

Function

The Roll Stability Program (RSP) uses a lateral accelerometer integrated in the TEBS Brake Module to monitor lateral acceleration of the trailer in addition to taking inputs of vehicle speed and axle loading. The program constantly monitors these inputs and uses them to predict when a potential roll-over of the trailer is imminent. Once this assessment has been made the brake module automatically applies certain brakes on the trailer to prevent the roll-over occurring.

Note:

The Roll Stability Program (RSP) function is standard in TEBS G2.0, TEBS G2.1 and TEBS G2.2 Brake Modules.



Operation

The RSP is an active safety system which is configured by default (but can be disabled) in the TEBS G2 Brake Module to protect against trailer roll-over during driving by automatic application of the trailer service brakes.

Roll-over accidents normally occur when the lateral acceleration acting upon a vehicle exceeds a vehicle-specific critical limit. For example, the lateral acceleration upper limit depends on the height of the centre of gravity, which can vary not only from one vehicle to the next, but also in the same vehicle depending on the load and the loading state. Moreover, the vehicle speed and the geometric data of each vehicle have a significant effect on the limit value of the lateral acceleration. In vehicles with a high centre of gravity, such as some tanker vehicles, the critical roll-over lateral acceleration is lower than with a flatbed trailer that is used for transporting steel plates. However the vehicle speed when cornering is also a critical element as the developed lateral acceleration varies with the square of the vehicle speed therefore small changes in speed have a major impact on lateral acceleration.

Often in semi-trailer combinations it is difficult, if not impossible, for the driver to be aware of how close the trailer is to roll-over. This is relevant when considering the characteristics of modern towing vehicles that provide high levels of driver comfort. Even if the driver did become aware of a potential roll-over it is very likely that it would be too late for him to intervene in time to reduce the vehicle speed enough to avoid an accident.

Note:

Even with the correct installation and observation of the above rules it is impossible to completely eliminate the possibility of a roll-over accident. Physical limits exist in any safety system which, for example, can be reached and exceeded by the vehicle speed being significantly too high. For that reason it is still the responsibility of the driver to drive according to the road and traffic conditions so that the RSP system only intervenes when absolutely necessary. Equally when a vehicle is driven in a way that induces repeated RSP interventions, the action of the RSP to slow the vehicle down means that time is lost compared to that if the vehicle had been driven more appropriately.

The RSP function provides a major advantage in that the critical factors influencing roll-over are continuously monitored by the TEBS Brake Module and therefore it is able to react before the condition becomes critical. The input variables required to fulfil the RSP function are monitored as follows:

- **Lateral acceleration:** a lateral accelerometer is mounted on the printed circuit board of the TEBS Brake Module.
- **Vehicle speed:** speed information is derived from the output of the wheel speed sensors.
- **Axle/bogie load:** this information is already available from a direct reading of the suspension air spring pressure by the integrated pressure sensor at port 42.

It is quite possible that the driver will apply the brakes before or during an RSP intervention. In all cases the TEBS Brake Module will compare the brake actuator delivery pressure associated with the braking demand with the pressure automatically generated by the RSP function. The pressure that is generated at the brakes will always be the higher of the two values.

The RSP functions integrated into the TEBS Brake Module are divided into two categories:

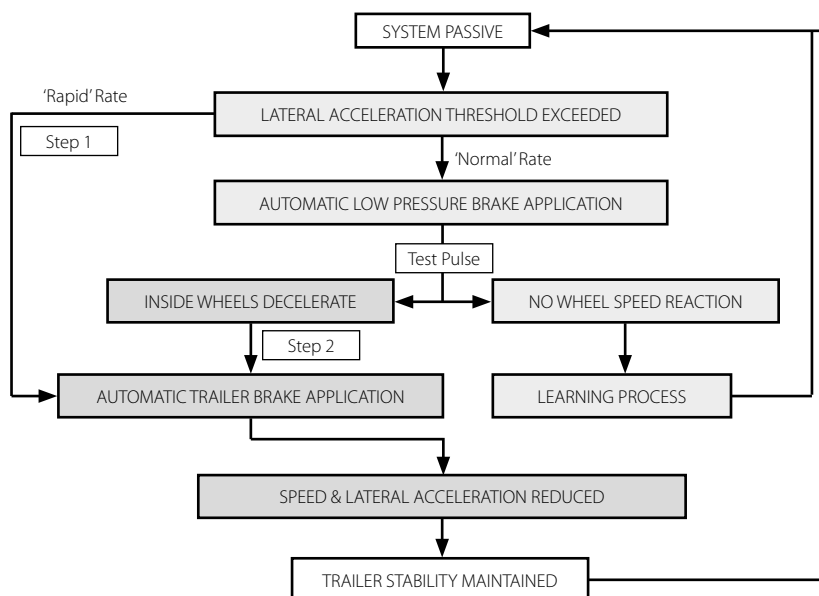
- **Roll-over control:** Applicable to semi- and centre- axle trailers
- **Oscillation control:** Applicable to centre-axle trailers only

1. Roll-over control

Within the RSP control logic three different operation states exists:

- **Test Pulse:** A routine which occurs when the lateral acceleration threshold has been exceeded; a check is made to establish if a roll-over is imminent.
- **Step 2:** RSP intervention following a test pulse that has determined roll-over is imminent.
- **Step 1:** RSP intervention that takes place without the need for a test pulse.

