Electronic Trailer Steering

ETS STEERING

Advanced Steering & Suspension Solutions
Introduction

The ETS - Electronic Trailer Steering system is a computer-controlled hydraulic steering system based on proven technology originally developed for trucks and now produced in large quantities (> 25,000 systems) for several leading European truck manufacturers. The ETS components are entirely designed for use in the automotive industry.

This brochure describes the operation and installation of the ETS system to give you an impression of the ETS trailer steering technology developed by VSE.

ETS is the trailer steering system for the 21st century. While the concept of steering trailer axles is certainly not new, the need to do so is becoming greater all the time. Achieving cost savings is an absolute necessity in order to remain profitable in the transport sector despite the ever rising costs.

Trailers with steered axles were already being built at the beginning of the 20th century, but those systems were entirely mechanical or hydraulic or relied upon simple trailing axles. To meet the demands placed on today’s vehicles, however, electronics are essential in nearly every system. The steering system is no exception, so it is easy to understand why the original systems are increasingly being replaced by electronic systems. VSE helps you meet the demands of today and tomorrow.

Following a short description of the system components, you will find examples of the Electronic Trailer Steering system integrated in various manufacturer’s trailers.

Should you have additional questions after reading this brochure, please contact VSE in Veenendaal at 0031(0)318 545744. We will be glad to tell you more about our products.
Product information ETS

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### Features

- Fully dedicated steering system for one or two axles per vehicle
- Computer-controlled electro-hydraulic steering
- No mechanical connections between the fifth wheel and the steered axle – reduces height, weight and maintenance costs
- No scheduled maintenance required
- Steering active in forward and reverse, also possible at a standstill
- Customized steering functions, such as manual override mode
- Automatic centring, active above 55 km/h – provides the same stability as a fixed-axle trailer
- Speed-dependent steering response for optimal steering angle under all conditions
- Display serves as interface for calibration and diagnostics (or use a PC)
- System is autonomous – only requires a battery charging connection to the tractor
- No special chassis design is necessary – the steering components are mounted on the axle (saves time and money for the trailer manufacturer)
- Lower total weight compared to conventional steering systems
- Simple installation on the semi-trailer because components are pre-installed in an enclosed system locker at VSE
- System bleeds off air automatically during calibration at system start-up
- System adapts automatically to ambient temperature – ensures trouble-free operation at extremely low temperatures
- Manual remote control of the steering angle, even when at a standstill
- Manual override mode – both steered axles are steered to the maximum steering angle, can be activated manually or at a pre-set speed
- Option to have steering angle adapt automatically to wheelbase changes on extendable trailers
- Equipped with special wiring harnesses with the highest IP rating
- Power pack with a brushless electric motor for maximum service life
Product information ETS

2. Steering Axles

The ETS steering system is, in principle, suitable for all axle types and makes. ETS has been successfully installed on the following axle types:

- trailing axles and self-tracking axles (axles with an offset)
- forced steered axles
- rigid axles with a turntable
- driven axles
- independent wheel suspension

Axles made by the following leading axle manufacturers:

- BPW
- SAF
- Arvin Meritor (ROR)
- Gigant
- Granning
- IMT
- Weweler

ETS is compatible with the following axle versions:

- Twin tyre
- Single tyre
- Weight ratings 5 – 16 T
- Disc, wedge and drum brakes
- 17.5”, 19.5” and 22.5”

2.1. Steering cylinder mounting examples

Track rod cylinder mounted vertically on BPW trailing axle with twin tyre mounting, steering angle +/– 25°
Standard steering cylinder on Weweler 9T steering axle with a turning angle of +/- 40°

Standard steering cylinder on Gigant 10T steering axle, twin tyre version

Track-rod cylinder, mounted horizontally on ROR steering axle, twin tyre version
3. **Operation**

In principle, ETS can be used with any axle configuration for steering up to two axles.

Figure 1 shows a steering system for steering two steered axles on a trailer.

A contactless, redundant angle sensor measures the yaw angle between the tractor and the trailer. The sensor is an integral part of the kingpin, which is a patented construction.

