

Product Manual

# Trailer EBS TEBS G2 (Generation 2)



- System configuration and functional description
- Installation instructions
- Diagnostics
- Servicing
- Trailer type approval

**KNORR-BREMSE**



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## Safety Advice

**Note:** The safety advice below is applicable to general service and diagnostic work on air braking systems and may not all be directly relevant to the activities and products described in this document.

Before and whilst working on or around air braking systems and devices, the following precautions should be observed in addition to any specific advice given in this document:

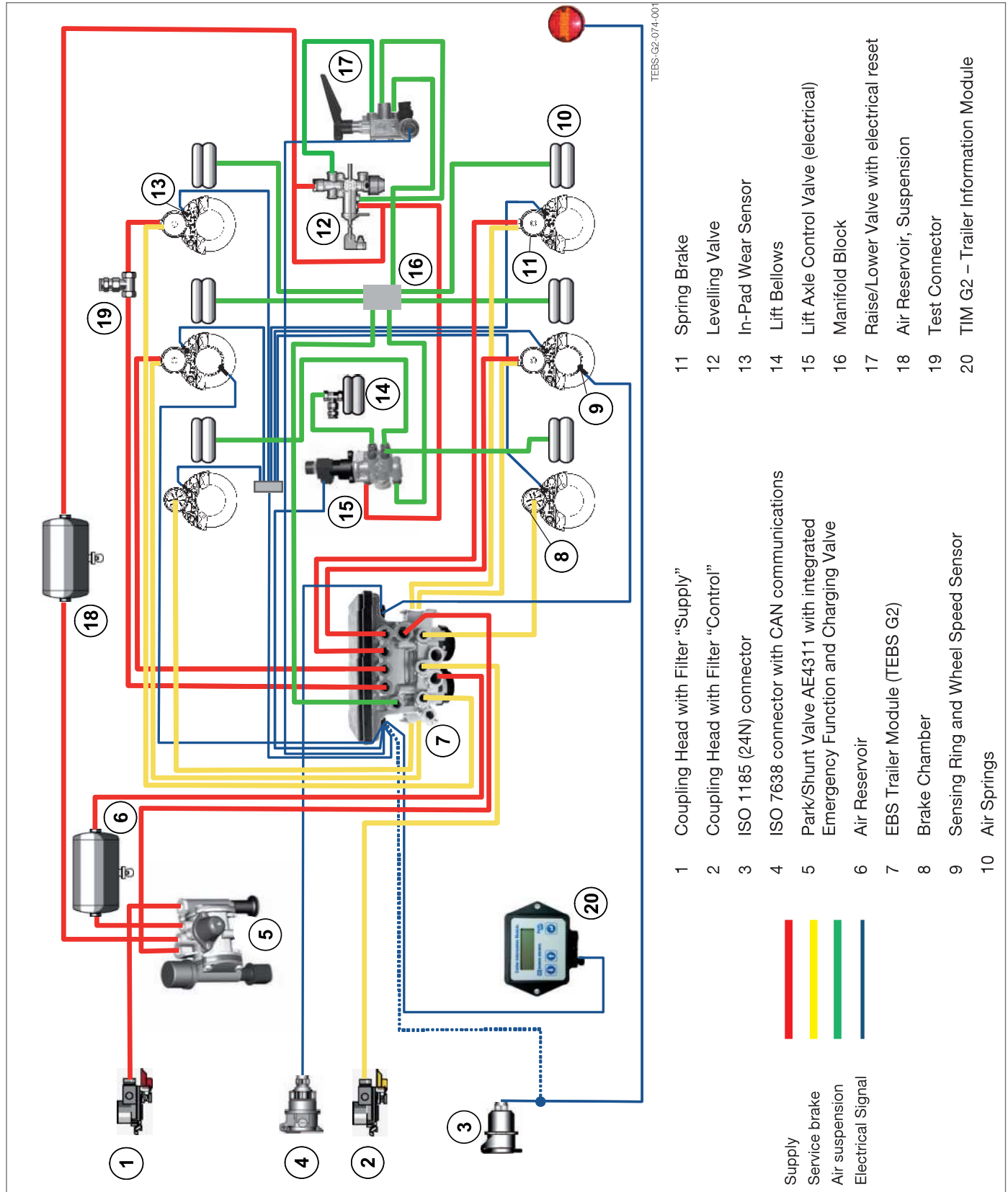
- Always wear safety glasses when working with air pressure.
- Never exceed manufacturer's recommended air pressures.
- Never look into air jets or direct them at anyone.
- Never connect or disconnect a hose or line containing pressure; it may whip as air escapes.
- Never remove a device or pipe plug unless you are certain all system pressure has been depleted.
- Park the vehicle on a level surface, apply the parking brakes, and always chock the wheels as depleting vehicle air system pressure may cause the vehicle to roll.
- If work is being performed on the vehicle's air braking system, or any auxiliary pressurised air systems, and if it is necessary to drain the air pressure from reservoirs, etc., keep clear of brake actuator push rods and levers since they may move as system pressure drops. Be aware that if the vehicle is equipped with an air dryer system, it can also contain air pressure along with its purge reservoir, if fitted, even after pressure has been drained from the other reservoirs.
- When working under or around the vehicle, and particularly when working in the engine compartment, the engine should be shut off and the ignition key removed. Where circumstances require that the engine be running, EXTREME CAUTION should be taken to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically charged components. Additionally, it is advisable to place a clear sign on or near the steering wheel advising that there is work in progress on the vehicle.
- Examine all pipework for signs of kinks, dents, abrasion, drying out or overheating. Be aware that kinks in pipework may result in air pressure being trapped in the pipework and associated equipment. Replacement hardware, tubing, hose, fittings, etc. must be of equivalent size, type and strength as original equipment and be designed specifically for such applications and systems. Check the attachment of all pipework; it should be supported so that it cannot abrade or be subjected to excessive heat.
- Components with stripped threads or damaged/corroded parts should be replaced rather than repaired. Do not attempt repairs requiring machining or welding unless specifically stated and approved by the vehicle or component manufacturer.
- Never attempt to install, remove, disassemble or assemble a device until you have read and thoroughly understood the recommended procedures. Some units contain powerful springs and injury can result if not properly dismantled. Use only the correct tools and observe all precautions pertaining to use of those tools. Before removing any device note its position and the connections of all pipework so that the replacement/serviced device can be properly installed. Ensure that adequate support or assistance is provided for the removal/installation of heavy items.
- Use only genuine Knorr-Bremse replacement parts, components and kits.
- Prior to returning the vehicle to service, make certain all components and systems are leak free and restored to their proper operating condition.

### Welding

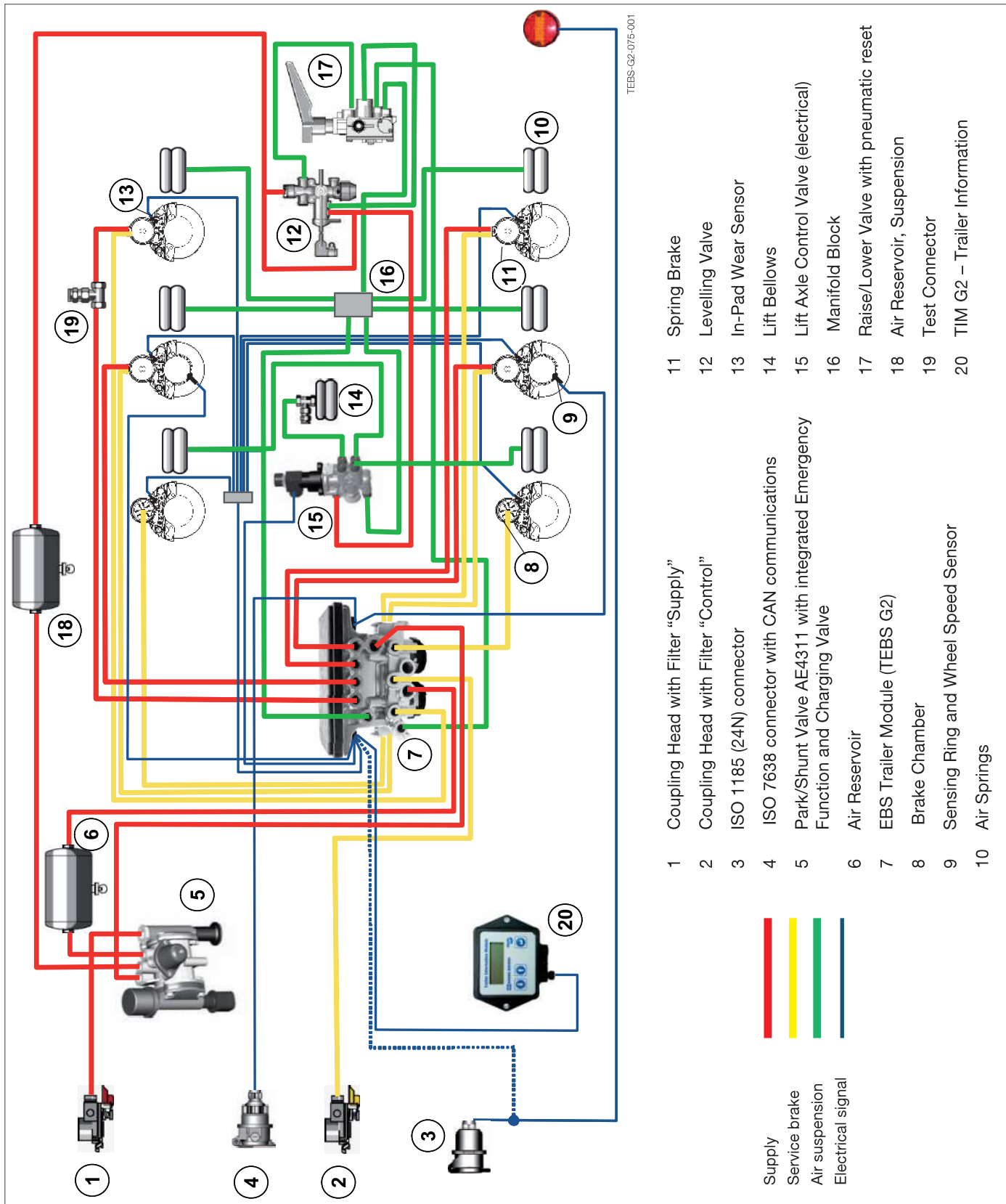
To avoid damage to electronic components when carrying out electrical welding, the following precautions should be observed:

- In all cases, before starting any electrical welding, remove all connections from any electronic control units or modules, noting their position and the order in which they are removed.
- When re-inserting the electrical connectors (in reverse order) it is essential that they are fitted to their correct assigned position - if necessary this must be checked by PC Diagnostics.

Electrically controlled suspension reset by Speed Pulse (SP), electrical Lift Axle Control (LAC)

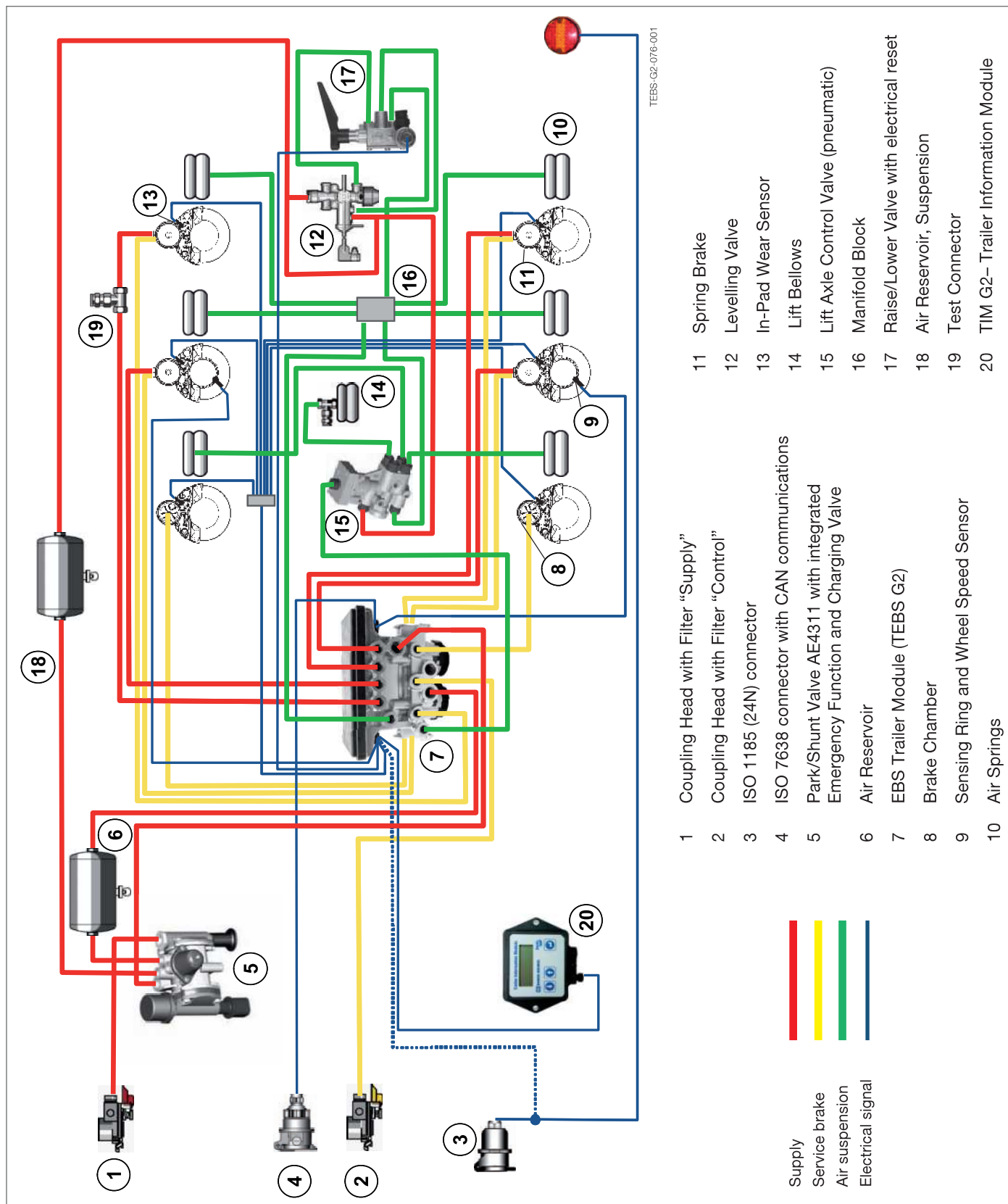


Pneumatically controlled suspension reset by Speed Pulse (SP), electrical Lift Axle Control (LAC)





Electrically controlled suspension reset by Speed Pulse (SP), pneumatic Lift Axle Control (LAC)



This document describes the system configuration, functionality and components that make up the new Trailer EBS generation from Knorr-Bremse, TEBS G2.

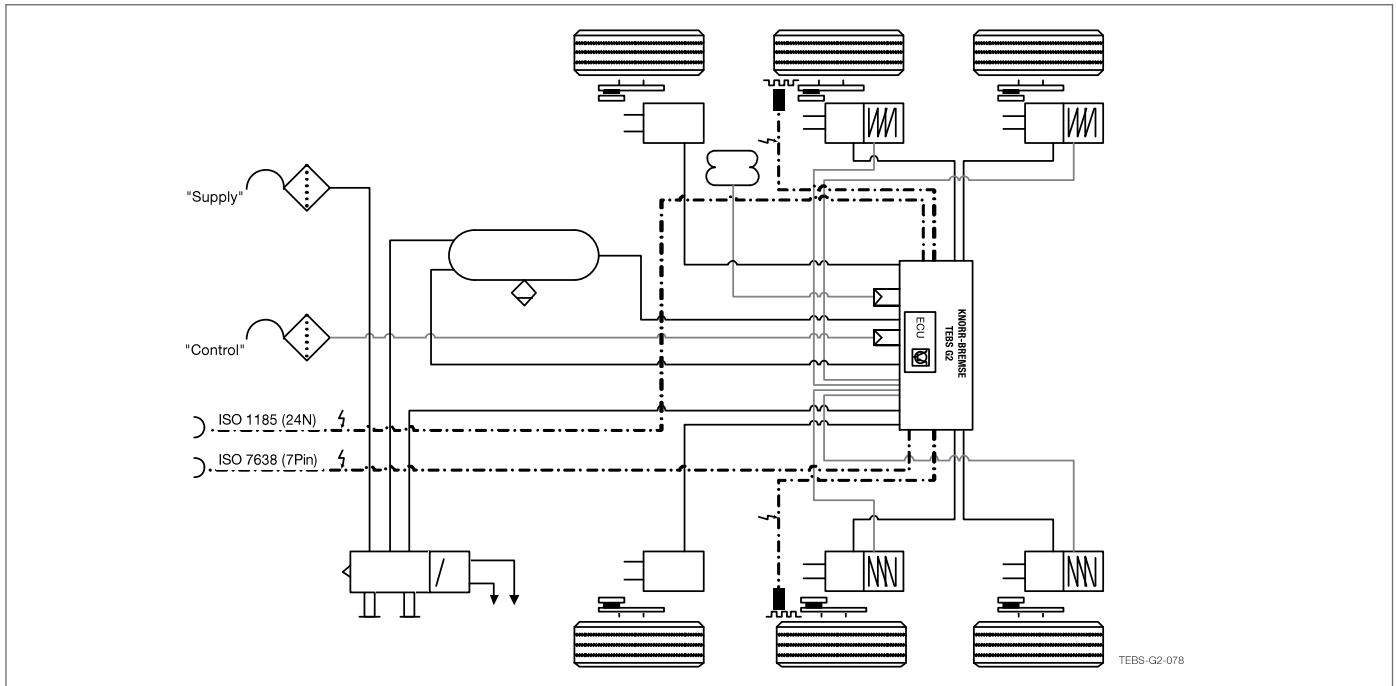
The following overview briefly describes some of the new features and functions that have been introduced into TEBS G2:

- Operating voltage range extended to 8 – 32 volts
- Push-to-connect (PTC) fittings
- All electrical connectors face downwards
- Four pneumatic ports to the spring brakes
- Internal 5V CAN J1939
- Option to configure different braking characteristics for the CAN and pneumatic brake demands
- Extended data logging capability.
- New auxiliary functions:
  - Switched pneumatic output
  - Tilt Angle (TA)
  - Manoeuvring Help (MH)
  - Steering Axle Lock (SAL)
  - Roll Stability Program (RSP) functionality extended and optimised

The trailer braking system consists of a park/shunt valve with integrated automatic brake control and charging valve plus the trailer EBS brake module. The module consists of an electronic control unit (ECU) with integrated pressure sensors, pneumatic and electrical connections, two pressure

modulators and an anti-compounding valve to protect the brakes from overload.

The schematic below illustrates a 2S/2M system configuration the name being derived from the number of wheel speed sensors (2S) and number of pressure modulators (2M).



**Figure 1:** Sample circuit diagram for a 2S/2M braking system in a semi-trailer with Knorr-Bremse TEBS G2

### 3.1 System description

#### 3.1.1 Electro-pneumatic function

The electro-pneumatic control system replaces the purely pneumatic control of a conventional braking system by the use of solenoids controlled by the TEBS G2 ECU. Therefore the functions of individual components in an otherwise complicated brake control system can be functionally combined and provide enhanced pressure control characteristics.

The Knorr-Bremse TEBS G2 represents a highly complex and integrated unit, since all the brake control processing and pressure modulators are combined in a single module.

To realise the brake control function the following features are available:

- Determination of the current load condition by measurement of the air spring pressure or alternatively

by the output of an externally mounted load sensor (e.g. hydraulic pressure sensor or deflection sensor).

- Determination of the braking demand from the towing vehicle via the electric control line (ISO 11992 CAN) as well as the pneumatic control line (yellow).
- Determination of the available reservoir supply pressure.
- Independent left / right modulation of the pressures to the brake actuators.
- Determination of the respective brake actuator pressures.
- Independent modulation of braking pressures during anti-lock cycling (ABS) or a Roll Stability Program (RSP) intervention.

To realise the functions described above, five pressure sensors are integrated in the TEBS G2 brake module. The pressure information is converted by the pressure sensors into electrical signals which are used in the brake control process. This information is also used as control variables for functions that are described below.

A conventional braking system, with ABS and automatic load-dependent braking force modulation, uses open loop control by mechanical adjustment and setting. The TEBS G2 brake module however realises improved functionality by means of closed loop pressure control based on the information available from the respective pressure sensors as described above.

For example, load-dependent braking force control is realised by using information recorded by the pressure sensors as follows:

#### **Process 1:**

It is essential that adequate reservoir pressure is available for the system to carry out the required brake pressure control. Should the reservoir pressure fall below a predefined value (4.5 bar) this is registered as a fault and signals will be transmitted to provide in cab the yellow and the red warning lamp signals that inform the driver of the fault condition.

#### **Process 2:**

The current axle or bogie load is determined by measuring the pressure in the air springs which are directly connected to port 42 of the TEBS G2 brake module. Alternatively this information may be obtained by means of an externally mounted pressure or deflection sensor electrically connected to the TEBS G2 brake module.

#### **Process 3:**

In the majority of installations the pneumatic braking demand is fed directly from the coupling head to port 4 of the TEBS G2 brake module where it is measured and used in the process to define the delivery pressure to the brake actuators.

#### **Process 4:**

The pressure to the brake actuators is determined by the ECU based on the values of axle/bogie load, braking demand (pneumatic or CAN) and previously defined laden and unladen braking parameters. When a braking demand is identified, the axle/bogie load at

that time is measured and used for the duration of the brake application, irrespective of any dynamic changes in air spring pressure. This is referred to as static load sensing.

#### **Process 5:**

To generate a pressure in the brake actuators the internal solenoid valves are used to control the pressure in each pressure modulator. The modulators each have a relay function meaning the actual pressure to the brake actuators is supplied directly from the supply reservoir. Signals from the delivery pressure transducers provide a feedback loop so that the brake actuator pressure at connections 21 and 22 is controlled to the value determined in Process 4.

#### **Process 6:**

The system must also have the capability to react to changes in driver demand during the braking process. Changes in driver demand are monitored by Process 3 and the system reacts by increasing, decreasing or holding the pressure delivered to the brake actuators. Realisation of these three states is achieved by a combination of energisation and de-energisation of the solenoids within the TEBS G2 brake module.

The above functionality can only be realised when the system is electrically powered. This is primarily achieved via the ISO 7638 connector (Pins 1 to 4) although there is also the possibility of having a backup electrical supply from the stop lamp circuit of the ISO 1185 connector should a failure of the ISO 7638 power supply occur.

### **3.1.2 Brake pressure control**

Control of the pressure at the brake actuators is dependent on three parameters:

1. Braking demand (see Process 3 above)
2. Current axle/bogie load (see Process 2 above)
3. Configured laden and unladen pressure characteristics (see Process 4 above)

Depending on the specification of the towing vehicle, there may be one or two brake demands present at the trailer. The following defines the different control line options available from the towing vehicle:

- Option 1: Pneumatic control line only
- Option 2: Pneumatic and electric (CAN) control lines
- Option 3: Electric (CAN) control line only \*

\* This option is currently prohibited in ECE Regulation 13

When both pneumatic and electric demands are present it is an ECE Regulation 13 requirement that electric braking demand shall be used in preference to the pneumatic braking demand to obtain the benefit of reduced braking system response time on the trailer. The electric control line (CAN) must conform to ISO 11992 and is available via pins 6 and 7 of the ISO 7638 connector. Determination of the required brake delivery pressure is the same, irrespective of whether the CAN or pneumatic braking demand is used in the process – see Process 5 and 6 above. Should the electric braking demand fail, the trailer must automatically switch to use the pneumatic braking demand. When the TEBS G2 equipped trailer is connected to a towing vehicle that does not have an electric braking demand signal available, the brake pressure control will be based on the pneumatic braking demand only. The pneumatic braking demand is converted into an electric signal in the TEBS G2 brake module and processed like a CAN signal.

Note:

It is acceptable for the electric (CAN) and pneumatic braking demand signal values to be different.

### 3.1.3 Pneumatic backup

Should the electrical power fall below 8 V, it is not possible to process any of the control functions or activate the solenoids. However this does not mean that the trailer will be un-braked when a braking demand signal is present. In this case the pneumatic braking demand is used to directly signal the relay valves within the TEBS G2 brake module which then react and supply pressure to the brake actuators. It is therefore still possible to generate maximum braking forces irrespective of the load of the vehicle but without the benefit of load sensing or anti-lock braking functions.

In the event of system faults that require a partial or total shut down of the TEBS G2 brake module (excludes failures

in the electrical power supply), the available brake pressure control will depend on the type and location of the failure. Faults that result in total system shut down will result in the brake module operating in backup mode which is the same as when no electrical power supply is available – see above. In other cases, even when a fault is present, it may be possible to process the brake pressure control in the usual way. However in both of these cases the TEBS G2 brake module will transmit a warning lamp signal via pin 5 of the ISO 7638 connector which will result in a warning being displayed to the driver that a fault on the trailer is present.

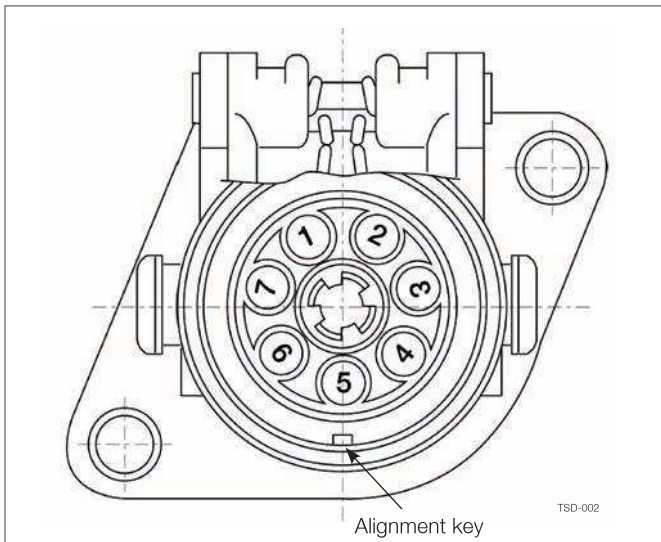
## 3.2 Electrical / electronic system configuration

### 3.2.1 Power connections and system power up

To obtain full functionality from the TEBS G2 brake module it must be supplied with electrical power in the range 8 to 32 V. This is usually realised by connection to a towing vehicle equipped with a 24 V interface conforming to ISO 7638-1 or alternatively a 12 V interface confirming to ISO 7638-2. Both of these connectors are designed to accommodate 7 pins although the number actually connected depends on the specification of the towing vehicle. When the towing vehicle is equipped with a conventional braking system including ABS, only pins 1 to 5 will be connected. In the case of a towing vehicle equipped with an EBS braking system it will also have an electric control line in which case all 7 pins will be connected.

Note:

While the pin location and functionality of the 12 V and 24 V ISO 7638 connectors are the same they are not interchangeable due to the use of alignment keys which prevents connection of vehicles with different operating voltages.



Pin no.	Cable colour	Cross section mm <sup>2</sup>	Function
1	Red	4.0	Battery supply
2	Black	1.5	ECU supply
3	Yellow	1.5	ECU ground
4	Brown	4.0	Battery ground
5	White	1.5	Warning lamp signal
6	White / Green	1.5	CAN High
7	White / Brown	1.5	CAN Low

If for any reason the voltage supply from the ISO 7638 should fail, as a safety feature the TEBS G2 brake module offers the option of a backup power supply via the stop lamp circuit of the ISO 1185 or ISO 12098 connector. In the backup power situation, the two main safety functions of load sensing and anti-lock braking are retained but, due to the power limitations of the stop lamp circuit, it is not possible to retain operation of auxiliary functions including Roll Stability Program (RSP).