The figure below summarises the logic routines.



Based on the control logic defined in the figure above, the following describes the logic in more detail.

Test pulse:

The lateral acceleration threshold is defined as a "realistic" value for the majority of conditions but it is still necessary to verify whether the trailer is really at risk from rolling over. Therefore, when the predefined threshold is exceeded, if the change in lateral acceleration takes place at a 'normal' rate instead of applying the brakes to significantly reduce the speed of the combination, a test loop (pulse) is run first. This is realised by automatically producing a low brake actuator pressure to evaluate the reaction of the wheel(s) on the inside of the curve.

If the wheel speed decreases as a result of the low pressure brake application then the control logic will move to Step 2.

If the low pressure brake application does not cause a reduction in the speed of the inside wheel(s), a Step 2 intervention will not occur and the lateral acceleration threshold will be increased as part of the TEBS Brake Module learning process.

Step 2:

A Step 2 brake intervention will always follow a "test pulse" which has resulted in a wheel speed reduction (i.e. likely to be caused by the wheel(s) being off the ground or very lightly loaded). In this case the trailer is judged to be in a critical condition and will roll over unless the lateral acceleration is reduced by a lowering of the vehicle speed. This means that the pressure generated at the brake actuators on the wheels of the trailer on the outside of the curve should be increased to achieve maximum combination deceleration and bring the lateral acceleration down to a non-critical level as quickly as possible. Once this is achieved the brakes will be released and the system will return to passive mode.

Step 1:

If however the increase in the lateral acceleration takes place very quickly then no test routine is run and an immediate RSP brake intervention is initiated on the wheels of the trailer on the outside of the curve. Such an intervention is generally caused by an evasive manoeuvre by the driver when there is insufficient time for the system to carry out the Test Pulse routine and there is the potential that the trailer would have rolled over before a full brake application could have been made. As the Step 1 intervention reacts to rapid evasive manoeuvres then it is equally likely that the driver could turn the vehicle in the opposite direction in which case the lateral acceleration could reduce to a level which no longer requires an RSP intervention. Therefore every Step 1 intervention must be evaluated by the level of pressure generated at the brake actuators. The different levels of pressure intervention and their number can be viewed in the "Operating Conditions" window of the diagnostic program *ECUtalk*® under the "Diagnostic Information" tab, "Drive Recorder" (see Section 5).

2. Oscillation control

The lateral acceleration sensor is utilised to monitor the swing of the trailer. Should the maximum lateral acceleration to the left and right exceed a preset value for a number of oscillations, the TEBS Brake Module will intervene to bring the oscillations under control. This is achieved by individual left and right brake applications which introduce an opposite yaw moment to counter that produced by the trailer. Within 2 or 3 brake applications the trailer is generally stabilised without a significant reduction in speed. The automatic brake intervention pressure is variable dependent on the load of the trailer.

Step 3:

The lateral acceleration sensor is utilised to monitor the swing of the trailer. Should the maximum lateral acceleration to the left and right exceed a preset value for a number of oscillations, the TEBS Brake Module will intervene to bring the oscillations under control. This is achieved by individual left and right brake applications which introduce an opposite yaw moment to counter that produced by the trailer. Within 2 or 3 brake applications the trailer is generally stabilised without a significant reduction in speed. The automatic brake intervention pressure is variable dependent on the load of the trailer.

Note:

RSP Step 3 is not needed for semi-trailers and is not recommended for full trailer applications.

In all cases it is possible to check the number of RSP interventions of each type by means of the diagnostic program *ECUtalk*® or the Trailer Information Module (TIM G2) (see Section 5).

When the RSP safety system is installed on a trailer, particular attention must be given to the installation of the TEBS Brake Module and other equipment on the trailer to ensure the satisfactory operation of the RSP (see Section 6).

In addition there are a number of application restrictions:

- Lift axle control is only permitted when all lift axles are directly controlled by the TEBS Brake Module i.e. the installation of separate lift axle control systems is not allowed.
- Input control functions such as 'Traction Help' (TH), 'Lower Lift axle' (LL) and 'Manoeuvring Help' (MH) that override the automatic lift axle control must be performed via the TEBS G2 Brake Module.
- If the trailer has a raise/lower valve it is recommended that the trailer is equipped with the facility for automatic suspension reset by the use of the 'Speed Pulse' (SP) auxiliary function.
- Any special lift axle control requirements must be implemented via an ADL file.
- RSP is only recommended for use on trailers with air or hydraulic suspension.

