (150) x
5/8 WELD-ON (150)
UA150150

5/8 WELD-ON (150) x
3/4 WELD-ON (100)
UA150100

Timing the Steering Wheel Position to the Rack Travel

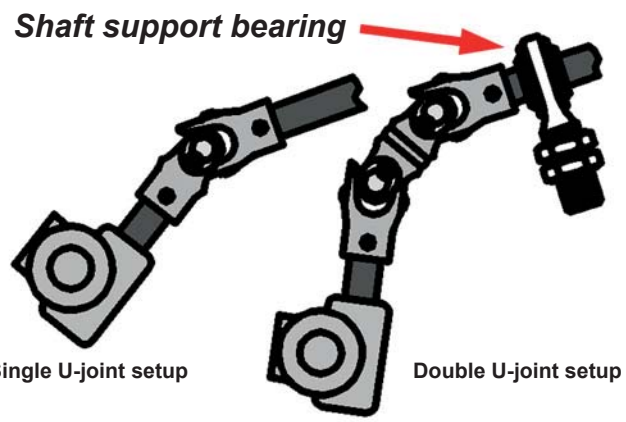
When a universal joint operates at a zero angle, it rotates at a constant velocity like a solid shaft. As it is called upon to transmit rotation "around a corner," that is, through an operating angle, its velocity accelerates during a given quarter-turn and then decelerates during the subsequent quarter-turn. The greater the operating angle, the more this action speeds and slows the car's steering. This can be tested by measuring the travel of the rack at 45-degree intervals. For example, turn the steering wheel through some arbitrary angle (like 20 degrees; it doesn't matter how far, provided you turn it the same each time) and measure the rack travel. Reposition the wheel at 45 degrees, turn it 20 degrees and again measure the rack travel. Checking every 45 degrees will reveal a pattern. Note that a rack which travels 2.09 inches in 360 degrees should theoretically travel .116 inch in 20 degrees. If your u-joints operate through considerable angular misalignment you may discover your rack travels .180 inch when turned from the initial or twelve o'clock steering wheel position, but slows down to .050 inch from the nine o'clock position and speeds up again to .180 inch from the six o'clock position. This sort of thing can make high-speed cornering highly unpredictable. The classic example is a sudden spinout resulting from a small steering wheel input. The output at the rack at that point may be disproportionately large. Of course this is frustrating to the driver but virtually impossible to pin down without doing the above test. It's easier to blame the tires.

There are two ways to address the problem. As a quick partial fix, disconnect the steering shaft from the pinion and reconnect it so the speedup and slowdown is timed to occur symmetrically about center–or on an oval track car, symmetrically about the most-used position of the steering wheel. Second, replace the most severely-angled u-joint (usually the one at the firewall) with a DOUBLE U-JOINT. The double joint will smooth out the rotation to practically constant velocity. Of course the best solution is to lay out the steering shaft so as to reduce all u-joint angles to the practical minimum, and position other elements of the car so they won't interfere.

This is an important enough in automotive engineering that OEMs frequently angle the steering wheel or offset the engine to avoid excessive u-joint angles, notable examples being the Lincoln Town Car and the big-block Corvette. However, real-world conditions don't often allow a wholesale redesign, especially if you're working on an existing race car that has nonconstant velocity in the steering.

Installing Double Universal Joints

Double U-joints neatly solve problems that cannot be dealt with any other way. However, unlike a single u-joint, a double joint does not make a stable connection between two shafts because it essentially *adds* a shaft. Therefore the two shafts to be joined by a double u-joint must both be supported individually or the connection will wobble. A direct connection to a fixed component (such as a steering rack or gearbox) will support that end, while the other end will require a rod end or other bearing as shown at right.



Single U-joint setup **Double U-joint setup**

Double Universal Joints and Splined Shafts

The 20-tooth spline in the Woodward 201 U-joint is timed with respect to the bearing axis, so any two joints assembled back-to-back on a 20-spline shaft will have parallel axes and will be in phase for maximum efficiency. In certain cases where both angular and parallel misalignment are present it may be necessary to index one of the joints by one spline tooth (or more) relative to the other in order to improve the rotational smoothness. If you have to offset the phasing in this way, use a dial indicator to measure the rack travel at various angles of the steering wheel and index one of the joints until you obtain reasonably constant velocity. This is a laborious procedure and sometimes it will prove easier to get rid of the parallel misalignment by rerouting the steering column. Although the maximum operating angle of a double U-joint is theoretically twice that of a single joint, it is always best to keep misalignment of the steering shaft to a minimum. Even where they are not absolutely necessary, double U-joints provide smoother rotation than a single joint used at the same operating angle.

SHAFTS for the standard double u-joints will accept any 201 splined half. The set-screw grooves are located .5 inch in from each end.

1.75 overall **UADS-3**
2.75 overall **UADS-4**
3.75 overall **UADS-5**

OTHER LENGTH SPLINED SHAFTS with one end machined with a locking groove for the set screws and the other end left blank for cutting to length and machining by user.

UADS-X-6
UADS-X-8
UADS-X-10
UADS-X-12
UADS-X-14
UADS-X-16

PERMANENT-TYPE DOUBLE UNIVERSAL JOINTS are pre-aligned to ensure correct phasing.

