

*Ride Performance innovation, accelerated<sup>SM</sup>*



# *Forward thinking. Forward moving.*

*Where transportation goes for innovation*

Shock absorbers are an essential component of the suspension system. Designed and tuned for each individual vehicle, they directly influence its characteristic feel – how the driver and passengers experience the ride, including their degree of comfort.



The heart of a shock absorber is its valve system. The valve's dynamic flow-pressure characteristic translates into a desired force velocity curve that describes the shock absorber's specific behavior and directly impacts the vehicle's performance. Tenneco has significant experience in defining and developing the right valve technologies for all types of vehicles and their desired attributes.

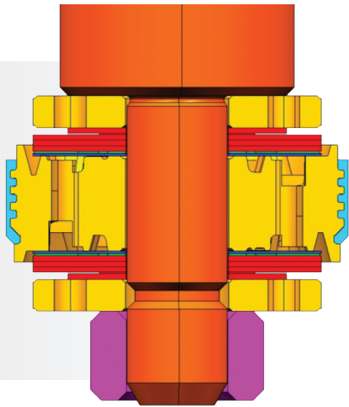
At Tenneco we know how to apply valve technologies that meet customer criteria and ride and handling expectations. This is

a critical core competency as the typical force-velocity curves used to describe a shock absorber are not sufficient to fully describe the shock absorber's impact on vehicle performance.

Tenneco's understanding of the interaction of all dynamic parts – including suspension parts other than the shock absorber – combined with our knowledge of NVH (Noise Vibration Harshness) performance levels that are critical to the comfort of the driver and passengers, are key to implementing the best design solution.

Tenneco offers many different types of valve technologies, including multi-tuned valve, position sensitive twin tube (PST) and frequency dependent damping (RC1).





### Multi-Tuned Valve (MTV)

The multi-tuned valve is a clamped-disc, full-displaced, twin tube valve system. The valve has been engineered to provide a wide range of tuning options, excellent noise performance and a well-defined durability envelope.

Its design allows for bleeds to be used on both sides of the piston. The ability to adjust two bleed discs for low-speed rebound damping provides a large number of total orifice area combinations. A large number of spring discs are available in the Multi-Tuned Valve package for mid-speed tuning. Ten discs can be assembled onto each side of the piston, allowing for many combinations with fine tuning resolution between steps. In addition, pistons are available with differing preloads.

The multi-tuned valve provides high speed tuning by limiting the travel of the deflecting discs using the diameter and thickness of up to two “fulcrum” discs available in the valve package. This provides a wide range of high-speed tuning options, with fine resolution between steps, without the need for multiple pistons or piston tools.

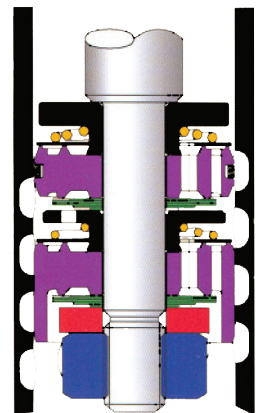
The Tenneco Multi-Tuned Valve accommodates four possible valve “architectures”. Each provides a unique character targeted to specific ride or handling characteristics of the vehicle. These architectures are assembled by modifying the order and size of spring discs assembled into the valve. All architectures can be made using the standard spring steel components available in the valve package.

### Position Sensitive Twin Tube (PST)

The emergence of multi-purpose vehicles that combine the comfort of a passenger car with the requirements of utility vehicles, helped spur the evolution of the position sensitive twin tube. The PST provides a simple but effective way to provide these vehicles with the required damping – and safety – in the most extreme conditions, while maintaining the comfort of a passenger car in normal loaded conditions.

Unlike a conventional shock absorber that has no displacement dependency, the piston in a PST shock moves according to the vehicle's payload, providing more damping as the load increases.

The Tenneco PST is a multi-stage hydraulic shock absorber, consisting of two pistons connected to a single rod that provides different levels of damping based on the position of the pistons within the shock absorber pressure tube. A series of notches in the wall of the tube allow the hydraulic fluid to flow around one of the pistons, but not both.



The PST design permits a wide range of tuning parameters. Almost any desired damping curve can be obtained while avoiding sudden transitions in performance between soft and hard damping modes. PST allows the choice of different damping forces for rebound and compression. This high degree of tuneability is of key importance to OEMs who desire specific ride characteristics.



## Frequency Dependent Damping (RC1)

When the emphasis is on the best possible comfort, a lack of road-holding seems to be an automatic consequence with conventional shock absorbers. This conflict between handling and comfort becomes an especially important issue when dealing with premium passenger cars, whose desire is to have the best of both.