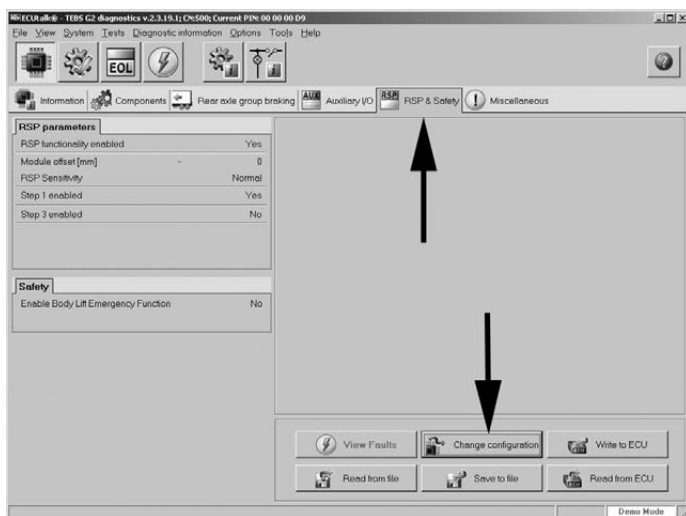
Only when all of the above conditions have been observed will the optimum functionality be obtained from the RSP stability system. Any deviations from these requirements could result in the TEBS Brake Module misinterpreting the bogie load which is determined from the air spring pressure and the status of the lift axles and result in impaired RSP performance.

Note:

Even with the correct installation and observation of the above rules it is impossible to completely eliminate the possibility of a roll-over accident. Physical limits exist in any safety system which, for example, can be reached and exceeded by the vehicle speed being significantly too high. For that reason it is still the responsibility of the driver to drive according to the road and traffic conditions so that the RSP system only intervenes when absolutely necessary. Equally when a vehicle is driven in a way that induces repeated RSP interventions, the action of the RSP to slow the vehicle down means that time is lost compared to that if the vehicle had been driven more appropriately.

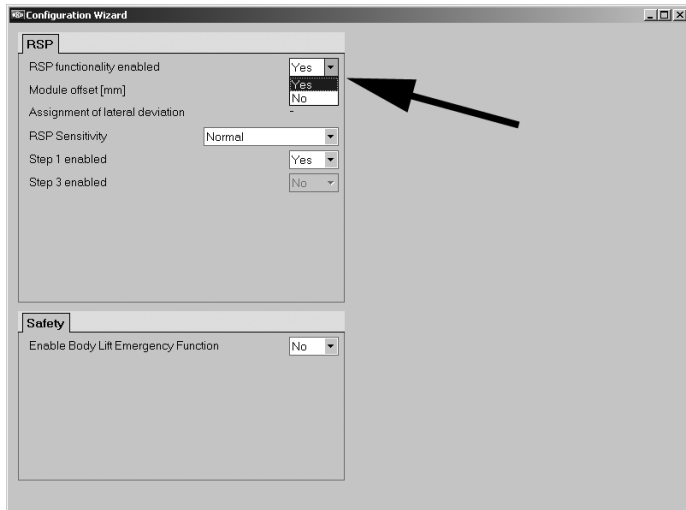
3. Setting up of RSP related parameters

RSP parameters are found under the "RSP & Safety" tab in *ECUtalk*®.



Switching the RSP function On and Off

Within the diagnostic program *ECUtalk*® the RSP function can be activated and de-activated. This option is found using the "Change configuration" option.



RSP speed cut-off

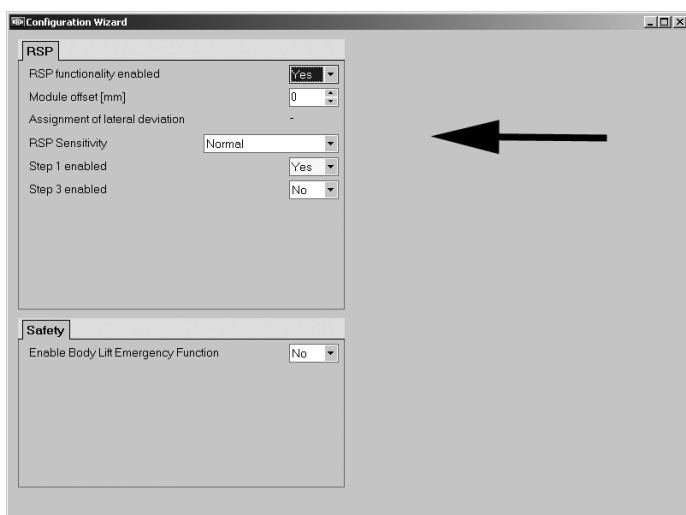
The RSP function is automatically switched off below 15 km/h - this setting is not adjustable.

RSP Step 1 enabled

The default setting is 'Yes'. This setting should be changed only after discussion with Knorr-Bremse.