2.18" bearing centers
.750-20 x .750-20 **UAD1-201201**
.750-20 x .750-48 **UAD1-201101**
.750-20 x .735-36 **UAD1-201102**
.750-20 x .720-30 **UAD1-201103**
.750-20 x .565-26 **UAD1-201106**
.750-20 x .625-36 **UAD1-201107**
.750-20 x 3/4-DD **UAD1-201109**
3/4 DD x 3/4-DD **UAD1-109109**
.563-36 x .563-36 **UAD1-110110**

Any other spline combination is available at no additional cost.

SHAFT-MOUNTED DOUBLE U-JOINT ASSEMBLIES are prealigned for correct phasing. Both ends are removable and can be installed on a custom length splined shaft.

3.62" bearing centers
.750-20 x .750-20 **UAD3-201201**
.750-20 x .750-48 **UAD3-201101**
.750-20 x .735-36 **UAD3-201102**
.750-20 x .720-30 **UAD3-201103**
.750-20 x .565-26 **UAD3-201106**
.750-20 x .625-36 **UAD3-201107**
.750-20 x 3/4-DD **UAD3-201109**
3/4 DD x 3/4-DD **UAD3-109109**
.563-36 x .563-36 **UAD3-110110**

4.62" bearing centers
.750-20 x .750-20 **UAD4-201201**
.750-20 x .750-48 **UAD4-201101**
.750-20 x .735-36 **UAD4-201102**
.750-20 x .720-30 **UAD4-201103**
.750-20 x .565-26 **UAD4-201106**
.750-20 x .625-36 **UAD4-201107**
.750-20 x 3/4-DD **UAD4-201109**
3/4 DD x 3/4-DD **UAD3-109109**
.563-36 x .563-36 **UAD3-110110**

5.62" bearing centers
.750-20 x .750-20 **UAD5-201201**
.750-20 x .750-48 **UAD5-201101**
.750-20 x .735-36 **UAD5-201102**
.750-20 x .720-30 **UAD5-201103**
.750-20 x .565-26 **UAD5-201106**
.750-20 x .625-36 **UAD5-201107**
.750-20 x 3/4-DD **UAD5-201109**
3/4 DD x 3/4-DD **UAD3-109109**
.563-36 x .563-36 **UAD3-110110**

Any other spline combination is available at no additional cost.

Weld-on splined couplers

Highly convenient for welding onto the steering shaft, these can replace universal joints in cases where a floating connection is not required. The coupler is counterbored 1 inch deep to accept 3/4 OD tubing, and the small C110B is available counterbored for 5/8 tubing.

Couplers are useful for splicing a servo into a steering shaft, and also for connecting to a rack mounted in pillow blocks close to the driver (such as the Type MR or MC) provided it is possible to accurately align the steering shaft with the pinion spline. However, a coupler should never be used to connect to a rack where there is any likelihood of misalignment resulting from chassis flex. In such cases (which is to say most race cars larger than formula cars) the rack should always be connected with a universal joint. We can make couplers with any spline provided the counterbore for welding is equal to or larger than the major diameter of the spline.

.750-20

Fits all Woodward parts (Pinion, servo input and output, safety steering columns, etc.)

C201

.750-48

Fine-pitch serration fits various makes of R&P steering; also found on Woodward racks built before 1992.

C101

.735-36

Fits Mustang power rack and most steering quickeners.

C102

.720-30

Fits current GM power steering boxes and servos using current GM parts such as Appleton and small style Sweet.

C103

.820-36

Fits 4-bolt early GM power steering box and all servos using early GM parts such as large style Sweet. *Note: spline ID is larger than tubing; has extra set screws to align for welding.*

C104

.563-26

Fits Pinto racks and aftermarket copies.

C106

.625-36

Fits Stilletto rack and pinion.

C107

WOODWARD
PRECISION POWER STEERING

Steering Universal Joints

.688-34/36

Has one spline tooth removed to fit Delphi-manufactured Toyota truck box. Not indexable on the steering box but works on other 17.5 mm shafts with base 36 spline.

C108

3/4 DD

Fits aftermarket DD shafting based on Ford dimensions of .75 diameter x .550 across the flats.
NOT for 17mm GM DD shafts.

C109

.563-36

Fits Jack Knight and Titan racks.

For welding to 3/4 tube:
C110A

For welding to 5/8 tube:
C110B

.625 (16 mm)-23/36

Fits Australian TRW power rack. Uses 23 spaces out of 36. Not index-able on the rack but works on other 16 mm shafts with base 36 spline.

C111

.585 (15 mm)-29

Fits Honda and aftermarket racks using Honda spline.

C112

.570 (14,5 mm)-28

Fits Datsun 240/260/280Z.

C113

.570 (14,5 mm)-36

Fits Mitsubishi Starion, Chrysler Concept, and some European electric-powered steering columns.

C114

.688 (17,5 mm)-54

ZF 60 degree profile used on many European makes such as BMW, Mercedes, Ferrari, Maserati

C115

Steering Universal Joints

.750-20 SPLINED THROUGH

Will couple any Woodward part to any other Woodward part without welding. Also useful in industrial applications. *NOTE: for HE racks, use part number VH201 at right.*

CD201

INTERNAL COUPLER for HE racks

Installs on the servo output spline and “plugs” the servo into the pinion. This coupler is smaller diameter to fit inside the servo adapter. *NOTE: the set screw spacing is special and will ONLY join the servo and pinion in a type HE rack.*

VHE201