

## **Damper Analysis using Energy Method**

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# Damper Analysis using Energy Method

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## ABSTRACT

The force x velocity graph is the most used tool for suspension damper analysis. This approach hides important information regarding the bleeds / spring / orifice combination. This paper describes the energy analysis, comparing two different damper suppliers, with comfort measurements using B&K Human Response Vibration Meter and MTS single channel Four Post system.

## INTRODUCTION

The damper is speed sensitive, but with some suppliers adds the displacement and even acceleration sensitivity.

In overall, the tuning work is select the bleeds / spring (disc) / orifice, changing the damping values for low / medium / high velocities respectively. This tuning work is performed for compression and rebound, creating a great number of combinations.

The focus of this paper will be the bi-tube design, were the valve design is different for each supplier.

The supplier A uses the blow off design for base valve and piston.

The supplier B uses the blow off design for piston and disc design for the base valve.

## SYSTEMS COMBINATION

Three proposals will be tested, assuming the following configurations:

- Reference dampers – supplier A
- First proposal – supplier B (peak damping forces and energy)
- Second proposal - supplier B (peak damping forces)

## TESTS PERFORMED

The tests will be divided in:

### - Damper Measurement

The dampers were measured in an electric hydraulic system, with constant displacement and different frequencies, resulting in different velocities. The plotted charts show the peak rebound force, peak compression force and energy.

### - Four Post Comfort Measurement

- Uneven Belgian Blocks
- Uneven Asphalt Road
- Bounce / Pitch / Roll Motion

### - Four Post Subjective Evaluations

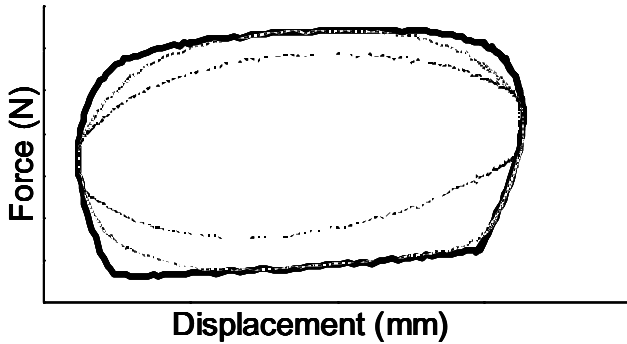
- Uneven Belgian Blocks
- Uneven Asphalt Road
- Bounce / Pitch / Roll Motion

The Four Post inputs are based on Cruz Alta Proving Ground tracks.

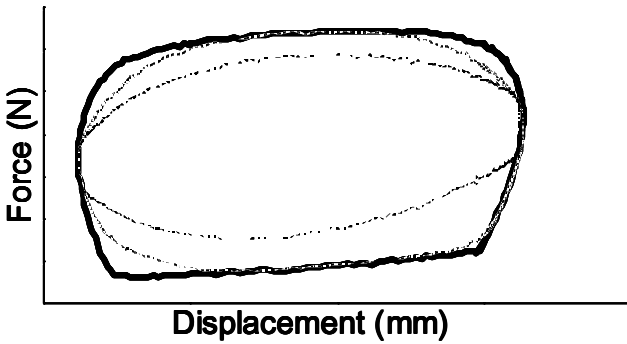
# DATA ANALYSIS

## Damper Measurements

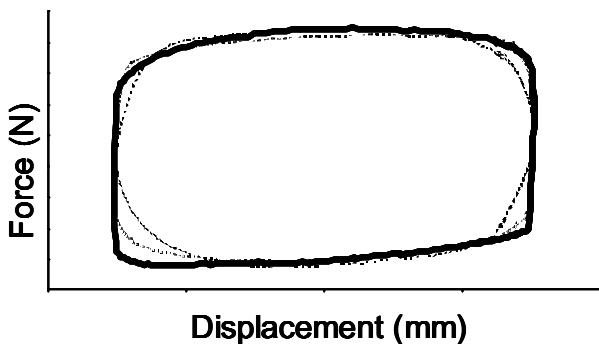
For the following charts, the reference damper is represented by the continuous bolt line, damper proposal#1 by the gray line and damper proposal#2 by the dashed line.