RSP Step 3 enabled

This function is greyed out for a semi-trailer and has a default setting of 'No' for other vehicle types. It should be changed only after consultation with a Knorr-Bremse representative.



RSP sensitivity

The RSP Sensitivity setting is used to allow the RSP algorithm to be tailored to non-standard trailers. The default setting is 'Normal'.

Note:

Decreasing the sensitivity values below the normal setting should be undertaken only after discussion with Knorr-Bremse.

- For special trailers with moving loads, such as hanging meat or tankers without slosh dampers or trailers with independent suspension e.g. glass carriers, based on the latest updates to the 'Knorr RSP algorithm' it is suggested that "Increased 1" is used.
- For trailers where cumulative factors such as hanging meat and independent suspension result in a very high roll over tendency, based on the latest updates to the 'Knorr RSP algorithm' it is suggested that "Increased 2" is used.
- For trailers that do not fall into the special categories above but have a high centre of gravity or where the wheel track (distance between the centres of the tyres) is narrow, selecting an increased RSP sensitivity may be advisable.

To aid system designers and / or trailer builders, the simplified approach given below can be followed for these trailers.

Sensitivity Calculation method.

For trailers having axles with single tyres:

Ratio of Unladen centre of gravity ¹⁾ Wheel track ²⁾	Sensitivity Value	Ratio of Laden centre of gravity ¹⁾ Wheel track ²⁾	Sensitivity Value
<0.89	Normal	<1.22	Normal
0.89 to 0.94	Increased 1	1.22 to 1.32	Increased 1
>0.94	Increased 2	2: > 1.32	Increased 2

Note:

Always select the highest sensitivity value.

For trailers having axles with twin tyres:

Ratio of Unladen centre of gravity ¹⁾ Wheel track ²⁾	Sensitivity Value
<0.84	Normal
0.84 to 0.89	Increased 1
>0.89	Increased 2

Ratio of Laden centre of gravity ¹⁾ Wheel track ²⁾	Sensitivity Value
<1.3	Normal
1.3 to 1.42	Increased 1
> 1.42	Increased 2

Note:

Always select the highest sensitivity value.

¹⁾ The centre of gravity used should be the worst case loading pattern for the vehicle e.g. with a double deck trailer, if it is allowed to load on the top deck only then this value should be used.

²⁾ For axles with single tyres, the track is the distance between the centres of the two tyres. Whereas, for axles with twin tyres, the track is the distance between the centre of the two tyres on the left and the centre of the two tyres on the right.

Note:

If in doubt please contact Knorr-Bremse for guidance.

4. 'RSP active' output

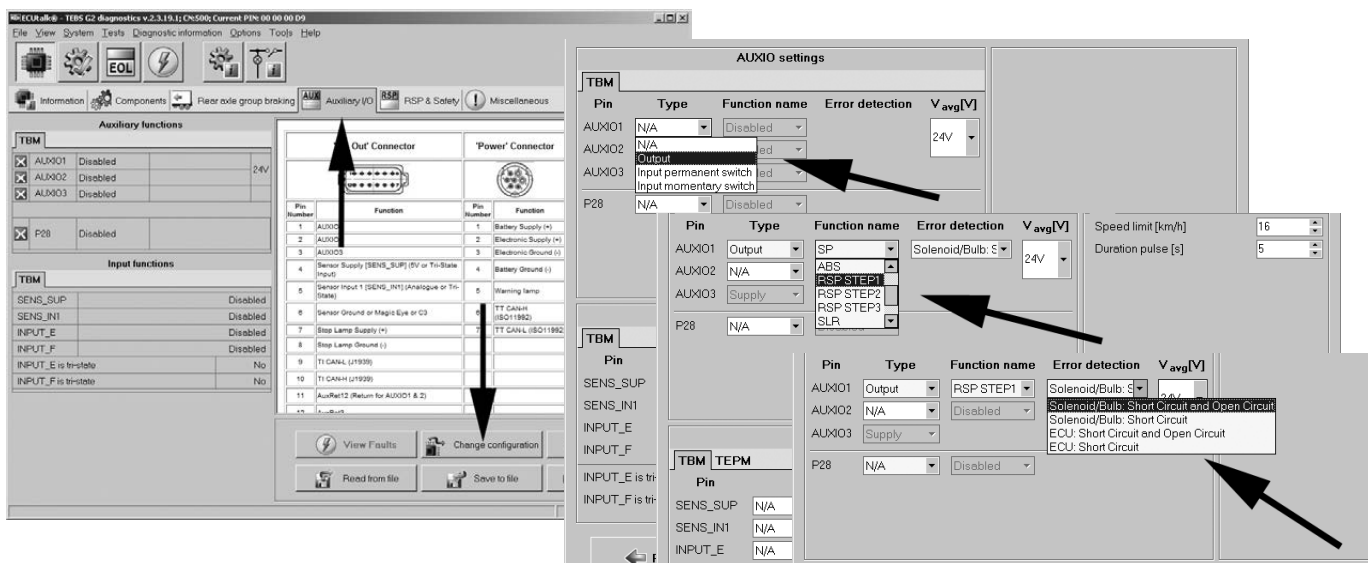
This function is configurable within the diagnostic program ECUTalk[®] to provide an output signal whenever there is:

- an RSP Step 2 intervention following a Test Pulse
- a Step 1 or Step 3 (if enabled) output is configurable as an alternative.