When the trailer is no longer directly in line with the tractor, the alignment of the magnetic field in the sensor changes and this is converted to a linear voltage signal. This signal serves as an input to the ECU (equipped with two processors for redundancy), which determines the yaw angle using software custom written by VSE.

The steering direction, speed and angle are monitored via the steering angle sensors mounted on each of the trailer’s steered axles.

The software is programmed to position the axles at the ideal steering angles based on the Ackermann principle. We make a complete set of calculations (including turning circles, swept circles, etc) for every application and customise the software accordingly.

Various output signals from the ECU are connected to the solenoid valves on a hydraulic manifold. The valves (on/off or proportional) control the flow of oil to and from the hydraulic cylinders. To ensure safe operation, all the electrical signals to and from the hydraulic manifold are continuously monitored.

The ETS system also uses numerous other vehicle signals, such as those of the speed sensor, voltage regulators, pump and system pressure regulators, and signals from other electronic systems that are available on the CAN bus.

The user interface is a display that can communicate with any version of the ETS system.
VSE Vehicle Systems Engineering B.V. understands how important flexibility and safety are when it comes to the transportation of goods. That is why VSE steering systems are equipped with a centring device. In the event of a malfunction the centring system, which is always active, straightens the wheels and locks them in the centre position, making it possible to safely continue driving and preventing the need for repairs while underway. The ETS system guarantees the safety of both the driver and the vehicle.

The redundancy in the electronics, the hydraulic centring circuit and the system control software offer ‘safe flexibility’ for the transport of goods.

Fig 2: Angle relationships in a typical tractor/trailer combination
4. System components

4.1. Steering cylinder

Each steering cylinder used in the ETS system is equipped with two completely independent steering circuits: one to steer the wheels and one to centre them and lock the axle in the straight-ahead position. The cylinder in figure 3, for example, has a steering (primary) section and a centring (secondary) section in parallel, constructed as a single assembly.

Figure 4 shows the standard version, in which the centring circuit is an integral part of the steering cylinder. While this construction is a less expensive solution, it is usually not an option for self-tracking axles due to the smaller distance between the steering knuckles. Therefore the decision to use an internal or external centring circuit is mainly based on the space available in the vicinity of the steering axle.

Fig. 3: “External centring circuit”

Fig. 4: “Internal centring circuit”

Fig. 5: Schematic drawing of cylinder placement on a self-tracking axle

1 : Centring cylinder  2 : Steering cylinder  
C1 : Pressure connection to left side of steering cylinder  
C2 : Pressure connection to right side of steering cylinder  
Y : Pressure connection to centring cylinder
4.2. Angle sensors

All the angle sensors used for the ETS system are designed and produced in-house. VSE produces a wide variety of different angle sensors. Although all the sensors are based on the same electronic design, they are available with different angle measurement ranges and housing shapes and as integrated or stand-alone sensors.

The basic design is a printed circuit board that is hermetically sealed inside a housing. Below the electronics, a rotating magnet connected to the axle or steering knuckle causes a change in the voltage signal.

The electronic heart of the sensor is a redundant design: it actually consists of two sensors, with the secondary sensor used to confirm the signal generated by the primary sensor. Because the electronic core of the sensor contains no moving parts, it is not subject to wear.

The big advantage of an integrated sensor design is that it is fully protected from outside influences. This design is perfectly suited for severe weather conditions and is less vulnerable to physical damage.
This patented and certified kingpin solution makes it possible to use the ETS steering system while maintaining normal trailer neck dimensions. It fits any combination of trailer neck and fifth wheel. Because the steering system does not require a turntable with a wedge, significant weight savings and height reduction are achieved, resulting in a greater loading capacity.

Another significant advantage over systems with a steering wedge is the fact that the trailer can always be coupled to the tractor, regardless of the angle between them. In other words, decoupling the trailer in the straight-ahead position and coupling it again at a 45° angle is no problem at all. The reaction arm can rotate freely, and alignment occurs automatically.