Note that without this power supply backup, control of all braking and auxiliary functions would be lost and the TEBS G2 brake module would operate in backup mode - see 3.1.3. above.

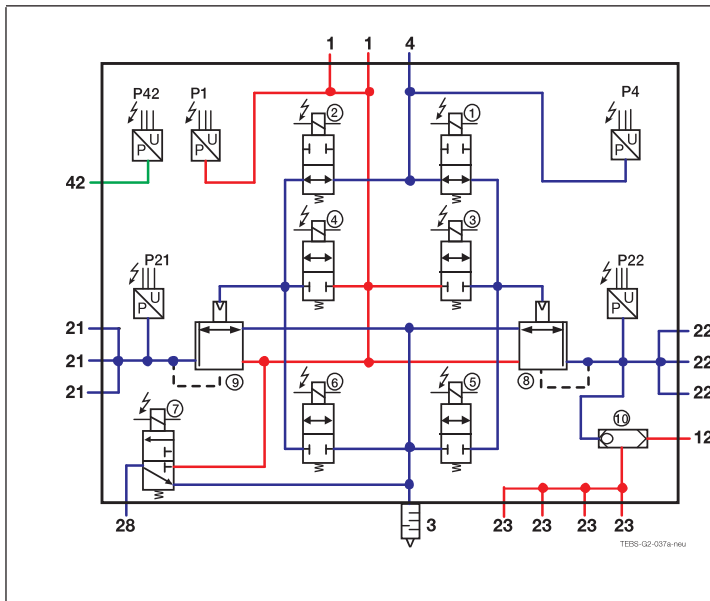
Each time the TEBS G2 brake module is powered, a safety check is made of the software and hardware. In addition, if the vehicle is stationary, each of the solenoids will be energised in a predefined sequence. Should no braking demand be present when this operation is carried out it will be possible to hear the solenoids “clicking” as they move from one position to another. When a braking demand is present at the time of system power up air can be heard exhausting from the respective pressure modulators. This function can be useful when trying to diagnose certain faults associated with the power supply.

### 3.2.2 Operating states

The following diagrams illustrate the state of the respective solenoids in relation to the control phase as follows:

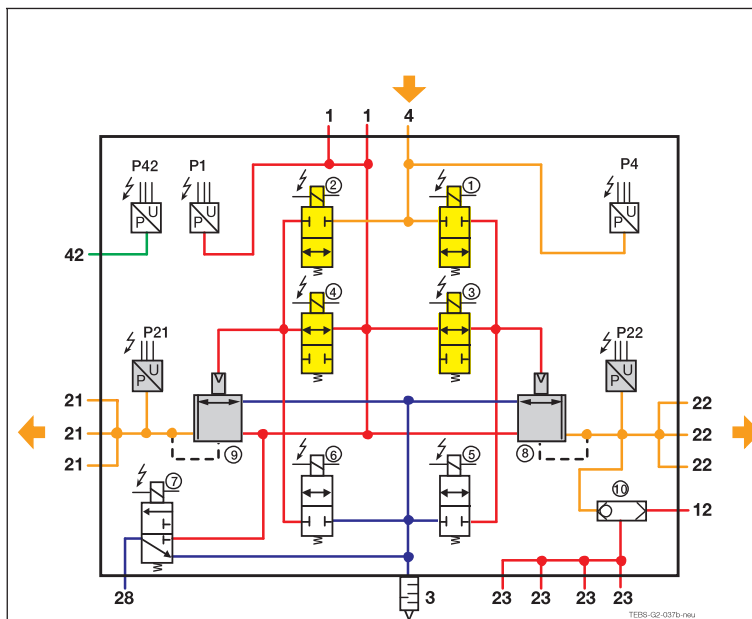
- Driving mode
- Pressure increase
- Pressure hold
- Pressure decrease
- ABS control
- Pneumatic backup



**Driving mode:**

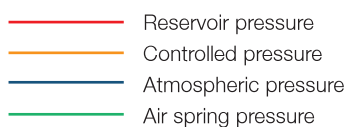
This illustration defines the solenoid layout and functionality associated with the drive condition:

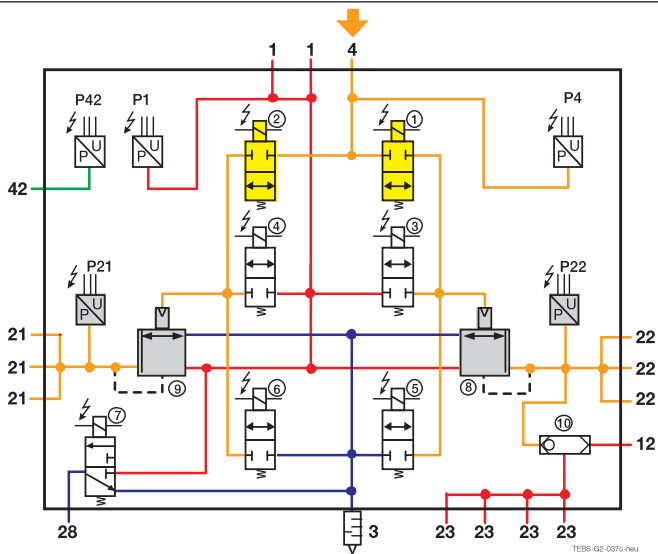
- 2 x Backup solenoid valves (1 & 2)
- 2 x Inlet solenoid valves (3 & 4)
- 2 x Exhaust solenoid valves (5 & 6)
- 2 x Relay valves (8 & 9)
- 1 x 3/2 solenoid valve – auxiliary control (7)
- 1 x Double check valve (10)
- 5 x Pressure sensors:
  - Suspension (P42)
  - Braking demand (P4)
  - Reservoir pressure (P1)
  - Brake actuators (P21 & P22)

**Pressure increase:**

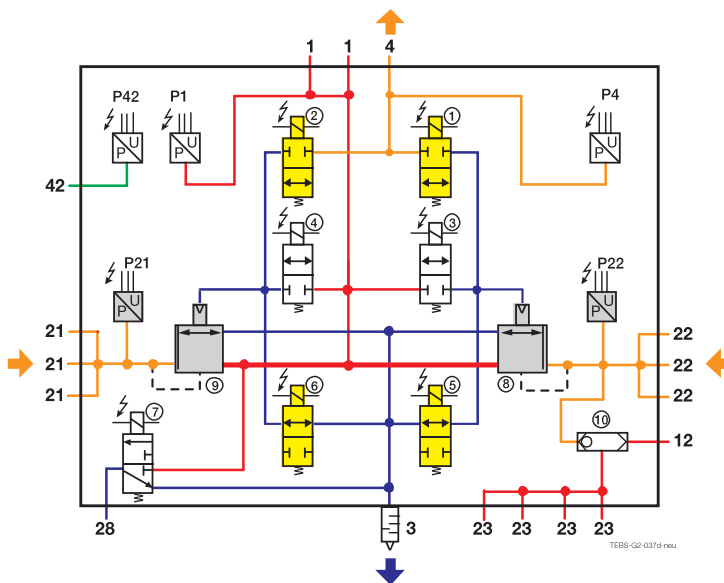
When a pneumatic braking demand is present at port 4, as detected by pressure sensor P4, or in the case of an EBS towing vehicle a CAN demand is present, the backup solenoids (1 & 2) are energised to isolate the driver's pneumatic demand from the brake control sections of the brake module. Simultaneously the inlet solenoid valves (3 & 4) are energised allowing air to flow from the reservoir supply to the control element of the relay valves (8 & 9). The relay sections of the brake module will then operate and air will flow from the reservoir to the brake actuators. This will be measured by the pressure sensors P21 and P22.

Without any other control, this would result in a rapid, uncontrolled pressure rise at the brake actuators which is unrealistic except under emergency braking conditions. To produce a more controlled pressure rise, a combination of pressure increase and pressure hold phases are employed. By varying the time of these phases, any pressure gradient can be produced to align with the braking demand characteristics.



**Pressure hold:**

When the required pressure has been produced at the brake actuators, relative to the braking demand and axle/bogie load condition, any further increase in brake actuator pressure is prevented by de-energisation of the inlet solenoids (3 & 4) while the backup solenoids (1 & 2) remain energised. This pressure will be maintained until there is an increase or decrease in driver demand or there is an anti-lock braking requirement.

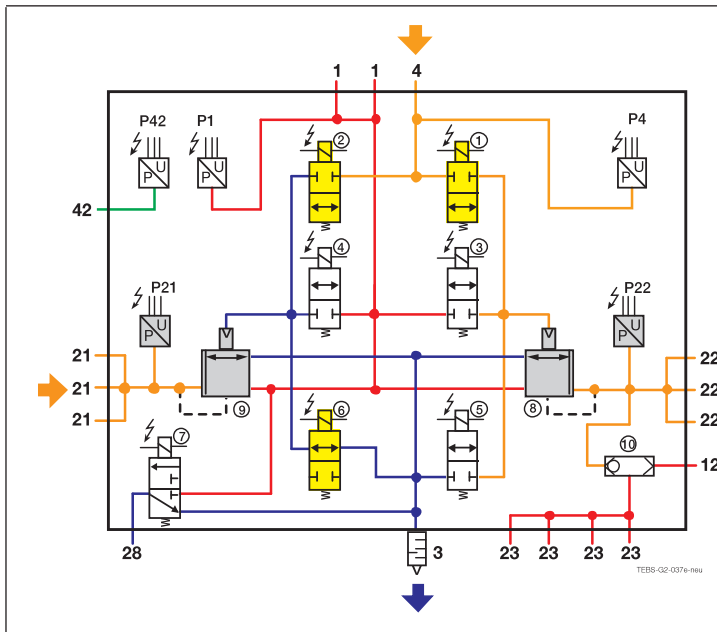
**Pressure decrease:**

In the event of a reduction in driver braking demand, or if an anti-lock braking intervention is required, the backup solenoids (1 & 2) remain energised but the exhaust solenoids (5 & 6) are energised. This action connects the control section of the relay valves (8 & 9) to atmosphere at port 3. Any reduction in relay valve control pressure will cause a corresponding reduction in the brake actuator pressure. Should the driver demand reduce to zero, the exhaust solenoids (5 & 6) will remain energised until the pressure at the brake actuators is exhausted after which they will be de-energised along with the backup solenoids (1 & 2) until the next braking demand.

In the case where there is a gradual reduction in the braking demand, a controlled pressure reduction at the brake actuators is realised by a combination of exhaust and hold control phases.

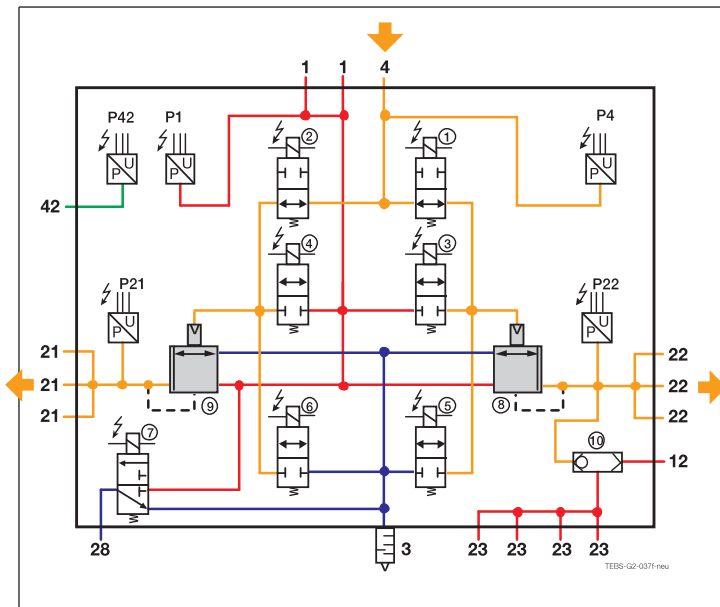






#### ABS control:

During an anti-lock braking intervention the three phases of pressure increase, hold and decrease will be utilised to realise the requisite wheel control during anti-lock cycling. However, during anti-lock cycling, it is most likely that the pressures at the left and right brake actuators, measured at ports 21 and 22 will be different and each section of the module could be in a different pressure control phase. As an example, the diagram shows pressure hold at port 22 but pressure decrease at port 21. Once anti-lock activity is no longer required the left and right brake actuator pressures will return to a common value based on the braking demand and axle/bogie load condition.



#### Pneumatic backup:

In the event of a failure in the power supply, or a failure which results in the load sensing function or anti-lock braking function being no longer available, the solenoids are either not able to be controlled (power failure) or control is suspended by the electronic control process (system fault). Subsequently when all solenoids are de-energised, brake control will be limited as load sensing will not be possible and the brake actuator pressures will follow the 1:1 relationship to the demand pressure.

- Reservoir pressure
- Controlled pressure
- Atmospheric pressure
- Air spring pressure

### 3 System Configuration and Function

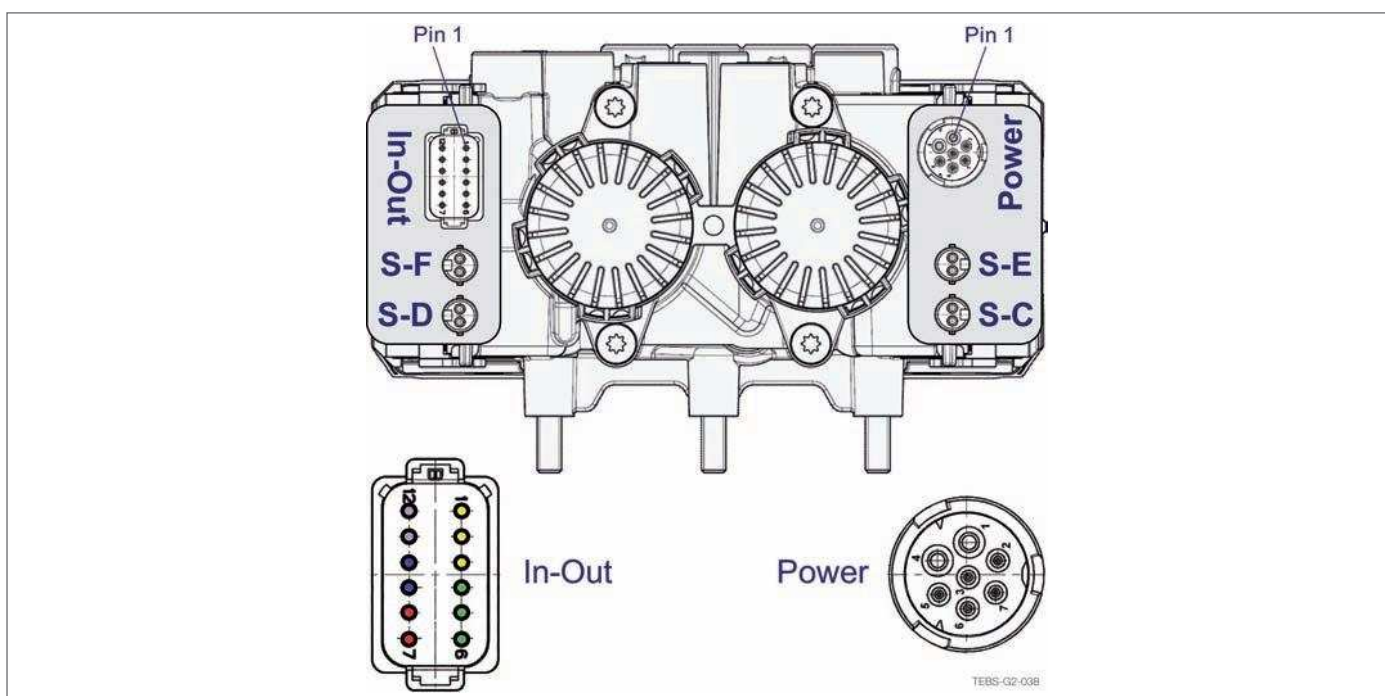
#### 3.2.3 Electrical connections

The location of the electrical connections is shown in figure 2. It should be noted that the sensor connections S-C and S-D are designated as the “primary” wheel speed sensors and are used in all system configurations. These sensors must therefore be fitted to non-lift axles to ensure the sensors can always provide a speed signal. Connections S-E and S-F have dual functionality as follows:

2S/2M Configurations: May be configured as auxiliary inputs.

4S/2M Configurations: Used as the additional wheel speed sensor inputs and may be installed on a lift axle.

The pin assignment of the “Power” connector and the auxiliary “In-Out” connectors are illustrated below:



**Figure 2:** Connector layout

Pin Number	Function
1	AUXIO1
2	AUXIO2
3	AUXIO3
4	SENS_SUP [Supply ext. sensor (5V)] Tristate 1
5	SENS_IN1 [Input ext. sensor] Tristate 2
6	SENS_GND [GND ext. sensor – ME and C3]
7	Stop lamp Supply
8	Stop lamp GND
9	5V TI CAN Low
10	5V TI CAN High
11	AuxRet12 (Return for AUXIO 1 & 2)
12	AuxRet3

**Figure 3:** Pin assignment of the In-Out connector

Pin Number	Function
1	Battery supply
2	ECU supply
3	ECU ground
4	Battery ground
5	Warning lamp signal
6	TT CAN High
7	TT CAN Low

**Figure 4:** Pin assignment of the Power connector

### 3.3 Warning lamp signals and sequences

#### General:

Driver warnings are provided which indicate the status of the TEBS G2 brake module with respect to braking and auxiliary functions by means of a yellow warning lamp in the towing vehicle; signalled via Pin 5 of the ISO 7638 connector. In addition, when coupled to a towing vehicle with EBS, certain other failure conditions are signalled via the ISO 11992 data communications using pins 6 and 7 of the above connector. These are displayed by a red warning lamp in the towing vehicle.

With respect to trailer braking, the two warning lamps define the status of the braking system as follows:

#### Yellow warning:

Continuous transmission of the yellow warning lamp signal indicates to the driver that there is a braking fault on the trailer that does not impact the fundamental braking performance of the trailer.

#### Red warning:

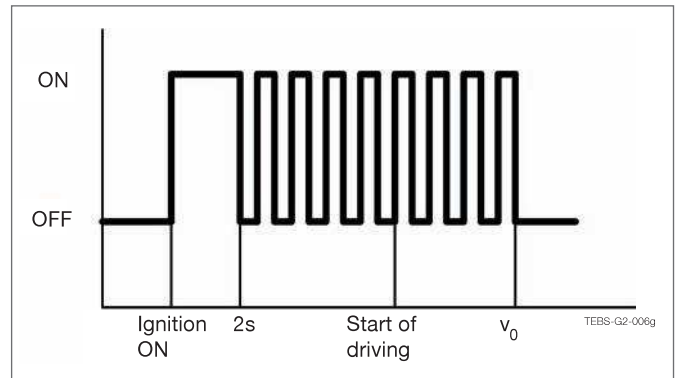
Continuous illumination of the red warning lamp indicates that there is a critical fault condition within the trailer braking system (this includes a warning when the reservoir pressure is below 4.5 bar).

#### 3.3.1 Warning lamp signals for the braking systems

When a TEBS G2 brake module is first installed on a trailer, the warning lamp signal(s) will be transmitted until all of the following conditions have been satisfied:

- The system has been parameterised.
- No faults are present.
- The vehicle is then driven at more than 10 km/h.

When the above conditions have been fulfilled the warning lamp signals will no longer be transmitted. However when an End of Line (EOL) test has not been carried out the yellow warning lamp will flash when the vehicle is stationary and the system is first powered – see Figure 5.



**Figure 5:** Warning lamp sequence after initial configuration when no EOL test has been carried out.

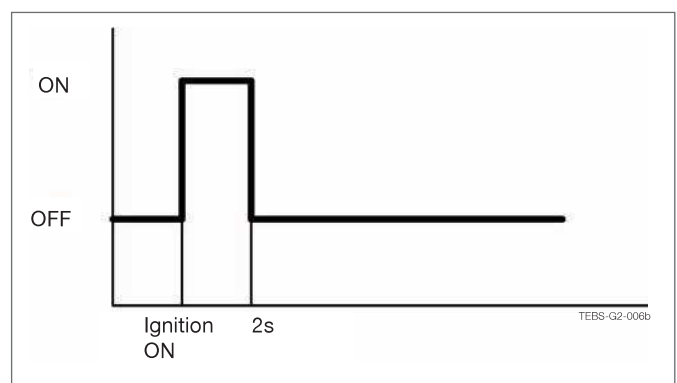
#### 3.3.2 Warning lamp signal sequences

During the parameter setting of a TEBS G2 brake module, the user can choose between two warning signal sequences by using the Knorr-Bremse diagnostic and configuration program ECUtalk®.

#### Option 1: Industry standard warning lamp sequence

##### Condition 1:

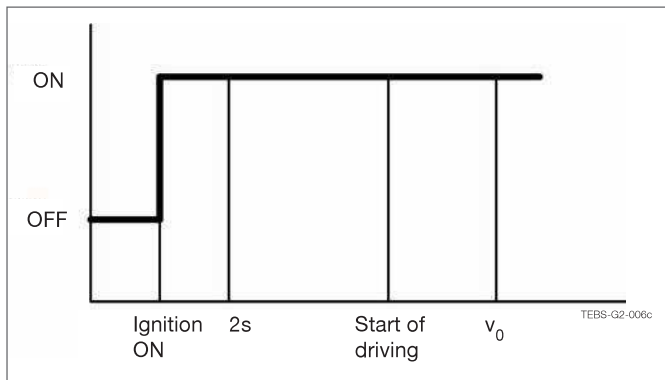
Following ignition “ON”, the warning signal will be transmitted for a period of approximately 2 seconds after which the signal will cease provided no static faults are detected and no dynamic faults are stored in memory – see Figure 6.



**Figure 6:** Warning lamp sequence when no fault is present

##### Condition 2:

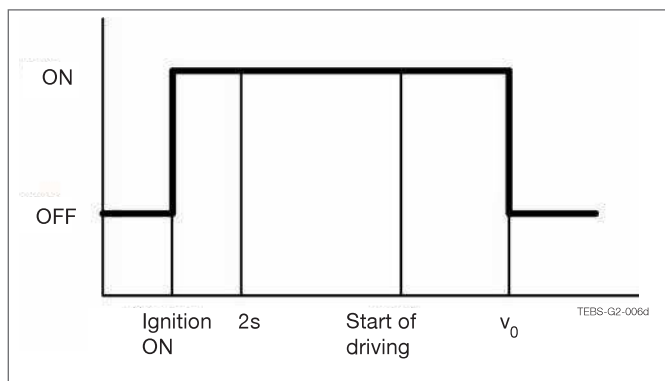
If a current fault is detected after ignition “ON”, the warning signal(s) remains on and will remain so until the fault is corrected – see Figure 7.



**Figure 7:** Warning lamp sequence when a static fault is present

#### Condition 3:

In addition to detecting current *static* faults, the system will interrogate the fault memory to establish if a *dynamic* fault, e.g. a dynamic wheel speed sensor fault, was detected the last time the vehicle speed first exceeded 10 km/h (15 km/h in certain cases). If so the warning lamp sequence will be the same as that defined for a current static fault illustrated in Figure 7 above. The next time the trailer exceeds a speed  $v_0$ , which must be below 10 km/h (15 km/h in certain cases) and the dynamic fault is no longer present, the warning lamp(s) will go out – see Figure 8.



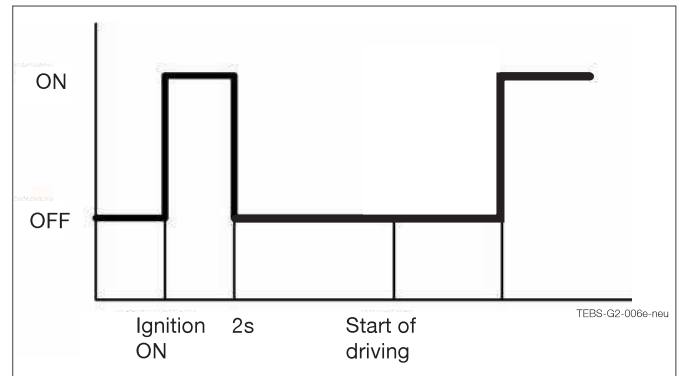
**Figure 8:** Warning lamp sequence when a dynamic fault is stored but no longer present

#### Condition 4:

The following conditions apply to the detection of dynamic fault conditions:

- The fault is not detectable under static conditions
- The fault was not present the last time the trailer exceeded 10 km/h
- The fault will be detected the next time the vehicle exceeds 10 km/h

The warning lamp sequence associated with this condition is illustrated in figure 9.

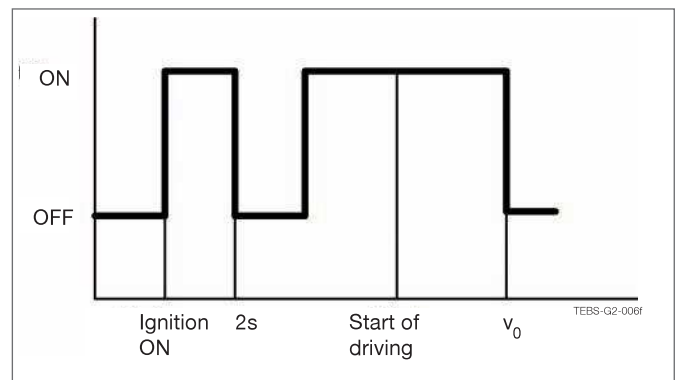


**Figure 9:** Warning lamp sequence when a dynamic fault is detected

#### Option 2: Alternate warning lamp sequence

##### Condition 1:

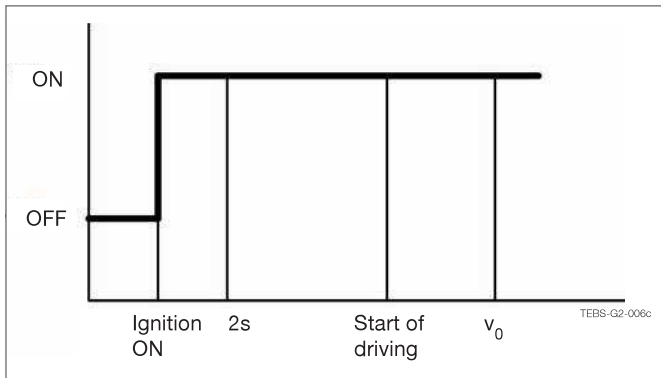
Following ignition “ON”, the warning lamp(s) will illuminate for approximately 2 seconds while the module carries out internal and external checks. If no faults are found during this period the warning lamp(s) will go out for a period of approximately 1 second and then come back on. The warning signal(s) will remain on until a speed has been reached when the wheel speed sensor outputs have been verified – following which the warning lamp(s) will go out – see Figure 10.



**Figure 10:** Dynamic warning lamp sequence when no fault is present

##### Condition 2:

Should a static fault be detected, the next time the ignition is turned “ON”, the resulting warning lamp sequence will occur as illustrated in figure 11.