It is possible to configure outputs for more than one step but this will use up extra AUXIO outputs and is not normally required. Under the tab "Auxiliary I/O" use the "Change configuration" option.

TEBS G2.0, G2.1 and G2.2 Standard up to CN1023:

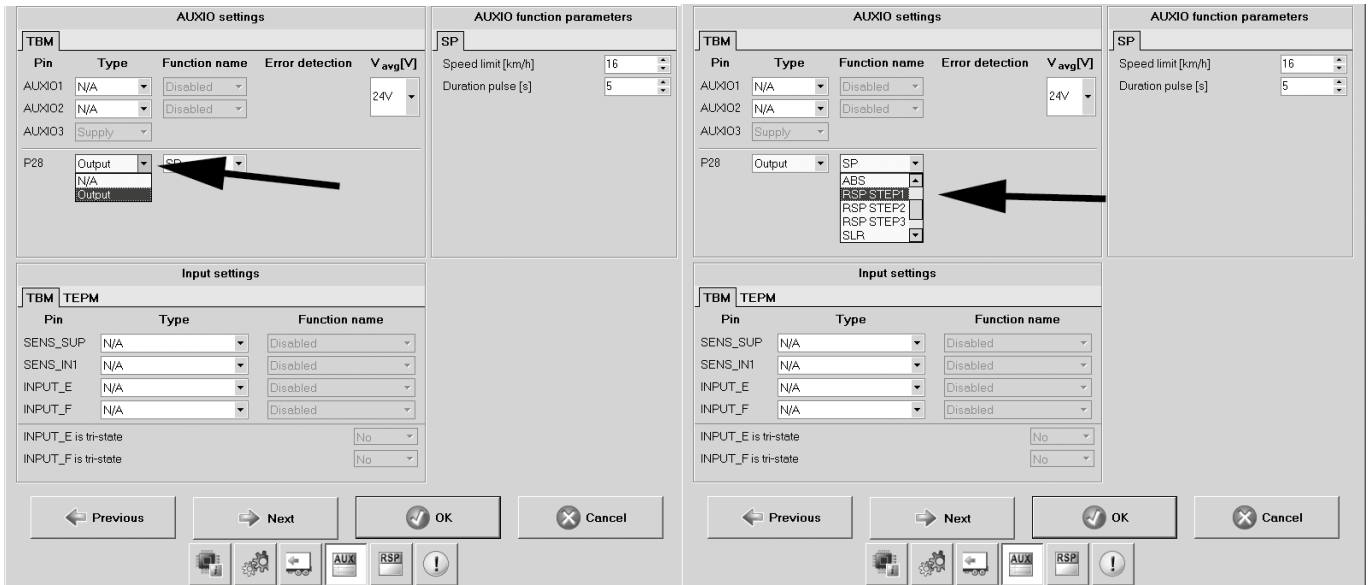
From the drop down list for the required AUXIO select 'Output', then the required Step. Under "Error detection" select the detection option required depending on the use of the output signal, then select the output voltage:



TEBS G2

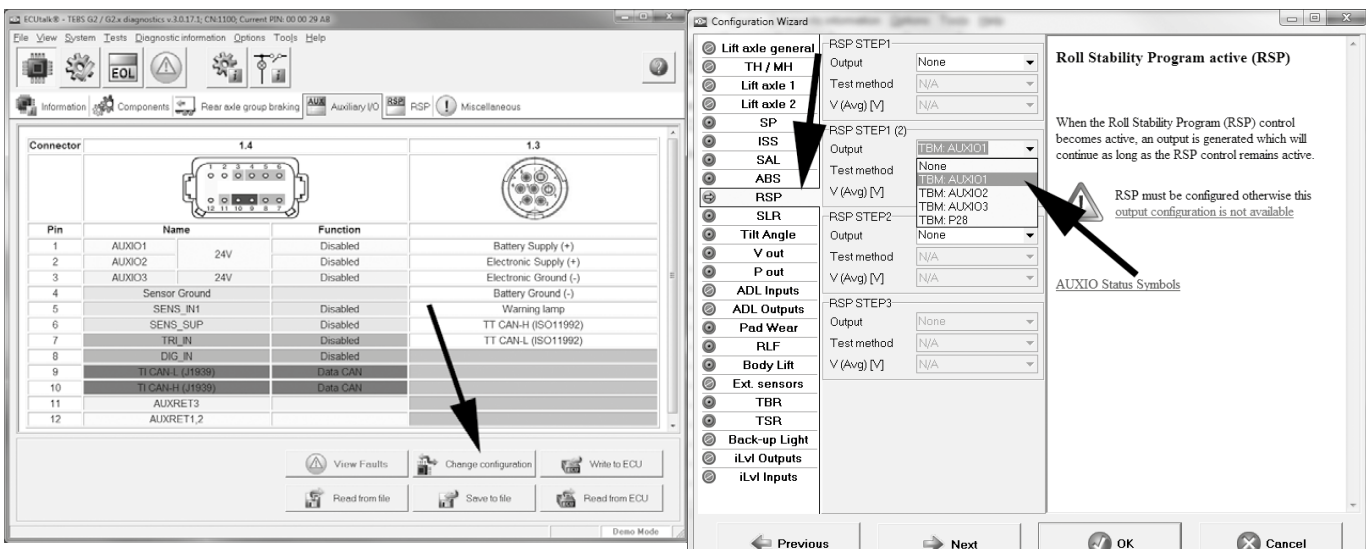
Roll Stability Program (RSP)