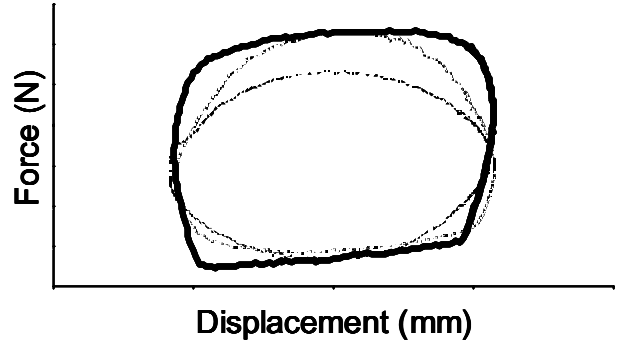
“Front Damper – Velocity # 1”



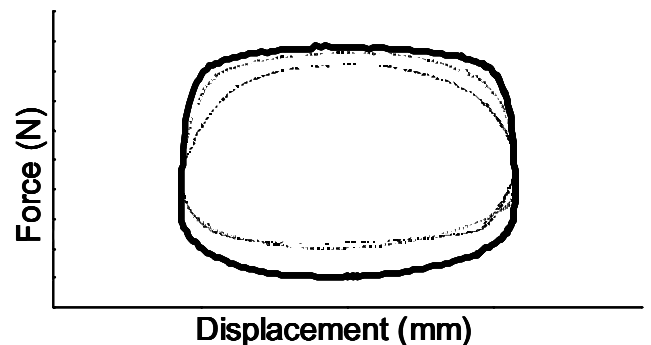
“Front Damper – Velocity # 2”



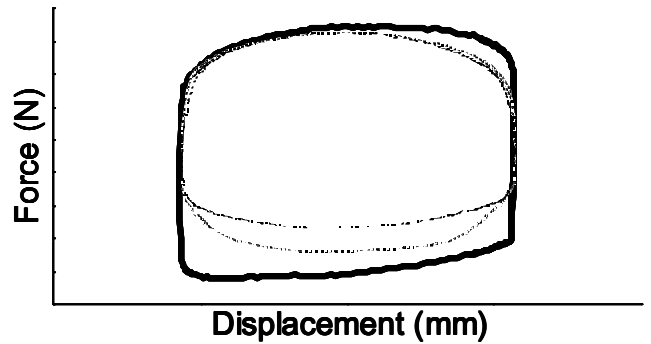
“Front Damper – Velocity # 3”



“Rear Damper – Velocity # 1”



“Rear Damper – Velocity # 2”



“Rear Damper – Velocity # 3”

The previous charts shows that the shape are different for the first and second velocity, being almost the same for the third velocity and higher. Just to remember the area of this curve means the energy.

## Four Post Measurements

The measurements were done at z-axis using special equipment (Human Response Vibration Meter – B&K).

Equivalent Exposure Measurement (EEQ) was used to compare the proposals. This parameter is a percentage of the daily whole body vibration mentioned in ISO 2631. The ISO 2631 defines the human limit exposure time for different frequencies.

The Human Response Vibration Meter could not read the differences between the three proposals for the Uneven Asphalt Road and Bounce / Pitch / Roll Motion.

For the Uneven Belgian Blocks, the values measured are represented below:

Supplier A	84%
Supplier B # 1	99%
Supplier B # 2	96%

## Four Post Subjective Evaluations

The supplier A damper will be used as reference. The used rating varies from 0 to 10.

### Uneven Belgian Blocks

- Supplier B#1 deteriorated by 0.5 point.
- Supplier B#2 improved by 2.0 points.

### Uneven Asphalt Road

- Supplier B#1 has the same rating.
- Supplier B#2 deteriorated by 1.5 point.

### Bounce / Pitch / Roll Motion

- Supplier B#1 has the same rating.
- Supplier B#2 deteriorated by 3.0 points.

## CONCLUSIONS

The EEQ could not be applied for some road conditions, which are important for the vehicle behavior, being limited for the Uneven Belgian Blocks.

The EEQ shows that the supplier B#1 and supplier B#2 have almost the same behavior and supplier A is completely different from supplier B#1 and supplier B#2. The subjective evaluation shows that the supplier A has almost the same behavior as the supplier B #1 and supplier B#2 is completely different from supplier A and supplier B#1. The EEQ value does not represent the driver feeling.

The use of the Four Post System gives us a controlled environment and being possible to create any vertical input combination. The negative side is that reactions due to lateral acceleration can not be repeated.

## ACKNOWLEDGMENTS

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