Dynamic Truck and Trailer suspension
Introduction

DTS stands for Dynamic Truck and Trailer Suspension. It is a micro controlled, hydro-pneumatic suspension system without compromises. Build with proven technology which is used on trucks and military vehicles from several European manufacturers.

The first VSE suspension system was launched in 1986. This so called HPVS (Hydro-Pneumatic Vehicle Suspension) is still in production for GINAF Trucks from Veenendaal in the Netherlands.

With the introduction of CAN in the automotive industry, VSE updated the suspension system with the digital control techniques of today. This new generation was called DTS.

This document will give you an impression on the functionalities, the general description and a short explanation on the used techniques to give you an idea on the suspension systems of VSE. With illustrations, photo material and some guidance text we will try to give you a clear view on the functionalities, features and quality of our hydraulic suspension systems.

If there are any questions unanswered after reading this document, please contact VSE in Veenendaal at +31 (0) 318 545744. We will be glad to tell you more about our products.
Product information DTS

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1. Functionalities / Features

Oil as a force transmitting medium can “not” be compressed. In situations where a platform has to be stable and controllable, oil gives you better possibilities compared to air as a force transmitter. When you are able to lock the oil up, give oil the free space and control every situation between these extremes, oil realizes the comfort as well as the stability of the cargo on the platform.

Basically that is what VSE does. VSE controls the oil flows from and to a hydraulic suspension cylinder, according customer demands and depending on circumstantial conditions. The latest generation “DTS” is a suspension system without the traditional compromise between comfort and stability.

1.1. Characteristics DTS:

• DTS is a high quality system
• Fully dedicated suspension system for one or more axles
• Micro controlled, hydraulic pneumatic suspension
• Springs, shock-absorbers, roll stabilizer and axle lift are combined within the DTS hydraulics
• Accurate positioning of the loading platform
• Automatic system adjustment related to the ambient temperature
• Perfect load distribution over all wheels: fully compensated
• Autonomous system for trailer applications with remote control
• Black box functionalities
• User interface through a display or a PC application

1.1.1. Static features

• Levelling, along or square to the drive direction for safely tipping
1.1.2. Dynamic features

• Semi-active roll stabilisation
• Super stabilisation as an option
• Manual or automatic control of several level and dampening settings
2. How does it work?

A contactless redundant angle sensor on each side of the chassis measure the distance between axle and chassis by a rotation of a magnet close to a hybrid print.

The sensor produces a linear signal between 0 and 4.5 [V]. This signal is a major input of an ECU. This ECU (redundant, due to the use of a second micro processor) anticipates on this signal the way our own software describes.

From the ECU various output signals go to the valves on a hydraulic manifold. The valves (black and white or proportional) will control the oil flow from and to the hydraulic cylinders. Accumulators with various pressures and gas volumes can be “switched on and off” to realize different damper settings.

The vehicle surrounding signals are “circumstantial” signals for our system. You can think of vehicle speed, on board voltage guardians, pump or system pressure guardians, all kinds of CAN signals from a motor management system.

Our user interface is a display which we can program ourselves to bring diagnostics and customisation on the level of all kinds of users.

Note: We have different system configurations for several transport applications.
VSE Vehicle Systems Engineering BV understands the need for flexibility and safety when it comes to the transportation of goods. The suspension systems from VSE are equipped with several safety devices. These devices are stand-by during operation of the vehicle and are a guarantee for the safety of man and machine.

The redundancy in the electronics, the hydraulic circuit and the software for the overall guidance of it all adds “safe flexibility” to the transport material.

3. Parts

3.1. Suspension Cylinders

The task of the suspension cylinder is to combine axle travel and axle load. VSE has gained experience in different working area’s:

- Independent wheel suspension
- Rigid truck and trailer axles, driven or non driven
- McPherson wheel suspension

Axle loads (static) varying from 2 tons till 16 tons.
The dimensions of the suspension cylinder is specified by the axle construction and the load. The inside of the cylinder is determined by the design of course, but most of all determined by the customer demands on the settings of the system. How fast must a vehicle react on the changing conditions? Common reaction times of the micro-electronics are around 4 [ms]. After about 60 [ms] the system has adapted to the change in the conditions and the vehicle behaviour is changed with it.

Our suspension cylinders are especially designed for obtaining a low friction level and a low stick-slip effect. This is the only way for obtaining a superb suspension characteristic, which indeed can reach the level of an air suspension.

Reaction times are important, for instance, for special features like automatic off road detection and adaptation. These special features are used in special trucks like the Dodge Ram Van for the American Army, the “Dodge Combatt”, and the Rally Trucks of several teams like for instance the GINAF Rally Power Team, who are using DTS on their trucks for the toughest rally in the world: “Le Dakar”.

### 3.2. Hydraulic oil

VSE uses different types of hydraulic oil in their systems. One important part for the choice of an oil of course, is that it is in accordance to the specifications for the application and more important, the expected climate conditions.