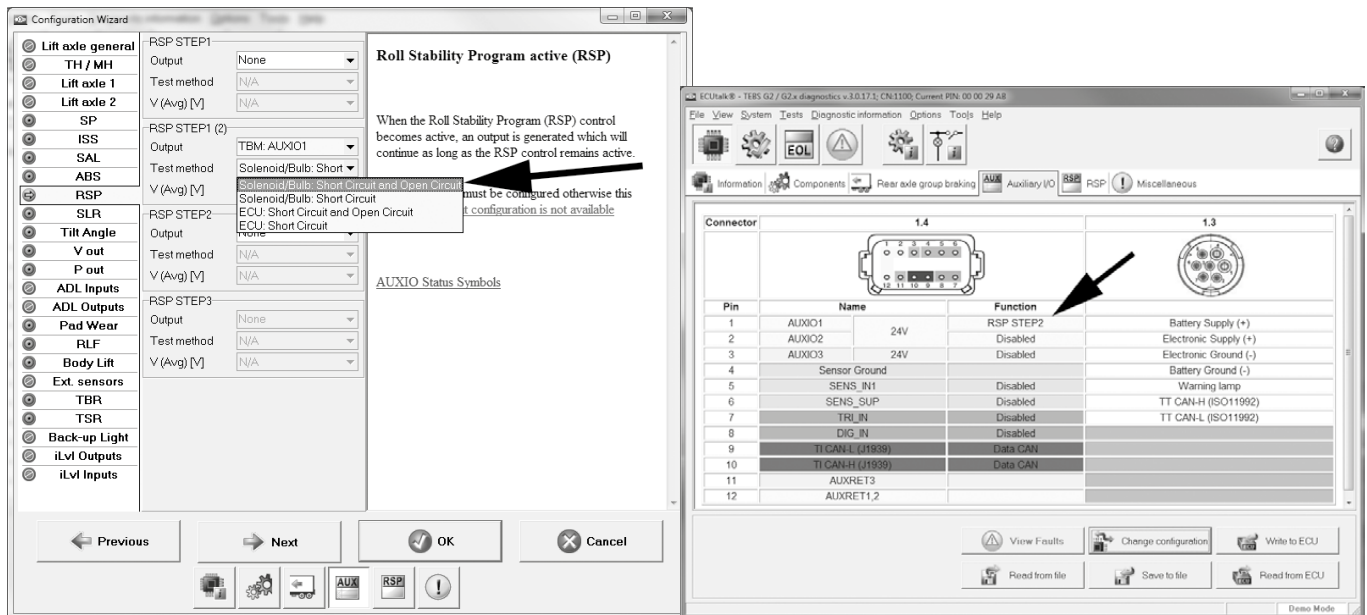
Certain variants of the TEBS Brake Module are able to provide a pneumatically switched output by using an integrated solenoid. To use this alternative output, firstly enable P₂₈ under the tab "Auxiliary I/O" using the "Change configuration" option then set the RSP Step:



TEBS G2.2 Standard (CN1030 and above), Standard Plus and Premium:

The ECUtalk® screens for these TEBS G2.2 are different. Having selected the "Change configuration" option, the screen will display a list of the available inputs and outputs together with a 'Help' panel on the right hand side. Click on the "RSP" tab and select the required RSP Step and AUXIO Output from the drop down list. Under "Test method" select the fault detection option required depending on the use of the output signal, then select the output voltage. Click on "OK" and the screen will show the RSP function assigned to the selected AUXIO.