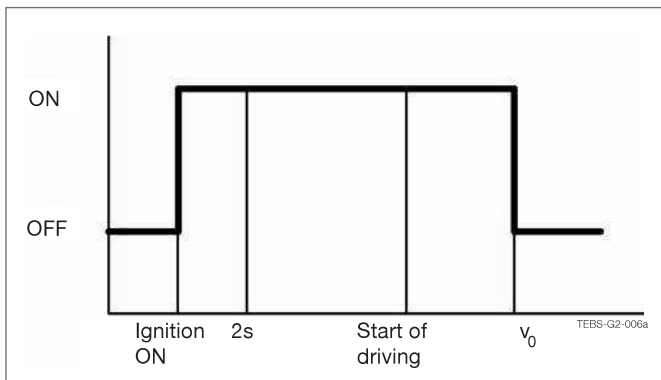


**Figure 11:** Warning lamp sequence when a fault is detected or stored in memory

### Condition 3:

The following conditions shall apply to stored faults:

- A stored fault is present when the ignition is turned "ON"
- The fault is not present when the trailer is stationary.
- The warning lamp shall remain illuminated until the trailer first exceeds 10km/h after which it will go out if the stored fault has not been detected by that speed.
- The warning lamp sequence associated with this condition is illustrated in Figure 12



**Figure 12:** Warning lamp sequence when a dynamic fault is stored but no longer present

### 3.3.3 Warning lamp signals for auxiliary functions

During setting of a TEBS G2 brake module, using the PC diagnostics program ECUTalk® the following options exist for fault detection:

#### Valve/bulb + Open Circuit detection:

When this option is selected, all sources of faults are monitored including open circuit.

#### Valve/bulb:

When this option is selected, the open circuit is not monitored. So only short circuits to ground or battery are indicated as an error.

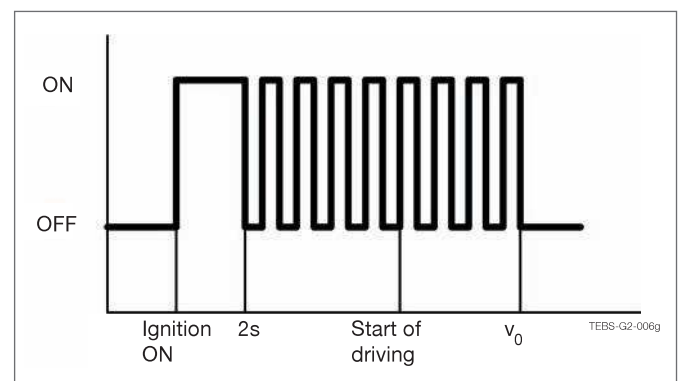
#### ECU + Open Circuit detection:

When this option is selected, all sources of faults are monitored including open circuit.

#### ECU:

When this option is selected, the open circuit is not monitored. So only short circuits to ground or battery are indicated as an error.

Irrespective of which of the above options are selected a warning lamp will display a sequence as illustrated in figure 13.



**Figure 13:** Warning lamp sequence when a fault in auxiliary equipment is detected

The above warning lamp sequence also applies when a new TEBS G2 brake module has been installed but no End of Line (EOL) test has been carried out – see 3.3.1. However a number of conditions must apply before such a warning is transmitted:

- The vehicle is stationary
- The ignition is first turned "ON"
- No braking faults are present
- The warning lamp will flash after the initial verification of the braking system.
- The warning lamp will cease to flash once the vehicle speed first exceeds 10 km/h
- The yellow warning lamp will be used.



### 4.1 Braking demand, selection and pressure regulation

The braking demand for the trailer is transmitted to the coupling head interface and is based on the application of the footbrake control by the driver and the pre-defined characteristics of the towing vehicle braking system. The number and type of braking demand signals at the coupling head is dependent on the specification of the towing vehicle braking system as follows:

#### ***Towing vehicle with pneumatic brake control and ABS:***

This specification of towing vehicle will normally be equipped with a pneumatic supply line (red) and a pneumatic control line (yellow). The control line carries the braking demand requested by the driver.

#### ***Towing vehicle with Electronic Braking System (EBS):***

This specification of towing vehicle will normally be equipped with a pneumatic supply line (red), a pneumatic control line (yellow) and an electric control line (CAN). In this case there are two braking demand signals transmitted to the trailer – as in the first case the yellow control line carries the pneumatic demand but, in addition, an electric demand is generated by the towing vehicle's EBS and transmitted through the electric control line via pins 6 and 7 of the ISO 7638 connector.

A trailer equipped with TEBS G2 is capable of operating behind either of the above towing vehicles and, in the case where two brake demands are present (pneumatic and CAN) the TEBS G2 brake module will decide which one to use. However, it is required that when both demands are present, the trailer **will** use the CAN signal in preference to the pneumatic to obtain the benefit of reduced system response time.

#### **Note:**

It is currently not permitted for a towing vehicle or trailer to be only equipped with an electric control line (CAN).

When only the pneumatic braking demand is present at port 4 of the TEBS G2 brake module, the associated pressure is measured by the braking demand pressure sensor. For calibration purposes, during the first brake

application after ignition "ON", the system allows the braking demand to generate a pressure at the brake actuators below that required to generate a braking force. This allows the outputs from the braking demand pressure sensor and the pressure sensors at ports 21 and 22 to be compared and validated. This process will not be carried out again until the next system power up. After the calibration check is complete the TEBS G2 brake module takes control of the brake pressure by energisation of the backup solenoids. This prevents any further increase in pressure being generated at the brake actuators until the braking demand signal is at a value equivalent to the coupling head pressure programmed into the TEBS G2 brake module at which braking should commence.

When both pneumatic and CAN braking demand signals are present, the same calibration procedure is carried out as described above however brake control will be based on the CAN demand unless this signal is considered unacceptable by the TEBS G2 brake module. In this case it will automatically utilise the pneumatic braking demand. As both signals must be present, it is required that the trailer verifies that the pneumatic demand signal is present before the CAN signal has reached the equivalent of 1 bar for a period of 1 second. Should the pneumatic demand not meet this criterion the TEBS G2 brake module will generate a signal to illuminate the yellow warning lamp via pin 5 of the ISO 7638 connector.

### 4.2 Load Sensing Function (LSF)

Automatic braking force regulation with respect to load is a primary function within the TEBS G2 brake module. It can influence the braking compatibility between towing vehicle and trailer as well as brake wear characteristics while fulfilling legal performance requirements. To fulfil the legal requirements it is necessary to define the geometric and load characteristics of the trailer and then, by using the Knorr-Bremse brake calculation program BSD, it is possible to define all the relevant pressure characteristics which can be saved as a file and written directly to the TEBS G2 brake module using the diagnostic program ECUtalk®.

As the TEBS G2 brake module is able to receive brake demands from two sources, it is logical that the possibility exists to program the respective pressure characteristics independent of each other.

To enable the automatic load sensing function to operate, it is necessary to define certain parameters as follows:

**Onset pressure point:** This is controlled by defining the coupling head pressure (A) at which braking should commence and the inshot pressure (B) required in the brake actuator which will overcome the thresholds of the brake actuator and brake (B).

**Laden delivery pressure:** Defined as the brake actuator pressure that is produced at a coupling head pressure of 6.5 bar when the trailer is fully laden.

**Unladen delivery pressure:** Defined as the brake actuator pressure that is produced at a coupling head pressure of 6.5 bar when the trailer is unladen.

**Note:**

This value may have been determined for the trailer without a body attached.

**Laden air spring pressure:** Defined as the pressure in the air springs when the trailer is fully laden.

**Unladen air spring pressure:** Defined as the pressure in the air springs when the trailer is unladen.

Using the above parameters, the respective brake actuator pressure can be determined for any braking demand and load condition as the line from the onset of braking to the laden and unladen brake actuator pressures follows a linear relationship – see Figure 14.

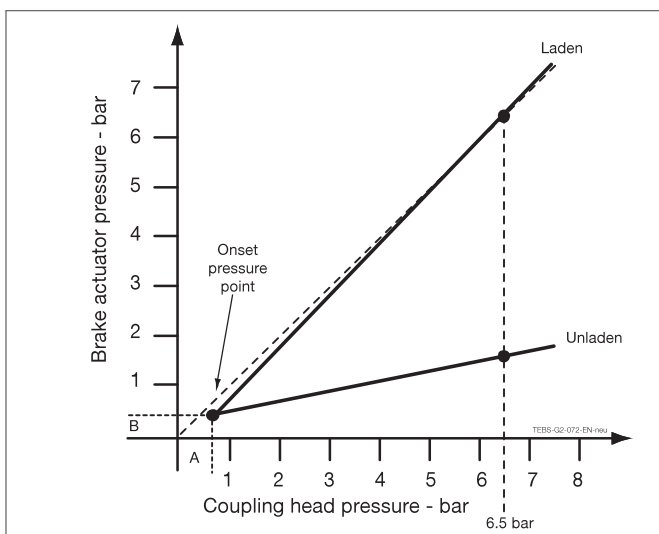


Figure 14: Load sensing characteristics

When producing a brake calculation, the program will include the characteristics of the brake actuator and brake – including the threshold forces that must be overcome before a braking force can be generated. These values are usually obtained from test reports produced in accordance with a defined procedure. However, if there is any doubt, a pressure gauge should be connected at the brake actuator and the pressure increased until it is no longer possible to rotate the wheel by hand, this value is the in-shot pressure (B). To comply with the legal requirements the coupling head pressure (A) at which the in-shot pressure is generated must be between 0.2 and 1.0 bar. Typical values would be 0.7 or 0.8 bar depending on the recommendations of the axle manufacturer.

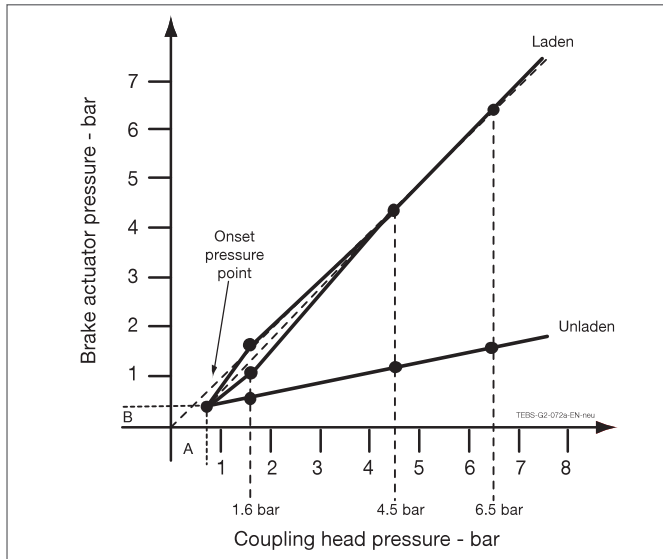
Once the parameters are defined and the values written to the TEBS G2 brake module the automatic load sensing will function as required. In all cases, irrespective of load, the “onset of braking” is common. When a braking demand is present, no pressure will be generated in the brake actuators until the specified coupling head pressure is measured. At that point the TEBS G2 brake module will generate a pressure in the brake actuators equivalent to the “in-shot pressure” so that a braking force will be developed. As the braking demand increases the pressure at the brake actuators will be calculated based on the value of the braking demand and current air spring pressure measured by the internal pressure sensor at port 42.

Depending on the type of trailer on which the TEBS G2 brake module is to be installed, it is possible to modify the linear relationship between the “onset pressure” and the laden and unladen brake actuator delivery pressures as follows:

#### Low range pressure compensation

It is well known that the majority of brake applications occur at relatively low braking demand values (more than 90% of all brake applications are < 2.0 bar) – it follows therefore that this is the pressure range where the majority of brake wear takes place. The TEBS G2 includes a function which allows the possibility to deviate from the linear relationship at a control line pressure of 1.6 bar. Therefore, from the onset pressure, the low range compensation is zero rising to the maximum configured value at 1.6 bar and reducing to zero at a coupling head pressure of 4.5 bar. Pressure compensation may be positive or negative; the former

would increase the braking contribution of the trailer, relative to that produced by the towing vehicle, and the latter would reduce it. Figure 15 illustrates the characteristic:



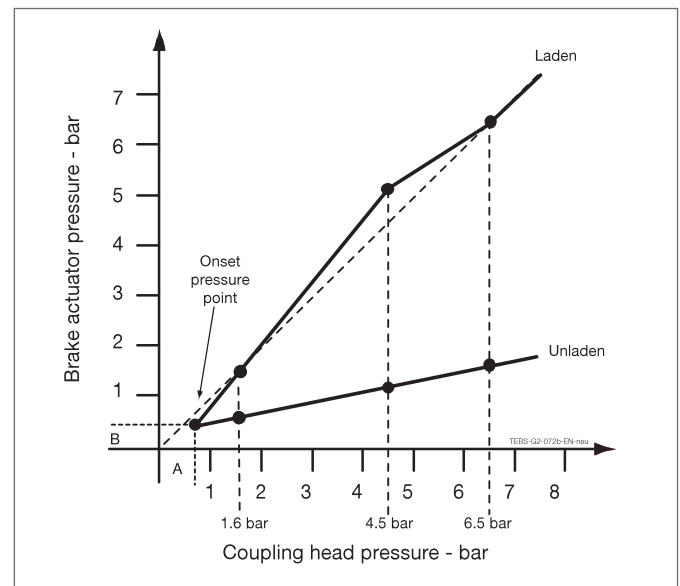
**Figure 15:** Characteristic – Pressure compensation at 1.6 bar

Only the laden lower pressure compensation is programmable and any offset required for other states of load will be determined by the TEBS G2 brake module based on the load ratio at the time of any brake application. This function can be used to “adjust” the braking characteristics of an ‘in-service’ trailer to more closely match the braking performance of the towing vehicle or to ensure that the brakes are operating in a range for which they were designed. This is most relevant to vehicles that run with high volume and low load.

### High range pressure compensation

It is often the case that trailer manufacturers cover a range of trailers with a single Type Approval. This usually means that a range of wheelbase and centre of gravity values are covered by the single approval. A further complication arises when a range of tyre sizes is also required. The geometric variables impact on the laden compatibility bands to the extent that it is not possible for a straight line pressure characteristic to fit within the boundaries and therefore the trailers would not fulfil the laden compatibility requirements. All trailer compatibility requirements follow a similar pattern where the upper and lower boundaries are non-linear and have a positive offset at a coupling head pressure of 4.5 bar. Therefore to accommodate the shape of the compatibility bands and the reduced acceptance

window of having multiple wheelbase and centre of gravity values, the TEBS G2 brake module includes a feature to specifically enable such combinations to fulfil the legal requirements. The high range compensation may only be set to a positive value as there is no requirement for a negative setting. Both laden and unladen compensation pressures are freely adjustable although it is mainly the laden setting that is required to ensure compatibility requirements are fulfilled. Figure 16 illustrates the characteristic.



**Figure 16:** High pressure compensation characteristics

The use of the high range pressure compensation is very specific and adjustments should not be made without first ensuring the respective compatibility requirements for the trailer are fulfilled.

## 4.3 Pressure regulation

Using a combination of the programmed pressure characteristics as defined above and the measured values of reservoir pressure, air spring pressure, braking demand and brake actuator pressure, the TEBS G2 brake module will produce the required pressure control at the brake actuators. This is realised by the use of integral solenoids which produce the pressure increase, hold and decrease phases to adjust or maintain the required brake actuator pressure. Additional information on the realisation of these control phases can be found in Chapter 3.

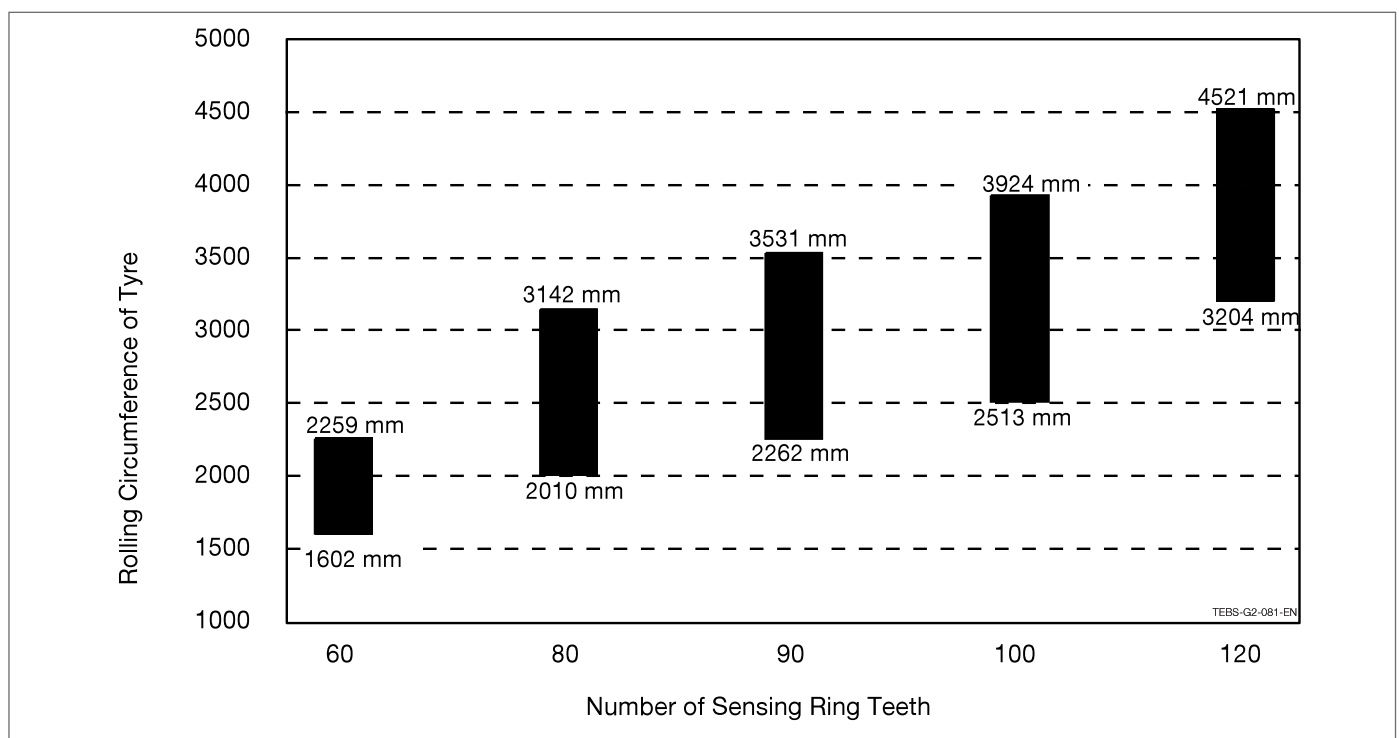


#### 4.4 Anti-lock braking function

Anti-lock Braking System (ABS) is another primary function within the TEBS G2 brake module to ensure trailer stability during braking by preventing wheels from locking.

The fundamental prerequisite to ensure efficient ABS functionality is the need to have an accurate and reliable indication of the speed of the trailer wheels at any point in time. This is achieved by the installation of sensing rings

and inductive wheel speed sensors within the wheel end assembly of at least one axle within a bogie. To ensure the speed signal is accurate it is essential that the number of teeth on the sensing ring is correct relative to the size of the tyre being used. Although the TEBS G2 brake module is configured with the number of sensing ring teeth and tyre size, recommendations exist on the tyre size which may be used with a given number of sensing ring teeth. Figure 17 graphically illustrates this relationship.



**Figure 17:** Relationship of number of sensing ring teeth to tyre size

It must be possible for the TEBS G2 brake module to accept a difference in wheel speeds between wheels equipped with wheel speed sensors. This is realised by incorporating a speed tolerance of 8% between the sensed wheels on the trailer which primarily takes account of different nominal tyre sizes and wear.

Unlike the conventional ABS control systems that are available, a modified ABS control algorithm has been implemented into the Knorr-Bremse TEBS G2 brake module. Typically a conventional ABS is reliant on the input from the wheel speed sensors to make all decisions since no pressure or load information is available. This means that the control logic must continually search for the higher adhesion meaning repeated increases in pressure. This in

turn leads to more brake release cycles which negatively impacts on wheel control and energy consumption. The ideal control cycle would be to hold the controlled wheels at a constant percentage slip but, unfortunately, this is not realistic due to limitations in suspension performance, brake hysteresis and irregular road surfaces. However as the TEBS G2 ABS algorithm makes use of the load and respective pressure information, it is much better placed to come close to the ideal by the use of small pressure changes to maintain the wheel slip in an optimum control band. This results in improved trailer stability as the number of high slip wheel cycles is kept to a minimum and this is reflected in reduced energy consumption. For further information see TÜV NORD test report EB154 and Knorr-Bremse ABS Information Document Y038142.

#### 4.4.1 Wheel speed sensors

In general, all commercially available wheel speed sensors can be connected to the TEBS G2 brake module since the connectors used as an interface are now industry standardised. However the following wheel speed sensors have been approved for use with the TEBS G2 brake module:

Manufacturer	Part/Type Number
Knorr-Bremse	ES5000 to ES5199
Robert Bosch	0265050 ---
	0486001 ---
	0486000 ---
Wabco	441032 --- 0

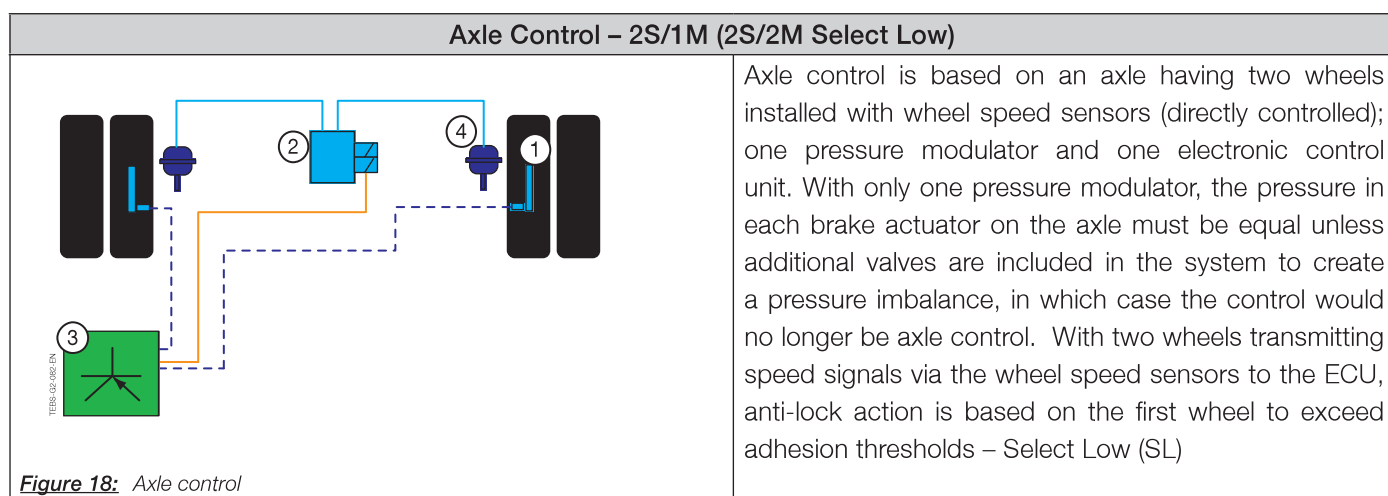
Should any other wheel speed sensor be used there is no guarantee of electrical or functional compatibility.

#### 4.4.2 ABS control principles

The objective of an anti-lock system is to optimise the adhesion available, at the same time limiting wheel slip to provide stability. However, different control philosophies need to be applied to commercial vehicles, in particular to steered axles, whether on the motor vehicle or full trailer. The following options exist:

Key to the following drawings:

1. Wheel speed sensor
2. Pressure modulator
3. Electronic Control Unit (ECU)
4. Brake actuator



## Independent Side Control – 2S/2M

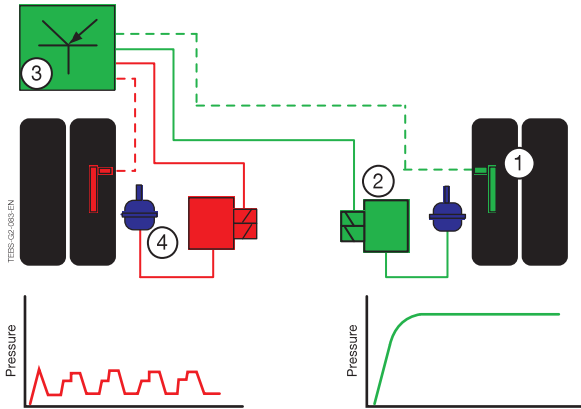


Figure 19: Independent control

Independent control is based on an axle having two wheels installed with wheel speed sensors (directly controlled), two pressure modulators and one electronic control unit. With two pressure modulators, the pressure in each brake actuator on the axle may be different and out of phase. Each wheel is controlled independently from the other thereby optimising the adhesion available at each wheel.

## Directly and Indirectly Controlled Wheels – 2S/2M

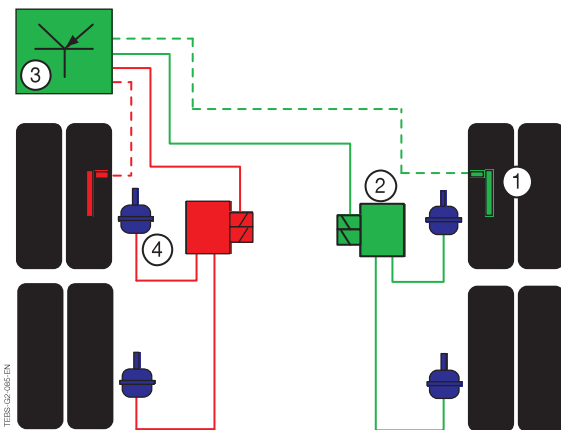


Figure 20: Directly and indirectly controlled wheels

It is often the case within a bogie that not all of the wheels are equipped with wheel speed sensors. In the example shown, the wheels of one axle are installed with wheel speed sensors (directly controlled) and the anti-lock control decisions will be based on the reaction of those wheels. The other wheels which are not installed with wheel speed sensors (indirectly controlled) will be controlled with the pressure used to control the associated directly controlled wheels.

## Independent Side Control – 4S/2M

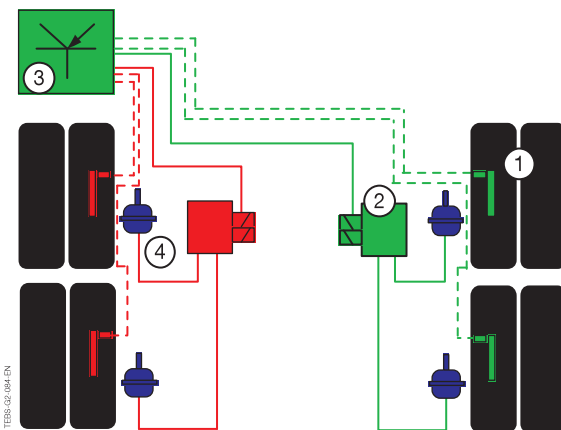


Figure 21: Independent side control

This is an adaptation of independent control where four wheels in a bogie are each installed with wheel speed sensors (directly controlled) yet only two pressure modulators are used – one to control each side. The basic control philosophy is that of independent control where the pressures on left and right sides are controlled independently. The two wheels on each side utilise select low control therefore whichever of the two wheels on a side requires anti-lock intervention, the pressure at both directly controlled wheels on that side of the trailer are controlled using the pressure characteristics associated with the lowest speed wheel.

#### 4.4.3 ABS control principles used in TEBS G2

The control logic defined in 4.4.2 is applied to the different ABS configurations supported by the TEBS G2 brake module as defined below.