Availability of the oil is another important part for the choice. VSE always applies standard available hydraulic fluids. To verify if the fluid is compatible with the seals inside the cylinder, VSE performs test work. A wrong combination will result in a higher friction and internal/external leakages.

When DTS is combined with ETS steering on the same vehicle, VSE prescribes the use of LHM oil.
3.3. Height sensors

VSE produces different types of angle sensors. These sensors can be integrated in most of the mechanical constructions. The technical principle is a print, placed in a housing. The print is completely isolated from the surroundings. Under the electronics a magnet is rotating, resulting in a change of signals (volts).

The electronic heart of the sensor is “redundant”. This means that the electronics of the sensor is a “twin-device” where the second sensor is used for controlling the quality of the signal of the main sensor.

*Height sensor mounted on the frame*
3.4. **Hydraulic manifolds**

Our Hydraulic Suspension is on the market since 1986. Since then, several development activities have been undertaken by VSE and the VSE suppliers to realize an automotive dedicated manifold with valves.

In the DTS installation up to three different type of Hydraulic Manifolds can be used:

1. The main Suspension Manifold for the chassis height control Left and Right

![Left for 3 axle trailer and Right for a 3.5T Van](image)

2. The stabilisation Manifold for controlling the roll angle of the body
3. The dampening Manifold for controlling the dampening of the suspension movement.

Typical VSE features for the hydraulic manifolds are:

- Manifolds and valves according automotive quality standards
- Integrated high pressure filter cartridges
- Integrated pressure sensor
- Prepared and tested for peak pressures up to 1000 bar
- Pre-assembled for first line vehicle production
- 12 [V] or 24 [V] valves
- Black anodised aluminium manifolds
- Protection class at least IP67
3.5. **Power pack unit**

Especially for trailer application VSE can supply an electrically driven pump for the oil supply. In this way the only DTS connection to the tractor will be the power supply for the back-up batteries.

The complete flow is available for the DTS system. This unit contains its own micro control unit, which is controlled by the DTS ECU. VSE regulates, by communicating with this ECU, the rotation speed of the pump. The electromotor is brush less for obtaining an excellent life time. This power pack is developed by VSE for Automotive purposes.

With this solution, we are able to supply sufficient oil for the DTS suspension and the VSE ETS steering system (if installed).

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*Power Pack unit*

The performances of a single pump Power Pack are:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>P nom</td>
<td>5,5 kW</td>
</tr>
<tr>
<td>U nom</td>
<td>24 V (20V ... 28V)</td>
</tr>
<tr>
<td>I max</td>
<td>300 A</td>
</tr>
<tr>
<td>Dry weight (excl. reservoir)</td>
<td>37 Kg</td>
</tr>
<tr>
<td>Pump displacement</td>
<td>4,95 or 6,61 cc</td>
</tr>
<tr>
<td>Output oil flow @ 40 bar</td>
<td>14 or 18 L/min</td>
</tr>
<tr>
<td></td>
<td>@ 100 bar 11 or 13 L/min</td>
</tr>
<tr>
<td></td>
<td>@ 185 bar 7,5 or 8 L/min</td>
</tr>
<tr>
<td>Dimensions (LxHxW)</td>
<td>632 x 350 x 260 mm</td>
</tr>
</tbody>
</table>
3.6. **Electronic Control Unit**

The ECU is a controller with two micro processors for redundancy reasons. The unit is equipped with an AMP Multi port connector with 69 pins and 4 slots. The connector is of the fool proof version for avoiding making wrong connections.

With this component, we are able to register, calculate and send out analogue signals, digital signals or even CAN messages. In combination with our software it makes it possible to change parameters for the application without the need for new intensive development activities. The software is developed in-house by the software engineers from VSE.

The electronic heart of the ECU is “redundant”. This means that the heart of the ECU, the micro processor, is a “twin-device”. One microprocessor monitors the other for safety reasons.

For the trailer application this ECU is mounted in a special protection box in order to obtain an IP 67 rating.
3.7. Level Sensor

The DTS suspension system can optionally be equipped with one or two level sensors. Levelling of the body is extremely important for a safe tipping operation.

Regularly articles appear in the press about rolling over of a tipper truck / trailer.

The levelling can be made in two directions: longitudinal and lateral. The sensor is a rather small device which can be placed anywhere in the vehicle. Of course after assembly on the vehicle, the sensor needs to be calibrated.

Levelling is an important contribution to the safety for the driver and his surrounding.
3.8. Remote control

The DTS suspension can be operated by the driver with a Remote Control. This control is of course, wireless making it possible to make adjustments of the suspension without getting out of the cab.

All functions can be operated via the remote control unit. The transmitter has eight function buttons. The receiver with antenna, is mounted in the system locker.
3.9. Display

A display is used as an interface between the user and the suspension system. On the display all relevant information is displayed related to the operation, the maintenance, the failure analysis and the repair.