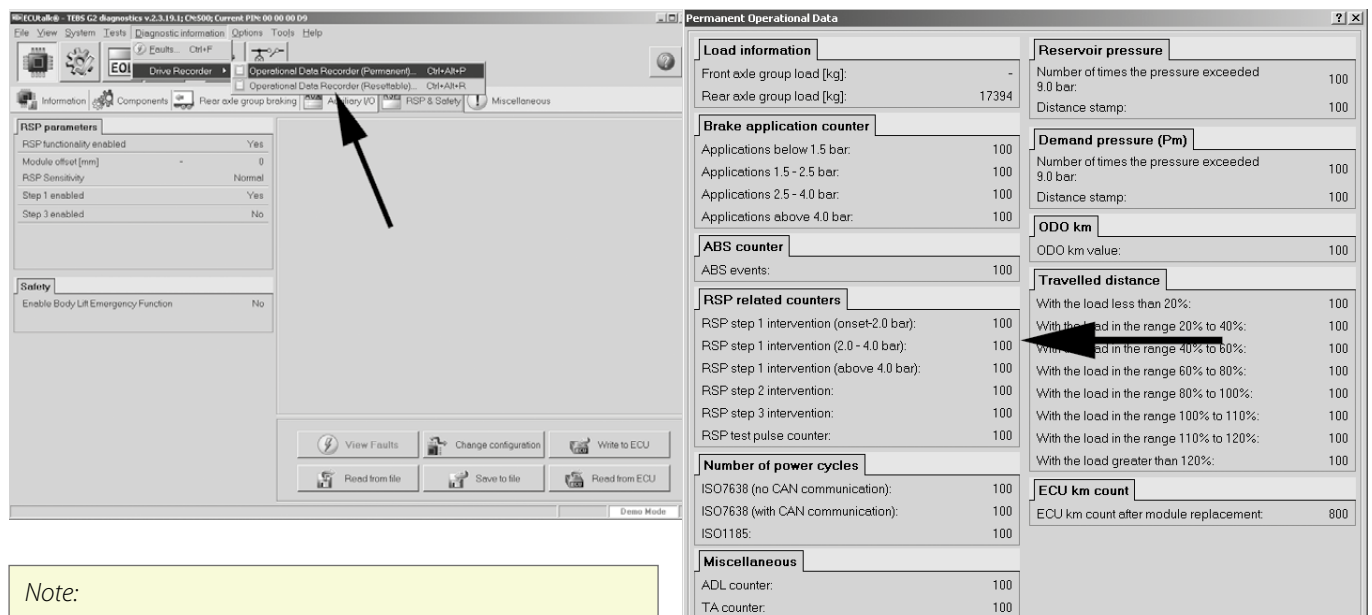


5. Operational Data Recorder (ODR) - RSP related counter

Whenever an RSP event occurs, the respective counter will be incremented. The counter ranges are:

- Step 1: Pressure ranges below 2 bar, from 2 to 4 bar and above 4 bar. This will enable the severity of the Step 1 interventions to be assessed.
- Step 2: Every time a Step 2 intervention occurs the counter will be incremented.
- Step 3: Every time a Step 3 intervention (if enabled) occurs the counter will be incremented.

The counters can be viewed using either the diagnostic program ECUtalk® or the Trailer Information Module (TIM G2). In ECUtalk® the counters are found under the "Diagnostic Information" tab, "Drive Recorder":



Note:

See also PD-214-F354, Document No. Y136134.

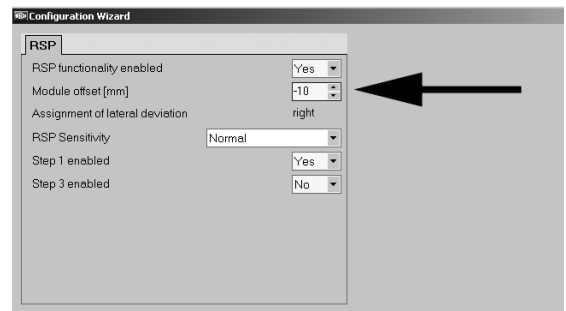
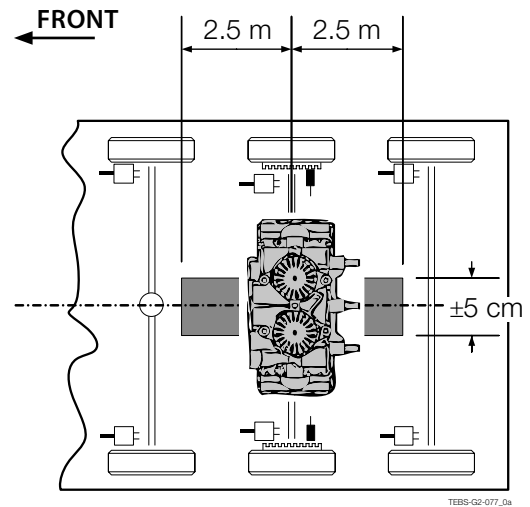
6. Installation restrictions when using RSP

If the Roll Stability Program (RSP) is used, special restrictions apply to the installation of the TEBS Brake Module. In the longitudinal direction, the deviation of the TEBS Brake Module from the centre of the bogie may be a maximum of ± 2.5 m however the maximum permitted pipe length of 5 m to the brake actuators must be observed.