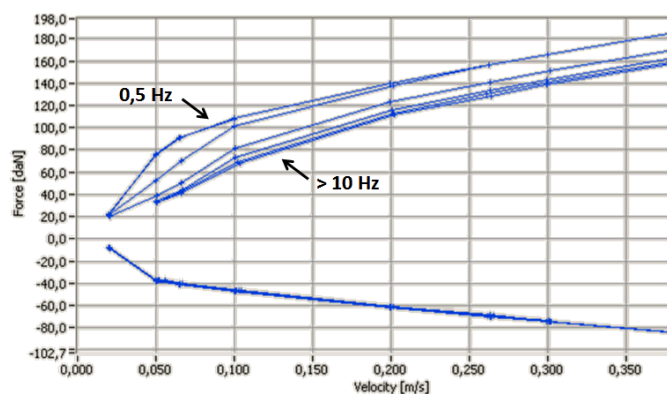
Developed and patented by Tenneco, RC1 technology can be used as an integrated part of the hydraulic valving system inside the damper as a means to end the compromise between comfort and road-holding. Consequently, no additional cables, sensors or any other electronic devices are needed to operate the system.

It is an economical and effective solution to improving a car's comfort and handling and will give engineers a constructive, additional variable in fine-tuning the car's behavior.

With the RC1 system, comfort and handling can be split into two different frequency areas:

- For comfort, with the suspension moving in a high frequency area (+/- 10 Hz), asking for low damping forces.
- For handling, with the suspension moving in a low frequency area (+/- 1 Hz), asking for high damping forces.

If you are able to change the damping force level in relation to the frequency of the movement, you create the possibility to solve the conflict in terms of comfort and handling ever presenting conventional dampers. Tenneco RC1 technology does just that.



## Partnership Built on Performance

At Tenneco, we don't simply provide a product. We provide a partnership – taking into account customers' entire systems, their unique needs and applications, technology requirements, market challenges and goals. With our new valve technologies and our complete line of ride performance solutions, we offer the partnership that drives the innovation that maximizes performance and enables true ride control.

### PIONEERS IN RIDE PERFORMANCE

At Tenneco, innovation is a hallmark of everything we do. In our advanced ride performance technologies and solutions. In our unique, total-system integration expertise and approach. In our commitment to partnership and collaboration. We're always looking beyond the technology horizon to foresee and develop the next-generation ride performance solutions that accelerate our customers' success and keep them moving toward the future.

From development through delivery and beyond – we help our partners drive transportation innovation, full speed ahead.

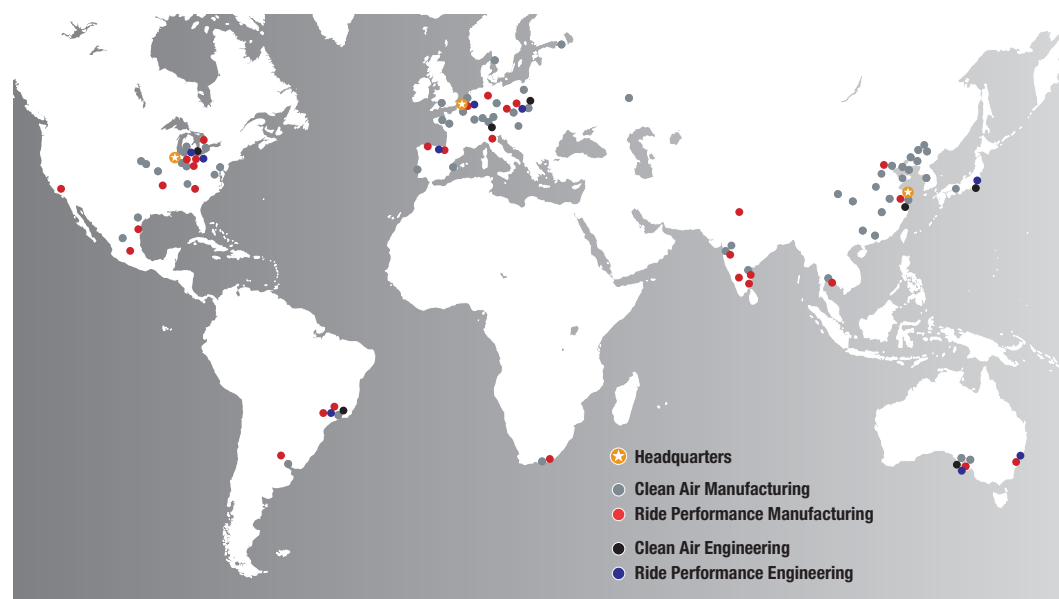
### TENNECO IS EVERYWHERE OUR CUSTOMERS NEED US

Our reach is global, but our focus is local, helping customers in each region adapt our global capabilities and technologies for local applications.

- Nearly 25,000 employees worldwide
- 89 manufacturing facilities
- 14 state-of-the-art research and development centers
- 3 dedicated research and development centers for ride performance engineering

#### Markets served:

- Light vehicle
- Motorcycle
- Bus and truck
  - Axle suspension
  - Cabin suspension
  - Seat suspension



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