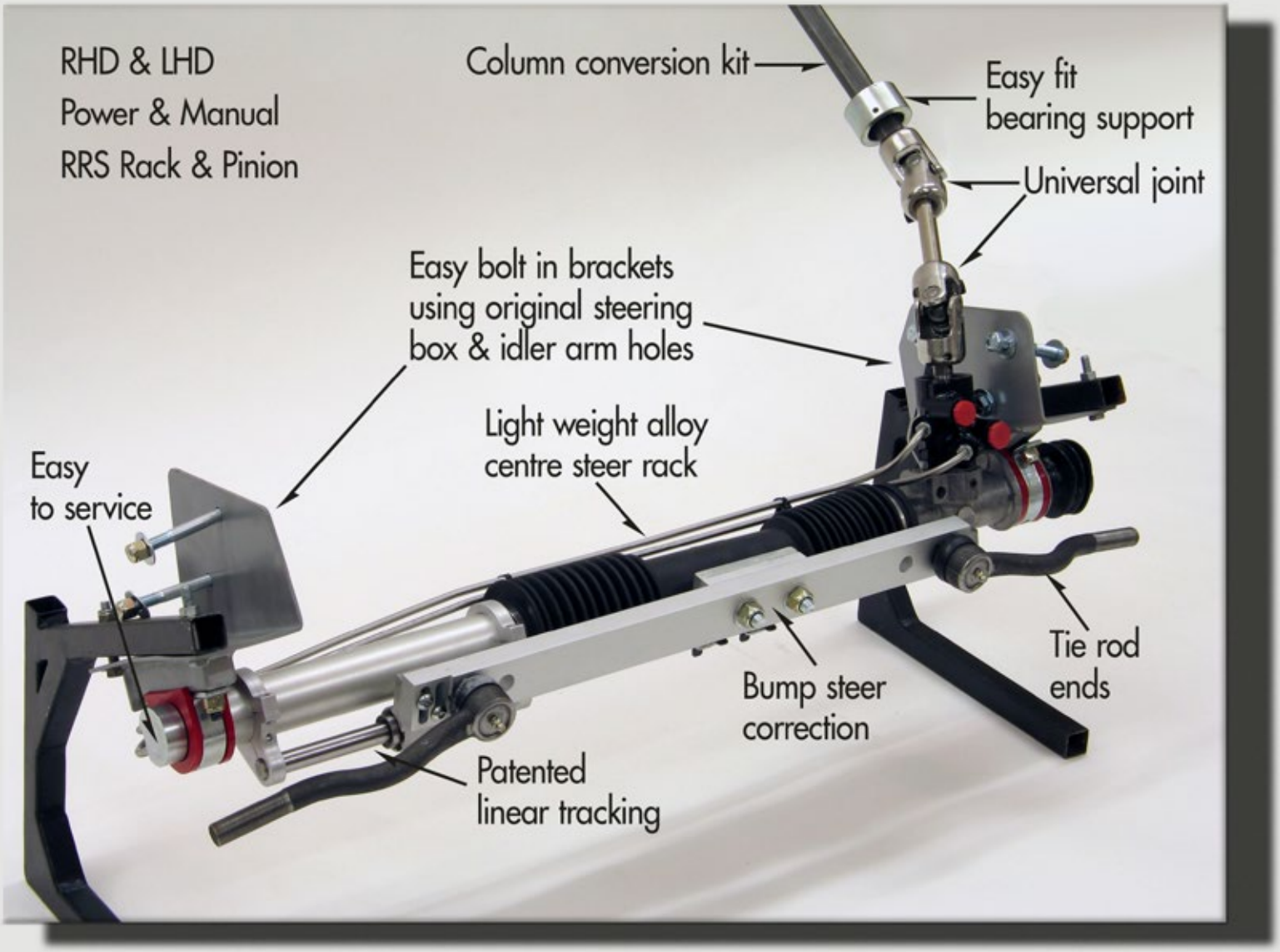
RRS

GT RACK



ENGINEERING CERTIFICATION

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GT RACK

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GT RACK

History & Development

RRS rack 2019

This document will explain and demonstrate the RRS GT-rack is a well-engineered, safe steering up-grade for the car models in table 1. This document will demonstrate that when the RRS GT-rack is installed as per manufacturer's instructions, the maintenance routine (as per instructions) are followed, the vehicle will have reduced bump steer, a safe, accurate and reliable steering system for many years to come.

Table 1

Rack variation groups:

Ford Customline, Mainline, Crown Vic 55-58
Ford Compact Fairlane FA FB FC
Ford Falcon XK-XP
Mercury Comet 1960-65, US Built Ford Falcon 1960-65
Ford Falcon XR-XY Mercury Comet 1966-1970, US Built Ford Falcon 1966-70
Ford Falcon XR-XY Ford Fairlane ZA to ZD
Ford Fairlane (US built) 66-67 Ford Torino 66-67 Ford Ranchero 66-67 Mercury Comet 66-67 Mercury Montego 66-67 Mercury Cyclone 66-67
Ford Fairlane (US built) 66-67 Ford Torino 66-67 Ford Ranchero 66-67 Mercury Comet 66-67 Mercury Montego 66-67 Mercury Cyclone 66-67
Ford Falcon XA-XF Ford Fairlane ZH to ZLFord Maverick
Ford Mustang 64-66
Ford Mustang 67
Ford Mustang 68-70 Mercury Cougar 68-70
Ford Mustang 71-73
Ford Torino 67-70
Ford Maverick 70-77 Mercury Comet 71-78

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GT RACK

The GT-rack is single design platform with tailored drag bar, drag bar interlink, and rack brackets. The use of a modular design principle allows RRS to custom locate the pivot point of the inner tie rods per model to minimize factory bump steer, while using the existing OEM securing architecture. The rack housing is manufactured by Nexsteer, used in multiple models with a wide range curb weights and power plants. The cars were sold across the globe in the millions, without incident. The power head and gear set are re-manufactured to strict tolerance and industry best practice, all other components are new with load rating that exceeds OEM equivalents.

Key Benefits

- **Improved bump steer**
- **No cutting or welding**
- **Maintain original column**
- **No additional load on chassis**
- **Increased steering accuracy**
- **Works with original suspension**
- **5 year unlimited warranty**
- **Full installation manual**
- **Load bearing data & finite element analysis**

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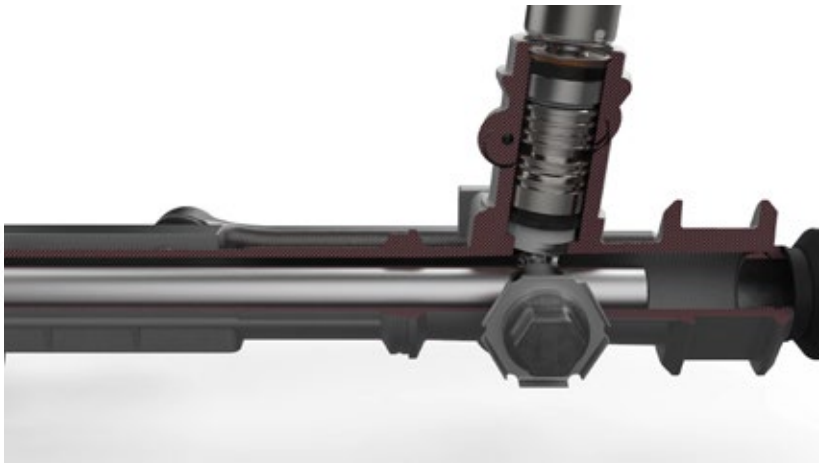
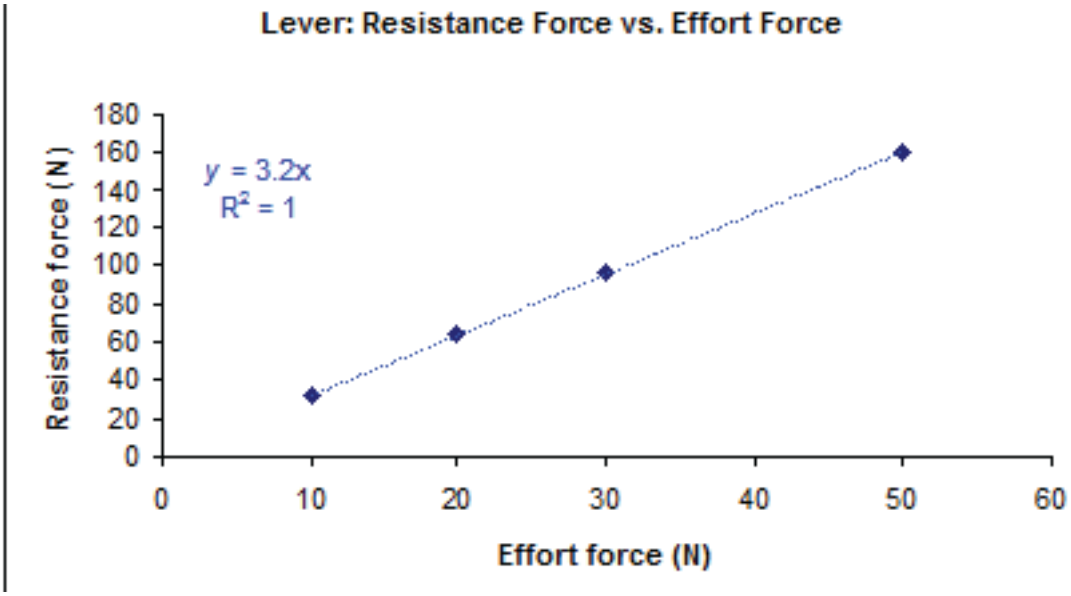
GT RACK

Design

Pinion Vs Pitman Arm



A Ford steering box drives A Pitman Arm typically 90-120mm long. A rack and pinion system is direct gear set to a lateral geared bar, the force required to drive the rack and pinion is 50% less than that required to drive a pitman arm. The steering forces remain the same but the load on the anchoring of the steering box is halved. The reduction in anchoring forces equates to stress reduction on the chassis rail of -50%.



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GT RACK

Rack Brackets

Rack Bracket

One of the design principles behind the RRS GT-rack is improved safety factoring, the rack brackets are great example of this. The brackets anchor in the original steering box and idler holes on the vertical chassis rails, they also affix to the horizontal bottom rail through a spreader plate. This second plane of attachment makes the new rack bracket more secure than the original steering infrastructure. The gusset is welded along the vertical face securing the bolt seat infill to the more secure platform.

Design

RRS continues to expand the range of cars the GT-Rack covers. When a new model is being prototyped RRS maps out the desired rack location, a bracket is designed and drawn up. These are usually made from four parts per drivers side and five parts per passenger side:

- The bracket body (image 1)
- The gusset (image 2)
- The bolt seat infill (image 3)
- Spreader plate (image 4)
- 1" UNF 3/8 bolts (image 5)

Image 1

Image 2

Image 3

Image 4

Image 5

Method of Construction

•The pieces are laser cut and bent in 3mm mild steel

•The elements are placed in welding jig and welded by a qualified welder

•The bracket is then painted and sealed

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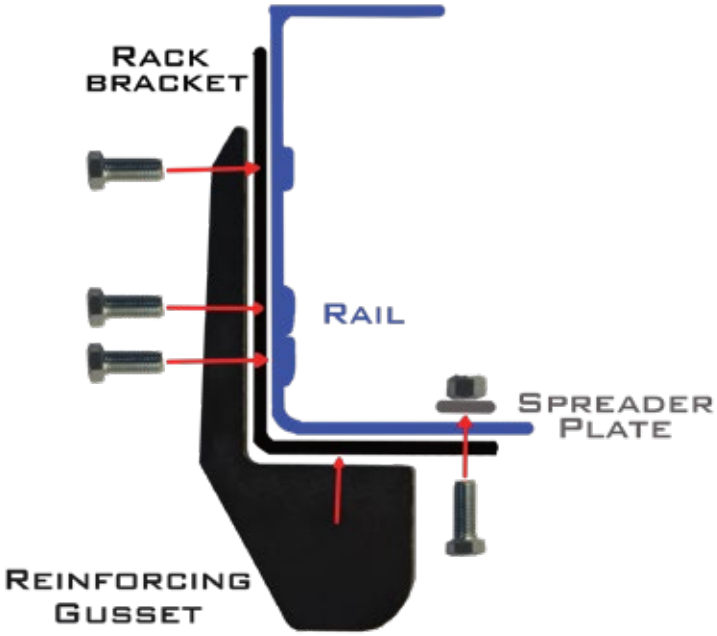
Rack Brackets

The RRS L-shaped rack bracket design with cross gusset reinforcement and secondary plane clamping through a spreader plate results in 25% increase in steering anchoring from stock.

Original steering box clamping, with single plan rail point of attachment.



VSB14 states: 4.14 Chassis Mounted Steering Gear
Chassis mounted steering gear installations must be carried out in accordance with the following:

• Where new chassis mounting bolt holes are required, the chassis must be reinforced to carry the steering gear loads and the bolt holes in box section chassis rails must be reinforced with tubes of 1.6mm wall thickness minimum to prevent crushing of the
chassis section.