ABS Configuration	No of Axles	Control Principles
2S/2M *	1 or 2	Select low control (for dolly applications only)
2S/2M	1	Independent side control
	2	Independent side control with one axle directly controlled and one axle indirectly controlled
	3	Independent side control with one axle directly controlled and two axles indirectly controlled
4S/2M	2	Independent side control
	3	Independent side control with two axles directly controlled and one axle indirectly controlled

\* It is also possible for a 2S/2M system to function using select low control (2S/1M) in which case both pressure modulators will be controlled simultaneously based on the first of the two directly controlled wheels to require ABS intervention.

The above ABS configurations and control applications ensure that the wheels of single and multi axle bogies remain under control to ensure stability, within the limits of the adhesion available, during emergency braking or in adverse weather conditions. The way indirectly controlled wheels react during anti-lock cycling is dependent on the type of suspension, number of axles in the bogie and the location of the directly controlled wheels as it cannot be guaranteed in all cases that indirectly controlled wheels will not lock.

#### 4.4.4 Use of lift axles

Several pre-requisites must be fulfilled on trailers equipped with one or more lift axles. In principle a lift axle may be installed on any axle that is not equipped with wheel speed sensors i.e. indirectly controlled.

It is permitted to install an axle as a lift axle equipped with wheel speed sensors i.e. directly controlled and the TEBS G2 brake module will automatically recognise when the axle is lifted provided the following conditions are fulfilled:

An axle installed with wheel speed sensors S-C and S-D cannot be a lift axle as these are designated as "primary" wheel speed sensors and must remain on the ground at all times otherwise a fault will be generated and ABS control will be switched off. Therefore, in the case of a 2S/2M configuration, it is only possible to install lift axles on axles not equipped with wheel speed sensors.

In the case of the 4S/2M configuration an axle installed with wheel speed sensors S-E and S-F may also be a lift axle as the TEBS G2 brake module will recognise when the lift axle is raised and automatically operate as a 2S/2M until the lift axle is lowered.

#### 4.4.5 Use of steering axles

Any axle intended for use as a forced-steering axle or a self-steering axle can be directly or indirectly controlled by the ABS system. This means that in terms of the ABS configuration, there is no special requirement for the use of steering axles.

However should it be necessary to increase the stabilising force applied to the steering axle(s) during an ABS control it is possible to utilise an auxiliary output from the TEBS G2 brake module. This can be realised by configuring an auxiliary output (AUXIO1, 2 or 3) to either "ABS active" (ABS) or "Steering Axle Lock" (SAL). In both cases the configured output will generate an electrical output signal which is speed dependent although different conditions will generate the signal as follows:

##### **ABS active (ABS):**

electrical signal is generated whenever the anti-lock braking system becomes active and will be switched off after anti-lock cycling has finished.

##### **Steering Axle Lock (SAL):**

electrical signal is generated at a pre-defined speed and will continue until the vehicle speed falls below a defined speed threshold and when ABS is active as defined above.

Alternatively it would be possible to configure the pneumatic auxiliary output ( $P_{2a}$ ) to Steering Axle Lock (SAL) and connect the output directly to the steering axle stabilisation system. This option would remove the need for an external solenoid valve.

The above control systems are generally not necessary unless required to fulfil a specific operator function. This is dependent on the type of steering axle installed on the trailer and there are many variants.

Note: independent ABS control can introduce a differential torque into a steering system. However, this can be eliminated by the installation of a mechanical “select low valve” which effectively connects the left and right delivery pressures and only the lowest pressure of the two deliveries is supplied to both brake actuators of the steering axle.

#### 4.5 Roll Stability Program (RSP) function

The RSP is an active safety system which can be configured as an option 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 fairly 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 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.

The RSP function provides a major advantage in that the critical factors influencing roll-over are continuously monitored by the TEBS G2 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 G2 brake module.
- **Vehicle speed:** speed information is required for the ABS control as well as other auxiliary functions and 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 G2 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 G2 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

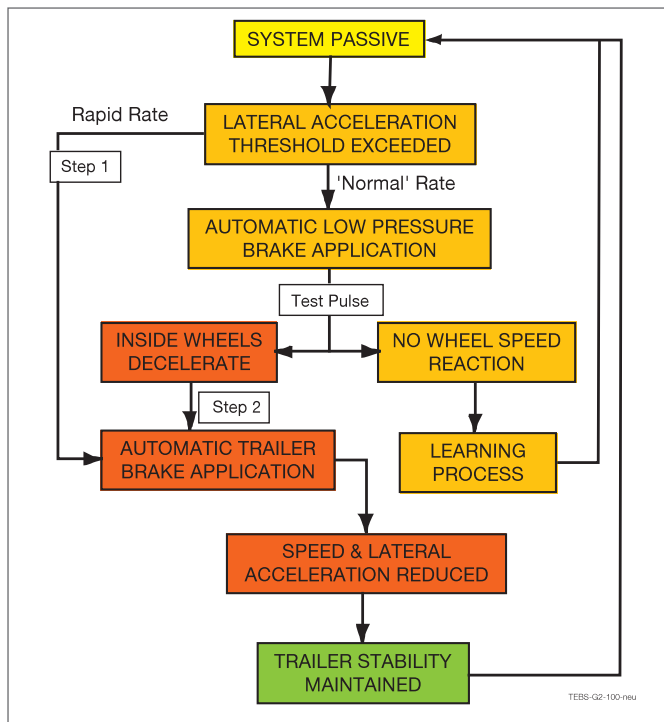
##### Roll-over control

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 1:** RSP intervention that takes place without the need for a test pulse.
- **Step 2:** RSP intervention following a test pulse that has defined roll-over as imminent.



Figure 22 summarises the logic routines which may or may not lead to an RSP intervention.



**Figure 22:** RSP control logic

Based on the control logic defined in Figure 22, 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 pre-defined threshold is exceeded, 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. Should the wheel speed decrease as a result of the low pressure brake application then the control logic will move to Step 2.

Should the low pressure brake application not cause a reduction in the speed of the inside wheels, Step 2 intervention will not occur and the lateral acceleration threshold will be increased as part of the TEBS G2 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®.

#### Oscillation control

The maximum permitted coupling load for a centre axle trailer is 1000kg however this is very difficult to control in many cases as it is primarily affected by the load distribution on the trailer. As the load on the coupling reduces, or even becomes negative, the possibility exists that the trailer will start to swing from side to side. In certain cases the swing, which can be initiated by the driver's steering input or irregular road surfaces, can become severe and lead to roll-over. It is for this reason that the Step 3 RSP control has been developed.

**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 G2 brake module will intervene to bring the oscillations under control. This is realised 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.

In all cases it is possible to check the number of RSP interventions for each type of intervention by means of the diagnostic program ECUtalk® or the Trailer Information Module (TIM G2) (see section 4.15).

When the RSP safety system is installed on a trailer, particular attention must be given to the installation of the TEBS G2 brake module and other equipment on the trailer to ensure the satisfactory operation of the RSP. Installation instruction for the TEBS G2 brake module can be found in section 6.1.

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 G2 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 over-ride the automatic lift axle control must be realised 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.
- RSP is not recommended for dolly applications.

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 will result in the TEBS G2 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.

## 4.6 Load sensing function, standstill condition

When the vehicle is at a standstill the LSF control is maintained at any time when the braking demand does not exceed 5 bar (a condition which may apply when the hand brake control of the towing vehicle is applied). Above this value LSF control is suspended which means that unnecessary power consumption is avoided. This mode of operation effectively suspends electro-pneumatic control and switches to pneumatic backup. Electro-pneumatic pressure control is reactivated when the braking demand falls below a pressure of 4.25 bar.

### 4.7 Air spring pressure “Out of Range”

As described previously, the LSF is based on the axle/bogie load which is determined from the measured air spring pressure. When the TEBS G2 brake module is configured, both the unladen and laden air spring pressures are defined. Should the pressure measured by the pressure transducer at port 42 be outside of this range the following will apply:

#### Unladen:

If the measured air spring pressure is below the configured unladen value, the load sensing pressure characteristic will be based on the configured unladen brake actuator delivery pressure. Should the measured air spring pressure be <50% of the configured unladen air spring pressure a fault may be recorded and a warning signal transmitted via pin 5 of the ISO 7638 connector to illuminate the yellow warning lamp.

Should RSP be configured, the detection of the above fault condition will result in the RSP function being suspended.

#### Laden:

Should the measured air spring pressure be greater than the configured laden air spring pressure the pressure delivered to the brake actuator will be increased in proportion to the degree of over pressure up to a value of +50% after which a fault will be recorded.

In the case of the load sensors for mechanical and hydraulic suspensions, the same principles apply to those defined above.

### 4.8 Brake Assist function

An integral part of the pressure control is a function known as ‘Brake Assist’. This is a safety feature which becomes active under all load conditions. From the earlier description of the system, the load sensing characteristics are based on the air spring pressure recorded by the pressure sensor at port 42 or external load sensor. Unfortunately it is not possible to cross check the calibration of the output from this pressure sensor therefore specific action must be taken to ensure that there is always the possibility to generate maximum braking forces irrespective of load when this is demanded by the driver – irrespective of load.

In all cases the load sensing characteristics will be generated

for the recorded air spring pressure (load). Yet, when the braking demand signal is > 4.5 bar, the characteristic will change. Figure 23 illustrates the pressure characteristics produced for various load conditions. It can be seen that for a given load condition when the demand signal – pneumatic or CAN – reaches 4.5 bar, the pressure produced at the brake actuators deviates from the expected load sensing value and will continue to increase with a linear relationship until a demand signal of 6.5 bar is reached. At this point, the brake actuator pressure will be coincident with the configured laden pressure characteristic. For brake demands >6.5 bar, the brake actuator pressure will be that associated with the laden trailer.

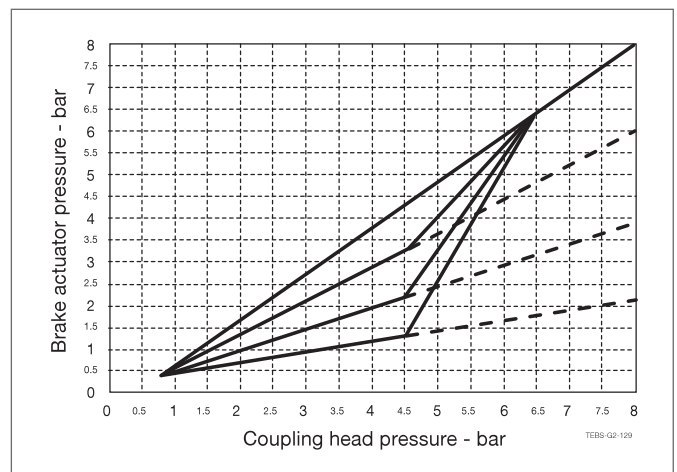


Figure 23: ‘Brake Assist’ pressure characteristics

### 4.9 Automatic braking system (Emergency brake function)

In the event that the supply of compressed air to the trailer braking system is no longer assured, i.e., if the supply line is broken or the red coupling head is uncoupled, the braking system of the trailer must react as follows:

- The brake(s) of the trailer are automatically applied
- The minimum developed braking force must be  $\geq 13.5\%$  of the static axle load for the laden trailer

Generally the above requirement is fulfilled by a function integrated into the trailer relay emergency valve which detects when the pressure in the supply line at the coupling is below a prescribed minimum and automatically applies the service brake of the trailer.

The prescribed requirements do not define which part of the trailer braking system must be used to realise the



above performance therefore other possibilities exist. Specifically Knorr-Bremse makes available, in conjunction with the TEBS G2 brake module, a park/shunt valve which includes the automatic detection of a broken or uncoupled supply line. However instead of automatically applying the trailer service brake, the spring brakes are exhausted to apply the parking brake. The required braking performance (13.5% of the laden static axle load) will always be available as it is required that the parking brake performance must be >18% of the total trailer weight. Therefore in all cases the parking brake performance will always exceed that required for the automatic brake.

Utilising the spring brakes to fulfil the automatic brake requirements has a number of advantages, one being that the developed braking force is not reliant on pneumatic pressure but the force mechanically generated by the springs in the spring brakes.

The use of the spring brakes however has one drawback in that the anti-lock braking function is not available. This limitation is overcome by a patented control mode defined as Emergency Mode Regulation (EMR). During driving, in the event of a break in the supply line when the spring brakes are automatically applied, this condition is recognised by the TEBS G2 brake module. Subsequently the service brakes of the trailer are automatically applied which has the effect of releasing the spring brakes via the integral anti-compounding valve and, since the service brakes are applied, an anti-lock braking function is now available.

### 4.10 Test mode for the load sensing function

Normally it is not possible to check the load sensing characteristics at a demand pressure of 6.5 bar as this is the point when the 'Brake Assist' function has modified the load sensing characteristic and the delivery to the brake actuators will follow the laden pressure characteristics unless pneumatic backup is operational. Therefore should it be required to check that the configured load sensing pressure values are correct, for whatever reason, one of the following test procedures may be used:

**Verification of the laden brake pressure characteristic:**  
At the time when the ignition is turned "ON" and a braking demand is present between pressures of 0.5 and 4.0 bar

for a period of at least 2 seconds, the laden pressure characteristics will be produced for a period of 15 minutes or until the vehicle is driven at a speed >10 km/h.

#### Verification of the brake pressure characteristic at the current axle/bogie load:

At the time when the ignition is turned "ON" and a braking demand is not present i.e. < 0.5 bar for a period of at least 2 seconds, the pressure characteristics will be produced without 'Brake Assist' associated with current axle/bogie load for a period of 15 minutes or until the vehicle is driven at a speed >10 km/h.

Should it be required to check the unladen pressure characteristic when the axle/bogie load is higher than the unladen value, the unladen condition can be simulated by reducing the pressure at port 42 to equal the unladen air spring pressure and then follow the procedure to verify the current axle/bogie load.

After the vehicle has been driven, and the ignition is left "ON", the TEBS G2 brake module will produce the following pressure characteristics:

**Braking demand is > 4.5 bar:**  
control reverts to pneumatic backup as it is assumed that the parking brake in the towing vehicle has been applied.

**Braking demand is < 4.0 bar:**  
electro-pneumatic load sensing control is based on the current axle/bogie load.

**Summary:**  
The following characteristics apply when the vehicle is stationary and the ignition is switched ON:

Braking demand present at Ignition "ON"	Pressure Characteristics	Duration (minutes)	Brake Assist
< 0.5 bar	Current load characteristics	≤ 15	No
< 0.5 bar	Current load characteristics	> 15	Yes
0.5 to 4.0 bar	Laden characteristics	15	Not relevant
≥ 4.5bar	Pneumatic backup	Indefinite	Not relevant

The following characteristics apply after the vehicle has been driven and is now stationary and the ignition remains switched "ON":

Braking demand present at Ignition "ON"	Pressure Characteristics	Duration (minutes)	Brake Assist
≤ 4.0 bar	Current load characteristics	Indefinite	Yes
≥ 4.5 bar	Pneumatic backup	Indefinite	Not relevant

#### 4.11 Supply pressure monitoring

It is a requirement that under certain operating conditions a low pressure condition must be detected and the driver warned by the transmission of both yellow and red warning signals. To fulfil this requirement the TEBS G2 brake module has the following functionality:

The pressure in the reservoir of the trailer braking system is continually monitored by the pressure sensor at port 1. Should the reservoir pressure fall to a value < 4.5 bar, both the yellow and red warning lamps are illuminated. The warning lamps will remain illuminated until the reservoir pressure exceeds 5.0 bar, after which the warning lamps will be extinguished. This condition applies irrespective of whether the trailer is moving or static. However should the above low pressure condition be registered during driving, this will be logged in memory as a fault as there may be a problem with the air supply from the towing vehicle.

While the above is a legal requirement, it is also necessary to record conditions that potentially over-pressurise the pressure sensor and could cause damage. It is a requirement that the supply pressure from the towing vehicle should be within the range 7.0 to 8.5 bar. However, in the event of a fault on the towing vehicle or the trailer is connected to a high pressure supply in a workshop, this pressure range could be exceeded. Should this occur the TEBS G2 brake module will react by recording a fault when the reservoir pressure exceeds 10.0 bar and will record every occurrence in the operational "Data Recorder" log when the reservoir pressure was > 9.0 bar.

#### 4.12 Odometer

The TEBS G2 brake module is equipped with an integrated odometer which determines the distance travelled by the trailer when the module is connected to the ISO 7638 power supply. There are also two possible sub-functions:

- The total distance function determines the total distance travelled with a connected ISO 7638 since the initial installation of the system. This value can be read by using the diagnostics program ECUTalk® or via the TIM G2 information module. This value cannot be manually reset as it is intended to record the distance travelled for the life of the trailer.
- The trip distance function determines the distance travelled on a daily basis or a distance that is specific to an operator. This value can be read and reset by using the diagnostics program ECUTalk® or via the Trailer Information Module (TIM G2).

Calibration of the odometer takes place when the TEBS G2 brake module is configured as it is required to define the number of teeth on the sensing ring and the dynamic tyre size. These are prerequisites, not only for the odometer but other speed related functions within the system.

If for any reason the tyre size or the number of teeth on the sensing ring is changed and the new parameters are configured using the diagnostic program ECUTalk®, the distance travelled at the point of reconfiguration will be the start point for the distance covered with the new parameters. Therefore the odometer always displays the total distance covered by the trailer irrespective of any change to the tyre size or sensing ring teeth number.

Should the TEBS G2 brake module be replaced, distance travelled by the trailer up to that point is logged within ECUTalk® and may be transferred to the replacement TEBS G2 brake module and used to display total distance travelled by the trailer.

#### 4.13 "Next Service" function

The "Next Service" function within the TEBS G2 brake module allows the operator or workshop to define when the trailer should have its next service or similar. Setting of the "Next Service" can be realised by the use of the diagnostic program ECUTalk® or via the TIM G2 information module. The value set can either be distance or time based

or both. If no other action is taken, the only way it can be established how much distance/time is left before the next service is to use ECUTalk® or via the TIM G2 information module. Two options exist to provide some form of warning so that it is not necessary to use ECUTalk®.

### Warning signal

In the field where the distance/time values can be defined, there is the option to require a warning to be transmitted to illuminate the yellow warning lamp. If this is selected and either the distance or time is reached, the warning lamp will flash – see section 3.3.3.

### Magic Eye

When a Magic Eye is installed on the trailer it can be set to indicate when the next service interval is exceeded. When the appropriate signal is received the Magic Eye will change status from black to red and will remain set until action is taken to reset the device. The indication will be present irrespective of whether the TEBS G2 brake module was powered or not.

## 4.14 Time/date stamp

When a TIM G2 information module is installed on the trailer its internal real time clock will transmit the information to the TEBS G2 brake module where the date and time can be assigned to a range of events including the fault record.

## 4.15 Operational data recorder

The TEBS G2 brake module includes two independent data fields, each containing a number of counters which can be accessed by the diagnostic program ECUTalk® under the menu heading “Diagnostic Information” and the submenu “Data Recorder” or via the Trailer Information Module (TIM G2). The two independent fields can be defined as follows:

- Operational Data Recorder (Permanent) where the respective counters reflect operational data for the life of the trailer.
- Operational Data Recorder (Re-settable) where the respective counters reflect operational data for the period since the data recorder was last reset.

The respective counters record the following information:

### Brake application counter

Whenever a braking demand, pneumatic or CAN, is generated, the respective counters will be incremented so it is possible to judge how the vehicle is being driven and this can be compared to brake lining wear. The counter ranges are:

Brake applications below 1.5 bar, from 1.5 to 2.5 bar, from 2.5 to 4 bar and above 4 bar.

### ABS active counter

Every time there is ABS cycling the counter will be incremented.

### 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 – see section 4.5.
- Step 2: Every time a Step 2 intervention occurs the counter will be incremented.
- Step 3: Every time a Step 3 intervention occurs the counter will be incremented (only available for centre axle trailers).

### Number of power cycles:

When the TEBS G2 brake module is first powered the source of the power is recognised and the respective counter incremented as follows:

ISO 7638 connection (no CAN communications)  
– number of times the trailer has been powered up with a non-EBS towing vehicle.

ISO 7638 connection (with CAN communications)  
– number of times the trailer has been powered up with an EBS towing vehicle.

ISO 1185 – number of times the trailer has been powered up by this means (no ISO 7638 power supply connected). Only applicable to trailers which are wired for stop lamp powering.

### Reservoir pressure

Records the number of times the trailer reservoir supply has been at a pressure > 9.0 bar, see section 4.11 of this Chapter. Additionally, the distance/time (when TIM G2 is connected) when the last over-pressure was recorded.

### Demand pressure ( $p_m$ )

Records the number of times the pneumatic braking demand has been at a pressure > 9.0 bar. Additionally the distance/time (when TIM G2 is connected) when the last over-pressure was recorded.

### Travelled Distance

This section records the distance travelled when the axle/bogie load is at a defined percentage of the configured laden value. The load ranges are as follows:

Less than 20%, 20 to 40%, 40 to 60%, 60 to 80%, 80 to 100%, 100 to 110%, 110 to 120% and above 120%.

## 4.16 Auxiliary Functions

In this section, the auxiliary functions supported by the TEBS G2 brake module are described. Depending on system configuration, up to four of the following auxiliary functions can be configured simultaneously via the three electrical AUXIO outputs of the module and one from  $P_{28}$  pneumatic output:

- **Lift Axle Control (LAC):**  
Two lift axle control outputs are available – LAC1 and LAC2.
- **Speed Pulse (SP):**  
Primarily used for resetting the suspension when a raise/lower valve is installed (suspension reset).
- **Integrated Speed Switch (ISS):**  
Speed dependent output signal.
- **Voltage supply ( $V_{out}$ ):**  
May be used to power other systems on the trailer associated with braking, suspension, etc, and the transmission of trailer related information e.g. TIM G2 and Telematics.
- **ABS active:**  
Provides an output signal whenever the ABS cycles. This is generally used for connection to trailer retarder control systems or the locking of steering axles.

- **Roll Stability Program (RSP) active:**  
Provides an output signal whenever there is a RSP Step 2 intervention excluding a Test Pulse. However the option of a Step 1 or Step 3 output is configurable.
- **Steering Axle Lock (SAL):**  
Provides a speed related output signal that may be used for connection to a steering axle locking mechanism. The signal is also generated when ABS is active.
- **Tilt Angle (TA) - (Patent Pending):**  
Provides an output signal when the RSP lateral acceleration sensor exceeds a pre-defined tilt angle – specifically for tipping trailers.
- **ADL A – F:**  
Links auxiliary input functions to realise a specific functionality not hard coded into the TEBS G2 brake module.
- **Digital speed signal (C3):**  
Provides a digital speed signal for use by other electronic control system, e.g. electronic air suspension.
- **Magic Eye:**  
Provides an indication of specific conditions even when the trailer is not powered.

On certain part numbers the TEBS G2 brake module is able to provide a pneumatically switched output by using an integrated solenoid. This output may be configured to either LAC, SP, ISS, SAL, ABS, RSP, RSP Step 1, RSP Step 3, TA, or  $P_{out}$ .

In addition, the following functions can be realised by switching the input to the respective AUXIO connections:

- **Lining-wear indicator (PW):**  
Input indicates when a wear limit of the brake lining/pad has been reached.
- **'Traction Help' (TH):**  
Controls lift axle(s) to increase imposed load on the tractor drive axle(s).
- **Manoeuvring help (MH):**  
Controls lift axle(s) to reduce the turning circle of the trailer.
- **Lower Lift axle(s) (LL):**  
Forces one or more raised lift axles to lower.
- **Advanced lift axle control:**  
Switches between 'Traction Help' and 'Manoeuvring Help' with one input.



- **External load sensor:**

Required to realise load sensing on mechanically or hydraulically suspended trailers.

- **ADL – Digital input:**

Digitally switched input used in conjunction with an ADL.

- **ADL – Analogue input (0-5 V):**

Analogue input used in conjunction with an ADL.

The individual functions will now be described in more detail.

#### 4.16.1 Auxiliary functions via AUX outputs

##### Integrated automatic lift axle control

In vehicles that are equipped with one or more lift axles, the TEBS G2 brake module can control the lift axle(s) automatically dependent on the current axle/bogie load and the predefined lift axle control parameters.

**Note:**

If RSP is configured and the trailer is equipped with a lift axle(s) the lift axle(s) must be controlled by the TEBS G2 brake module – see section 4.5.

To realise lift axle control one or more lift axle valves should be connected via the AUXIO outputs 1, 2 or 3 for electrical switched lift axle valves and pneumatic AUX P<sub>28</sub> for pneumatically switched lift axle valves. The following parameters associated with lift axle control may be defined by using the diagnostic program ECUTalk® or the brake calculation program BSD:

- Number of lift axles
- Location of lift axles
- Number of lift axles that are controlled via one AUX output
- Definition of the maximum axle/bogie load at which the lift axle should be lowered
- Definition of the axle/bogie load at which the lift axle should lift

The function of lift axle control is dependent on the air spring pressure. This is continuously monitored by the TEBS G2

brake module and used to determine the respective axle/bogie loads based on the configured laden and unladen axle loads and the number of axles.

A lift axle may only be installed on an axle which is not equipped with wheel speed sensors or, in the case of 4S/2M configurations, the lift axle may be installed with wheel speed sensors S-E and S-F. Failure to follow this requirement will result in a fault being generated when a lift axle is raised.

The status of the lift axle is transmitted to the towing vehicle via the ISO 11992 (CAN) interface when the trailer is coupled to a towing vehicle which is equipped with EBS. In such cases it is also possible that the lift axle(s) is/are controlled from the towing vehicle via the same interface.

**Important:**

When the trailer suspension control system is “two circuit” it is important that the connection of the air springs to port 42 of the TEBS G2 brake module is taken from the opposite side of the trailer to air springs associated with the lift axle(s). Failure to observe this requirement may lead to lift axle instability.

##### Number of lift axles that can be controlled via one AUXIO output

It is possible, by using the correct cable harness, to connect two electrically controlled lift axle valves to one AUXIO output; the lift axles will then operate simultaneously. In the same way, more than one pneumatically controlled lift axle valve may be connected to AUX P<sub>28</sub>.

##### Determination of the axle load at which the lift axle should be lowered

When defining the lift axle control parameters using the diagnostic program ECUTalk®, the axle/bogie load at which the lift axle(s) will lower is, by default, the laden axle/bogie load permitted for the trailer - otherwise the axles remaining on the ground would be overloaded. It is possible to configure a lower value than the laden axle/bogie load, for example to comply with specific national axle loading requirements.

**Note:**

When the TEBS G2 Brake Module has an electrical AUXIO configured to "Speed Pulse" (SP) and raise / lower valve SV3801 is connected the maximum duration of the "Speed Pulse" signal **must not exceed 5 seconds**.

**Tip:**

When the trailer is loaded with a large individual load, in order to prevent temporary overloading of the axles, the axle/bogie load when the lifted axle(s) is lowered should be set to a value below the maximum value.

**Hysteresis**

When setting the lift axle parameters for the TEBS G2 brake module, it is required to define the position of the lift axle and the number of lift axles controlled by LAC1 or LAC2. This effectively defines the lifting sequence since LAC1 is always the first axle to lift. In addition it is required that the geometric data of the wheelbase and axle spread is also defined. When defining the lift axle parameters it is not necessary to define a hysteresis value to determine when the lift axle(s) should lift using the information above.

The diagnostic program ECUtalk®, and brake calculation program BSD, will automatically calculate the maximum axle/bogie load at which the axle(s) should lift. It is possible to define a lower axle/bogie load than the default maximum but not higher. This calculation takes into consideration a factor which ensures that, irrespective of the position or lifting sequence of the lift axle(s), or the wheelbase of the trailer, the defined axle lifting loads will ensure that overloading does not occur and the lift axle(s) remains stable.