The kingpin itself is produced by leading manufacturer Georg Fischer (subsidiary of SAF Holland). The pin is available as a 2”-version with a D-value of 152 kN and a 3.5”-version with a D-value of 280 kN. The kingpin sensor is supplied as part of a complete set that includes the mounting flange (8, 10 or 12 mm for the 2”-version and 16 mm for the 3.5”-version) and mounting bolts. Both the modified kingpin and the mounting flange with central hole for the sensor shaft are EEC type-approved pursuant to directive 94/20/EC.

In some cases it is nevertheless desirable to install a turntable. For this purpose a heavy-duty angle sensor can be fitted to the turntable. This alternative is suitable for operation under extreme conditions, such as very low temperatures, when the grease on the fifth wheel inhibits the relative movement between the trailer and the tractor. In such situations, a turntable may be the best solution.
4.4. Power pack

The ETS steering system on the trailer is completely independent, except for a single electrical connection for charging the battery pack on the trailer.

The oil is supplied by an electrically-driven hydraulic pump integrated into a power pack containing the oil reservoir, optical and electronic sight glass and a pressure regulating valve. The electric motor is controlled by a dedicated ECU mounted in an IP-67 rated protective housing. The motor ECU is controlled by the ETS ECU.

The electric pump unit is specially designed for use in steering systems. It provides the highest level of performance, employs a brushless motor (no carbon brushes to replace) and has a high IP rating.

Technical specifications of single-pump power pack:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{\text{nom}}$</td>
<td>5.5 kW</td>
</tr>
<tr>
<td>$E_{\text{nom}}$</td>
<td>24 V (20 - 28V)</td>
</tr>
<tr>
<td>$I_{\text{max}}$</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</td>
<td></td>
</tr>
<tr>
<td>@ 40 bar</td>
<td>14 or 18 l/min</td>
</tr>
<tr>
<td>@ 100 bar</td>
<td>11 or 13 l/min</td>
</tr>
<tr>
<td>@ 185 bar</td>
<td>7.5 or 8 l/min</td>
</tr>
<tr>
<td>Dimensions (LxHxW)</td>
<td>632 x 350 x 260 mm</td>
</tr>
</tbody>
</table>

A single-pump power pack is used in the standard ETS 1 and ETS 2 configuration. The pump displacement largely depends on the size of the steering cylinders.
Technical specifications of double pump power pack:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P nom</td>
<td>5.5 kW</td>
</tr>
<tr>
<td>E nom (24 V, 20V - 28V)</td>
<td></td>
</tr>
<tr>
<td>I max</td>
<td>300 A</td>
</tr>
<tr>
<td>Dry weight (excl. reservoir)</td>
<td>28 kg</td>
</tr>
<tr>
<td>Pump displacement</td>
<td>4.95 or 6.61 cc</td>
</tr>
<tr>
<td>Output oil flow</td>
<td>27 l/min, 17 l/min, 11 l/min, 8 l/min</td>
</tr>
<tr>
<td>Dimensions (LxHxW)</td>
<td>623 x 210 x 350 mm</td>
</tr>
</tbody>
</table>

The double-pump version is used for ETS 2 when greater turning angles are required and/or the volume of the steering cylinder is greater. The power pack with a double pump has a separate oil reservoir to keep the oil temperature as low as possible.

As an option, the steering system power pack can be designed to supply oil to other hydraulic systems on the vehicle, such as ramps, a lift gate, roof and floor lifts, etc.

These auxiliary functions can be activated via the manual control unit and only function when the vehicle is at a standstill. We offer a power pack with a 60-litre oil reservoir especially for this purpose.
4.5. Hydraulic steering manifold

The hydraulic steering manifold serves as the connection between the electronics and the hydraulics. All functions are integrated in a single manifold. The solenoid valves in this manifold are controlled by the ECU. In steering systems with two steered axles, each axle is controlled separately.

Hydraulic steering manifold for independent steering of two axles

The oil flow from the hydraulic pump enters the steering manifold at pressure port PP. If no steering movement is required, the proportional pressure regulating valve is in the open position and the oil flows directly back to the return line TX.