RRS GT-rack mounts to original idler arm and steering box bolt holes, then through the L shaped bracket and use of loader spreader is attached in the horizontal plane. The brackets are more secure and by using a rack over a pitman arm the chassis is less stressed than stock therefore the RRS GT-rack satisfies this section of 4.14

RRS has (@ June 2019) 37 rack bracket variants all with two plane rail fastening.

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Rack Brackets

Part No: RRS-GTB 01
Description: U-bracket stamped from 5mm mild steel then Zinc plated. Source: Poole Engineering

Part No: RRS-GTB 02
Description: Positive locater allowing for chassis racking
Source: Nolathane 41106

Part No: RRS-GTB 03
Description: Nylock 3/8 UNC nuts
Source: Hobson Engineering

Part No: RRS-GTB 04
Description: Spacer plate nylock nut, 1" nut and washers
Source: Hobson Engineering

Part No: RRS-GTB 06
Description: Rack bracket 2 hole (idler arm) 3mm mild steel
Source: Hygrade Engineering

Part No: RRS-GTB 07
Description: Rack bracket 3 hole (steering box) 3mm mild steel
Source: Hygrade Engineering

Part No: RRS-GTB 05
Description: Horizontal spacer plate made from 3MM 304SB STAINLESS STEEL
Source: Hygrade Engineering

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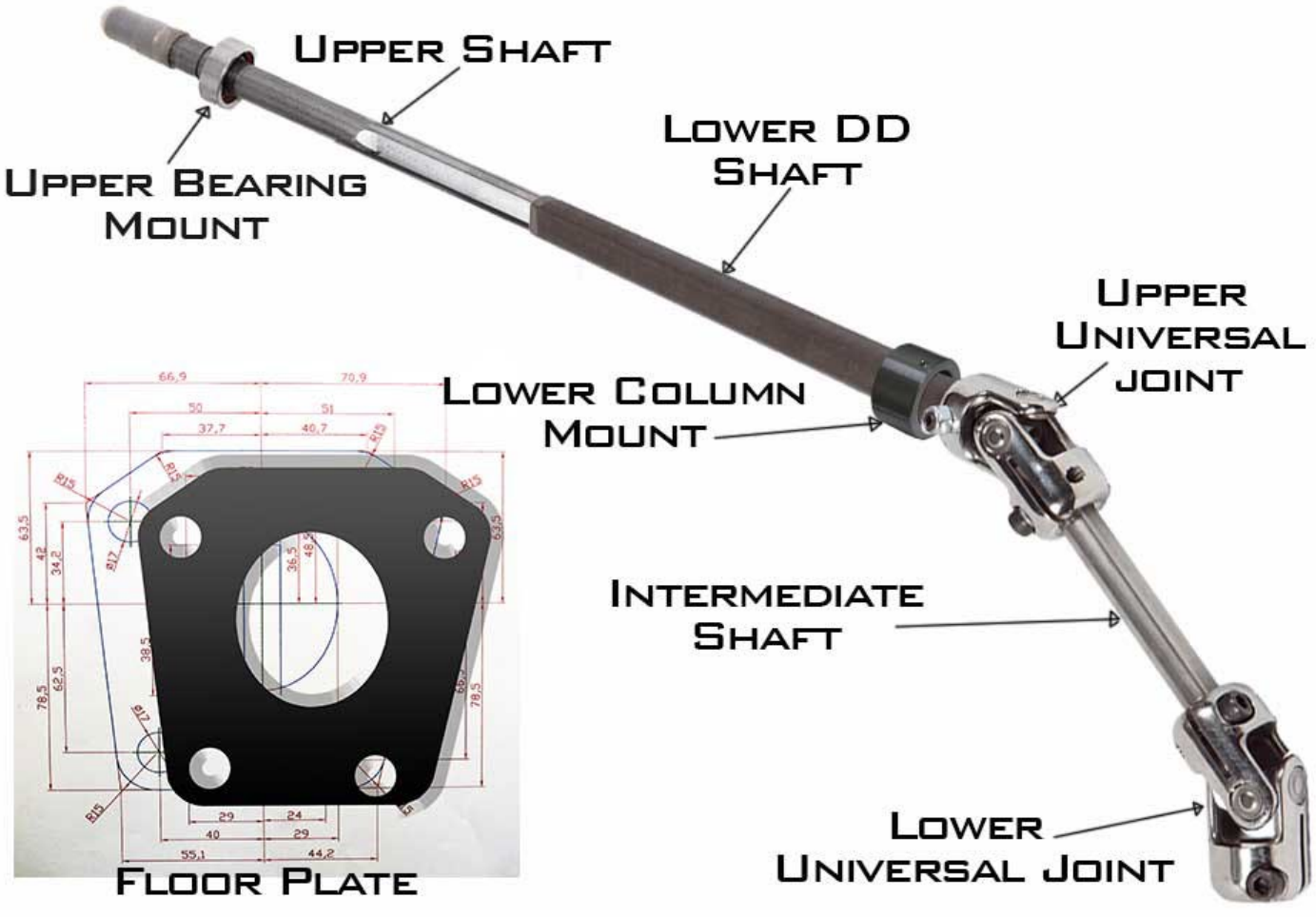
Internal Column Conversion



The RRS GT-rack is supplied with a column conversion kit. This allows the installer to connect the pinion to the stock column and maintain the collapsibility of the column. For conversions to cars with a non-collapsible column the same column conversion system is supplied.
The RRS column conversion kit uses OEM spec parts (same material, same dimensions) for all parts above the upper universal joints.

The universal joints are supplied by Maval Manufacturing LLC, they have safety factor of 7.5 (assuming 42nM of force could be supplied by the driver).
The intermediate shaft are supplied by Poole Engineering (Aus.) load rated greater than the universal joints.

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COLUMN CONVERSION KIT MATERIALS LOAD

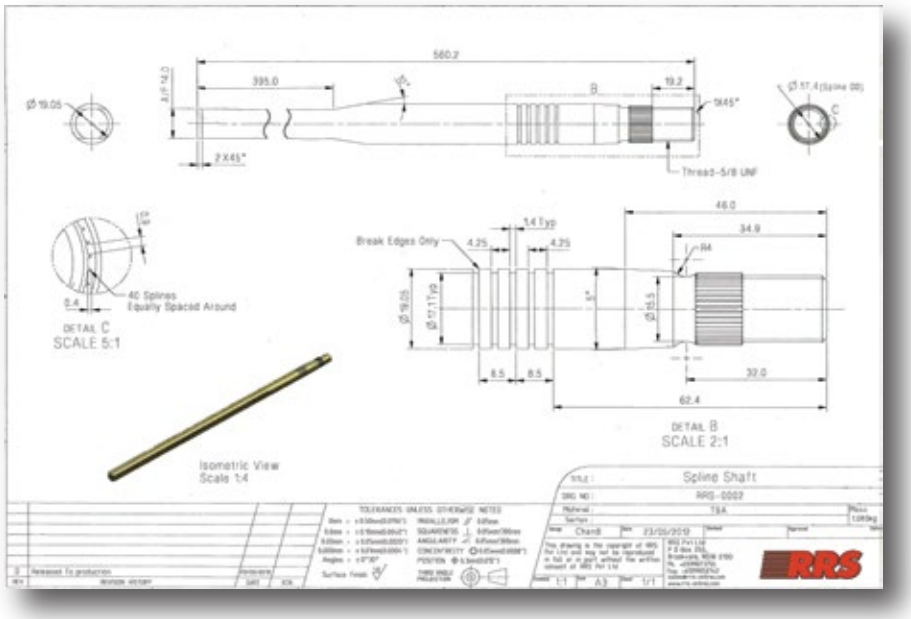
Part No: RRS-GT027
Description: Upper shaft bearing
Source: OEM spec.

Part No: RRS-GT027
Description: Upper shaft locater bearing
Source: OEM spec.

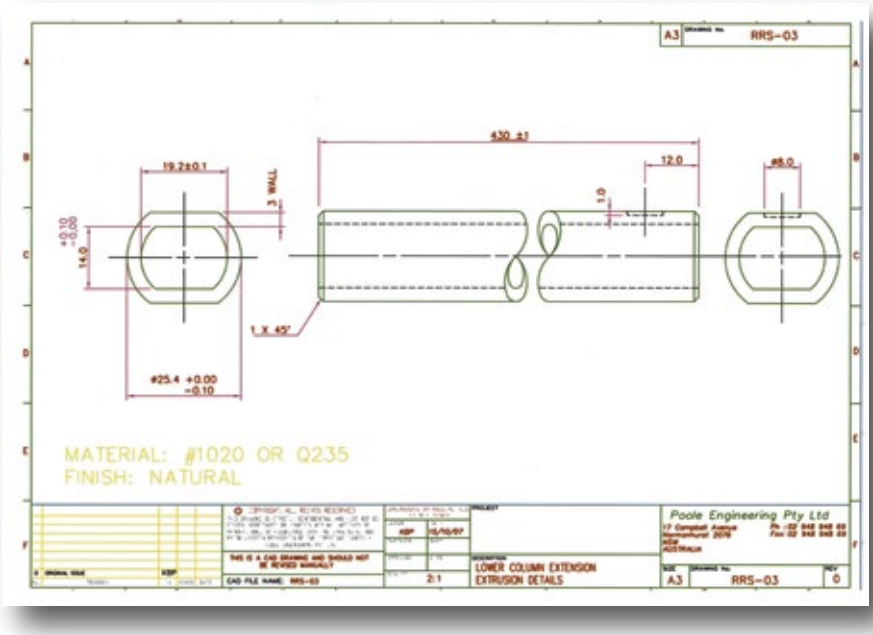
Part No: RRS-GT029

Description: lower column shaft locating bearing

Source: OEM SPEC.



Part No: RRS-GT028 Description: Upper column shaft.
Source: OEM spec/ PMP Engineering. Material: Bright bar steel



Part No: RRS-GT030 Description: Lower Double D column
Source: OEM spec/ Poole Engineering. Material: OEM spec extrusion.

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Column conversion kit materials load

Part No: RRS-GT029C

Description: Upper universal joint spider and yoke load rated to 320Nm

Source: Maval Manufacturing (USA)
Materials: Stainless steel,
nickel steel alloy, mild steel.

Part No: RRS-GT029D

Description: Lower universal joint spider and yoke load rated to 320Nm

Source: Maval Manufacturing (USA)
Materials: Stainless steel,
nickel steel alloy, mild steel.

VSB 14 states: 4.14 Chassis Mounted Steering Gear
Chassis mounted steering gear installations must be carried out in accordance with the following:
• Chassis mounted steering gear assemblies must be sourced from a vehicle of similar or larger mass than the finished vehicle as modified;
• Unless the steering column is aligned with the steering gear with no more than 5˚ of angular mismatch, fabric or rubber couplings may not be used at the steering gear input shaft. Where more than a 5˚ angular mismatch exists, a metallic universal joint may be used. If the axes of the column and steering gear input shaft do not intersect at the position of the coupling, an intermediate shaft must be fitted with two universal joints to provide for the misalignment;

The RRS GT-rack is sourced from vehicles with GVM up to 2140Kg and uses load rated universal joints to couple steering column to rack pinion, there RRS GT-rack satisfies 4.14

VSB14 states: 4.20 Steering column Shaft Couplings
Steering column shaft couplings must be selected and installed as follows:
• Couplings which are designed for use on manual steering may be used on power steering vehicles;
• Couplings designed for use on power steering vehicles only, are not to be used on manual steering vehicles;
• Re-assembly of steering couplings utilizing revised components must ensure that the resulting assembly has the torsional strength to withstand an applied torque of 200Nm;
• Machining of couplings to alter the PCD of the attaching bolts must ensure that the resulting assembly has the torsional strength to withstand an applied torque of 200Nm; and
• The alignment of the coupling must be maintained to within the manufacturer's specification and phasing of the universal joints must be correct.