**Initiation of lift axle control**

By means of the diagnostic program ECUtalk®, it is possible to define whether the lift axle control should be active when the trailer is stationary and the ignition is switched "ON", i.e., the lift axle would raise - provided the load state allows this, or whether the lift axle control should begin only when a speed threshold is exceeded. This threshold is linked to the Speed Pulse (SP) which has a default switching speed of 16 km/h. However, this applies only in the event that

either no SP function is configured, or the SP speed is not changed from the default value. If the SP speed is changed, for example to 20 km/h, then lift axle control will not commence until after this speed has been reached. By linking the lift axle control to the SP speed it is ensured that the suspension is reset before lift axle control commences as the air spring pressure may not be representative of the load condition due to operation of the raise/lower valve.

Once the lift axle is lifted, irrespective of whether at standstill or after the SP speed, it will remain so until either a higher loading state is detected or a 'lower lift axle' is activated – which can take place electrically or pneumatically – or the ignition is switched off. This means that the option "Lift axle active at standing still" relates only to the period that the trailer is stationary immediately after switching "ON" the ignition.

**ISS – Integrated Speed Switch**

The ISS signal is a speed dependent signal - the threshold values for switching "ON" and "OFF" are defined within the diagnostics program ECUtalk®. Should the vehicle speed exceed or fall below these thresholds, the status of the configured AUXIO output will change. This applies to both the electrical and pneumatic outputs.

Examples of typical application could be:

- The speed-dependent locking of a removable towing drawbar by switching the state of a solenoid or pneumatically controlled valve.
- Interlock function on tankers to prevent the spring brake safety feature operating while driving.

The following parameters can be defined:

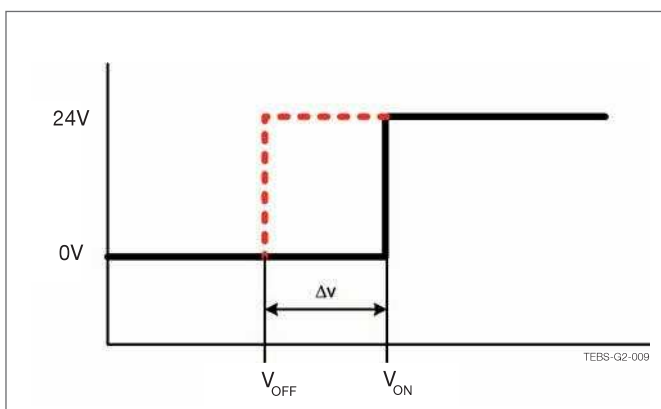
- Switching "ON" threshold
- Switching "OFF" threshold
- ISS inverted

The switching "ON" threshold can be set to any speed within the range 4 to 120 km/h. The switching "OFF" threshold can be set to any value within 2 km/h of the switching "ON" threshold, i.e. minimum hysteresis = 2 km/h.

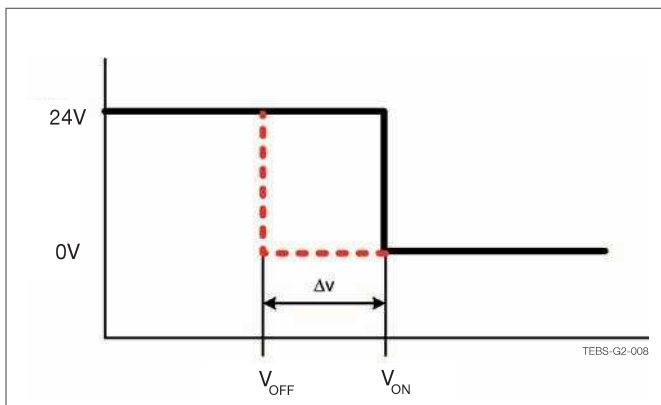
The third parameter, "ISS inverted" set to "YES" or "NO" determines the operating mode of the AUXIO output. By default, the selection for this parameter is "NO" which means that when the switching speed threshold is reached, the electrically controlled AUXIO output will switch from 0 V

to  $V_{avg}$  e.g. 0 V to 24 V. However if the parameter is set to “YES”, when the switching speed threshold is reached the electrically controlled AUXIO output will switch from  $V_{avg}$  to 0 V e.g. 24 V to 0 V. Once the speed threshold has been reached, the output will be either permanently “ON” until the speed falls below the “OFF” threshold or the opposite in the case of inverted mode.

The diagrams below illustrate the difference between the two modes of operation:



**Figure 24:** ISS default setting (Inverted mode = “NO”)



**Figure 25:** ISS inverted (Inverted mode = “YES”)

### Speed Pulse (SP)

The auxiliary function Speed Pulse (SP) is available primarily for use with trailers having air suspension and equipped with a raise/lower valve that includes a function to automatically return the operating position of the raise/lower valve to the “drive” position by electrical or pneumatic signalling. There are several advantages of using this function as follows:

- Prevents damage to the suspension if the raise/lower valve is left in any operating position other than “drive”.
- Unless the raise/lower valve is in the “drive” position it is not possible to guarantee that the air spring pressure measured by the pressure sensor at port 42 of the module is appropriate to the load carried by the axle/bogie.

In the latter case any function that is reliant on using the correct load information based on the air spring pressure may not function as intended, e.g. load sensing, RSP etc. Therefore, when suspension reset using the Speed Pulse is not available, the responsibility of ensuring that the raise/lower valve is returned to the “drive” position is the sole responsibility of the operator. Knorr-Bremse therefore recommends in all cases, particularly when RSP is configured, that automatic suspension reset is available.

On certain tipping trailers there is a requirement for independent raising and lowering on left and right sides. To realise the suspension reset function, two outputs may be configured or a special “Y” splitter cable is available so that both raise/lower valves can be simultaneously returned to the drive position. This auxiliary function, like all the others, can also be connected to one of the three AUXIO electrical outputs or the pneumatic  $P_{28}$  output.

The Speed Pulse auxiliary output is similar to the ISS function described above as both have a speed threshold that generates a switching signal. Speed Pulse however, has the following characteristics:

- Switching speed range: 4 to 40 km/h
- Signal duration: 5 to 30 seconds
- Hysteresis is preset and non-adjustable
- Signal will only switch from 0 V to  $V_{avg}$  or 0 bar to  $P_{res}$  (inverted signal is not available)

#### Note:

It is not recommended that the default value of 5 seconds for the signal duration is exceeded. If the default duration is modified check the data sheet of the connected component for compatibility.

### Power Supply ( $V_{out}$ )

The TEBS G2 brake module is able to provide a voltage output from any of the three electrical AUXIOs. However a number of conditions apply:

- The maximum current available from each configured AUXIO output is referred to in the tables on page 42.
- The electrical energy available from the AUXIO outputs is taken from the ISO 7638 interface and restrictions are defined within ECE Regulation 13 as to how this power may be used:
  - Power available from the ISO 7638 connector shall be used exclusively for braking and running gear function (brakes, chassis, suspension, tyres) and the transfer of trailer related information (TIM G2, telematics etc.). The power supply for other functions must use a different power source.
- Although not recommended, should the output be used to charge a battery it is essential that a diode is placed between the AUX output and the battery to prevent back flow to the TEBS G2 brake module. It is the responsibility of the user to ensure that the diode is the correct specification for the application.

### ABS active (ABS)

The auxiliary function 'ABS active' is generated whenever the trailer ABS is cycling and may be configured on any of the electrical AUXIOs or the pneumatic output  $P_{28}$ . The signal will be terminated when no further cycling of the ABS occurs. In the case of the electrical AUXIOs the output will be switched from 0 V to  $V_{avg}$ .

Generally this output is used to signal the retarder installed on the trailer so that it would be disengaged during ABS cycling when a braking demand is present, or when no braking demand is present and wheel slip generated by the retarder alone will be controlled by switching the output "ON" and "OFF". In addition, with the aid of this function it is possible to use the signal to engage a stabilising function for steering axles - see section 4.4.5.

### RSP active (RSP)

The auxiliary function 'RSP active' is generated whenever the trailer RSP function becomes active and may be configured on any of electrical AUXIOs or the pneumatic

output  $P_{28}$ . The signal will be terminated when the RSP brake intervention is no longer required. In the case of the electrical AUXIOs, the output will be switched from 0 V to  $V_{avg}$ . For each of the auxiliary outputs the following configuration options are available:

RSP Active:	Output signal is generated when a RSP Step 2 intervention takes place. A "Test pulse" does not generate the signal.
RSP Step 1 Active:	Output signal is generated when only a RSP Step 1 intervention takes place.
RSP Step 3 Active:	Output signal is generated when only a RSP Step 3 intervention takes place.

### Steering Axle Lock (SAL)

This output signal is a combination of ISS and ABS Active as defined above and, while it may be used for the locking of steering axles via a solenoid valve using an electrical output or pneumatically controlled valve using the  $P_{28}$  output, it may also be used for other functions where the operation is to be speed controlled.

### Tilt Angle Lock (TA) (Patent Pending)

The lateral acceleration sensor, used primarily for RSP, may also be used to define the lateral angle of the trailer platform. Therefore, when a predefined lateral angle is exceeded, an electrical output will be generated from the configured AUXIO or a pneumatic signal from the  $P_{28}$  output. This function is of value to tipping trailers where, due to irregularities in the surface on which the trailer is standing, the trailer may tip over as the body is lifted to offload the contents of the body. The output from the TEBS G2 brake module may be connected to realise the following possibilities:

- Connect to an audible warning system to alert the operator of a potential problem.
- Connect to the tipping control system to prevent the body from being lifted.
- Connect to the tipping control system to automatically lower the body.



The tilt angle may be set at any angle between 2° and 15°. The signal is generated up to a predefined maximum within the range 0 to 15 km/h. Once the defined speed has been exceeded the signal will be terminated.

The electrical signal can be set to switch between 0 V and  $V_{avg}$  or, in inverted mode, between  $V_{avg}$  and 0 V.

#### ADL A – F

An ADL (Auxiliary Design Language) is a file produced by Knorr-Bremse that makes use of independent functions available within the TEBS G2 brake module. This includes auxiliaries (inputs and outputs) and automatic brake interventions that may be linked in a way that is operator specific to realise a given overall functionality that is not hard coded into the ECU.

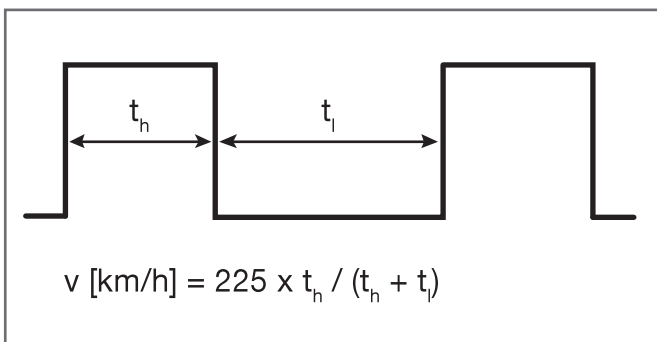
#### Digital Speed Signal (C3) Signal

The C3 signal is a digital speed signal of a specification similar to that generated by tachographs and may be used to provide a speed signal to other electronic control systems for example electronic air suspension.

##### Tip:

As the C3 signal is provided on Pin 6 of the In-Out connector, it is not possible to use this Pin as the return line for Tristate Inputs.

The figure below details how the C3 signal can be interpreted.



## Specification of AUXIOs

All electrical AUXIOs are subject to operational requirements which must be adhered to in order to ensure correct operation of the associated auxiliary function. The following tables define the electrical characteristics of the respective AUXIOs:

AUXIO1	AUXIO2	AUXIO3	AuxRet12	AuxRet3	SENS_SUP	SENS_IN1	SENS_GND
X2-1	X2-2	X2-3	X2-11	X2-12	X2-4	X2-5	X2-6
'High side driver' / digital input	'High side driver' / digital input	'High side driver' / digital input	'Low side driver'	'Low side driver'	Sensor supply / Tri-state input	Analogue input / Tri-state input	'Low side driver'

AUXIO1	Min	Typ	Max
Load power (watts)			60 <sup>1)</sup>
Load resistance (ohms)	15		2k <sup>2)</sup>
Output current (A)			2.0 <sup>1)</sup>
Off-state load current (mA)	0.5		2.0
Saturation voltage (V)			0.2
Clamping voltage (V)	41		52
Pull-up resistor (ohms)		14.7k	
Input low voltage (V)	-0.4		2.0
Input high voltage (V)	8.0		32

AuxRet12	Min	Typ	Max
Load power (watts)			90 <sup>1)</sup>
Load resistance (ohms)	10		500 <sup>3)</sup>
Output current (A)			3.0 <sup>1)</sup>
Off-state load current (mA)	1.2		2.5
Saturation voltage (V)	0.08		0.15
Clamping voltage (V)	60		73
Pull-up resistor (ohms)		14.7k	
Analogue input voltage (V)	0		32

AUXIO2	Min	Typ	Max
Load power (watts)			60 <sup>1)</sup>
Load resistance (ohms)	15		2k <sup>2)</sup>
Output current (A)			2.0 <sup>1)</sup>
Off-state load current (mA)	0.5		2.0
Saturation voltage (V)			0.2
Clamping voltage (V)	41		52
Pull-up resistor (ohms)		14.7k	
Input low voltage (V)	-0.4		2.0
Input high voltage (V)	8.0		32

AuxRet3	Min	Typ	Max
Load power (watts)			90 <sup>1)</sup>
Load resistance (ohms)	10		500 <sup>3)</sup>
Output current (A)			3.0 <sup>1)</sup>
Off-state load current (mA)	1.2		2.5
Saturation voltage (V)	0.08		0.15
Clamping voltage (V)	60		73
Pull-up resistor (ohms)		14.7k	
Analogue input voltage (V)	0		32

AUXIO3	Min	Typ	Max
Load power (watts)			45 <sup>1)</sup>
Load resistance (ohms)	20		2k <sup>2)</sup>
Output current (A)			1.5 <sup>1)</sup>
Off-state load current (mA)	0.5		2.0
Saturation voltage (V)			0.2
Clamping voltage (V)	41		52
Pull-up resistor (ohms)		14.7k	
Input low voltage (V)	-0.4		2.0
Input high voltage (V)	8.0		32

SENS_IN1	Min	Typ	Max
Analogue input voltage (V)	0		5
Pull-up resistor (ohms) Switchable for Tri-state		21.5k	
Pull-down resistor (ohms) Switchable for Tri-state		21.5k	
Tri-state input voltage (V)	0		32

SENS_GND	Min	Typ	Max
Load power (watts)			15 <sup>1)</sup>
Load resistance (ohms)	60		
Output current (A)			0.5 <sup>1)</sup>
Off-state load current (mA)		0	
Saturation voltage (V)			0.84
Clamping voltage (V)	60		75
Pull-up resistor (ohms)		2.6k	

Knorr-Bremse Approved Products		Permitted AUXIO Connections	Notes
Product	Part Number		
Lift axle valve	K008546	AUXIO 1, 2 or 3	
Lift axle valve	K014117		
Lift axle valve	K015384		
Raise/Lower valve	SV3801		
Raise/Lower valve	SV32..		
3/2 valve	AE9120		
3/2 valve	EA1152		
Lift axle valve	K019882	AUXIO 1 or 2	Must be configured to a 6V output

**Notes:**

<sup>1)</sup> Valid for resistive loads only. For inductive loads the maximum current/power depends on the commutation energy and switching frequency. For inductive loads not included in the table below the application must be reviewed and approved by Knorr-Bremse.

<sup>2)</sup> Resistive load >1k ohms, ECU detects "open circuit"

<sup>3)</sup> If both AUXIO 1 and AUXIO 2 are used, the combined maximum current must not exceed the maximum current of AUXIO Ret 1 & 2.

**P<sub>28</sub> Pressure Control**

The auxiliary pneumatic output P<sub>28</sub> is controlled by a solenoid within the TEBS G2 brake module. There is no pressure limitation, therefore the pneumatic output pressure will be equivalent to that of the braking system reservoir pressure. The control logic for the generation of the signal is defined and applies for the following functions:

- Speed Pulse (SP)
- Lift axle control (LAC)
- Integrated Speed Switch (ISS) – inverted mode available
- Steering Axle Lock (SAL) – inverted mode available
- ABS active (ABS)
- RSP Step 1
- RSP Step 2
- RSP Step 3
- Tilt Angle (TA) – inverted mode available
- P<sub>out</sub> (permanent connection to the braking system supply pressure)

**Note:**

The pneumatic auxiliary output function is only available when the trailer braking reservoir pressure is > 5.2 bar. Should the pressure fall below 5.2 bar, control of the auxiliary output will be terminated until this pressure is > 5.7 bar.

**4.16.2 Control of auxiliary functions by inputs**

The previous section 4.16.1 described the auxiliary functions that are available within the TEBS G2 brake module. It is possible to control certain of these functions by external inputs in addition to having specific inputs that realise a predefined function. With system configuration 2S/2M it is possible to have 7 inputs while with 4S/2M only 5 inputs are possible.

**Tip – Selection of inputs:**

When configuring any given input it is recommended that the Tri-state inputs on Pins 4 and 5 of the IN/OUT connector are used first, followed by sensor inputs S-E and S-F (2S/2M configurations only) and then the AUXIO connections on pins 1, 2 and 3. This leaves the possibility that an auxiliary output may be configured on AUXIOs 1, 2 and 3 at a later date without having to reconfigure the existing inputs.

The following auxiliary input functions may be configured to any, or specific, input pins:

- Traction Help (TH)
- Lower Lift axle (LL)
- Manoeuvring Help (MH)
- Lining wear indicator (PW)
- Advanced lift axle control
- External load sensor
- ADL – Analogue input (0-5 V)



When configuring the TEBS G2 brake module using ECUTalk®, the following connections may

be used on the In-Out connector:

- SENS\_SUP
- SENS\_IN1
- Input E (2S/2M configurations only)
- Input F (2S/2M configurations only)
- AUXIOs 1, 2 and 3

For each of the above it is possible to select a switch which is permanently locked in a selected position until selected again (permanent) or a switch which will only operate for the period of time that it is selected after which it automatically returns to its original state (momentary). Within ECUTalk® the switches are defined as:

- Permanent = \_P  
Or
- Momentary = \_M

Therefore any associated function would be designated as follows:

Switch Type	
Permanent	Momentary
TH_P	TH_M
MH_P	MH_M
LL_ALL_P	LL_ALL_M
LL_LAC1_P	LL_LAC1_M
LL_LAC2_P	LL_LAC2_M
PW	LLTH

The respective functions realised via the use of auxiliary inputs are described below:

**Traction Help (TH)**

It is often the case that, due to poor road conditions, the driver of a semi-trailer combination may experience difficulty in pulling away from rest or loses traction at low speed. When the trailer is equipped with one or more lift axles it is possible to use the weight distribution changes between an axle being lifted or lowered to increase the imposed load on the coupling with the tractor thereby increasing the load on the tractor drive axle(s) and its/their tractive power capabilities.

However, European legislation defines specific requirements for axle overload and maximum operating speed when using 'Traction Help'. These requirements are defined within Directive 97/27/EC as amended by Directive 2003/19/EC as follows:

"The use of a traction help function may only overload any axle by up to 30% of its permitted maximum load until the vehicle speed has reached 30 km/h after which any lifted axle must automatically lower".

For practical reasons a manual lift axle control system cannot fulfil this requirement as lifting an axle within a bogie without any form of load control is likely to result in the axle(s) remaining on the ground exceeding the 30% overload value. Equally, once moving, the driver would have to stop to manually lower the lifted axle(s) which again may result in subsequent traction problems.

The lift axle and 'Traction Help' control integrated into the TEBS G2 brake module automatically includes criteria to ensure that the legislative requirements are fulfilled.

For 'Traction Help' to operate the trailer must have either a lift axle or the capability of exhausting the air from the air springs of certain axles on the trailer to increase the imposed load. Selecting 'Traction Help' mode cannot be realised automatically as the trailer has no information about the tractive capabilities of the tractor therefore the driver must be able to select the function by means of a signal transmitted to the TEBS G2 brake module. The input connections that may be used are defined above. The signal can be presented in various ways. The Knorr-Bremse TEBS G2 brake module offers the following options for doing this:

1. Tri-state inputs via single wire connection to either pin 4 or 5 where the following conditions will be recognised as requiring 'Traction Help':
  - Change of state – open circuit to 12 / 24 V
  - Change of state – open circuit to ground
2. Inputs S-E, S-F (2S/2M configurations only) and AUXIOs 1, 2 and 3 require a 2 wire connection to recognise a change in state from open to short circuit or short circuit to open circuit.
3. Activation via actuation of the brakes.
4. Manual operation via the Trailer Information Module (TIM G2).
5. Signal transmitted from the tractor via a specific message request included in ISO 11992 (CAN) data communications.

**Note:**

A signal received via the ISO 11992 communications data link will take priority over other lift axle control signals.

When a switched voltage signal or a ground signal is used, the associated switch may be of the permanent type or momentary type as described above and the TEBS G2 brake module will automatically recognise the single change in state. When a permanent switch is used and the vehicle speed exceeds 30 km/h, the lifted axle(s) will automatically be lowered. Should the vehicle speed then fall below 30 km/h the lowered axle(s) will remain on the

ground. To re-activate 'Traction Help', the switch must first be de-activated before a second actuation is possible.

Generally, 'Traction Help' is used in conjunction with a front lift axle within the semi-trailer bogie. In this case the effective wheelbase of the trailer will increase, when the axle is raised, which results in some of the load previously supported by the lifted axle being transferred to the tractor and the remainder onto the axle(s) of the trailer remaining on the ground. The ratio of the load distribution is effectively controlled by the ratio of the effective wheelbases between lowered and lifted states. It is also possible to have a 'Traction Help' function with a rear lift axle. However increasing the imposed load on the tractor coupling can only be realised by lowering of the rear lift axle(s) as this action results in an increase in wheelbase. Both of these control elements are integrated into the TEBS G2 brake module and, during configuration, it is necessary to define the location of the lift axle(s), whether they are controlled by LAC1 or LAC2, and the respective wheelbase and axle spread. From this information the lifting or lowering of lift axle(s) will be automatic to realise the function of 'Traction Help'.

**Axle overload control:**

As defined above, legislation controls the amount of axle overload permitted and, as it is possible to exceed the prescribed value when axles are at or close to their maximum permitted load, it is necessary to recognise this condition and react accordingly. To prevent axle overload, first the condition is recognised by the TEBS G2 brake module based on the measured air spring pressure at port 42 and then, by repeatedly cycling the lift axle control between lifted and lowered, the average axle load is controlled to fulfil legislative requirements.

**Note:**

ADL files are available that are able to provide different 'Traction Help' functionality to that described above - see section 4.17.

**Tip – 'Traction Help':**

Should it be required to switch off 'Traction Help' at a speed below the automatic lowering speed (30 km/h), this can be realised by using the 'Lower Lift axle' option described below.

### Lower Lift axles (LL)

Forcing a lifted axle to lower when the automatic control dictates that it should be in the lifted position is often a desirable function and has been integrated in the TEBS G2 brake module. It can be realised by any of the following methods:

1. Tri-state inputs via single wire connection to either pin 4 or 5 where the following conditions will be recognised as requiring 'Lower Lift axle'(s):
  - Change of state – open circuit to 12 / 24 V
  - Change of state – open circuit to ground
2. Inputs S-E, S-F (2S/2M configurations only) and AUXIOs 1, 2 and 3 require a 2 wire connection to recognise a change in state from open to short circuit or short circuit to open circuit.
3. Activation via actuation of the brakes.
4. Manual operation via the Trailer Information Module (TIM G2)
5. Signal transmitted from the tractor via a specific message request included in ISO 11992 (CAN) data communications.

#### Note:

A signal received via the ISO 11992 communications data link will take priority over other lift axle control signals.

When a switched voltage signal or a ground signal is used, the associated switch may be of the permanent type or momentary type as described above and the TEBS G2 brake module will automatically recognise the single change in state. When a permanent switch is used its selection will result in the lift axle being lowered. To re-activate 'Lower Lift axle' the switch must first be deactivated before a second actuation is possible.

After selection of 'Lower Lift axle' as described above the lift axle control will remain disabled unless 'Traction Help' is selected or the ignition is turned off.

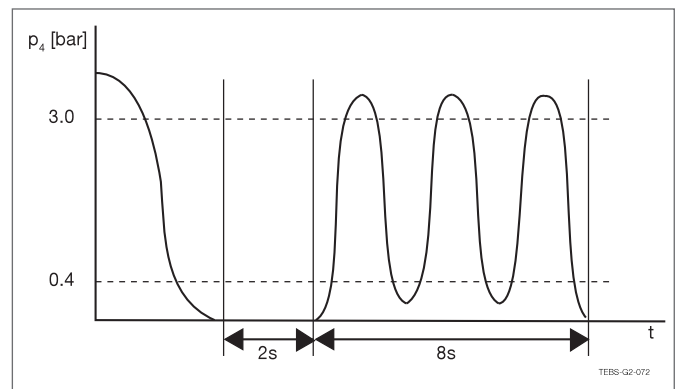
#### Note:

ADL files are available that are able to provide different 'Lower Lift axle' functionality to that described above - see section 4.17.

### Traction Help (TH) and Lower Lift axle (LL) via operation of the service brakes

Activation of 'Lower Lift axle'(s) and 'Traction Help' via actuation of the brakes is a standard feature within the TEBS G2 brake module therefore no additional wiring or system configuration is necessary – only configuration of a lift axle is required. To realise the 'Lower Lift axle' function via brake actuation the following criteria must be fulfilled:

- The vehicle must be stationary.
  - When connected via a 5 pin ISO 7638 connector – No brake application from any source (hand brake or foot brake) for a period of 2 seconds.
  - When connected via a 7 pin ISO 7638 connector – No ISO 11992 (CAN) brake application, irrespective of whether a pneumatic braking demand is present or not, for a period of 2 seconds.
  - Within a period of 8 seconds, 3 brake applications must be made where the braking demand must exceed 3 bar and then fall to below 0.4 bar on each application.
- Figure 26 graphically illustrates the characteristic.



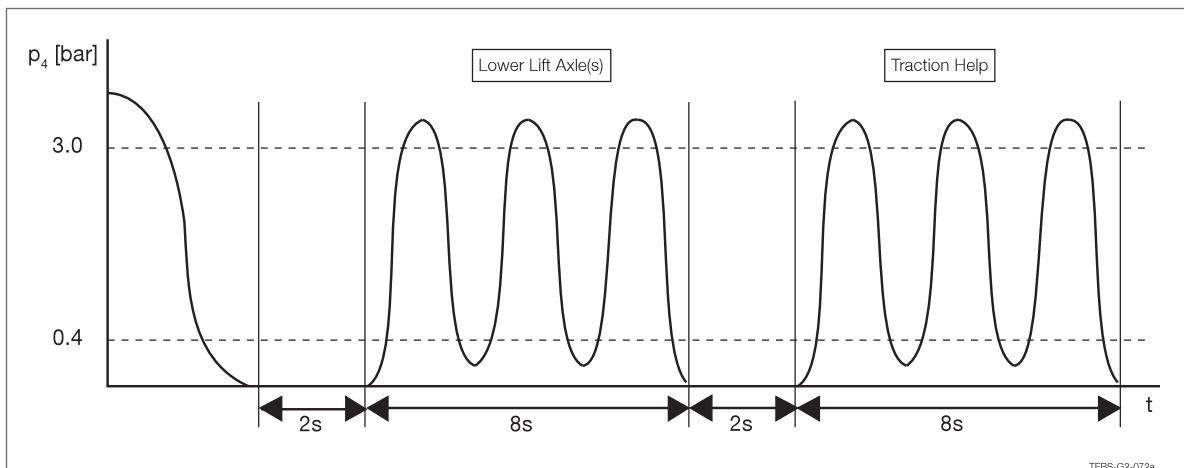
**Figure 26:** Lower Lift axle (LL) via brake actuation



To realise the 'Traction Help' function via brake actuation the following criteria must be fulfilled:

- The vehicle must be stationary.
- When connected via a 5 pin ISO 7638 connector – No brake application from any source (hand brake or foot brake) for a period of 2 seconds.
- When connected via a 7 pin ISO 7638 connector – No ISO 11992 (CAN) brake application, irrespective of whether a pneumatic braking demand is present or not, for a period of 2 seconds.