When an ETS steering movement is required, the ECU activates the necessary solenoid valves in the manifold. The number of valves depends on the configuration: ETS 1 or ETS 2. The accumulator valve is put in the open position, the release valve(s) is/are closed, the pressure regulating valve and the steering valve(s) are proportionally activated, pressurising either port X1 or port X2 which are connected to the steering cylinder(s) for turning the wheels to the left or right. The pressure regulating valve, in combination with the steering valve, controls the steering speed of the ETS-steered axle(s). The maximum achievable ETS pressure is limited by the software in the ECU. Pressure settings of up to 200 bar are possible.

The PSX pressure sensor(s) monitor(s) the pressure in the ETS system. This is part of the regulation system. The manifold also includes several valves, a second pressure sensor (PSY) and a number of other components that are responsible for the centring function. If a serious failure occurs within the ETS system, the active steering system is disabled and the centring system takes over. When this happens the ETS-steered axle is centred and hydraulically locked in the straight-ahead position. An accumulator ensures that pressure is always available for this ETS emergency steering circuit.

When the accumulator valve is deactivated, a check valve prevents oil in the steering cylinder from flowing back to the accumulator. However, oil can always flow in the opposite direction. This means that the accumulator always maintains pressure on cylinder port Y, keeping the cylinder in the centred position.

This special design guarantees return to the straight-ahead position! The accumulator valve is always activated during a steering manoeuvre in order to enable the flow of oil from the cylinder to the accumulator.

To detect deviations in the centring pressure, pressure sensor PSY is fitted in the emergency circuit. When a malfunction occurs in the centring system, the rear axles are actively centred and held in
that position. Steering movements are no longer possible.

4.6. **Electronic Control Unit (ECU)**

The ECU is equipped with two microprocessors for the purpose of redundancy. It is equipped with an AMP multi-port connector with 69 pins and 4 slots. The connectors are of a fool-proof type to prevent wrong connections.

The ECU makes it possible to send and receive and make calculations based on analogue and digital signals as well as CANbus messages. Because the system is software-controlled, we are able to customise parameters for a specific application without an extensive development process. The software is developed in-house by VSE’s software engineers.

The ECU contains redundant microprocessors. They run in parallel, each monitoring the other, so normal operation can continue even if one fails.

For use on trailers, the ECU is mounted in a special protection box in order to obtain an IP-67 rating.

The ECU is EMC tested and certified for compliance with ECE R10.02.
4.7. Display

A display is used as the interface between the user and the steering system. The display shows all information relevant to the operation, maintenance, troubleshooting and repair of the system.

The display can be permanently mounted in the vehicle for use as a control panel. It is 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 licenses are used.

The display must be used for performing calibration and diagnostics and for changing parameters. Various users can be given access to different data. The status of the system is displayed in real time.
4.8. Manual control

The manual control makes it possible to steer the axles when there is no yaw angle between the tractor and the trailer. In some cases it is only possible to achieve the desired steering angle through manual control.

The steering system will automatically switch to normal steering mode once a configured vehicle speed has been reached. There is never any need to readjust or align the combination after manoeuvring with the manual control.

With manual control, the driver is able to steer the axles before moving the tractor-trailer to the desired spot. During driving, the driver has the option to select the steering mode based on the yaw angle between the tractor and trailer, to adjust the steering angle of the axles or even to lock the axles. With a push of a button he can activate ‘manual override’, which means that from that point on the steered axles will both steer with the same angle and not according to the ‘Ackermann’ principle.

This option reduces the number of movements necessary to position the tractor-trailer combination, which saves time and reduces fuel consumption.

The manual control is wireless. The receiver with antenna is mounted in the system locker.
4.9. Charger/booster for trailer batteries

The power pack receives its power from a pair of batteries located on the trailer. These batteries have to be charged by the tractor’s alternator.

The tractor must be equipped with an alternator rated for an output of at least 100 A at 28 V. The connection between the tractor and trailer must be made using a suitable combination of cables and connectors. VSE can provide you with specific recommendations.

Due to the high current consumption of the power pack it is necessary to mount two 12V/190Ah batteries close to the electric pump.

To reduce the charging time and isolate the batteries in the trailer from those in the tractor, VSE has developed a special charging device: the ‘Booster’. This component is connected directly to the power supply from the tractor and is software-controlled.