The universal joints in RRS GT-rack are load rated to 320Nm and if installed as RRS installation instructions (pages 7-11) the universals will operate within tolerance, therefore RRS GT-rack satisfies 4.20

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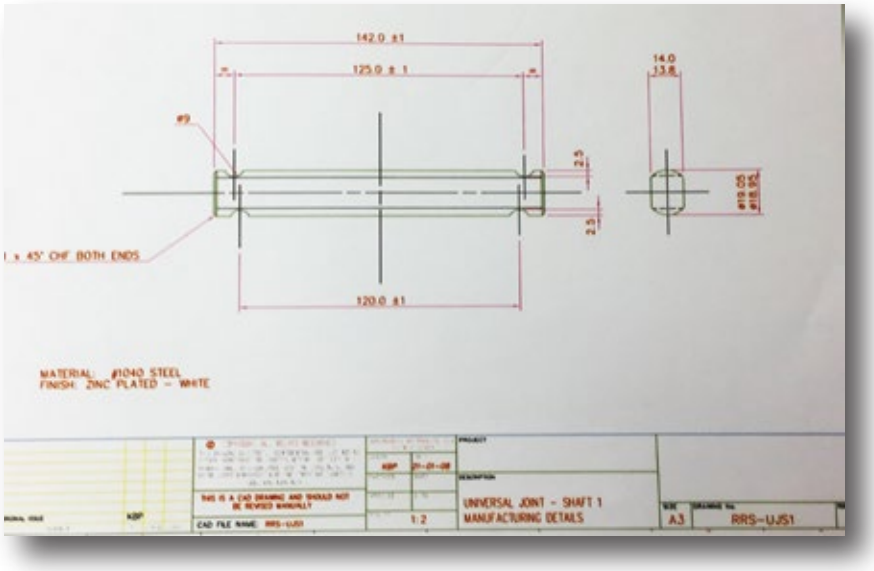
COLUMN CONVERSION KIT MATERIALS LOAD



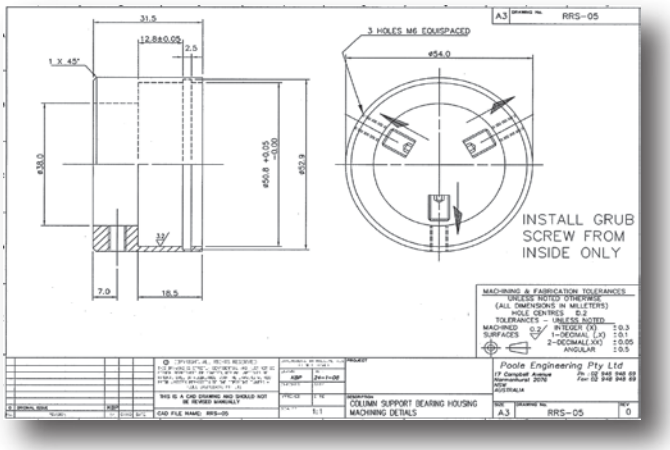
Part No: RRS-GT029E Description: lower column shaft locating bearing holder
Source: RRS design/ PMP engineering.

The VSB14 states: 4.21 Intermediate Shafts
Intermediate shafts must be selected and installed as follows:
• Intermediate shafts designed for use only on power steering vehicles must not to be used on manual steering vehicles;

The RRS-GT029E Intermediate shaft is load rated to greater than 320nM and therefore exceeds OEM for both the manual and powered versions of the RRS GT-rack therefore satisfies 4.21

Part No: RRS-GT029B
Description: lower column shaft locating bearing seal

Source: OEM design
Material: Rubber



Part No: RRS-GT029A
Description: lower column shaft locating bearing holder
Source: RRS design/ PMP engineering.

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Rack housing, Pinion, Gear Set

RRS GT-Rack uses a Nexteer Automotive rack housing, pinion and gear set, originating from vehicles sold between 1999-2009, in North America, Europe, and Asia, in vehicles with a GVM of 1450Kg to 2210Kg and OEM wheel sizes of 16x8 to 21x7. The Nexteer Automotive rack housing, pinion and gear set has been used in vehicles such as Land Rover and Cadillac, being driven for more than 20 years, establishing an unblemished record of longevity and reliability.

The VSB14 states:

4.13 Rack and Pinion Steering Gear

Rack and pinion steering gear installations must be carried out in accordance with the following:

• Rack and pinion assemblies must be sourced from a vehicle of similar or larger mass than the vehicle being modified;

The choice of Nexteer Automotive rack housing, pinion and gear set satisfies 4.13.

Part No: RRS-GT018 Description: Rack housing Source: Nexteer Automotive OEM.

Part No: RRS-GT017 Description: Gear Set Source: Nexteer Automotive OEM.

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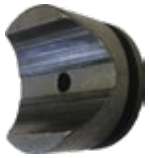
GT RACK

Rack housing, Pinion, Gear Set

Part No: RRS-GT036
Power Head
Description: Power head
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT036-L
Description: Power-head seals
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT036-K
Description: Power head welch cap
Source: OEM Saginaw/ Delphi.



Part No: RRS-GT037
Description: Pinion slider
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT039
Description: Sector shaft adjuster
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT039A
Description: Sector shaft adjuster locking ring
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT036-A
Description: Upper power head cir clip
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT036-B
Description: Upper power head seal
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT036-C
Description: Upper power head bush
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT036-D
Description: Upper power head bearing
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT036-E
Description: Mid power head cir clip
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT036-F
Description: Power head lower bush
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT036-G
Description: Power head nylon bush
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT036-H
Description: Lower Power-head bearing locater
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT036-I
Description: Lower power-head cir clip
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT036-J
Description: Power-head locating nut
Source: OEM Saginaw/ Delphi.

Part No: RRS-GT038
Description: Upper Bearing locater
Source: OEM Saginaw/ Delphi.

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Gear-set to Drag Bar Inter linkage

The RRS GT-rack gear set is connected to the drag bar via an acetel block, OEM metal bushes, ISO grade 8.8 bolts, a model specific 10mm "interlink plate". The linkage cab sustain lateral load of 800Nm insuring a safety factor of 7.6 of the gear set to drag bar inter linkage.

SB 14 states: 4.14 Chassis Mounted Steering Gear
Chassis mounted steering gear installations must be carried out in accordance with the following:
• Chassis mounted steering gear assemblies must be sourced from a vehicle of similar or larger mass than the finished vehicle as modified;

The GT-rack gear set drag bar inter linkage strength is greater than the Nexteer system supplied with the housing which was rated for vehicles with GVM 2140Kg, therefore the GT-rack gear set drag bar inter linkage satisfies 4.14.

Drag Bar Bolt ISO grade 8.8
RRS-GT 007

Lock Tab
RRS-GT 008

The Acetel block creates the RRS GT-rack steering stops.

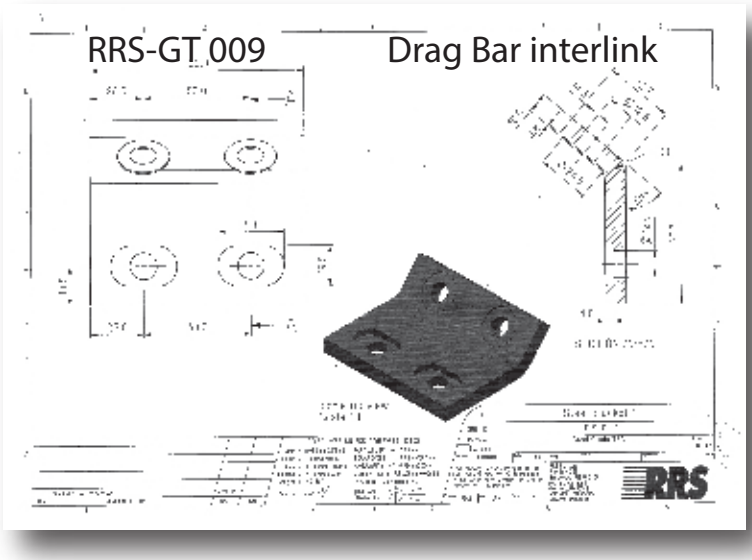
The VSB14 states:2.1.5 Turning Circle The vehicle must have a sufficient turning circle in each direction and must meet all ADR dimensional requirements.

The acetel block is the internal steering stops this mimics the original steering stop therefore RRS GT-rack satisfies 2.1.5

Acetel block
RRS-GT 011

Acetel block seating bush
RRS-GT 012

Drag bar seating bush
RRS-GT 010



RRS currently manufacturers 7 different drag bar interlink

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GT RACK

Hydraulic and Housing Extension

Part No: RRS-GT019
Description: Inner Hydraulic Tube
Source: RRS design / Poole Engineering.
Material: Hydraulic tubing precision honed

Part No: RRS-GT019A
Description: Hydraulic tube locater
Source: RRS design / PMP Engineering.
Material: Mild steel

Part No: RRS-GT019B
Description: Viton O-ring
Source: Dupont.
Material: synthetic rubber and fluoropolymer elastomer

Part No: RRS-GT019C
Description: Glacier bearing
Source: Thyssing Industries
Material: Steel Back + Porous Bronze Sinter + PTFE + Lead

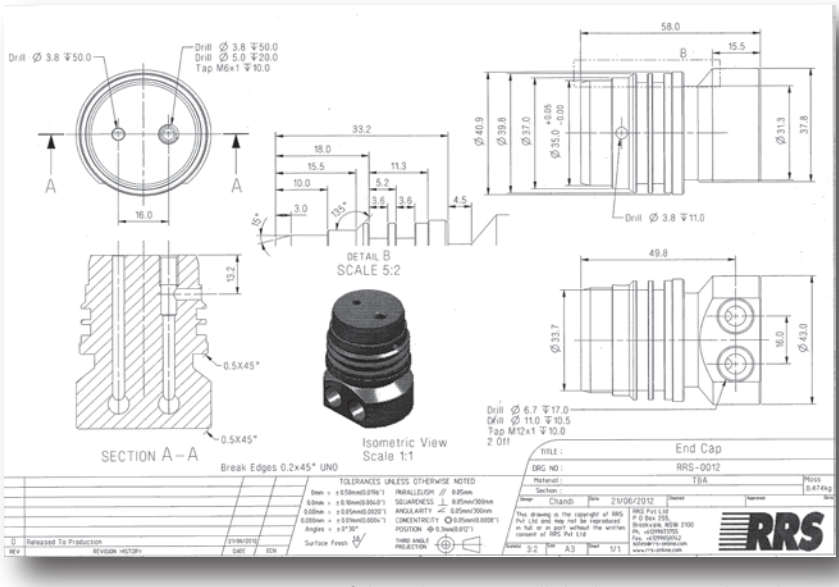
Part No: RRS-GT019D
Description: Piston seal
Source: OEM parts supplier.
Material: Rubber with Teflon insert

Part No: RRS-GT019E
Description: Piston Head
Source: OEM parts supplier.
Material: Mild steel

Part No: RRS-GT020
Description: Outer Hydraulic Tube
Source: RRS design/ PMP Engineering.
Material: High strength machined scaffold tube.

Part No: RRS-GT020A
Description: Housing to Hydraulic Tube
Source: RRS design/ PMP Engineering.
Material: 6061 Aluminum CNC milled.

Part No: RRS-GT019F
Description: Teflon seal
Source: OEM parts supplier.
Material: Teflon



Dimensions: 10mm of thread. 5.4mm wall thickness 59mm length.

Part No: RRS-GT019G
Description: Expansion O-ring
Source: OEM parts supplier.
Material: Rubber

Part No: RRS-GT019H
Description: Compression Olive
Source: OEM parts supplier.
Material: Mild steel

Part No: RRS-GT019I
Description: Piston nut
Source: OEM parts supplier.
Material: Mild steel

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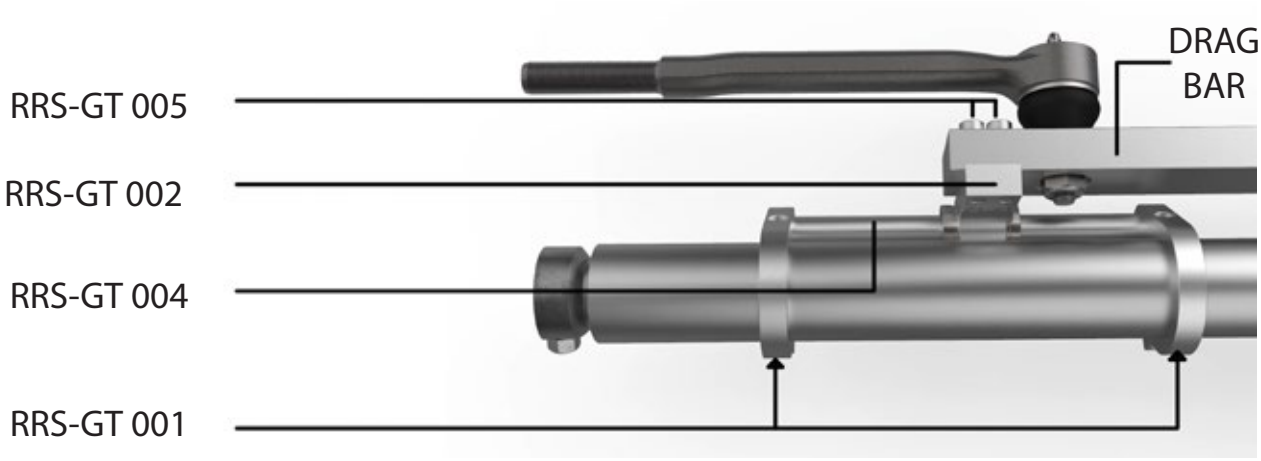
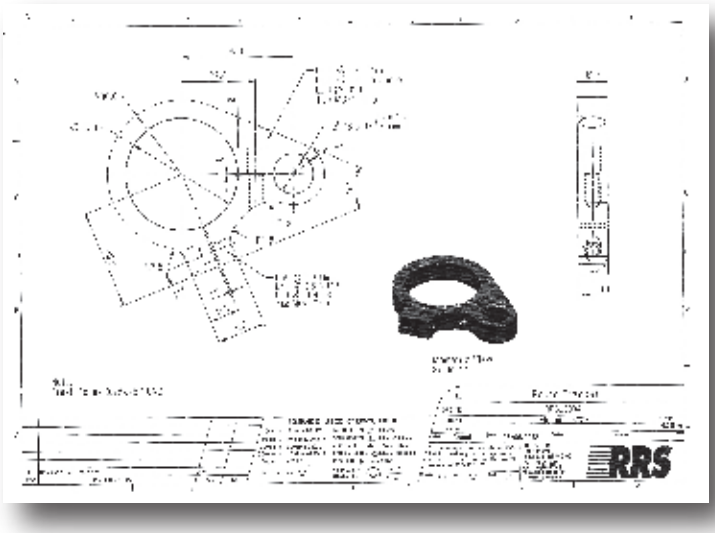
GT RACK