- Before 'Traction Help' can be selected, it is necessary to first select 'Lower Lift' axle(s) by following the procedure defined above. There must then be a period of at least 2 seconds when no braking demand (pneumatic or CAN) is present, after which a further 3 brake applications must be made within a period of 8 seconds. Note, during each brake application the brake demand must exceed 3 bar and then fall to below 0.4 bar. Figure 27 below graphically illustrates the characteristic.



**Figure 27:** Traction Help via brake actuation

As long as the vehicle is stationary and the system remains powered the functions "Lower Lift" axle(s) and "Traction Help" will switch alternatively with each subsequent 2 second period without a brake application followed by three brake applications within an 8 second period. Once the vehicle speed has first exceeded 30 km/h "Traction Help" will be set to "OFF" and cannot be re-activated until the vehicle is again stationary.

"Lower Lift" axle(s) will remain selected until the power to the system is turned "OFF" but once turned "ON" again the function will revert to automatic lift axle control via the TEBS G2 Brake Module.

If the towing vehicle has ISO 11992 data communications (CAN), the three brake applications with the foot brake pedal within 8 seconds will be detected even if the handbrake of the towing vehicle is applied.

#### Advanced lift axle control

This auxiliary function combines the functions of 'Traction Help' and 'Lower Lift' axle by the use of a single switch and a single momentary connection to the TEBS G2 brake module as follows:

**Activate 'Traction Help':** select the appropriate control switch for a period of less than 5 seconds.

**Activate 'Lower Lift' axle:** select the appropriate control switch for a period of more than 5 seconds and less than 10 seconds.

#### Note:

Should the operating control switch be selected for a period of more than 10 seconds this will NOT result in the lift axle being lowered.

### Manoeuvring Help (MH)

This function is the opposite to 'Traction Help' in that its application will always reduce the effective wheelbase of the trailer, irrespective of where the lift axle(s) is/are located, thereby enabling the trailer to be manoeuvred more easily in confined spaces. With a front lift axle(s) 'Manoeuvring Help' would have the same functionality as 'Lower Lift axle' however in the case of a rear lift axle neither 'Traction Help' or 'Lower Lift' axle will realise the same functionality as 'Manoeuvring Help'. Therefore when 'Manoeuvring Help' is configured the TEBS G2 brake module must control the appropriate trailer lift axle(s) in a way that would reduce the effective wheelbase. The function is only available up to a speed of 30km/h above which the controlled axes will return to their normal automatic control mode. To realise this capability the TEBS G2 brake module can be configured for 'Manoeuvring Help' on any of the following connections:

1. Tri-state inputs via single wire connection to either pin 4 or 5 where the following conditions will be recognised as requiring 'Manoeuvring Help':
  - Change of state – open circuit to 12 / 24 V
  - Change of state – open circuit to ground
2. Inputs S-E, S-F (2S/2M configurations only) and AUXIOs 1, 2 and 3 require a 2 wire connection to recognise a change in state from open to short circuit or short circuit to open circuit.
3. Manual operation via the Trailer Information Module (TIM G2).

**Note:**

By using an ADL file, different functionality to that defined above may be realised.

### Lining-wear indicator (PW)

The friction material of any brake will wear until the linings (drum brakes) or pads (disc brakes) need replacement. Failure to replace the worn component at the appropriate time will lead to a reduced level of safety and significant on-cost due to possible damage to other components. When brakes are installed with wear indicators, see Figure 28, it is possible to provide information on the wear status of

the friction material to the driver or the workshop. Typically each brake is installed with wear sensors which connect to a junction box, see figure 29, from which a connection is made to the TEBS G2 brake module by the following options:

1. Tri-state inputs to either pin 4 or 5 and ground pin 6
2. Inputs S-E, S-F (2S/2M configurations only)
3. AUXIOs 1, 2 and 3.

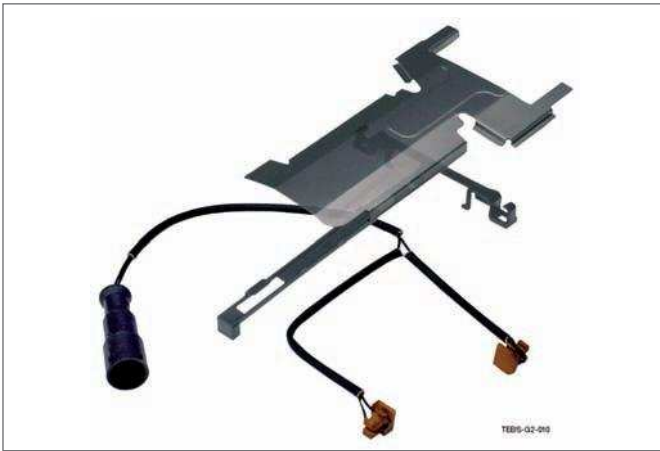
The selected connection from the above should then be configured:

- Select "Input permanent switch"
- Set function to PW (Pad Wear)

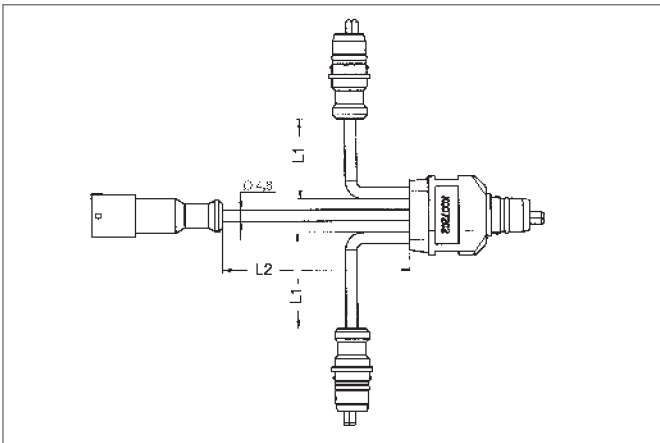
The monitoring system, provided by the wear sensors, records when any one of the brakes equipped with wear sensors reaches a predefined wear limit (approximately 2 mm remaining). This status is recognised by the TEBS G2 brake module by an open circuit in the monitoring system and a warning can then be generated by the following means:

- Transmission of a warning signal via Pin 5 of the ISO 7638 connector to inform the driver. The yellow warning lamp will flash to define a non prescribed fault is present – see section 3.3.2. for more information.
- Transmission of an electric signal meaning "brake lining insufficient" via the ISO 11992 data communications (CAN). Transmission of this message does not guarantee that the towing vehicle will provide the relevant information to the driver or record an error has been received as this is dependent on the specification of the towing vehicle.
- Transmission of a signal to the Magic Eye which would need to be configured to "Display pad wear errors".
- Transmission of a signal to TIM G2.

In the case of Magic Eye and Trailer Information Module (TIM G2), the fault information will be available even when the trailer is uncoupled or the ignition is "OFF". Should either Magic Eye or Trailer Information Module (TIM G2) not be installed on the trailer it will be necessary to connect the diagnostics system ECUtalk® to establish the reason for the flashing warning signal.



**Figure 28:** Illustration of the components of a lining wear-indicator set



**Figure 29:** Axle connecting cable set for lining-wear indicator

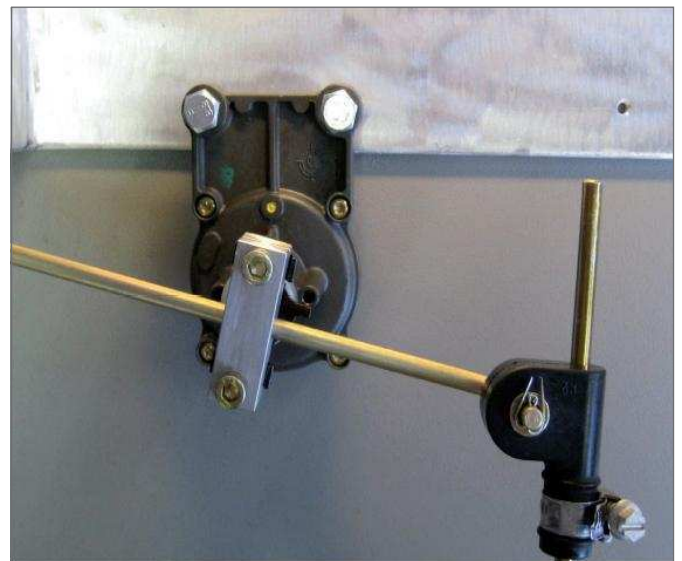
### External load sensor

Load information is a prerequisite to enable the operation of the load sensing function and, in the case of air suspension trailers, this information is obtained by measurement of the air spring pressures at port 42 of the module. However not all trailers utilise air suspension therefore the option must exist to provide load information from an external means. Three possible external sensors may be configured for use with mechanical, air and hydraulic suspension and must be configured by use of the diagnostic program ECUTalk®.

Within the LSF configuration window of ECUTalk® the type of load sensor can be defined, the default being “internal”, which means the pressure sensor integrated into the TEBS G2 brake module. The other options are “LS1” and “LS2”. Following this, the voltage settings

for the selected transducer require configuration for unladen and laden conditions. In the case of hydraulic or pneumatic sensor it is also necessary to define the unladen and laden suspension pressures. In the case of mechanical suspension it is also necessary to define spring deflection (linear distance between unladen and laden load conditions) and the length of the lever. This must be obtained by using the Knorr-Bremse brake calculation program (BSD) or from the installation instructions for the sensor - see Knorr-Bremse document Y053529. Figure 30 illustrates the recommended Knorr-Bremse sensor for use with mechanical suspensions.

In the AUXIO settings window it is now necessary to configure analogue input at SENS\_IN1 to LS1 which is associated with pin 5 of the In-Out connector. Power and ground connections are taken from pins 4 and 6 respectively from the same connector.



**Figure 30:** Knorr-Bremse sensor

### 4.17 ADL – Auxiliary Design Language

ADL is a Knorr-Bremse patented developed programming language that enables the expansion of the functionality of the TEBS G2 brake module without having to update the basic hard coded software; this enables significant flexibility. By using an ADL it is possible to adapt the individual or combined functionality of any combination of configured AUXIO functions as well as update the content of the TI CAN communications to realise specific customer objectives. The latter is used to interface with external communication systems e.g. Telematics - see section 4.18.

ADL is an important feature for the following reasons:

- Continuous development within the commercial vehicle industry in general and a varied customer base demands flexibility.
- A clear trend towards realising an increasing number of functions by electronic means,
- Products are developed based on what is known to be required up to the time of launch. The introduction of new functions takes significant time to introduce on a permanent basis.
- Special applications require special solutions.

If a modified functionality is desired for an auxiliary function, the user now has the possibility of reaching a timely implementation through the Knorr-Bremse Technical Field Service. Knorr-Bremse has set up a database in which all inquiries and their solutions are stored and this makes it possible to react very quickly, since the majority of the function variants are covered.

A suitable form is available for inquiring about a function modification.

The programming of the new auxiliary function created by the ADL takes place via the PC diagnostics program ECUtalk® which is accessed via the “Miscellaneous” tab in the program.

When an ADL is loaded, ECUtalk® will display the following:

- Program number associated with the loaded ADL.
- Expected AUXIO input and output configurations required.
- Brief description of the function.

During the download of the ADL, ECUtalk® will carry out a plausibility check of the file and configuration.

**Tip:**

Before requesting a new ADL please ask your customer service representative whether the required function is already available or can be realised without the need for an ADL.

### 4.18 TI-CAN – Data communication

The TEBS G2 brake module offers the option of retrieving information from the control system including braking, Roll Stability Program (RSP), auxiliary functions etc. This information is then transmitted via the internal 5 V CAN and available from pins 9 and 10 of the In-Out connector. From this connection a continuous data stream is available to the specification defined in the Knorr-Bremse document Y022641.

The following list illustrates the standard available information:

- Vehicle speed
- Pneumatic braking demand
- CAN braking demand
- ABS activity
- Step 1 RSP interventions
- Step 2 RSP interventions
- Step 3 RSP interventions
- Fault information
- Odometer – total
- Odometer – trip
- Next service interval
- Current axle load
- Current bogie load
- Status of lining-wear indicator
- Left and right brake delivery pressures
- Braking system reservoir pressure
- Air spring pressure



## 5.1 TEBS G2 brake module

The TEBS G2 brake module forms the core of the electro-pneumatic brake control system. It may be installed on semi-trailers and centre axle trailers with up to 3 axles and on dollies with up to 2 axles.



**Figure 31:** Knorr-Bremse TEBS G2 brake module

When powered via the 7-pin ISO 7638 connector, the TEBS G2 brake module communicates with the towing vehicle through the ISO 11992 data communications (CAN) using pins 6 and 7 of the above connector. Two independent pneumatic pressure regulating channels are integrated into a common housing with connections to the brake reservoir supply, park/shunt valve and brake actuators. Internally there are 5 pressure sensors, up to 7 solenoids controlled via the common electronics, an anti-compounding valve and two independent pneumatic relay valves.

The pneumatic braking demand is measured by an integrated pressure sensor at port 4 and, when connected to an EBS controlled towing vehicle via the ISO 11992 (CAN) interface, supplies an electronic braking demand signal. Axle/bogie load is determined from the air spring pressure at port 42 and is measured by the internal pressure sensor. Pressure to the brake actuators is determined from the following:

- Braking demand value (pneumatic or CAN)
- The current load of the trailer axle/bogie
- Brake control parameters determined from a brake calculation.

Signals from up to 4 wheel speed sensors provide information which is then used by the ABS function. This modulates the pressure at the brake actuators in the event that the generated braking force exceeds the maximum that can be transmitted to the road without wheel lock – see section 3.2.

A 5<sup>th</sup> pressure sensor records the pressure available in the trailer brake reservoir and, in the event of low pressure (< 4.5 bar), generates a yellow warning signal via pin 5 of the ISO 7638 connector and transmits a red warning request signal via the ISO 11992 data communications.

The TEBS G2 brake module includes the option to program auxiliary functions such as lift axle(s) control, speed-dependent reset of the raise/lower valve(s) as well as other – see section 4.16.

As a backup, in the event of a failure or disconnection of the ISO 7638 power supply, it is possible to connect to the stop lamp supply available from the ISO 1185 connector. Therefore when the brakes are applied in the towing vehicle, and the stop lamps are subsequently illuminated, power is taken from this source to power the TEBS G2 brake module. However due to the power limitations of the ISO 1185 supply it is only possible to provide load sensing and ABS functions. The control of all auxiliary systems will be suspended until power is once again available from the ISO 7638 connector. This backup mode ensures the safe operation of the trailer until the cause of the ISO 7638 power failure can be determined and rectified.

Configuration and diagnostics is realised by use of the Knorr-Bremse diagnostics program ECUtalk® for TEBS G2 that communicates with the TEBS G2 trailer brake module using UDS (ISO 14229) protocol. Diagnostic connections can be made via either the ISO 7638 connection using pins 6 and 7 or via the TI CAN connection at the TEBS G2 brake module.

In Figure 31, 4 port connections can be seen at the upper part of the aluminium housing. These connect directly to the spring brakes and via port 12 to the park/shunt valve. Within the TEBS G2 brake module, an anti-compounding valve prevents over stressing the brakes should the service brakes and spring brakes be applied simultaneously.

## 5.2 Other control valves within the trailer braking system

### 5.2.1 Park/shunt valve with integrated automatic brake (AE4311)



**Figure 32:** Illustration of the AE4311 park/shunt valve with integrated charging valve

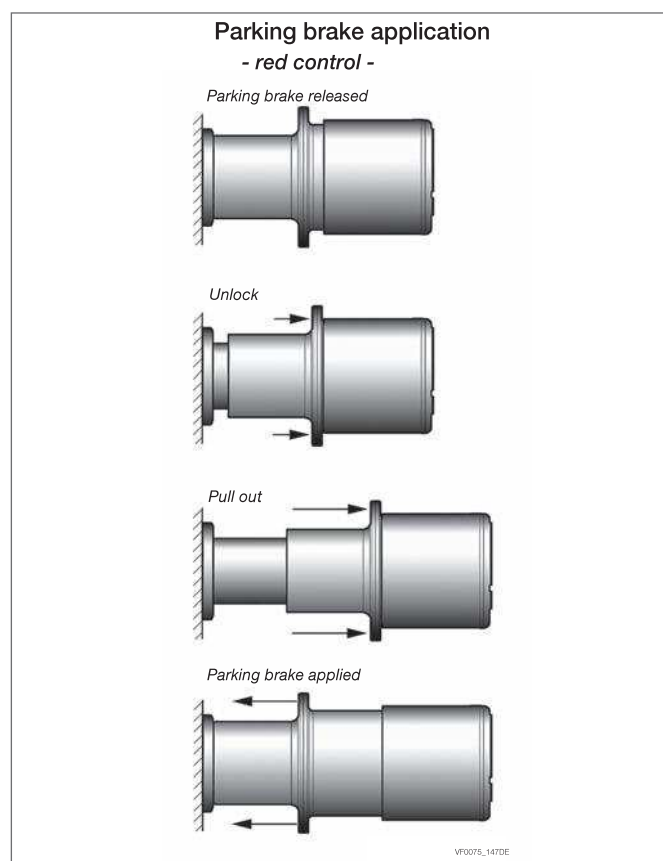
Prior to the introduction of TEBS the standard method of fulfilling the automatic braking requirements in the event of a supply line failure, or the trailer being uncoupled, was to automatically apply the trailer's service brakes via the relay emergency valve (REV) – see Figure 35. While TEBS and also TEBS G2 brake modules may be used in conjunction with this valve, the preferred option is to fulfil the automatic braking requirement by controlling the pressure to the spring brakes via the park/shunt valve (Knorr-Bremse number AE4311) which includes the follow functionality:

- Automatic application of the spring brakes in the event of a failure in the supply line or the trailer is uncoupled.
- Priority charging of the service brake reservoir before starting to pressurise the spring brakes.
- Integrated charging valve to control the pressure to/from the auxiliary supply circuit (air suspension). This ensures the braking system is protected in the event of a failure in the auxiliary equipment.
- Manual control of the parking brake (red control).
- Manoeuvring (shunt) function for use when the trailer is uncoupled (black control).

Operation of the manoeuvring control (black) is limited to when the trailer is uncoupled and there is a need to release

the parking brake to “manoeuvre” the trailer without connecting the supply line. Pushing in the black control diverts air from the trailer braking reservoir to the spring brakes which are subsequently released. Manual pulling out of the control will reapply the parking brake. Additionally when the supply line is reconnected, and pressurised, the manoeuvring control will automatically return to the ‘out’ position to apply the spring brakes - only if park valve control (red knob) is pulled out.

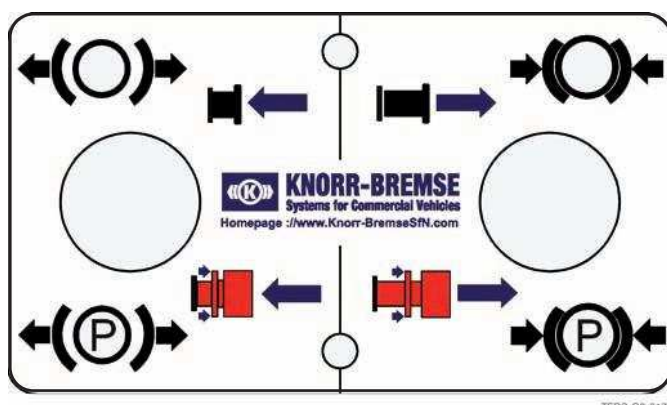
The parking control (red knob) has the function to manually apply and release the spring brakes although release of the spring brakes is not possible by this control once the trailer has been uncoupled. As a safety feature to prevent the parking brake control from being inadvertently released, a locking mechanism for the control is used – see Figure 33.



**Figure 33:** Locking mechanism of the parking brake control

For the trailer itself a label is available which is located by the mounting screws of the park/shunt valve to provide the driver/operator with information on the operation of the two controls – see Figure 34.





**Figure 34:** Information plate for the Park/Shunt valve AE431x

There are several advantages in utilising the spring brakes to fulfil the automatic braking requirements:

- When the trailer is uncoupled the trailer is always braked by mechanical means (spring brakes) therefore any reduction in the trailer reservoir supply pressure does not impact on the braking forces. Note, this is not always the case when a conventional relay emergency valve is used.
- When the spring brakes are applied, the only element of the trailer braking system that is pressurised is the braking system supply reservoir. This means that the potential for air leakage is greatly reduced.

**Note:**

Utilising the spring brakes to fulfil the automatic braking requirements does not remove the obligation for the driver/operator to ensure the trailer is correctly parked by checking that the park brake control (red knob) is in the 'park' position.

### 5.2.2 Relay emergency valve AS3... with combined manoeuvring valve AE424..



**Figure 35:** Illustration of a relay emergency valve (AS3150A) with release valve

It is still possible to utilise a conventional relay emergency valve in conjunction with the TEBS G2 brake module and a standard park/shunt valve (without emergency function). However a limitation exists that it is not permitted to use a relay emergency valve which includes the option of predominance, fixed or adjustable. The recommended Knorr-Bremse type numbers are therefore AS3150A and AS3050A. This is necessary on vehicles without spring brake actuator to ensure the "tear off / emergency function" in the common way.

When such an installation is used it is necessary to take account of the threshold of the relay emergency valve when configuring the TEBS G2 brake module. If, as an example, it is required for the onset of braking to commence at 0.8 bar then it would be necessary to define a different onset pressures for the CAN braking demand and the pneumatic braking demand. In this case the CAN demand would have an onset pressure of 0.8 bar and the pneumatic demand an onset pressure of 0.6 bar.

### 5.2.3 Lift axle control valve AE1141

Figure 36 illustrates two variants of the lift axle control valve that may be used in conjunction with the TEBS G2 brake module, one being controlled by an electrical signal to switch the valve's solenoid and the other by a pneumatic control signal directly from port P<sub>28</sub>.



**Figure 36:** Electrical / pneumatic lift axle valve AE1141.

Due to the legislative requirement that a lifted axle must automatically lower to prevent adjacent axles from being overloaded, all lift axle control systems are automatically controlled with respect to axle/bogie load. The common practice is to utilise single circuit pressure control to the lift axle(s) as this is the most cost effective option. In this case only one lift axle control valve is required and that valve may directly control one or two lift axles. To ensure that single circuit lift axle control does not prejudice trailer stability, intensive tests have been carried out with particular emphasis on vehicle behaviour when moving in a curve. The results of these tests are documented in TÜV report AL 232.OE, 112IR03001\_01 and DEKRA report 200208105. However, should a two circuit lift axle control be required, for example on tipping trailers having two raise/lower valves that independently control left and right suspension circuits, it is possible to use two lift axle control valves both of which can be connected to one AUXIO output using a 'Y' cable (part number K002285) or to P<sub>28</sub> via a 'T' piece.

When lift axle control is available, various options within the TEBS G2 brake module are available to enable the driver/operator to over-ride the automatic lift axle control function to realise certain operation requirements as follows:

- Traction Help (TH)
- Lower Lift axle (LL)
- Manoeuvring Help (MH)
- ADL options

Should any of these functions be required, the TEBS G2 brake module can be configured accordingly. This is described in more detail in section 4.16.

### 5.2.4 Raise/lower valve

Raise/lower valves are used to over-ride the automatic suspension height control of the levelling valve and feature 4 operating positions, 'Drive', 'Raise', 'Lower' and 'Stop'. The valves are generally used to adjust the height of the trailer platform for docking purposes. Unfortunately, after use, the valve is not always returned by the operator to the 'Drive' position which effectively means that the pressure recorded at port 42 of the TEBS G2 brake module may not be representative of the actual load on the axle/bogie. The result is that a control function within the TEBS G2 brake module that utilises load to determine how the system should react to a braking demand (load sensing function) or potential roll-over (RSP) cannot be guaranteed to be correct. With respect to braking there is a safety feature within the brake control which will always ensure that maximum braking forces can be generated under emergency braking conditions ('Brake Assist' – see section 4.8). RSP however uses load information to determine if there is a need to react to a potential roll-over. Therefore to overcome these limitations it is a Knorr-Bremse recommendation that the raise/lower valve has an integrated reset function to return the operating position of the valve to the 'Drive' position after the vehicle moves away from rest. This function is generally known as 'Reset to Ride' and may be triggered by an electrical or pneumatic signal generated by the TEBS G2 brake module (Speed Pulse – see section 4.16.1)

### 5.3 TIM G2 – Trailer Information Module

The Trailer Information Module G2 (TIM G2) is a display device that combines the functionality of system diagnostics with the ability to display and store other trailer related information of value to an operator, driver or workshop – see Figure 37. Maximum benefit is obtained from the TIM G2 functionality when it is mounted on the trailer so that it is able to record events that occur during driving. Alternatively it is possible to reconfigure a TIM G2 to enable it to be used as a workshop tool to access diagnostic information, check configuration or the operation of auxiliary functions. In both cases the TIM G2 is connected to the 5V TI CAN connection of the In-Out connector which supplies the necessary information.



**Figure 37:** Trailer Information Module (TIM G2)

#### Features:

- Graphical display with back light \*
- Integrated battery \*
- Real time clock \*
- Configurable front screen \*
- Display of bogie load \*, \*\*
- Data logging capability
- “Smart Update” (Patented)
- Integrated language options \*
- Event counters

- System pressure read outs \*
- System configuration information \*
- Diagnostic information \*

#### \* Note:

All of the above features are available when the TIM G2 is permanently installed on the trailer but as a workshop diagnostic tool, only the features defined as \* remain available many of which can be displayed even when the TEBS G2 brake module is not powered.

#### \*\* Note:

The bogie load is calculated from the configured air spring pressures and axle loads and is not calibrated.

#### Tip:

If the trailer is to be used with TIM G2 only as a workshop tool, i.e. TIM G2 not permanently installed, then configure AUXIO 3 as a ‘Power Supply’, and do not configure ‘TIM Connected’ in the diagnostic program ECUtalk® otherwise an error will be detected when the TIM G2 is not connected.

For further information please refer to the TIM G2 product manual Y053530.

### 6.1 General installation guidelines

- The protective covers for the electrical connections of the TEBS G2 brake module must be fitted at any time the vehicle is in use.
- During assembly the ports and electrical connections of the TEBS G2 brake module and cabling shall be protected against ingress of contamination, e.g. sand blasting particles.
- The TEBS G2 modules must never be stored or transported with the exhaust ports pointing upwards.
- If a TEBS G2 module has been damaged in transport or during the assemble process, e.g. dropped on the floor, it shall not, under any circumstances, be assembled to the vehicle.

#### Note:

If at any time the vehicle is to be welded using an electric welding tool the following has to be observed:

- Remove the “Power” and “In-Out” connectors from the module.
- Remove the wheel speed sensor connectors, ensure that when reassembling the sensors they are reconnected to the correct positions. Knorr-Bremse recommends that an End of Line (EOL) test is run using the diagnostic program ECUtalk® following reassembly of the wheel speed sensors to ensure correct fitment.