Note:

When a self-steering or command steered axle is fitted the 'centre of the bogie' is deemed to be between the fixed axles.

An ideal installation would be where the TEBS Brake Module is laterally positioned within 5 cm of the centre of the trailer (see figure), this would result in the respective pipe lengths being approximately equal for each axle. However it is possible to mount the TEBS Brake Module in other positions dependent on the design of the trailer and space available and any lateral offset greater than 5 cm must be configured by the use of the diagnostic program *ECUtalk*® otherwise the lateral acceleration information generated by the internal sensor may be incorrect and impact on the RSP performance. The configuration of the offset in 10 mm increments is found under the "RSP" tab in *ECUtalk*® then "Change configuration":

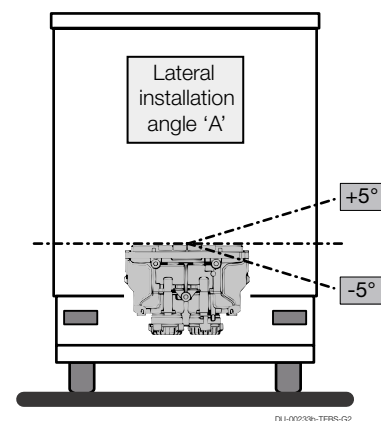


Note:

If the required lateral offset is greater than 1 metre please contact a Knorr-Bremse representative for advice.

When RSP is configured it is important for the TEBS G2 Brake Module that during installation the angular displacement in three planes is controlled to ensure the output from the internal lateral acceleration sensor is accurate and therefore able to allow effective RSP control. The most important angle is the lateral installation angle 'A' which must be kept within $\pm 5^\circ$ of horizontal.

Note that this value is checked during the EOL test.



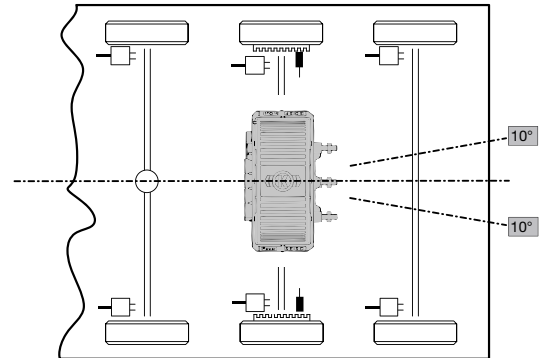
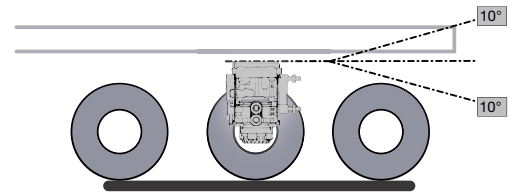
TEBS G2

Roll Stability Program (RSP)

In the longitudinal and vertical planes the installation tolerance is +/- 10°. The longitudinal and vertical angles cannot be checked during EOL testing therefore the installer must ensure that the defined installation limits are not exceeded.

When RSP is configured for use a number of restrictions apply as follows:

- Any lift axle must be:
 - either controlled by the TEBS G2 Brake Module
 - or, if external lift axle control is used, the status of any lift axle must be monitored by the TEBS G2 Brake Module using the “ext LAS” inputs (see PD-214-F101, Document No. Y136118).
- Any control that interfaces with the lift axle such as ‘Traction Help’ (TH), ‘Lower Lift’ axle (LL) and ‘Manoeuvring Help’ (MH) must be controlled directly by the TEBS G2 Brake Module.
- Where raise/lower control is installed on the trailer it is recommended that the valve incorporates a reset function which will accept either an electric or pneumatic reset signal.
- During configuration it must be ensured that the parameters of dynamic tyre diameter and sensing ring teeth number are correct for the trailer on which the TEBS G2 Brake Module is installed.



The above recommendations ensure that the trailer load is calculated accurately by the TEBS G2 Brake Module. The load calculation is based on the total number of axles, the number of axles on the ground and the air spring pressure.

Note:

an incorrect configuration of the tyre size and sensing ring teeth number will result in an inaccurate speed calculation.

If any of the above recommendations are not adhered to the possibility exists that the RSP function may not be appropriate, i.e. intervene too early, leading to driver disturbance, or too late, possibly resulting in trailer roll over.

Note:

For more information on ECUTalk® use the ‘on-line’ help function by pressing “F1” or see the Product Information Document No. Y051496 available at www.Knorr-BremseCVS.com.

Revision Details		
Rev. 006	January 2019	New Layout



Knorr-Bremse Group

Knorr-Bremse Systems for Commercial Vehicles

Moosacher Strasse 80 | 80809 Munich | Germany
Tel: +49 89 3547-0 | Fax: +49 89 3547-2767
WWW.KNORR-BREMSECVS.COM

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