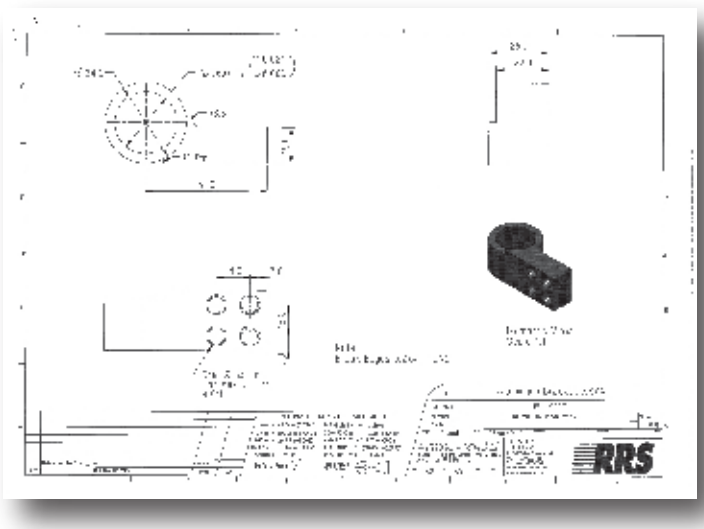
Linear Tracking

RRS patented the linear tracking or third stabilizer system, this innovation allows RRS to create long drag bars on centre steer rack design, without compromising the drag bar stability.
The angular forces from the tie rods are absorbed by the anchoring.





RRS-GT 001

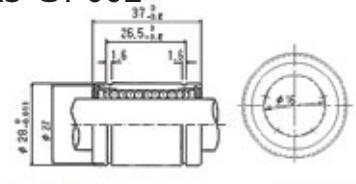


RRS-GT 002

RRS-GT 004

Stainless steel linear tracking rod

RRS-GT 005
Socket bolt



PART NUMBER		DIA METER		OUTER DIAMETER		L	B	W	D 1	BASIC LOAD RATING(N)		NO.OF BALL CIRCUIT	WEIGHT (gf)
Resin	Steel	dr.	TOLERANCE	D	TOLERANCE					DYNAMIC (C)	STATIC(Co)		
LM16	LM16-A	16	0 -0.009	28	0 -0.013	37	26.5	1.6	27	770	1170	5	69

RRS-GT 003

Linear tracking bearing

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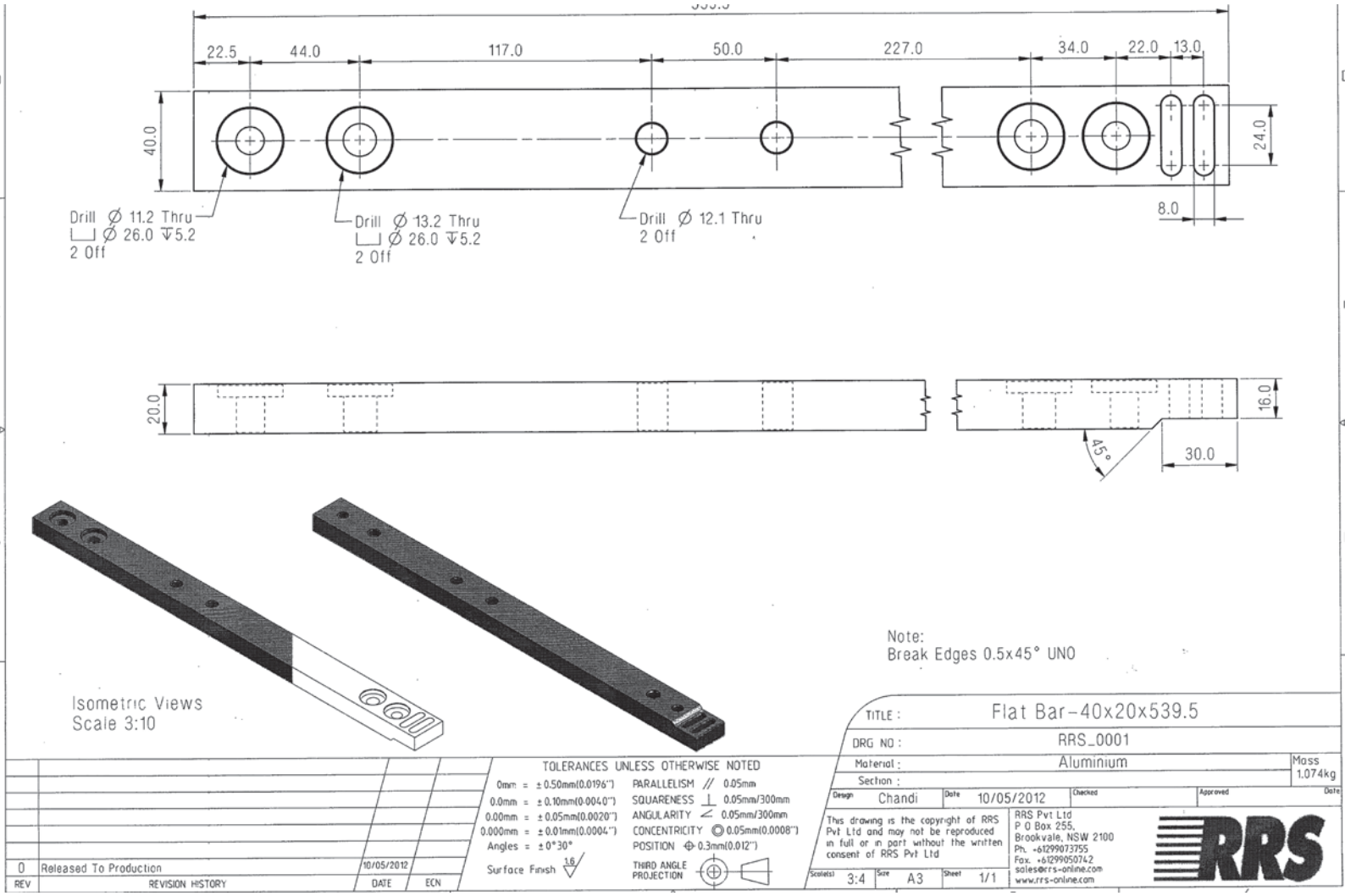
GT RACK

Custom Drag Bars

The RRS GT-rack is fitted with a model specific custom drag bar. RRS commissioned finite element analysis (FEA) to prove the operating strength and destruction limits.
The drag bars vary in length and inner tie rod positions, the material and material mass is constant, so the inherent strength is constant across the models RRS makes.

The VSB14 states: 4.19 Drag link
Drag link specific requirements are:
• A new drag link may be manufactured provided that it is one continuous length of material between end fittings and the selected material is suitable for the design and method of manufacture; and
• Sectioning and re-welding of the drag link must always be performed in accordance with the processes and controls described in this section.

The RRS drag link components are not welded. The RRS drag link components are load rated to exceed any possible steering load. The RRS drag bar is tested (see following report), therefore the RRS GT-rack satisfies VSB14 4.19



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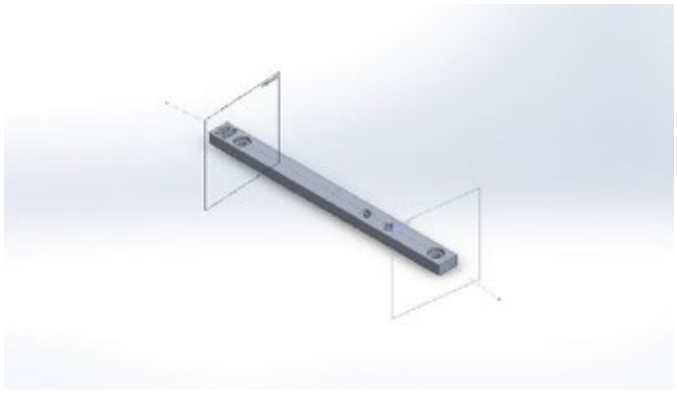
GT RACK

DRAG LINK FEA



Simulation of 012-018

Date: 19 May 2019
Designer: W. Rogulski
Study name: SimulationXpress Study
Analysis type: Static

Table of Contents

Description

RRS-ONLINE

Part: STEERING DRAG LINK

This Simulation Study Is applied onto LH (Passenger) side Only.

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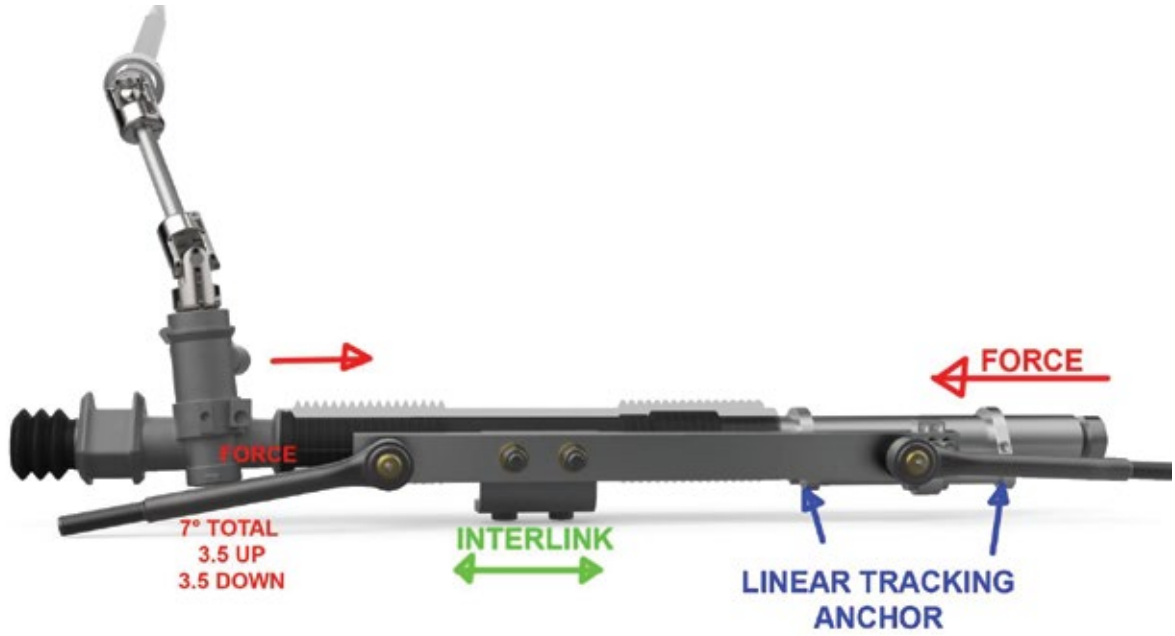
GT RACK
Drag Link FEA

W. Rogulski
19/05/2019

Assumptions

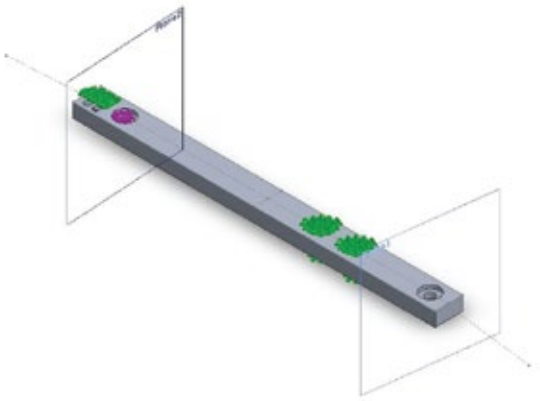


ONLY FORCES ARE LATERAL AS THE DRAG BAR IS ANCHORED TO THE HOUSING VIA LINEAR TRACKING
MAXIMUM CAR WEIGHT 1800KG MAX CORNERING FORCE 2G
FORCE ON TIE ROD EQUAL MAX FORCE ON STUB AXLE
THE INTERLINK MAX-LOAD IS 800N

GT RACK
Drag Link FEA

W. Rogulski
19/05/2019

Model Information



Model name: 012-018
Current Configuration: FEA

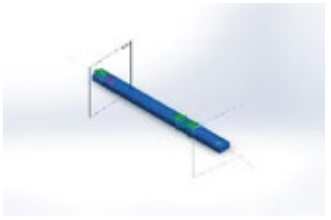
Solid Bodies

Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Split Line 1 	Solid Body	**Mass:1.05228 kg** **Volume:0.000389732 m^3** **Density:2,700 kg/m^3** **Weight:10.3123 N**	**W:\CADtek\JOBS\012 RRS\012-018 Steering Drag Link\01 - 2D, 3D\012-018.SLDPRT** May 19 14:24:20 2019