The main functions of the booster are:

- Boosting the voltage level up to 28V to reduce the charging time
- Separating the batteries on the trailer from those on the truck
- Controlling and regulating the charging (during charging of the tractor batteries)
- Monitoring the state of charge of the trailer batteries
4.10. System locker

To reduce assembly time, risk of malfunctions and maintenance, and to increase the service life of the ETS system on a trailer, VSE delivers the main steering components pre-assembled and tested in a stainless steel locker. This makes installation on the vehicle a matter of bolting it on and plugging it in.

Hydraulic and electrical connections in the locker - ETS 2 version with auxiliary functions

The standard locker is 1000x500x500 mm (LxHxW). This locker size only provides enough room for the ETS components. The trailer batteries and the booster must be placed elsewhere. For low loader trailers the locker height is reduced by 100 mm.

VSE can determine the correct locker size for your application.

Most common locker sizes:

- 1500 x 400 x 500 with double doors ETS2, incl. oil and power supply
- 1250 x 500 x 550 with single door ETS1, incl. oil and power supply
- 1000 x 400 x 500 with single door ETS2, incl. power supply, external oil reservoir

1250x500x550 mm locker for double-pump ETS including batteries and electrical system

1000x400x500 mm locker for low loaders with a removable top for better access
5. Overview VSE components placed on the trailer

5.1. Semi trailer with twin tyre BPW self-tracking axles

- **Kingpin sensor**

- **Hydraulic steering manifold, power pack, display and Electronic Control Unit - built into a locker**

- **Hydraulic steering cylinder with external centring circuit, mounted on a BPW self-tracking axle**

- **Angle sensor integrated into the kingpin of a BPW self-tracking 10T axle**
5.2. 3-axle tipping trailer, with single-tyre SAF steered axles

Hydraulic steering cylinder with internal centring circuit

Steering cylinder on a 3 axle tipping trailer

Locker without power pack

Stand-alone angle sensor on a SAF 10T forced steered axle
5.3. 3-axle bulk trailer with turntable steered axles

- Heavy-duty angle sensor - for measuring the actual angle of the steering axles

- Steering system components - mounted in a customer-specific locker

- Steering cylinder with integrated centring circuit between axles one and two
6. Examples of trailers with ETS 1 axle steering

**AWB (B):** SAF steering axle 32°

**Cuppers (NL):** Turntable steering 18°

**Vang (N):** BPW trailing axle 24°

**Welgro (NL):** Turntable axles, max. 30°
7. Examples of trailers with ETS 2 axle steering

**Vang (N):** BPW trailing axles, 24°

**GS Meppel (NL):** SAF steering axles (max. 30°)

**BPW 16T steering axles, 37° turning angle. Axles 1 and 4 steered**
8. **VSE as a supplier**

VSE understands the need for a proper evaluation of new products. That is why we advise all our customers to first spend some time testing a prototype. This approach ensures that both parties will be pleased with the result.

VSE produces and delivers high-end vehicle systems. We are ISO certified and have extensive experience with electronically-controlled hydraulic vehicle systems gained through development, construction and testing.

**Cylinder testing at VSE**

To illustrate: We manufacture our own cylinders so we can keep the costs low for small production quantities and to meet the high quality requirements demanded of us. We perform assembly under very controlled conditions to guarantee maximum cleanliness inside the hydraulic manifolds and cylinders. Past experience has taught us that the best way to be certain of the quality of high-tech cylinders is to produce them ourselves.

This not only applies to the components; we take the same approach to vehicle dynamics:

**Steering system behaviour under extreme conditions**

Our trailer steering systems have passed the homologation tests of both the RDW (Dutch Road Transport Directorate) and the TÜV (German certification body). We recently obtained a type approval for ETS trailer steering in accordance with directive R79 – appendix 6.

VSE and ETS are now ready for the rapidly approaching implementation of new requirements that will make semi-trailers subject to ‘European Whole Vehicle Type Approval’ based on directive 2007/46/EC as well.
VSE Trailer Systems 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
- Designed for complete integration in the vehicle
- Requires virtually no maintenance
- ISO 9001-2000 certified (since 2003)

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