The display can be mounted fixed in the system locker. It’s also available as a workshop tool mounted in a case. And finally it can run on any laptop computer when the correct interface and Software license are used. This display can be used for calibration, first line diagnosis and for changing parameters. The level of access can be altered for different users. The status of the system is displayed, “real time”.

Optionally the display can be used for operating the suspension system: changing height, return to ride level, levelling etc.

“user – system” interface

Also available on laptop
4. Examples VSE suspension systems

4.1. Dodge Ram Van, “Combatt”

Vehicle settings:

- Driver entry
- Normal
- Off-road
- High Off road
- Maximum

System specifications:

- Response time specified by customer
- Settings during driving and on demand
- Manual control of the system through a display in the console of the vehicle
- “Walking beam effect”
- Special boarding settings
4.2. Dynamic Trailer Suspension on a three axle tipper trailer

Vehicle settings:

- Levelling, along and square to the drive direction
- Axle load compensation
- Axle loads up to 12 tons
- Integrated axle lift

System specifications:

- System access through display and PC application
- Programmable height settings
- Manual control from the cabin
- Levelling in X and Y direction
- Oil supply through a separate power pack unit

Levelling functionalities

Dynamic Trailer Suspension on VSE Promotion Trailer
4.3. Dynamic Truck Suspension, designed for Rally Trucks

Vehicle settings:

- Oil temperature controlled
- Several level and height settings available on drivers demand
- Settings for several road surfaces programmable

One of the rally trucks in action

Hydraulic cylinder with Timoney independent suspension wishbone

A clear picture of the hydraulic suspension cylinder, height sensor and an accumulator mounted straight on the cylinder. On this vehicle, each wheel has its own micro control network and its own hydraulic suspension parts.
4.4. DTS on Military truck 10x10

This DTS system consists of four sub-systems and for the controlling of all functions and the additional military requirements. In total 5 ECU’s are needed.

Independent Wheel Suspension with two struts per wheel. Wheel load 12 t.
4.5. **DTS light commercial vehicles**

For the category up to 3.5 tons, VSE developed a system using KONI suspension cylinders for replacing the McPherson wheel suspension unit.

Vehicle settings:
- Walking beam effect
- No compromise between comfort and stability
- McPherson front
- Independent at the back

System specifications:
- Oil supply through a separate power pack unit 12V
- GW up to 3.5 tons
- Adjustable height setting
- Pre-programmed “Dynamic stability settings”

*Hydraulic cylinder with McPherson construction*

*Hydraulic cylinder with COXX - independent wheel suspension*
4.6. **DTS Control system for non-VSE hydraulic suspension systems**

VSE developed for the agricultural applications a control system for an existing hydraulic suspension. Following pictures are taken from a three axle BECO Tipper.

Vehicle settings:
- Levelling, square to the drive direction
- Lift device for 1st axle
- Anti Roll
- Manual control
- Programmable height settings

System specifications:
- Hydraulic components delivered by customer
- Manual control is customer delivery
- Oil supply through tractor
- Tridec axle construction
5. VSE as a supplier

VSE understands the need for a proper evaluation of new products. That is the reason why we advise existing and new customers to start with a prototype assembly testing period. Such an approach is a good way to be sure that both parties are heading into the desired direction.

VSE delivers and produces high-end vehicle systems. We are ISO certified. We have gained a lot of experience in the past on Electronically Controlled, hydraulic vehicle systems. “Simply” by developing, doing and verifying by testing.

Cylinder testing at VSE

For example: we produce our cylinders ourselves, simply to reduce costs by low order amounts and because of the Automotive Quality standards we have to deal with. We have special conditioned assembly spaces to keep the production process of manifolds and cylinders as clean as possible. We learned in the past that there is a lot to say about the quality of a high tech hydraulic cylinder “built by others”.

This goes not only for the components. We have the same approach on vehicle dynamics. For each DTS application it becomes necessary to execute a number of vehicle tests to adjust the suspension and establish the damper setting in the different load conditions.

Normally DTS isn’t an off-the-shelf product. For VSE each new application is a complete project starting with the development of the most appropriate cylinder, fitting in the given envelope and defining the manifold dimensions. On the first prototypes we run an extensive test program on rigs. (Durability, fatigue, burst and surge tests).

In the mean time the software is written. In the moment the first proto vehicle is assembled VSE put the DTS in service and our Engineers can make the damper setting and other necessary test drives for the fine tuning of the system.
VSE Vehicle Systems Engineering B.V. is a supplier of top-quality solutions for high-end steering and suspension systems for trucks, buses and (semi)trailers as well as for the agricultural market.

Main features:

- Combination of digital electronics and hydraulics
- Full integration within vehicle possible
- Very high serviceability level
- ISO 9001-2000 certified (since 2003)

VSE is your partner for development, production, supply and integration of systems and components!