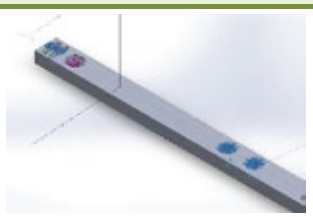
DRAG LINK FEA

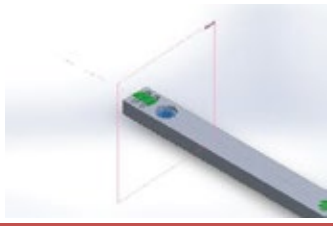
W. Rogulski
19/05/2019

Material Properties

Model Reference	Properties	Components
	**Name:** 6061-T4 (SS) **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Yield strength:** 2.27527e+08 N/m^2 **Tensile strength:** 2.4e+08 N/m^2	Solid-body 1(Split Line 1)(012-018)

Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** 14 face(s) **Type:** Fixed Geometry

Load name	Load Image	Load Details
Force-1		**Entities:** 2 face(s), 1 plane(s) **Reference:** Plane 2 **Type:** Apply force **Values:** ---, ---, -,800 N

GTRACK
Drag Link FEA

W. Rogulski
19/05/2019

Mesh information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	7.30638 mm
Tolerance	0.365319 mm
Mesh Quality Plot	High

Mesh information - Details

Total Nodes	13001
Total Elements	7533
Maximum Aspect Ratio	9.2842
% of elements with Aspect Ratio < 3	98.9
% of elements with Aspect Ratio > 10	0
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:01
Computer name:	DUPA-JASIU-02

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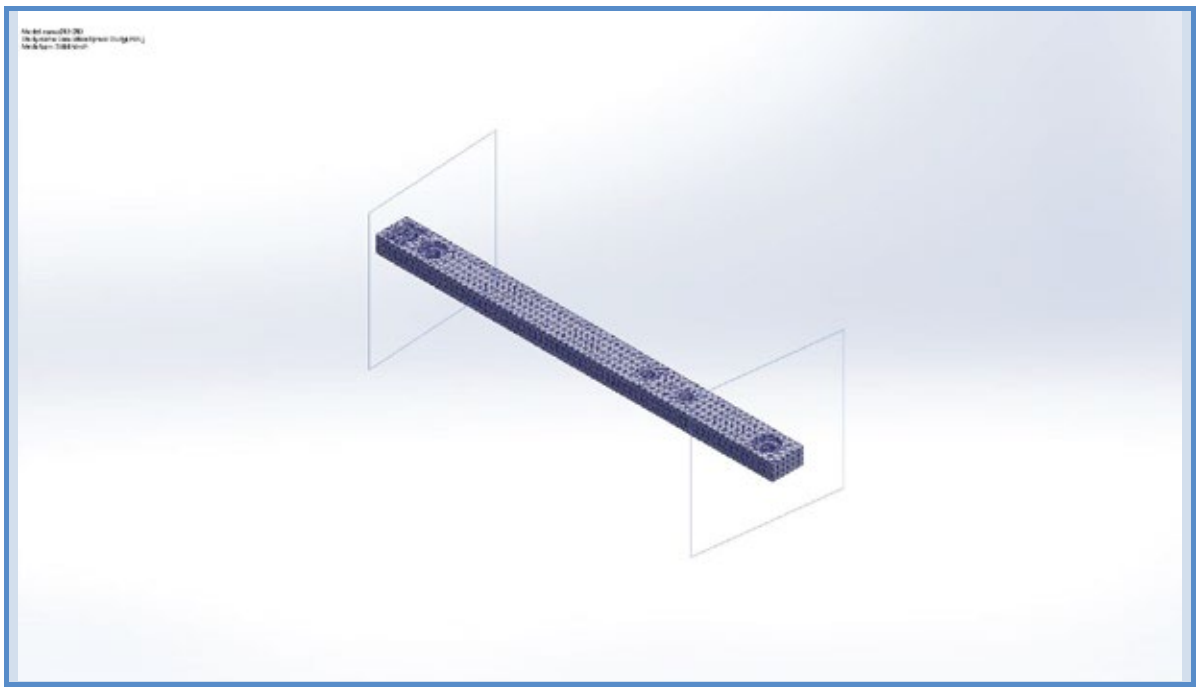

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Study Results

Name	Type	Min	Max
Stress	VON: Von Mises Stress	2.018e-03 N/m^2 Node: 619	1.011e+07 N/m^2 Node: 10448

012-018-SimulationXpress Study-Stress-Stress

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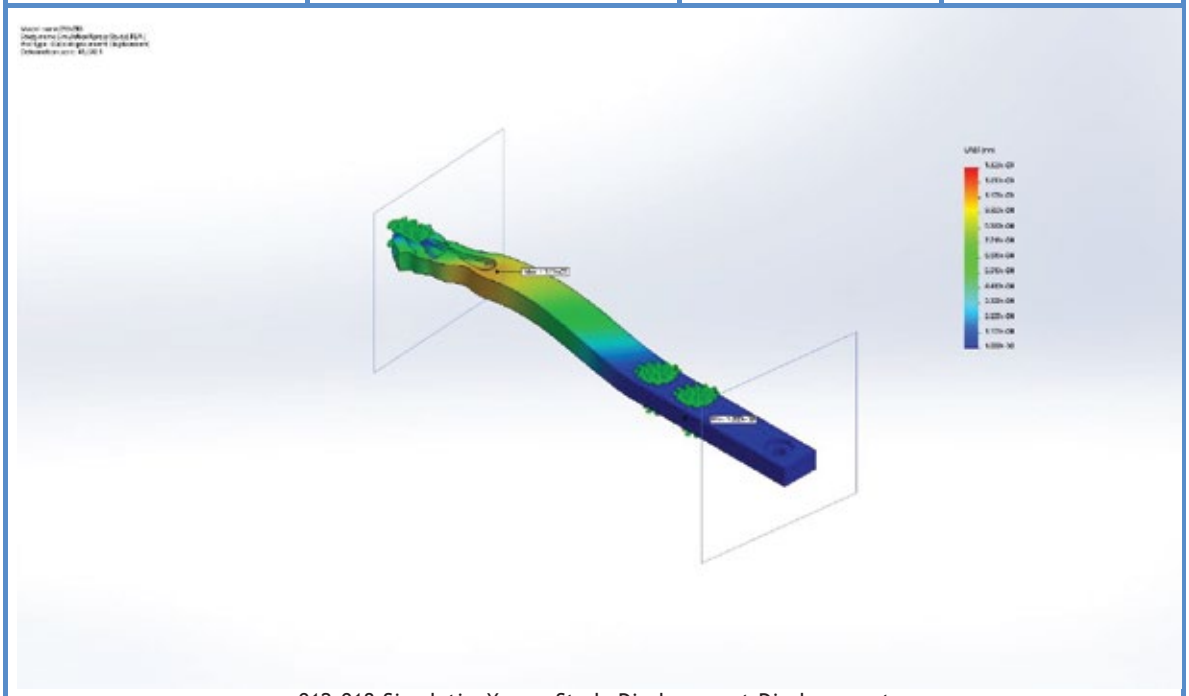
Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0.000e+00 mm Node: 125	1.323e-03 mm Node: 12399



012-018-SimulationXpress Study-Displacement-Displacement

DRAG LINK FEA

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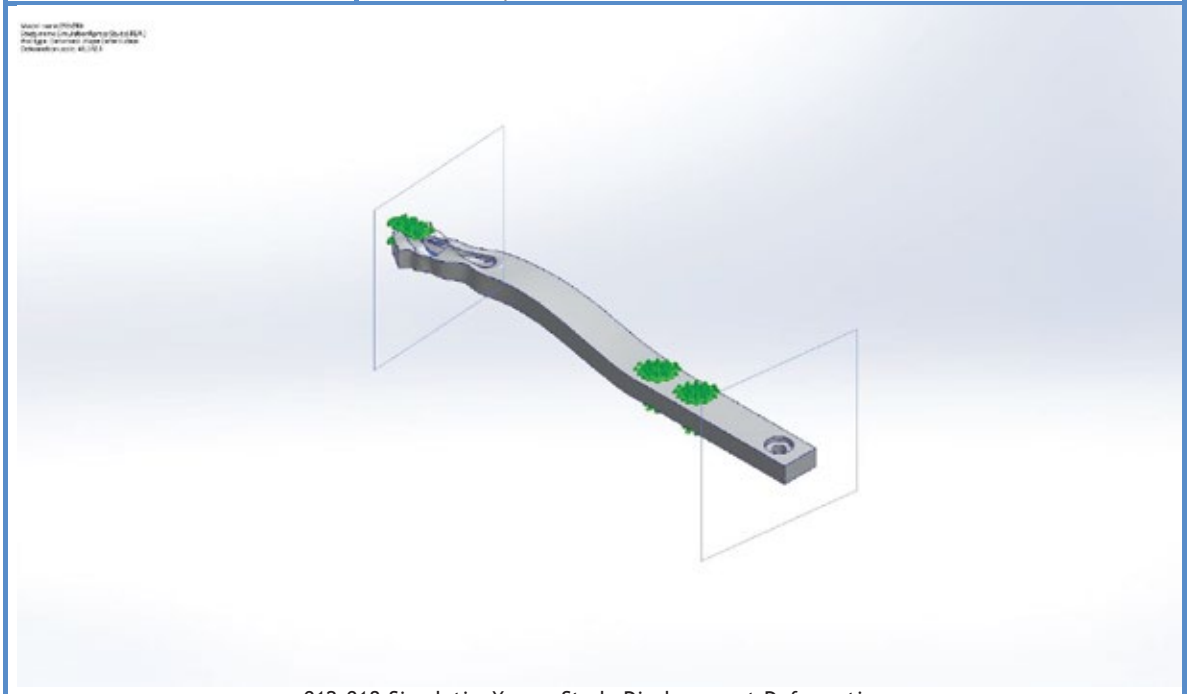
Name	Type
Deformation	Deformed shape



012-018-SimulationXpress Study-Displacement-Deformation

DRAG LINK FEA

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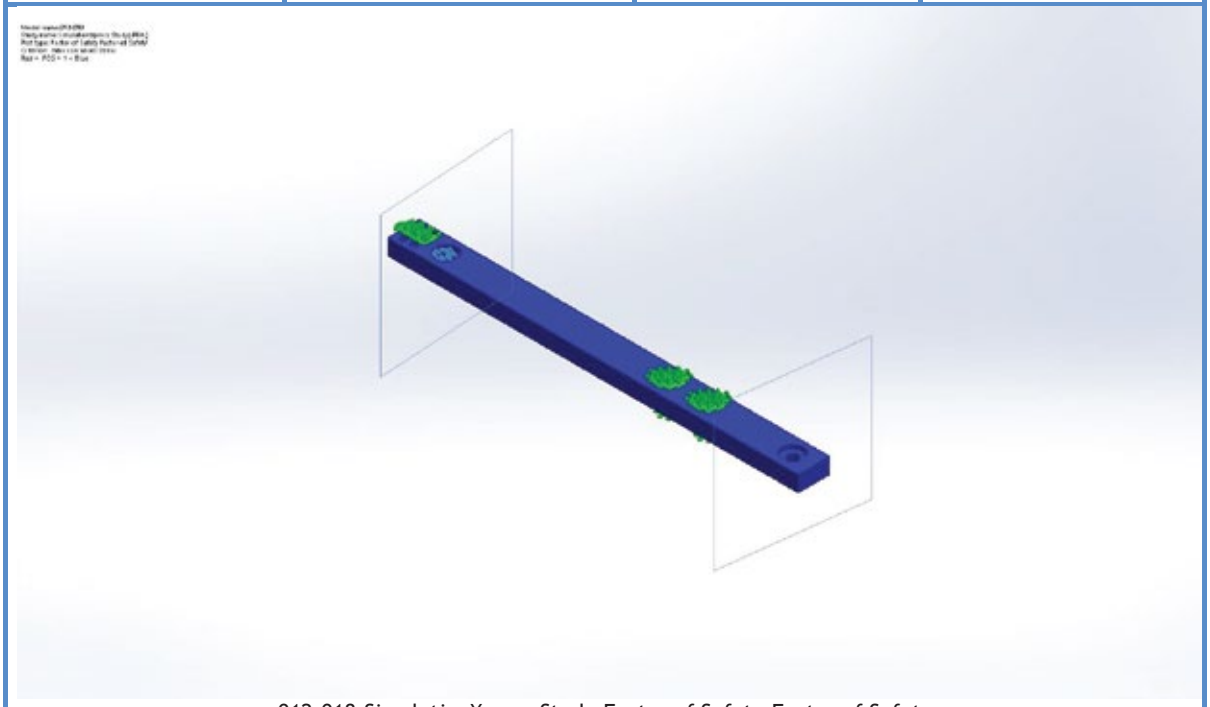
19/05/2019

Name	Type	Min	Max
Factor of Safety	Max Von Mises Stress	2.252e+01 Node: 10448	1.127e+11 Node: 619



012-018-SimulationXpress Study-Factor of Safety-Factor of Safety

Conclusion

FEA study carried out for purpose of design validation.