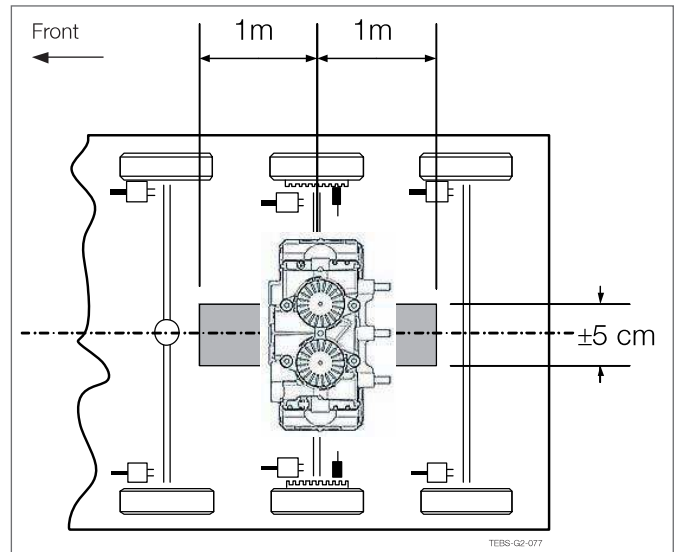
### 6.2 Installation of the TEBS G2 brake module

The following provides a guide to the installation of the TEBS G2 brake module.

In the longitudinal direction, the deviation from centre of the bogie may be a maximum of  $\pm 1\text{m}$  however the maximum permitted tube lengths to the brake actuators must be observed.

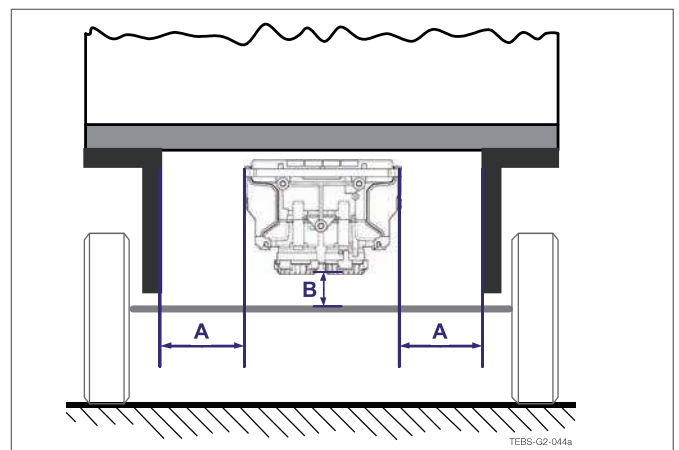
An ideal installation would be where the TEBS G2 brake module is laterally positioned within 5cm of the centre of the trailer – see Figure 38, this would result in the respective tube lengths being approximately equal for each axle. However it is possible to mount the TEBS G2 brake module in other positions dependent on the design of the trailer and space

available. If Roll Stability Program (RSP) is configured, special restrictions apply and any lateral offset must be configured by the use of the diagnostic program ECUtalk® otherwise the lateral acceleration information generated by the internal sensor may be incorrect impacting on the RSP performance.



**Figure 38:** Mounting position of the TEBS G2 brake module

During installation, consideration must be given to being able to access the left and right electrical connections and a minimum clearance must be observed ( $A > 50\text{mm}$ ) to ensure that covers can be removed. Additionally a clearance ( $B > 25\text{mm}$ ) must be ensured below the exhaust silencers at the base of the valve; this must be checked when the suspension is deflated and on its bump stops – see Figure 39.



**Figure 39:** Mounting position of the TEBS G2 brake module



### 6.3 Tube dimensions

The following table defines the minimum bore of tube used to connect the reservoir to the port 1 and the deliveries from port 21 and 22 to the respective brake actuators.

Tube size			Limitations
<b>Dimensions of connecting tubes between the pressure modulators and brake chambers</b>			
Plastic tube	Minimum inside diameter	9 mm	May be increased
Rubber hose	Minimum inside diameter	11 mm	May be increased
<b>Dimensions of connecting tubes between the air reservoir and pressure modulators</b>			
Plastic tube	Minimum inside diameter	12 mm	May be increased

The maximum permitted tube length between the TEBS G2 brake module and the brake actuators is 5m.

Utilising the tube sizes and lengths does not guarantee that the prescribed braking system response time can be fulfilled. Therefore installation of the braking system will need to be optimised to meet the prescribed requirements.

### 6.4 Securing the TEBS G2 brake module

To aid installation, the TEBS G2 brake module has three M10 mounting studs on the rear face - the centre distance of which are the same as those for the current TEBS – see Figure 40. The recommended tightening torque of the nuts is  $40 \pm 5$  Nm.

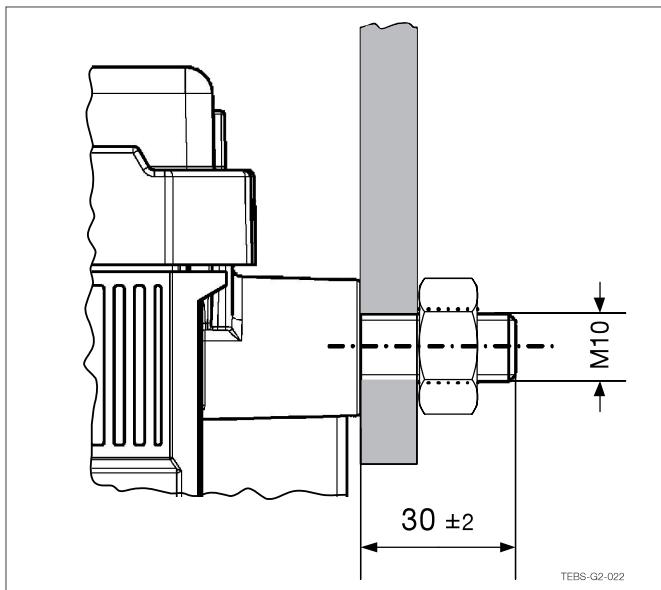


Figure 40: Attachment of the TEBS G2 brake module

### 6.5 Special requirements for Roll Stability Program (RSP) and Tilt Angle (TA) installations

When RSP or TA is configured it is important that 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 roll angle which must be kept within  $\pm 5^\circ$  – see Figure 41 below. Note that this value is checked during the EOL test.

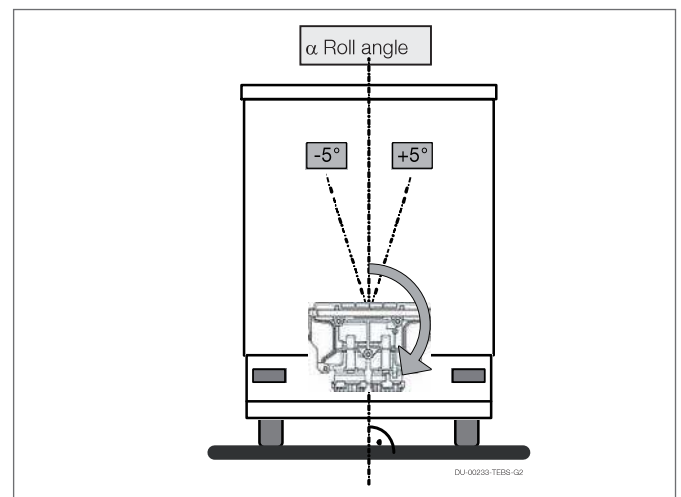
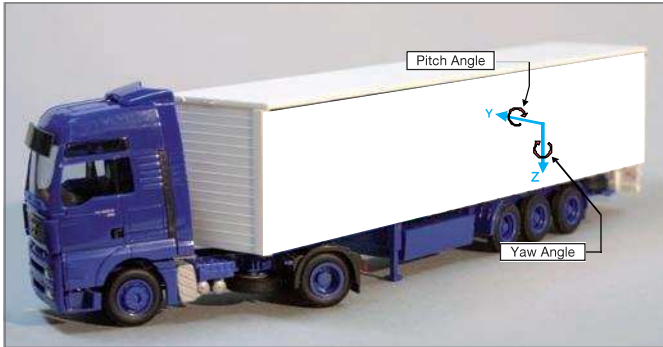


Figure 41: Roll angle installation limitation

In the other planes of yaw and longitudinal pitch the installation tolerance is  $\pm 10^\circ$  – see Figure 42.



**Figure 42:** Yaw and Pitch angle installation limitations

The yaw and pitch angles cannot be checked during EOL testing therefore the installer must ensure that the defined installation limits are not exceeded.

If the RSP is to be configured for use on a trailer a number of restrictions apply as follows:

- Any lift axle must be controlled by the TEBS G2 brake module. External lift axle control is NOT permitted.
- 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.

## 6.6 Wiring diagrams

The TEBS G2 brake module has a total of 6 electrical connections:

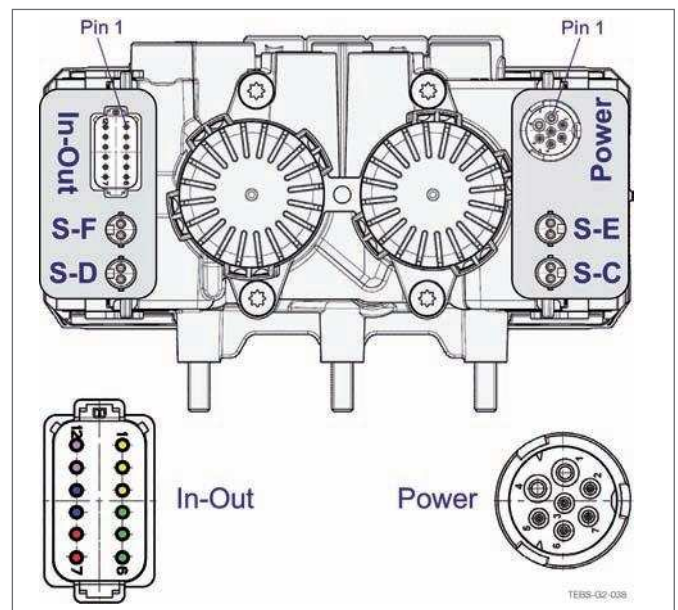
**Sensors S-C and S-D:** Wheel speed inputs for 2S/2M and 4S/2M configurations.

**Sensors S-E and S-F:** Wheel speed inputs for 4S/2M configurations or auxiliary sensor inputs for 2S/2M configurations.

**Power connector:** 7 pin connection which provides power, failure warning and CAN communications via ISO 7638 connector.

**In-Out connector:** Auxiliary inputs and outputs.

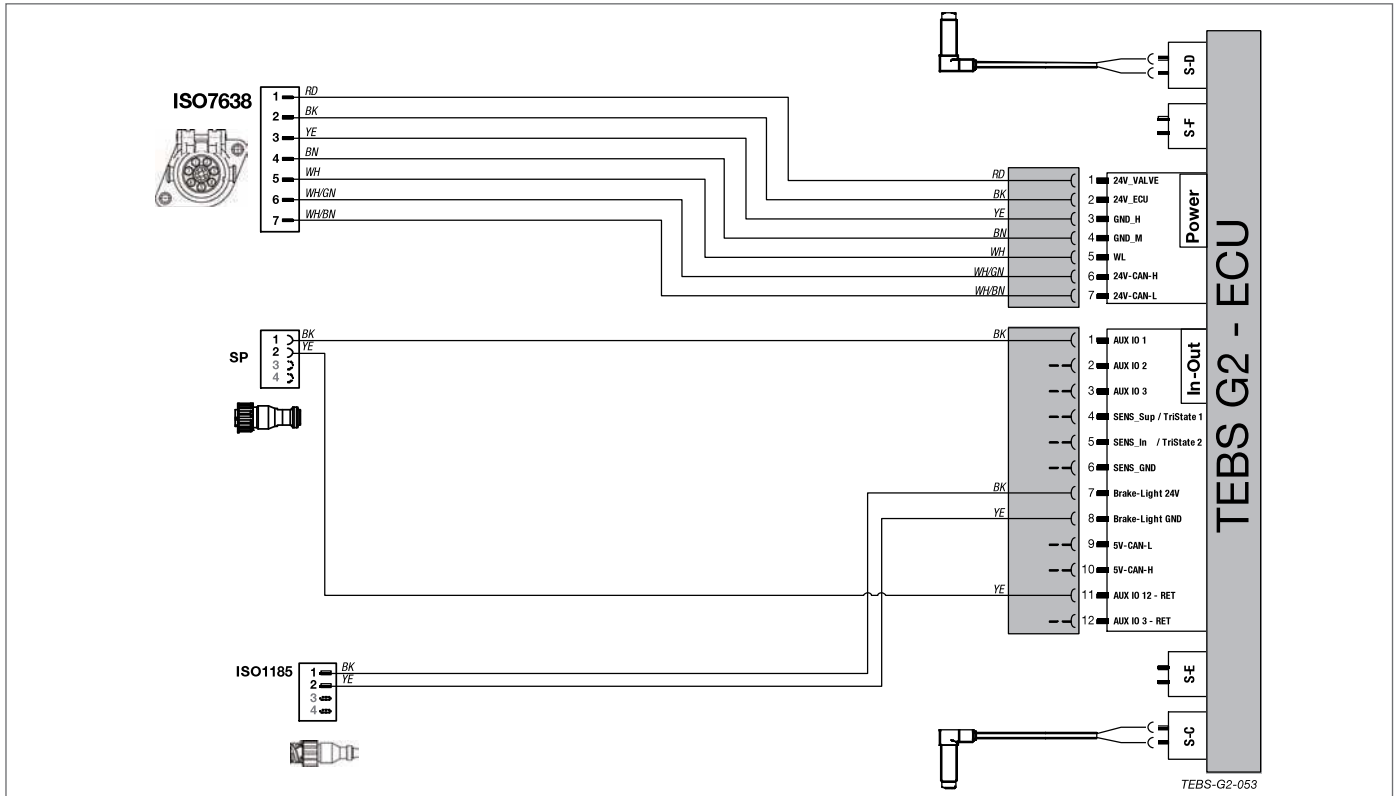
See Figure 43.



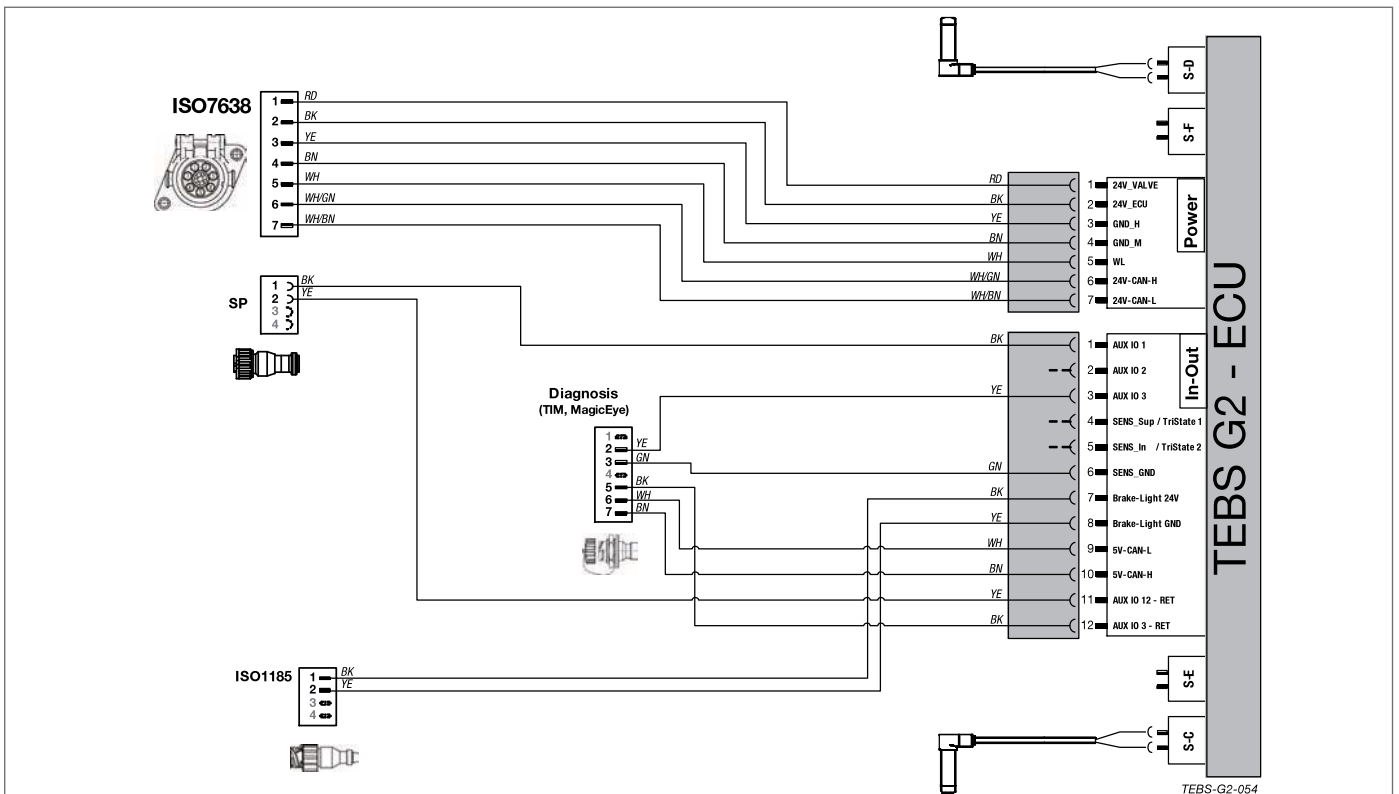
**Figure 43:** TEBS G2 brake module electrical connections



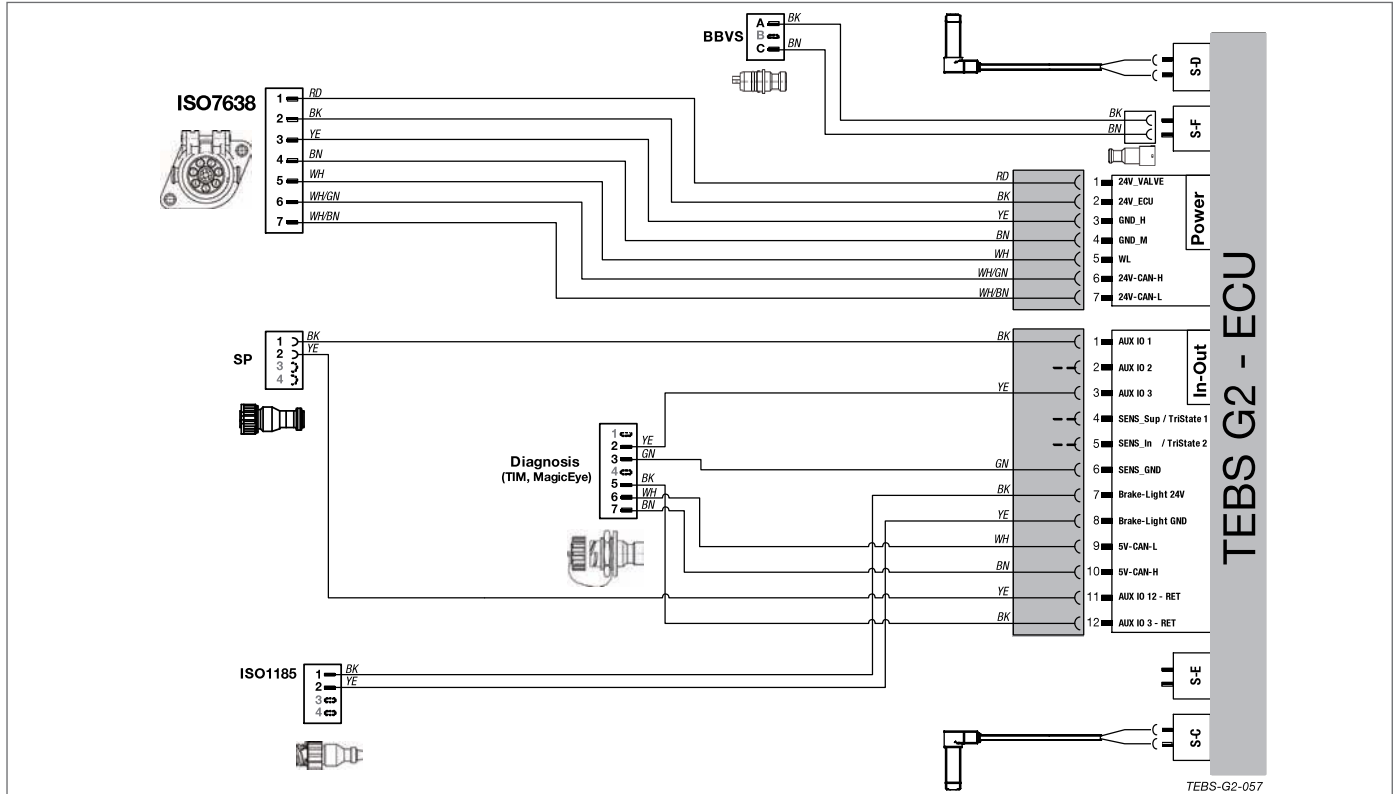
One electrical output (SP) and ISO 1185 stop lamp power (Example for 24 V system)



One auxiliary output (SP), diagnostics (TIM, Magic Eye) and ISO 1185 stop lamp power (Example for 24 V system)



One auxiliary output (SP), diagnostics (TIM G2 or Magic Eye), brake wear monitoring and ISO 1185 stop lamp powering

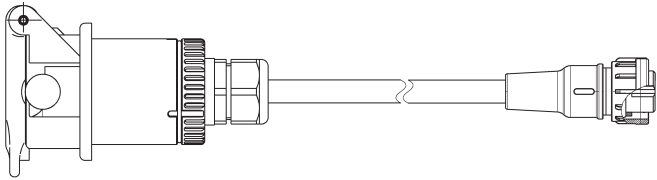
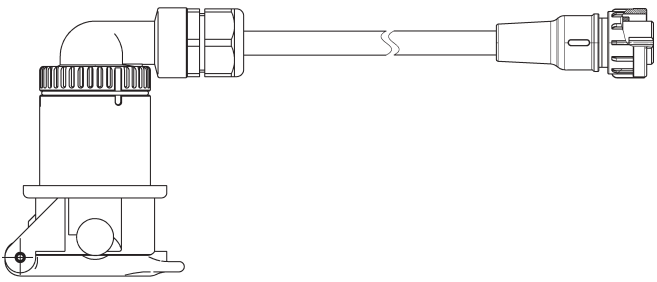
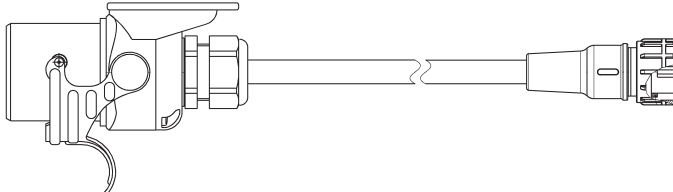
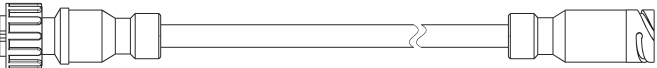



## 6.7 Cabling

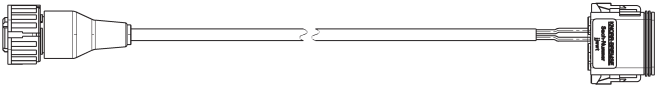
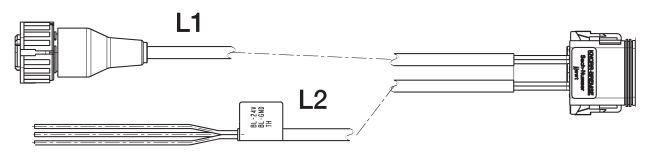
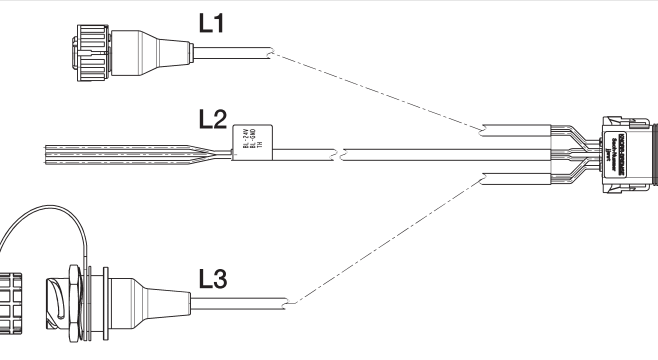
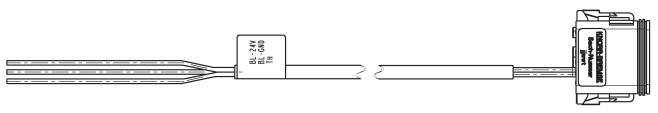
### 6.7.1 Cable options

The tables below list the common cable options, further cable options / assemblies may be available, please contact your local Knorr-Bremse representative, or refer to the Knorr-Bremse trailer catalogue for details.