FEA study results show minimum FOS of 22, which is deemed satisfactory.

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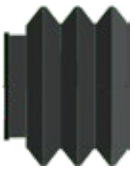
Boots, Tie Rods and Tapers

The RRS GT-rack has two concertina rubber boots, these are to protect the exposed moving parts from road grit and the weather. The rubber boots are custom made by Poole Engineering.

Part No: RRS-GT013 Description: Rubber centre rack boot.
Source: RRS design/Poole Engineering. Material : Rubber



Part No: RRS-GT016
Description: Rack end boot.

Part No: RRS-GT014
Description: Stainless clip..
Source: Boltmaster.
Material: Stainless Steel

4.17 Tie-rods
Tie Rods may be modified by:
• shortening by extending the thread and removing the excess threaded portion, provided that the rod is suitable for this operation, the length of thread engagement is equal to or greater than the original manufacturer's specification; or
• extending by provision of threaded adapters, provided that the original manufacturer's specification in respect to buckling strength, shear strength, thread engagement, thread locking and material selection are all maintained.

The RRS GT-rack uses new OEM inner tie rods on all kits, therefore RRS GT-rack satisfies 4.17

Part No: RRS-GT015 Description: Inner tie rods. Source: OEM after market parts supplier.

All tie rod tapers are CNC machined to match OEM for tie rods.

VSB14 states 4.8 Tapered Adapter Sleeves
Tapered adapter sleeves may be used provided they are made of suitable steel, i.e. equivalent in strength and hardness to the stud to be mounted.

The RRS GT-rack uses OEM tapers for tie rods on all kits, therefore RRS GT-rack satisfies 4.8

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Load Data

The RRS rack housing and gear set is sourced from Nexteer commonly used in GM vehicles such as Cadillac's with GVM up to 2000 kg. Left Hand & Right Hand versions use mirror versions of every component and operate in an identical way with the same load bearing capacity.

The highest stressed component in the RRs steering system is the steel adapter plate. Steering torque is greatest when vehicle is static. Research by R.S.Sharp and R. Granger have shown turning torque on a wheel with 3000 N load were a maximum of 180 Nm when the tyre was under-inflated at 1 bar and reduced to 800Nm when inflated to 3 bar.

With a steering arm length of 150mm
Load in the steering link = 180 x 1000/150
= 1.2 kN

Steering arm inner ball joints have an offset of the face of the plate of 30 mm that generates a bending moment in the bar = 1.2 x 30 kNm

Moment of inertia minor axis = $40 \times 10^3 / 12$
= 3330 mm^4

Bending stress in bar = 1.2 x 30 x 5/3.3 Mpa
= 55 Mpa

The steering torque with the vehicle in motion is substantially lower thus the risk of failure of the adapter plate by fatigue from the cyclic loading is acceptably low.
RRS rack drag bar design: - RRS uses 6061 Aluminum Alloy heat treated to T6. Then anodized clear for maximum durability and corrosion resistance. The RRS patented Linear Tracking design –a 3rd stabilizing point to decrease lateral stress.

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SUSPROG SIMULATED BUMP STEER

The graphic below shows a simulated bump steer outcome for an XY Falcon with an RRS GT-rack fitted. The simulation was identical to the real bump steer outcome. RRS ran the simulation across all the cars covered by the RRS GT-rack systems, all vehicles had a 70% or better reduction in bump steer.

The VSB14 states: The bump steer characteristic must be selected to suit the entire vehicle dynamics and should be established in conjunction with the rear suspension bump steer characteristics.

The RRS GT-rack systems improves the bump steer outcome on all models.

Steering

SusProg3D XY with RRS rack standard suspension set up with wheel alignment.s3d Front Steering

Rack and pinion RHD, rear steer (fixed chassis & upright pivots)

Vehicle lateral datum (X): Vehicle centreline
Vehicle vertical datum (Y): Ground
Vehicle longitudinal datum (Z): centre between camber bolts

Chassis pivot points (from vehicle X, Y, Z datum)

- tie rod (steering rack)	- X	220.00
	- Y	187.34
	- Z	154.97
- tie rod (steering arm)	- X	601.03
	- Y	189.95
	- Z	156.90

Steering tie rod length	381.05
Steering arm length (actual)	139.09
Steering arm length (effective)	135.26
Steering arm - tie rod angle (effective, degrees)	103.39

Rack c-factor 48.30

Bump steer	absolute mm		relative mm	
100.00 bump	0.10	toe in	-1.90	toe out
90.00 bump	0.72	toe in	-1.28	toe out
80.00 bump	1.25	toe in	-0.75	toe out
70.00 bump	1.70	toe in	-0.30	toe out
60.00 bump	2.06	toe in	0.06	toe in
50.00 bump	2.32	toe in	0.32	toe in
40.00 bump	2.48	toe in	0.48	toe in
30.00 bump	2.54	toe in	0.54	toe in
20.00 bump	2.48	toe in	0.48	toe in
10.00 bump	2.31	toe in	0.31	toe in
Static	2.00	toe in	0.00	
20.00 droop	0.94	toe in	-1.06	toe out
40.00 droop	-0.85	toe out	-2.85	toe out
60.00 droop	-3.58	toe out	-5.58	toe out
80.00 droop	-7.64	toe out	-9.65	toe out

Steering turn angle	Toe out in turn	Wheel toe angle LH	Wheel toe angle RH	Rack travel	Steering Ratio:1 LH	Steering Ratio:1 RH
30.00 LH	-6.78	-36.97	30.19	72.23	10.98	17.63
25.00 LH	-3.75	-28.94	25.19	60.40	13.17	17.92
20.00 LH	-1.95	-22.14	20.19	48.38	14.75	18.10
15.00 LH	-0.81	-16.00	15.19	36.24	15.93	18.15
10.00 LH	-0.11	-10.30	10.19	24.07	16.79	18.06
5.00 LH	0.26	-4.93	5.19	11.95	17.41	17.82
Straight	0.38	0.19	0.19	0.00	17.61	17.61
5.00 RH	0.26	5.19	-4.93	11.95	17.82	17.41
10.00 RH	-0.11	10.19	-10.30	24.07	18.06	16.79
15.00 RH	-0.81	15.19	-16.00	36.24	18.15	15.93
20.00 RH	-1.95	20.19	-22.14	48.38	18.10	14.75
25.00 RH	-3.75	25.19	-28.94	60.40	17.92	13.17
30.00 RH	-6.78	30.19	-36.97	72.23	17.63	10.98

Steering turn angle	Camber (actual) LH	Camber (actual) RH	Camber (change) LH	Camber (change) RH	Caster (actual) LH	Caster (actual) RH	Caster (change) LH	Caster (change) RH
30.00 LH	2.93	0.80	2.33	0.20	5.30	-2.19	3.85	-3.64
25.00 LH	2.22	0.64	1.62	0.03	4.61	-1.60	3.16	-3.05
20.00 LH	1.70	0.52	1.09	-0.08	3.96	-1.00	2.51	-2.45
15.00 LH	1.30	0.46	0.69	-0.14	3.32	-0.39	1.87	-1.84
10.00 LH	0.99	0.45	0.39	-0.15	2.68	0.23	1.23	-1.22
5.00 LH	0.76	0.50	0.16	-0.10	2.06	0.84	0.61	-0.61
Straight	0.60	0.60	0.00	0.00	1.45	1.45	0.00	0.00

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LS3 Checklist

REPLACEMENT STEERING BOX OR RACK
1.1 Steering Box/Rack Selection

Is the specified RHD steering box/rack of equivalent capacity to the original?	Yes	See pages 12-27
Is the Pitman arm size/length and arc of travel equivalent to the original?	N/A	
Does the Pitman arm spline match the steering box spline?	N/A	
Is the drag link attachment taper identical?	Yes	See page 28

1.2 Steering Rack Modification

Are all modifications as per the Specific Requirements detailed in Code LS3?	**Yes**	**See pages 3-32**

1.3 Steering Box/Rack Mounting

Does location and angle of steering box/rack replicate original?	Yes	See pages 5-7
Will the chassis rail be reinforced and fitted with steel sleeves?	N/A	
Is mounting of steering box/rack equivalent strength to original?	Yes	See pages 5-7

1.4 Steering Box/Rack coupling

Will the original column coupling (or equivalent) be used?	Yes	See pages 8-11
Will the original steering box/rack coupling (or equivalent) be used?	Yes	See pages 8-11

1.5 Idler arm

Does the design ensure that the mounting brackets will be adequately secured to chassis rail?	Yes	See pages 5-7
Does the design idler arm location and angle replicate the original?	N/A	
Are mounting bolts replaceable?	Yes	See pages 5-7

1.6 Drag link

Is the original drag link to be used without modification?	N/A	
Is the original drag link to be used without modification?	N/A	
Are the proposed modifications as per VSB 4 requirements?	Yes	See pages 14-27

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GT RACK

LS3 Checklist

REPLACEMENT STEERING BOX OR RACK continued

1.7 Steering geometry

Will the turning circle in both directions remain within legal limits? Yes Page 14

Has the original geometry been replicated in the new configuration? within 90%

The RRS GT-rack uses the original steering mounts (idler arm and steering box holes), the turning circle is maintained, however a small adjustment to the inner pivot point, via the model specific drag linkage reduces the factory bump steer by more than 70%-95% (depending on model.

If the geometry is to be altered, will the bump steer still be within specified limits? Yes Page 30

2 REPLACEMENT FRONT SUSPENSION CROSS-MEMBER SUSPENSION AND STEERING

2.1 Cross member Mounting

Have the cross member mountings been designed to be at least equivalent in strength to the original mountings? N/A

Will the chassis rail be reinforced and fitted with steel sleeves? N/A

2.2 Design Loadings

Do all components have adequate strength for the application? Yes See pages 12-27

3 REPLACEMENT FRONT SUSPENSION STRUTS OR UPRIGHTS

3.1 Ball Joints and Tie-rod Ends

Are all ball joint tapers compatible or to be modified in accordance with Code LS3 requirements? N/A

3.2 Steering geometry

Will the turning circle in both directions remain within legal limits? Yes Page 14

Has the original geometry been replicated in the new configuration? within 90%

The RRS GT-rack uses the original steering mounts (idler arm and steering box holes), the turning circle is maintained, however a small adjustment to the inner pivot point, via the model specific drag linkage reduces the factory bump steer by 70%-95% (depending on model).

If the geometry is to be altered, will the bump steer still be within specified limits? Yes Page 30

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LS3 Checklist

4 STEERING COLUMN

4.1 Mounting

Have support brackets been designed to be equivalent in strength to the original brackets? Yes

The RRS Gt-rack kit is designed to use the original column with modification to the internal . The upper column mounts therefore remain factory, RRS supplies a model specific fire wall plate , the material and inherent design strength are identical to stock.
Therefore the RRS GT-rack is compliant with 4.1 of LS3

4.2 Intermediate Shaft

Will the modified shaft meet Code LS3 requirements? Yes See Page 11

If applicable, do the specified couplings and attachments meet the requirements of VSB 4? Yes

The RRS Gt-rack kits for steering conversions for left hand drive vehicles use the same mounting brackets (using original idler arm and steering box chassis rail mounting holes) as the left hand drive RRS GT-rack, and the universals and intermediate shaft are also the same i.e. load rated, with safety factor of more than 7.
Therefore the RRS GT-rack is compliant with VSB4

4.3 Collapse Operation

Does the specified column installation retain its designed collapse system? Yes

Are the original telescopic sections to be left unmodified? Yes

The RRS Gt-rack kit s are designed to use the original column replacing the lower D-shaft and upper column and bearing mount (for selected models) therefore if the column was designed as collapsible it maintains it's original collapsibility.

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LS3 Checklist

5 LHD STEERING CONVERSION USING LHD STEERING BOX OR RACK

5.1 5 LHD STEERING CONVERSION USING LHD STEERING BOX OR RACK

5.1 Drag Link

Is the original left hand drive drag link to be used without modification? Or N/A

Is the original right hand drive drag link to be used without modification? Or N/A

Does the designed modified drag link replicate the original? N/A

Are modifications designed in accordance with the specific requirements of Code LS3? N/A

5.2 Steering geometry

Will the turning circle in both directions be retained? Yes

Is original geometry replicated in right hand drive form? Yes /within 90%

The RRS GT-rack uses the original steering mounts (idler arm and steering box holes), the turning circle is maintained, however a small adjustment to the inner pivot point, via the model specific drag linkage reduces the factory bump steer by more than 70%-95% (depending on model).

If geometry is altered, is bump steer still within specified limits? Yes See page 30

Section 6 through to 11 are not applicable to RRS GT-rack.

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LS4 Checklist

CHECKLIST LS4 FRONT SUSPENSION AND STEERING MODIFICATION CODE LS4

The RRS GT-rack complies with LS3 and should therefore be compliant with LS4, where relevant we will address the questions.

3 STEERING

3.1 Steering Box Mounting

Is chassis rail reinforced and fitted with steel sleeves? No

The RRS Gt-rack mounting plates use the factory idler arm and steering box chassis rail holes, the brackets use bolts and spreader plates on the horizontal rail (see page 6), this with reduces forces of a rack over a pitman arm (see page 6).

Although the answer is no RRS contends the design means an increase in safety factoring.

Drag Link 3.2

If modified, does drag link comply with Code LS4 requirements? Yes See pages 14-27

Are weld X-ray and hardness results satisfactory? N/A

Steering Rack 3.3

If modified, does the rack comply with Code LS4 requirements? N/A

Steering Geometry 3.4

Is turning circle in both directions within specified and legal limits? Yes See page 14

Yes: if installed as per instructions

Is the amount bump steer still within specified limits? Yes See page 30

Yes: if installed as per instructions

Wheel Alignment 3.5

Have all wheels been aligned in accordance with the Design specifications?

NB. Car must wheel aligned as per installation instruction

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VS14 Compliance

VSB14 Reference points

2.1 Drive-ability

2.1.5 Turning Circle
The vehicle must have a sufficient turning circle in each direction and must meet all ADR dimensional regulations

Vehicle Standard (Australian Design Rule 43/04 - Vehicle Configuration and Dimensions) 2006

TURNING CIRCLE

Every vehicle must have a turning circle in either direction, as determined by reference to the extreme outer edge of the tyre track at ground level, not exceeding 25 metres in diameter.

The RRS GT-Rack system maintains original vehicle turning by maintaining the factory steering stops, so is therefore compliant to VSB14 2.1.5

2.1.6 Tyre Deflation
Any Modification to suspension and steering, including replacement tyres and rims, must ensure that the vehicles body, exhaust system, axles, suspension or steering components do not contact the road when the tyre(s) deflate. Therefore, if one or more tyres deflate when the vehicle is level road, the rims and tyres must be the only part of the vehicle in contact with the road.

The RRS GT-Rack system's lowest point is the base of the outer tie rod end, on stock (14") rims with no tyre clears the road by 1.65cm therefore is complaint with VSB 14 2.1.6

2.1.7 Ride Height
Ride height is a very important parameter as it has a direct influence on a vehicle's centre of mass (centre of gravity) and hence its stability and performance.

The RRS GT-Rack system does not affect ride height

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VS14 Compliance

2.1.8 Suspension Travel

It is important to retain at least two thirds of the original suspension travel in either direction in border to maintain safe road holding characteristics.

The RRS GT-Rack system does not affect suspension travel

2.2 Strength and Flexibility

2.2.1 Strength of Suspension and Steering Components

Changes in wheel width and offset, and bump clearance can cause significant increases in stress levels in suspension and steering components of both independent and beam axle suspensions.

The RRS GT-Rack replaces the steering box that uses a pitman arm therefore a 50% reduction in steering load on the chassis mounting is achieved see page 6 of this document therefore an increase in the rolling diameter of the front tyre to no greater 275/30 R20 means steering load increase does not increase the load on the chassis. Therefore the RRS GT-Rack fitted with tyres that have a rolling diameter no greater than 275/30 R20 (as per the fitting instructions) the GT-Rack is compliant with VSB 14 2.2.1

2.2.2 Fatigue Strength

Some modifications that are satisfactory in the short term (e.g. on competition cars that travel relatively short distances) are often completely unsuitable for road because of the effects of metal fatigue. A suspension component on a road car can break from metal fatigue at stresses much less than that experienced during competition use.

The RRS GT-rack system maintains original points of attachment and eliminates the use of the pitman arm, reducing chassis stress. All stressed components have had finite element analysis, vindicating safety factoring assumptions (see Cadtek reports attached to this document) therefore the RRS GT-Rack is compliant with VSB 14 2.2.2

2.2.3 Flexible Arms and Joints

Some suspension components (flexible arms and joints) are designed to twist when the suspension moves vertically. Boxing-in these components and/or using stiffer replacement bushes can cause large stresses in mounting bolts and brackets causing them to break or tear out. It is recommended that replacement of rubber flexing bushes with harder bushes should only be done in applications where single plane movement occurs.

The RRS GT-rack system maintains original points of attachment and eliminates the use of the pitman arm so reduces chassis stress. The tie rods are OEM. The universal joints are load rated to exceed a safety factor of 3.
Therefore the RRS GT-Rack is compliant with VSB14 2.2.2

VS14 Compliance

2.3 Fabrication

All work must be performed in accordance with recognised engineering standards. Cutting, heating, welding or bending of components should be avoided by choosing unmodified production components wherever possible.

2.3.1 Welding, Fasteners and Electroplating

Mandatory requirements and guidance on the above items are contained in Section LZ Appendices.
- For the use of fasteners refer to Appendix A Fasteners;
- For welding techniques and procedures refer to Appendix C Heating and Welding of Steering Components; and
- For electroplating refer to Appendix D Electroplating.

The RRS GT-rack system has no welded parts. The fasteners used are ISO Grade 8.8 (metric sizes) and SAE grade 5 (imperial sizes) or better, no parts are chrome plated and suffer no hydrogen embrittlement. Therefore the RRS GT-rack is compliant with VSB 14 2.3.1

2.3.2 Mating Parts

Standard features such as splines, tapers and keyways must conform to published standards and their mating parts must conform to matching standards.

RRS GT-rack system only uses splines, tapers and keyways that conform to all matching standards for therefore the RRS GT-rack system is compliant with VSB 14 2.3.2

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FRONT SUSPENSION AND STEERING MODIFICATION (DESIGN) CODE LS3

SPECIFIC REQUIREMENTS

The following requirements apply to all suspension and steering LS Codes: Where change is made to the suspension or steering system design, the basic functional and construction requirements are provided as a guide for suitably qualified and experienced signatories when designing or certifying such modifications or conversions.
Each design should be fully documented, with drawings, calculations, procedural details, test results, wheel alignment specifications and any other data necessary to fully describe the vehicle modifications and should have a unique design number.
The design document should contain:
• Details of all drawings needed to fully describe the full extent of the modification;
• Details of any special modification techniques, procedures or adjustments; and
• Details of any testing of components (e.g. X-rays of modified drag links) and performance (e.g. bump steer plots) with related acceptance criteria. It is recommended that suspension and steering conversions utilise production components that do not require cutting, heating, bending or welding.

1 SUSPENSION AND STEERING GEOMETRY

Modified or redesigned suspension systems should meet the following requirements:

Free Movement. Suspension members and pivot bushes must be free to move through the full range of suspension travel from metal to metal positions at full bump and full rebound, without any geometric binding within the linkage and without any pivot being articulated beyond its design angles. This requirement applies when one wheel is at full bump and the opposite side wheel is at full rebound;

The RRS GT-rack is connected to the stub axle via an OEM tie rod and articulates through its full range. The pinion is connected to the steering wheel via 2 load rated universal joints and if installed as per the RRS instructions will travel freely through the full range. Therefore the RRS gt-rack is compliant with the free movement criteria

Roll Centre. The vehicle's roll axis is determined by the relative roll centre heights of the front and rear suspensions. A higher roll centre will reduce body roll but can result in unsatisfactory track variations and camber change on independent suspensions. The front suspension roll centre should not be higher than the rear suspension roll centre;

The RRS Gt-rack system does not affect the roll centre

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Camber and Track Change. The suspension design should minimise track change with vertical wheel travel and maintain the outside wheel as close to vertical (or at slightly negative camber) as the body rolls under cornering. This will maximise cornering adhesion and minimise tyre wear;

The RRS Gt-rack reduces bump steer by more than 70%. This reduces track change through the range of suspension, therefore the RRS GT-rack meets the camber and track change criteria.

Anti-squat, anti-dive. The amount of anti-dive geometry at the front suspension and anti-squat geometry at the rear is a matter of choice, depending on the vehicle characteristics desired. The pitch axis of the front suspension should be behind the front wheels while that for the rear suspension should be ahead of the rear wheels;

The RRS Gt-rack system does not affect anti-dive anti-squat

Vertical Wheel Travel. Spring rates and damper settings need to be selected to suit the character required for the vehicle. Spring rates should not be so high that an uncomfortably firm ride is achieved while they should not be so low that vehicle handling is compromised. Similarly damper settings should be selected to complement the spring rates. The latter may require some development effort. In general, the more vertical wheel-travel the better, because it allows larger wheel movements before bump rubbers are contacted;

The RRS Gt-rack system does not affect vertical wheel travel

Bump steer. When a wheel turns or steers as a result only of vertical suspension movement, this behaviour is called bump steer. A wheel can also steer as a result of longitudinal wheel movement in longitudinally compliant suspensions.
The bump steer characteristic must be selected to suit the entire vehicle dynamics and should be established in conjunction with the rear suspension bump steer characteristics. As a guide, a very small toe-out on bump will produce a stable understeer characteristic. The toe-out must not be excessive because it produces unresponsive steering and tyre wear. Front wheels should never toe-in on bump (unless the rear suspension also toes-in) because this causes unstable oversteer.
When the front wheels are deflected rearwards under the influence of road shocks, the wheel direction should either remain unchanged or should toe out slightly. Toe-out under these conditions produces a smoother ride. However too much can cause excessive tyre wear.

The RRS GT-rack system is tailored to the vehicle model to minimize bump steer. RRS achieve the bump steer reduction by optimizing the pivot point of the inner tie rod in the steering linkage. The bump steer readings post installing the GT-rack will show a bump steer reduction of greater than 70% from stock steering.

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Ball joint operating angles. The complete range of combinations of steering/suspension travel must be considered to ensure that there is no possibility of joints being over-articulated.

The RRS GT-rack is designed to work with original suspension, steering arms, lower control arms and steering stops, therefore the ball joints will not over-articulated. If the rack is installed along with the RRS coil over system the attaching points are in stock locations and subject to OEM movement restriction so the ball joint can not over articulate.

Over-articulation, even by a small amount can result in joint failure. An allowance must be made for deflection of suspension bushes under dynamic loading, as this can be significant at the extremes of travel. The compound angle of articulation of all steering and suspension ball joints must be established and compared with the manufacturer's specification for each joint.

Note: The specification will usually quote a slightly smaller angle than might be measured using a production component.

The RRS GT-rack is connected to the steer column through two universal joints and if installed as per the RRS installation instructions the universal joints will operate at angles less than their recommended maximum angles. The RRS GT-rack is fitted with OEM ball joints and the angles of articulation are the same as OEM whether operating with stock suspension or RRS coil over suspension.

Operating Clearances. All suspension members and steering levers and linkages must clear other vehicle components such as engine, transmission exhaust system and chassis members etc. over the full envelope of steering/suspension travel, after allowing for any likely movement of engine or other mechanical assembly. It is recommended that a clearance of at least 10mm be provided between these components and 25mm be provided for tyres.

The RRS GT-rack if installed per RRS installation instructions will clear engine, transmission exhaust system and chassis member etc by more than 10mm.

Track. Where non-original axle or suspension cross-member components are fitted, the offset of the wheel in relation to the axle or hub assembly used must not be increased by more than 12.5mm each side of the vehicle based on the specifications of the axle components used. If an axle assembly is shortened then the track width limit is taken as the axle manufacturers original track dimension, less the amount the assembly has been narrowed, plus 25mm.

The RRS GT-rack track width is unaffected by the coil over installation.

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GT RACK

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Linkage stability. Steering linkages must be evaluated to ensure that they cannot over-centre at any stage, under the influence of either steering gear forces or road wheel forces. Allowance must be made for significant deflection and wear in pivot bushes in the steering and suspension and a large safety margin must be maintained.

The RRS GT-rack connects from the column through D shaft then through an upper universal joint an intermediate shaft then a second universal joint which is attached to the pinion. All of these items are load rated to have a rotating safety factor of greater than 4. The rack bar is connected to the drag bar by a 10mm steel interlink to the aluminium which has had FEA showing a safety factor of 3. The tie rods are OEM

Steering stops. Must be provided and be installed as per those from the donor vehicle or as approved by the steering gear manufacturer. Reductions in steering gear travel must be designed to ensure that operating loads or stresses on the steering system are not increased.

The RRS GT-rack system maintains the factory steering stops

Ackermann principle. The Ackermann principle ensures accurate wheel geometry and tyre contact in turns avoiding excessive scuffing. All vehicles should incorporate a reasonable degree of Ackermann steering geometry. This concept is important when designing replacement steering systems and when altering the wheelbase of vehicles, e.g. limousine conversions.
At full lock, the lock angles must be appropriate for the desired turning circle and must not change significantly over the range of suspension travel. The toe-out at full lock should be selected, bearing in mind the true Ackermann angle, the types of tyres to be catered for and the use intended for the vehicle.
At partial lock, the toe-out should be suitable for the vehicle application. This usually means slightly less than the true Ackermann angle due to the operating slip angle of the outside front tyre.

The RRS GT-rack has a neutral effect on the Ackermann angle

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2 STRUCTURE

The body/chassis structure should meet the following requirements:

Body/Chassis. Reinforcements must be added to achieve comparable structural strength and stiffness at body attachment points whenever a replacement suspension or steering system from a different vehicle model is used. The modifications must not create local stress concentrations; and Cross-member.
When a cross-member is modified, or when a cross-member from another vehicle model is fitted, it must be reinforced where necessary to maintain its original structural strength and stiffness.

The RRS GT-rack system is attached to the chassis by the original steering box and idler holes. The brackets also attach in the horizontal plan via two bolts and a spreader plate. This dual plane attachment and the replacement of the pitman arm with pinion gear set makes a reduction in chassis loading, therefore there is no need to reinforce the chassis.

4 MODIFIED COMPONENTS

Where modifications of steering components cannot be avoided, the operations employed should be determined and controlled such that the final properties can be predicted and verified on an individual component basis by a NATA approved materials laboratory, using relevant Australian or International Standards as a reference. The following post process testing by the laboratory is a minimum for such components:
•Welded parts should have the weld material identified, a hardness test traversing across the weld area including the heat affected zone, an X-Ray inspection and a statement of weld integrity;

RRS GT-rack has no welded parts. The mounting brackets are constructed from 3 laser cut sections. The centre bolt mount piece is hydraulic stamped. They are placed in a welding jig and welded by a certified welder.

•Heated parts should be stress relieved, heat treated to a defined specification and undergo non-destructive testing such as magnetic particle or ultrasonic;

RRS GT-rack systems have no heated parts

•Parts which have been cold worked (where permitted) must be checked to ensure that the cold working is not excessive, stress relieved if required and undergo nondestructive testing such as magnetic particle or ultrasonic.

RRS GT-rack systems have no cold worked parts

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VS14 Compliance

4.1 Standard Features Standard features such as splines, tapers and keyways must conform to published standards and mating parts to matching standards.

R***RS GT-rack use OEM tapers on the drag bar.***
Therefore the RRS GT-rack is compliant with VSB 14 4.1

4.2 Machining of Input Shafts Machining of input shafts is allowable to reduce length, provided that welding is not involved, the same spline is machined at the new length and the minimum cross section, including radii, of the shaft is not reduced below that of the original. The modified pinion shaft should not be subsequently heat-treated.

R***RS GT-rack shafts are machined to size, they are not cut or welded.***
Therefore the RRS GT-rack is compliant with VSB 14 4.2

4.3 Machining of Any Components Machining of any components must meet the relevant specifications of tolerance and radii.

R***RS Gt-rack components are CAD drawn, laser cut to the program, and CNC machined to the program. All critical components are checked with GO/NOGO gauges.***
Therefore the RRS GT-rack is compliant with VSB 14 4.3

4.4 All Splines All splines must meet the original vehicle specifications and must engage over the same length as the original.
N/A

4.5 Threaded Bosses Threaded bosses where used for steering gear mounting, must provide full depth thread for engagement over 1.5 times the mating bolt diameter.
N/A

4.6 Welding of Steering Components to Chassis Steering components must not be welded to the chassis structure.

RRS GT-rack is a bolt in system and no part of the steering linkage is welded.
Therefore the RRS GT-rack is compliant with VSB 14 4.6

4.7 Re-machining of Ball Joint Tapered Stud Holes in Steering Arms Re-machining of ball joint tapered stud holes in steering arms may be undertaken provided that the re-machining does not reduce the safety of the design and the surface finish is equivalent to that of the original manufacture.

RRS Gt-rack use OEM tapers on the drag bar
Therefore the RRS GT-rack is compliant with VSB 14 4.7

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4.8 Tapered Adapter Sleeves Tapered adapter sleeves may be used provided they are made of suitable steel, i.e. equivalent in strength and hardness to the stud to be mounted.

N/A

4.9 Mounting Surfaces Mounting surfaces for steering components must designed and in a condition that ensures no stress inducing deflection of either mounting surface or steering component occurs when the attachment bolts are tightened.

RRS GT-racks are mounted to model specific brackets that mate to the original idler arm and steering box mounting locations replicating OEM mated surfaces. Therefore the RRS GT-rack is compliant with VSB 14 4.9

4.10 Braces Braces if required to achieve appropriate steering box/rack mounting stiffness, may be bolted into position to allow easy removal for subsequent vehicle servicing or dismantling.

RRS GT-racks brackets allow easy removal for subsequent vehicle servicing or dismantling. Therefore the RRS GT-rack is compliant with VSB 14 4.10

4.11 Power Steering Conversions – Separate Ram Type

Power steering conversions – separate ram type, must be carried out in accordance with the following:

•Power cylinder location, orientation, articulation angles and operating pressures must be in accordance with the manufacturer's specifications, taking into consideration the full movement of the suspension and steering; and

•The vehicle structure at the point of attachment of the power steering ram must be reinforced if required to accommodate the power cylinder loads, taking into consideration the peak hydraulic pressures, mounting bush deflection loads and the frequency of application of these loads.

N/A

4.12 Steering Linkage

Steering linkage installations must be carried out in accordance with the following:

• Steering gear linkage assemblies must be sourced from a vehicle of similar or larger mass than the finished vehicle as modified;

RRS GT-rack sourced from vehicles GVM of up to 2140Kg

• Reshaping, sectioning, re-machining of drag links, steering arms and the relocation of the inner and outer pivots or tie-rod pivots in order to achieve correct steering geometry may be done, provided that the processes are conducted under the controls described in this section; and

RRS GT racks use model specific load rated drag bar linkage

• Ball joints and plain bearing end fittings and idler arm pivots must have manufacturer's ratings in excess of the loads and angular travel imposed on them in the modified vehicle. If the manufacturer's rating is not available, evidence of equivalent usage in a production vehicle, together with stress calculations may be used.

RRS Gt-rack steering linkage is load rated with stress calculations (see page 29).Therefore the RRS GT-rack is compliant with VSB 14 4.12

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VSB14 Compliance

4.13 Rack and Pinion Steering Gear

Rack and pinion steering gear installations must be carried out in accordance with the following:

• Rack and pinion assemblies must be sourced from a vehicle of similar or larger mass than the vehicle being modified;

RRS GT-rack assemblies are sourced from vehicles with a GVM of up to 2140Kg

• Rack and pinion type steering must not be used in conjunction with beam front axles if the independent arcs of the tie rods (upon suspension movement of the axle) creates toe-in or toe-out with suspension movement resulting in dangerous bump steer; N/A

•Any rack extension (to achieve correct steering geometry) must be by means of machined adapters provided that they are of the same strength as the steering rack. Retention of such adapters must be identical to that of the original tie rods together with suitable thread securing compound. Steering racks must not be welded. The effects on rack bending stresses of the additional ball joint offset as well as the strength of the connection between rack and adapter must be assessed in accordance with this subsection. Rack boot requirements must also be addressed;

RRS GT-racks are machine to length and have no welded parts, FEA conducted on drag bar (see pages 16 to 27 of this document)

• Rack shafts may be shortened by machining provided that the machining does not affect the teeth area;

RRS GT-racks are machine to length

• For variable ratio racks, any shortening must be performed at each end symmetrically to maintain the on-centre rack location with the road wheels straight ahead; N/A

• A rack shaft must not be shortened by cutting and re-welding;

RRS GT-racks are machine to length no cutting or re-welding

• Rack housing length may be shortened. It is recommended that only housings in which the centre section is a steel tube are so modified and that the shortening be confined to this section. It is suggested that a close fitting steel sleeve of equivalent material and wall thickness be used to bridge the joint and be welded on both ends;

RRS GT-racks use an unchanged OEM (Nexteer) rack housing

• On assembly, the preload of the rack must be checked every 25mm of rack travel to ensure no binding has resulted from the rework. The rack manufacturer's preload specification should be used; and

RRS GT-rack gears are mated to ensure no binding and preload to OEM specifications

• Mounting of the rack should replicate the original mounting configuration.

RRS GT-rack are mounted to the original idler arm and steering box bolt-holes

Therefore RRS GT-rack satisfies VSB14 4.13

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VS14 Compliance

VSB 14 states: 4.14 Chassis Mounted Steering Gear

Chassis mounted steering gear installations must be carried out in accordance with the following:

• Chassis mounted steering gear assemblies must be sourced from a vehicle of similar or larger mass than the finished vehicle as modified;

The RRS GT-rack is sourced from vehicles with GVM up to 2140Kg

• Unless the steering column is aligned with the steering gear with no more than 5˚ of angular mismatch, fabric or rubber couplings may not be used at the steering gear input shaft. Where more than a 5˚ angular mismatch exists, a metallic universal joint may be used. If the axes of the column and steering gear input shaft do not intersect at the position of the coupling, an intermediate shaft must be fitted with two universal joints to provide for the misalignment;

The RRS GT-rack uses load rated universal joints and intermediate shaft to connect the steering column to the rack & pinion

• Sector shafts may be reworked only by re-machining the master splines. The re-machined spline must replicate the remaining splines in all dimensions; ***N/A***

• Sector shafts must not be welded to change length or to alter spline details, ***N/A*** and

• Where new chassis mounting bolt holes are required, the chassis must be reinforced to carry the steering gear loads and the bolt holes in box section chassis rails must be reinforced with tubes of 1.6mm wall thickness minimum to prevent crushing of the
chassis section. ***N/A***

Therefore RRS GT-rack satisfies VSB14 4.14

4.15 Pitman Arms

Pitman arms may be modified by:

• the removal by machining of the master spline; and/or

• cold working, hot working, sectioning and re-welding, provided that the processes are conducted under the controls described in this section. ***N/A***

4.16 Idler Arms

Idler arms may be modified by:

• re-machining to accept revised pivots, provided that the strength of the component is sufficient to accept the maximum input load that can be applied by the steering gear; and/or ***N/A***

•cold forming, hot reforming and sectioning and re-welding are allowable provided that the processes are conducted under the controls described in this section. ***N/A***

4.17 Tie-rods

Tie Rods may be modified by:

• shortening by extending the thread and removing the excess threaded portion, provided that the rod is suitable for this operation, the length of thread engagement is equal to or greater than the original manufacturer's specification; or

• extending by provision of threaded adapters, provided that the original manufacturer's specification in respect to buckling strength, shear strength, thread engagement, thread locking and material selection are all maintained.

RRS GT-rack uses OEM inner tie rods unmodified therefore satisfies VSB14 4.17

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4.18 Steering Arms
Steering arms may be modified by hot-working, provided that the processes are conducted under the controls described in this section. ***N/A***

4.19 Drag link
Drag link specific requirements are:
• A new drag link may be manufactured provided that it is one continuous length of material between end fittings and the selected material is suitable for the design and method of manufacture; and

The RRS GT-rack drag link is a continuous alloy bar with certified finite element analysis (see pages 18 to 27)

• Sectioning and re-welding of the drag link must always be performed in accordance with the processes and controls described in this section. ***N/A***

Therefore the RRS GT-racks Satisfies VSB14 4.19

4.20 Steering column Shaft Couplings
Steering column shaft couplings must be selected and installed as follows:
• Couplings which are designed for use on manual steering may be used on power steering vehicles;
• Couplings designed for use on power steering vehicles only, are not to be used on manual steering vehicles;
• Re-assembly of steering couplings utilizing revised components must ensure that the resulting assembly has the torsional strength to withstand an applied torque of 200Nm;
• Machining of couplings to alter the PCD of the attaching bolts must ensure that the resulting assembly has the torsional strength to withstand an applied torque of 200Nm;
and
• The alignment of the coupling must be maintained to within the manufacturer's specification and phasing of the universal joints must be correct.

The universal joints in RRS GT-rack are load rated to 320Nm and if installed as RRS installation instructions (pages 7-11) the universals will operate within tolerance.
Therefore RRS GT-rack satisfies VSB14 4.20

4.21 Intermediate Shafts
Intermediate shafts must be selected and installed as follows:
• Intermediate shafts designed for use only on power steering vehicles must not to be used on manual steering vehicles;
• Collapsible intermediate shafts designed in conjunction with a specific steering column to meet ADR 10 should be utilized with a matching column where the vehicle is subject to that ADR;

The RRS-GT029E Intermediate shaft is load rated to greater than 320nM and therefore exceeds OEM for both the manual and powered versions of the RRS GT-rack.
Therefore satisfies VSB14 4.21

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Conclusion

RRS GT-rack kits use a Nexteer housing from a wide range of vehicles with GVM of up to 2140Kg

RRS GT-rack kits use a load rated drag link

RRS GT rack kits use load rated steering linkage

RRS GT rack kits use original steering box and idler arm holes with fully matted mountings

RRS GT rack kits use OEM inner tie rods

RRS GT racks kits maintain collapsible columns and allows retro fitting of collapsible columns to appropriate models

RRS GT-rack kits reduce bump steer by more than 70%

RRS GT rack kits are constructed from CAD designed elements, laser cut to the program and CNC machined to the program then passed through tolerance tests

RRS GT rack kits are supplied with full installation instructions

RRS GT rack kits a covered by a 5 year warranty

RRS GT rack kits have been refined over two decades and many thousands of units sold globally achieving millions of road and track miles with zero critical failures.

For these reasons the RRS GT-rack is a safe, fully engineered, highly evolved design, manufactured to a quality assured standard with a proven track history of performance and reliability.