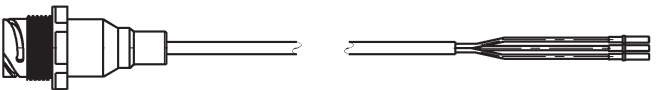
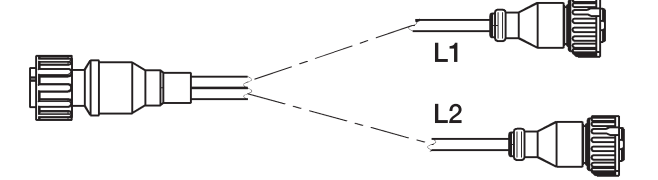
#### Power cables

	Part Number	Length (m)	Description	Figure
1	K008430 K008431	10 13	Power supply cable for semi-trailers	
2	K008432	16	Power supply cable for semi-trailers - 90° connector	
3	K010710 K010711	10 13	Power supply cable for centre-axle trailers	
4	K021138	4	Power supply extension cable	
5	K010718	0.5	Power supply adapter cable	

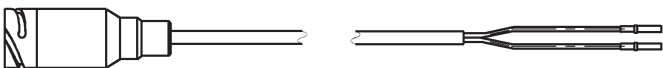
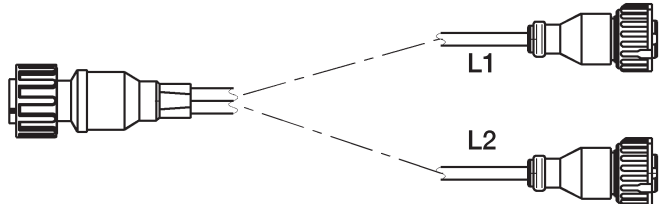
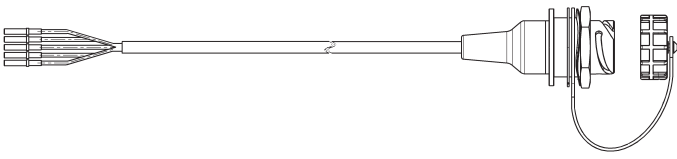
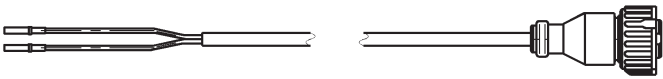
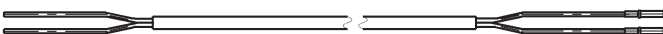




## In-Out cables

	Part Number	Length (m)	Description	Figure
1	K021335	6.5	In-Out cable for AUX function (2-pin)	
2	K021336	6.5 (L1) 7 (L2)	In-Out cable for AUX function (2-pin), stop lamp and 'Traction Help' with open ends (3-pin)	
3	K021340	6.5 (L1) 7 (L2) 6 (L3)	In-Out cable for AUX function (2-pin), stop lamp and 'Traction Help' with open ends (3-pin), diagnostic (5-pin)	
4	K021345	7	In-Out cable for stop lamp and traction help with open ends (3-pin)	

## In-Out modular cables

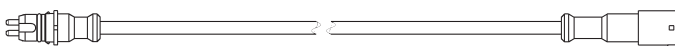
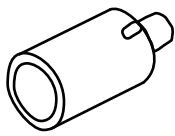
	Part Number	Length (m)	Description	Figure
1a	K002270 <sup>1)</sup> K002271 <sup>1)</sup>	2 6	Magic Eye-Connection or "Bayonet Splitter" (3-pin); Application: e.g. Splitting of a ground pin for two auxiliary functions	
1b	K002284	4 (L1) 2 (L2)	Connection cable for AUXIO 1+2	

<sup>1)</sup> A mounting kit (Part No: K005378, consisting of a closure cap, a spring ring and a nut) may be used

	Part Number	Length (m)	Description	Figure
2a	K002273	6	"Y-Cable" adaptor (to be used in conjunction with K002285)	
2b	K002285	0.5 (L1) 0.5 (L2)	Connection cable for two valves (Not to be used to connect 2 x SV3801 in parallel)	
3	K010713	6	Diagnostics cable (5-pin)	
4	K002274 K002275 K002276 K017003	2 6.5 10 15	Connection cable for AUX functions (2-pin)	
5	K002280 K002281	7 15	Stop lamp cable with open ends (2-pin)	
6	K021643 K021644	7 15	Stop lamp cable and 'Traction Help' with open ends (3-pin)	
7	K010715 K010716	1 7	Stop lamp cable and 'Traction Help' (3-pin)	
8	K002287N00		Parts kit for In-Out connector	
9	K026197		Closing plug for In-Out connector	

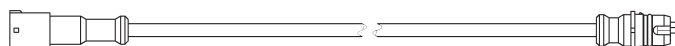
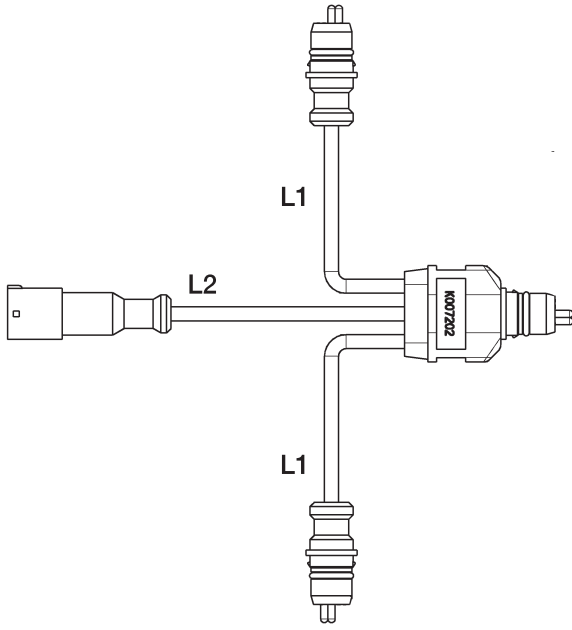


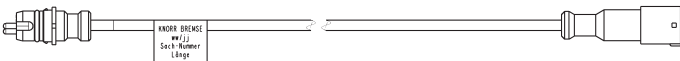
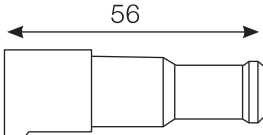
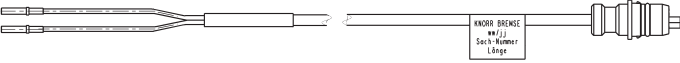
## Wheel-speed sensing cables

	Part Number	Length (m)	Description	Figure
1	II367562000 II367563000 II367564000 II367566000 II367568000 II3675610000 II3675615000	2 3 4 6 8 10 15	Wheel speed sensor extension cable (EK3130)	
2	K022848	---	Closing Cap <sup>2)</sup>	

<sup>2)</sup> EBS-module will be delivered with closing caps at the sensor-connections "S-E" and „S-F“

## Lining-wear sensing cables

	Part Number	Length (m)	Description	Figure
1	K019786	1	Lining wear connection	
2	K007202	2 (L1) 2 (L2)	Axle module; Application: Connection brake pad wear sensor	

	Part Number	Length (m)	Description	Figure
3	K007217 K007218 K007219	1 3 5	Extension cable; Application: Extension between the axle modules or between axle module and wear sensor	
4	K003848	---	End connector; Application: Contact bridge	
5	K007205	1	Connecting cable	

#### Necessary diagnostic hardware

	Part Number	Description
1	II39809F	UDIF
2	II39808F	24V CAN Adapter
3	K028584	12V CAN Adapter
4	II39812F	Diagnostic Cable for 24V CAN
5	K010837	Diagnostic Cable for 5V CAN
6	Z007887	USB Adapter Cable
7	K010714	5-pin Diagnostic Extension Cable 11m

### 6.7.2 Installation

#### General cabling guidelines

The power supply and wheel speed sensor cables should be installed separately avoiding parallel cable runs in all cases; the minimum separation should be 5 cm.

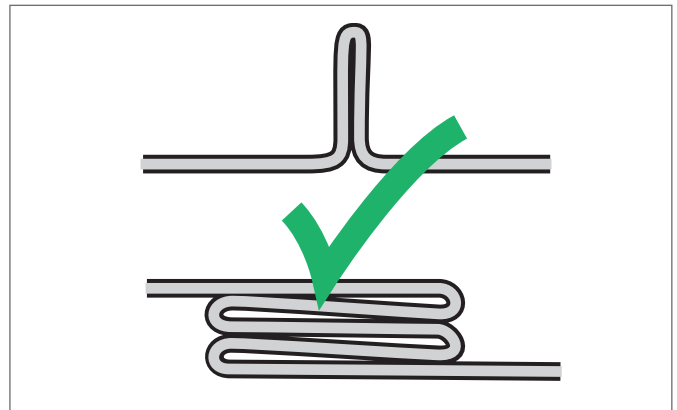
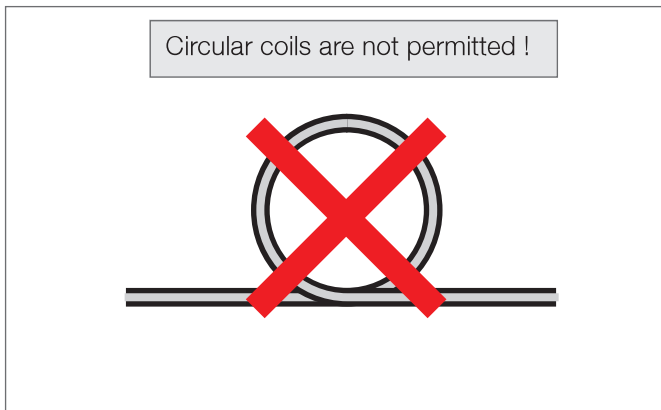
Cables must be protected against damage, especially when passing through holes in the chassis or bodywork.

Should a cable be too long the excess may be 'lost' by wrapping the cable as defined below:

All cables must be secured in such way as to allow freedom of movement - particularly those connected to the axles, i.e. wheel speed sensor and pad wear cables.

Other than the case defined above, the arc through which a cable should follow must not exceed 90° with the following bend radii being maintained:

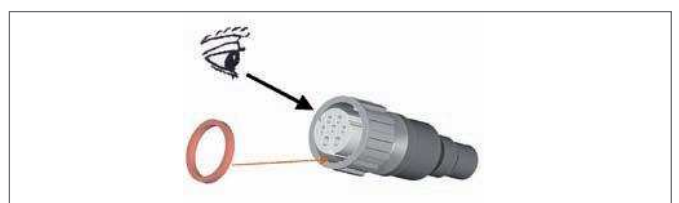
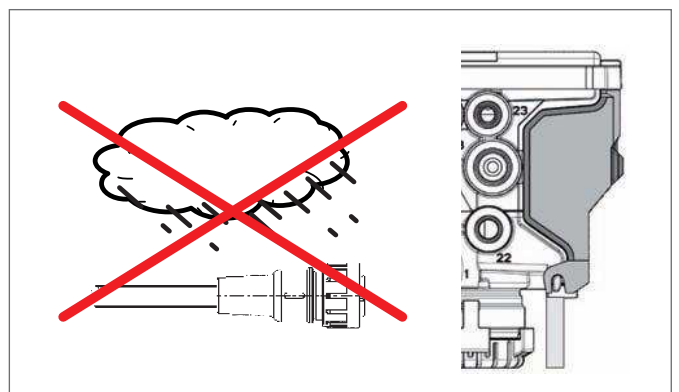
- Power supply cable: min. R 80 mm
- In-Out cables: min. R 50 mm
- Wheel-speed sensor cable: min. R 50 mm



#### Assembly / disassembly of the power cable

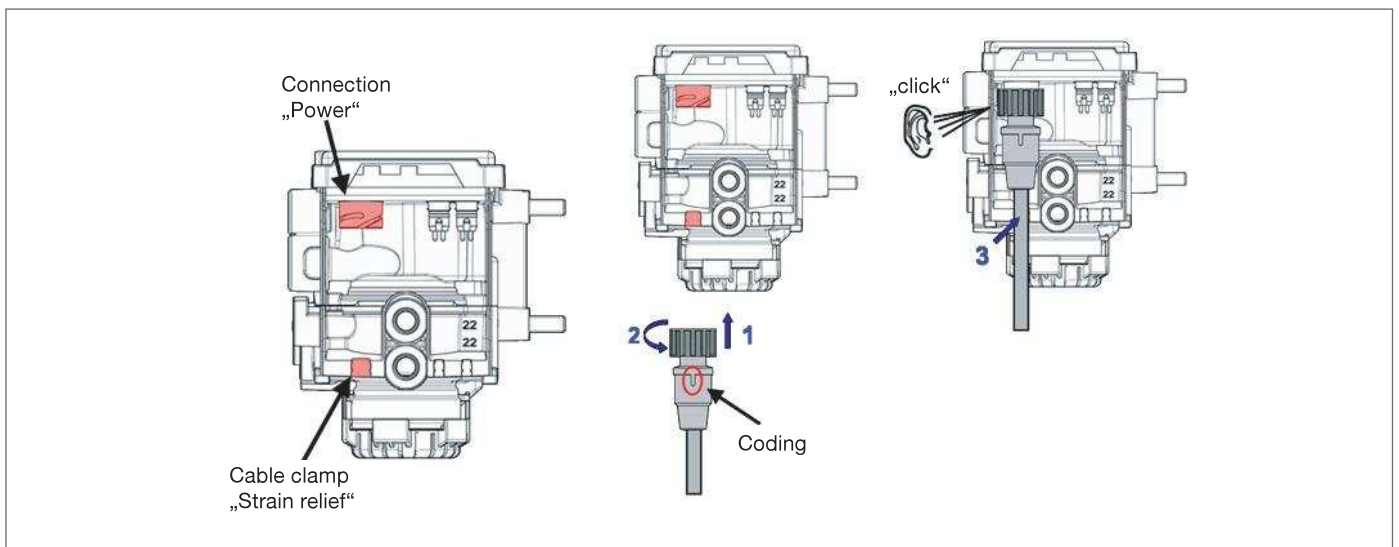
To avoid stress fractures, leakage and corroded contacts in the power cable the following issues have to be considered:

- The assembled connectors shall be protected against exposure to direct environmental influences such as water, snow, dust etc. - this is achieved by ensuring the covers are fitted.
- The gasket must be present in the bayonet connector and needs to be checked for visible signs of damage.



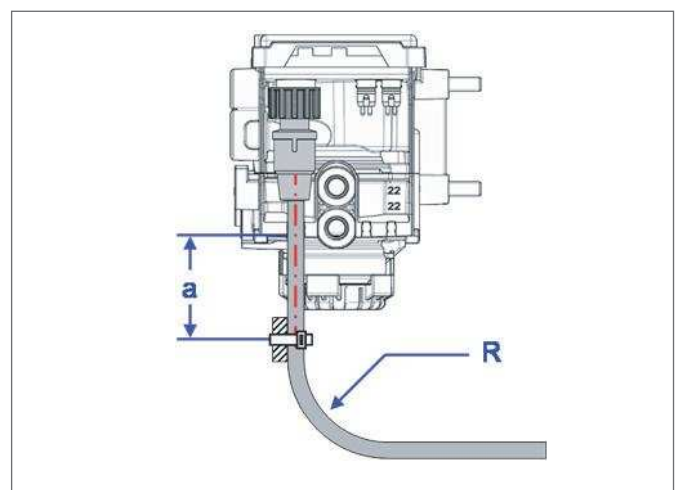
### Assembly of the power cable to the TEBS G2 brake module

- Familiarise yourself with the bayonet connector, there is an indication mark to aid orientation.
- Align the cable to the connector, and push it in as far as it will go (1), do not tilt it.
- Turn the locking nut (2) until a positive stop is felt, and an audible “click” is heard.
- Press the cable firmly into the strain relief (3).



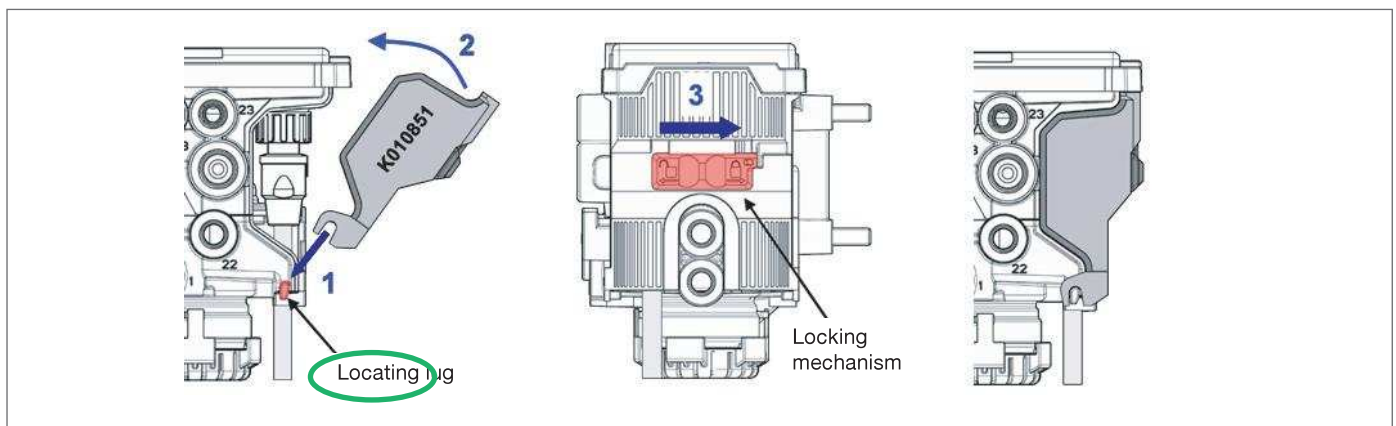
### Cable fixation and routing

- The power cable has to be fixed to a suitable fixation point on the chassis in the range 80 to 120 mm (a) of the cable exit from the bottom of the TEBS G2 brake module.
- The cable shall run vertically from the TEBS G2 brake module until the first fixation point (indicated by the red dashed line).
- After the fixation point, routing of the cable can be as required, however the minimum bend radius (R) of 80 mm must be observed.



### Assembly of the cover

- Tilt the cover and locate the bottom on to mounting lugs on the brake module (1).
- Push the top of the cover towards the brake module (2).
- Slide the locking mechanism to the right (3).



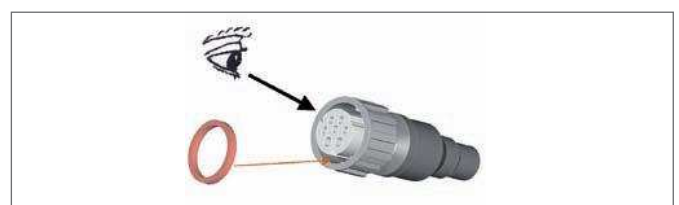
### Disassembly of the cover and cable

- Remove the cable fixation near the brake module.
- Unlock the cover, by sliding the locking mechanism to the left, and remove.
- Rotate the locking nut on the bayonet connector until it is loose.
- Grasp the bayonet connector (not the cable) and pull vertically downwards.

### Assembly / Disassembly of the power-extension cable

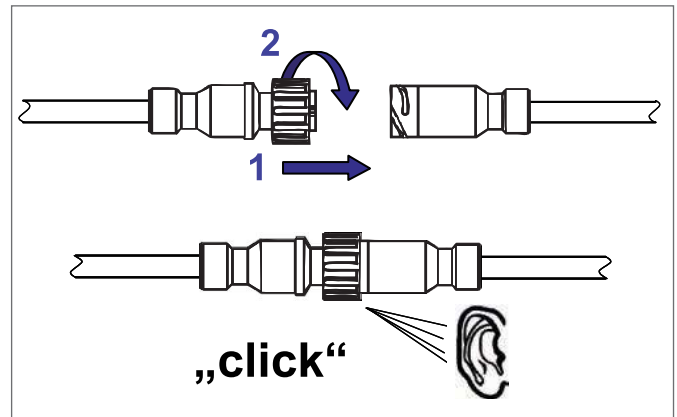
To avoid stress fractures, leakage and corroded contacts in the power extension cable the following issues have to be considered:

- Any non assembled connectors shall be protected against exposure to direct environmental influences such as water, snow, dust, etc.
- The gasket must be present in the bayonet connector and should be checked for visible signs of damage.





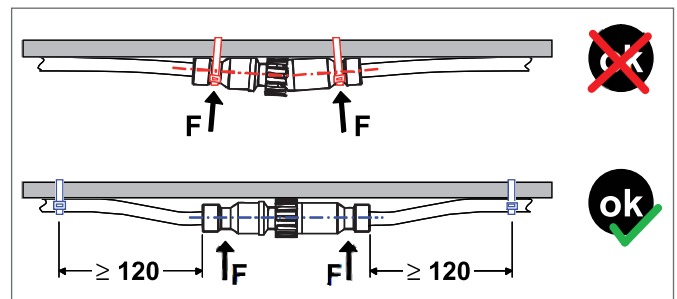
- Push the female connector into the male connector as far as it will go (1), do not tilt it.
- Turn the locking nut (2) until a positive stop is felt, and an audible “click” is heard.



- The bayonet connection must be securely fixed, without tension, using cable straps ensuring that there are no bending forces created.
- Use as large a radius as possible during the laying of cables.

Refer to the power cable section for:

- The assembly of the cable to the TEBS G2 brake module
- The cable fixation and routing
- Cover assembly and disassembly options

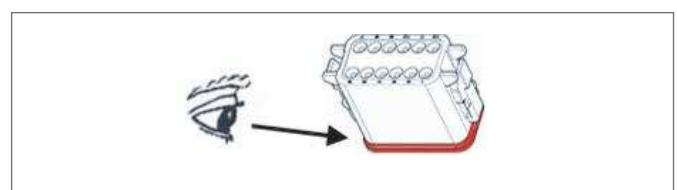
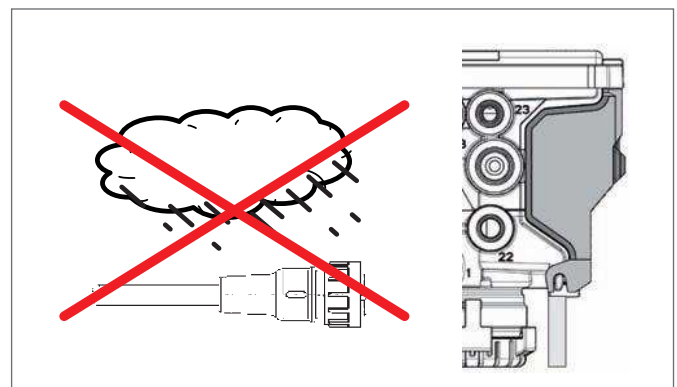


### Assembly / disassembly of the In-Out cables

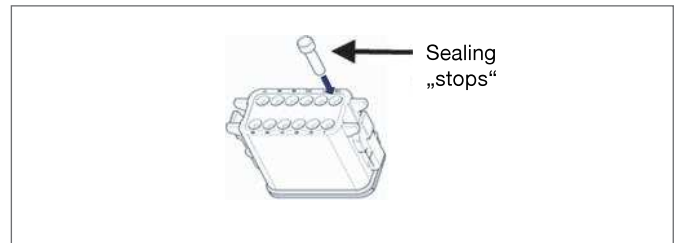
Due to the various cabling options of the In-Out connector, the following shall be considered as an example only – you should adapt the instructions to suit your specific cabling situation.

To avoid stress fractures, leakage and corroded contacts in the In-Out connector/cable the following issues have to be considered:

- In all cases the In-Out socket must be protected against water ingress and contamination. This is either achieved by the use of an In-Out plug and cable assembly or by the fitment of the closing plug K026197.
- The assembled connectors shall be protected against exposure to direct environmental influences such as water, snow, dust etc. - this is achieved by ensuring the covers are fitted.

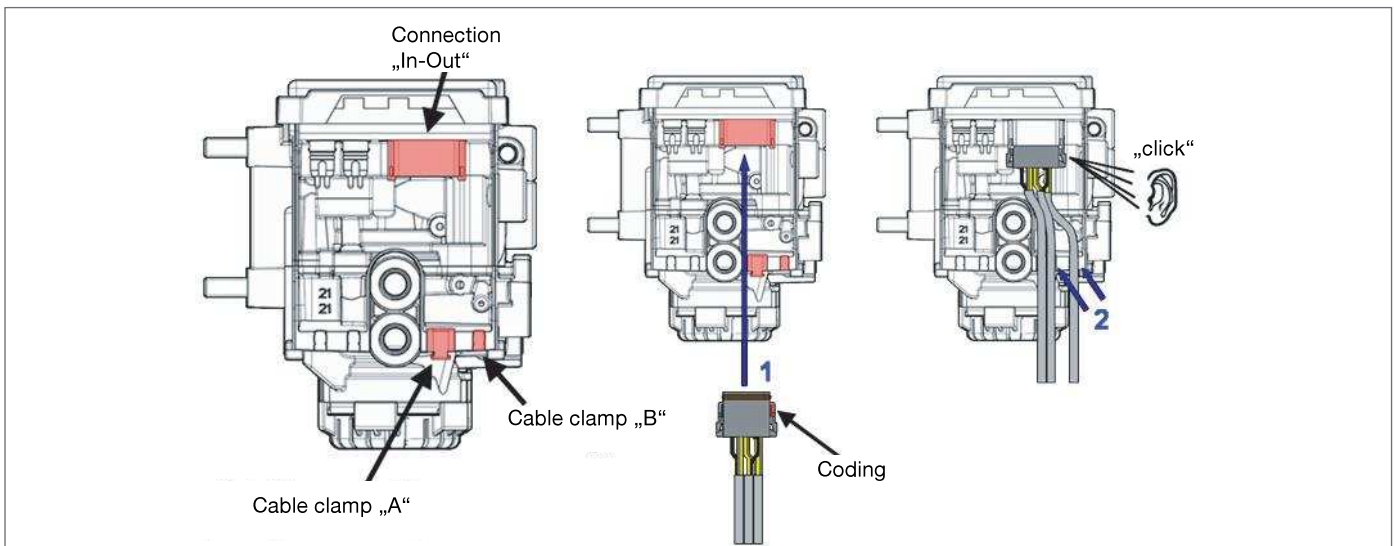


- The gasket must be present on the connector, and needs to be checked for visible signs of damage.
- Any unused cable entries shall be closed using the supplied sealing "stops".



#### Assembly of the In-Out cable to the TEBS G2 brake module

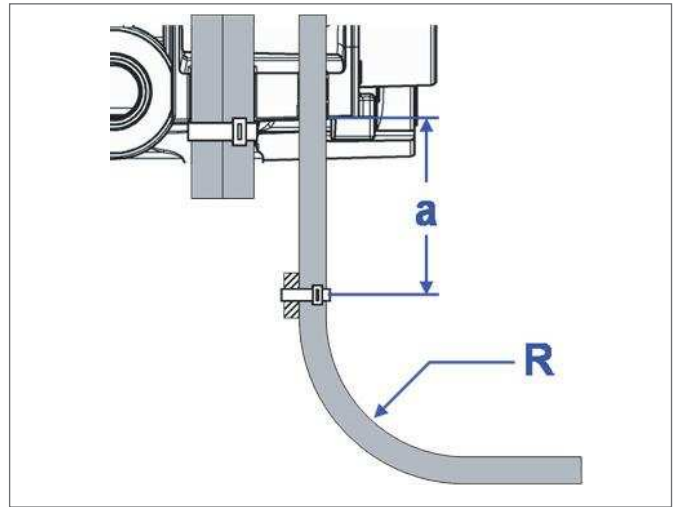
- Familiarise yourself with the In-Out connector, there is a coding key which needs to be orientated to the front (long face without studs) of the TEBS G2 brake module.
- Align the cable to the connector, and push it in as far as it will go (1), audible "click" is heard, do not tilt it.
- Press the cable(s) firmly into the strain relief slots (2). There are two slots, the first (A) provides space for four cables which have to be secured using a suitable cable tie. The second (B) is suitable for a single cable.



### Cable fixation and routing

- The In-Out cable(s) has to be fixed to a suitable fixation point on the chassis in the range 80 to 120 mm (a) of the cable exit from the bottom of the TEBS G2 brake module.
- The cable shall run vertically from the brake module until the first fixation point.
- After the fixation point, routing of the cable can be as required, however the minimum bend radius (R) of 50 mm must be observed.

Refer to the power cable section for cover assembly and disassembly options.



### Assembly / disassembly of the wheel speed sensor cables

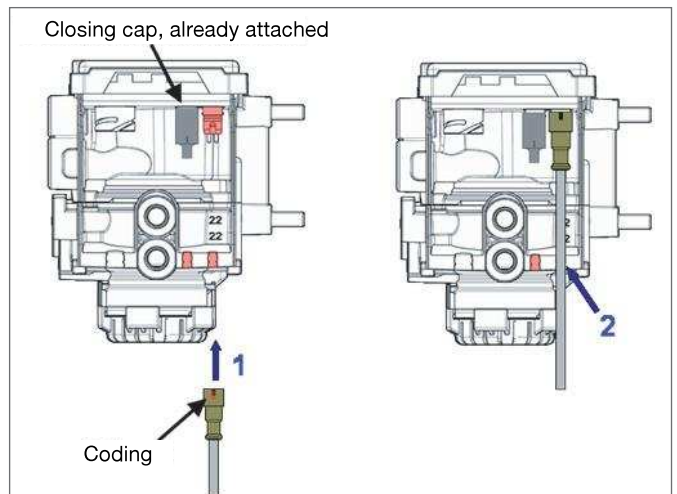
#### 2S/2M Systems:

- The unused wheel speed sensor connections “S-E” and “S-F” shall be protected against water ingress and contamination by the fitment of a closing cap, part number K022848.



### Assembly of the wheel speed sensor cable to the TEBS G2 brake module <sup>1)</sup>

- Familiarise yourself with the wheel speed connector, there is a coding key which needs to be orientated to the side of the TEBS G2 brake module.
- Align the cable to the connector, and push it in as far as it will go. The top of the connector shall be above the “O” ring seals (1).
- Press the cable firmly into the strain relief slot.

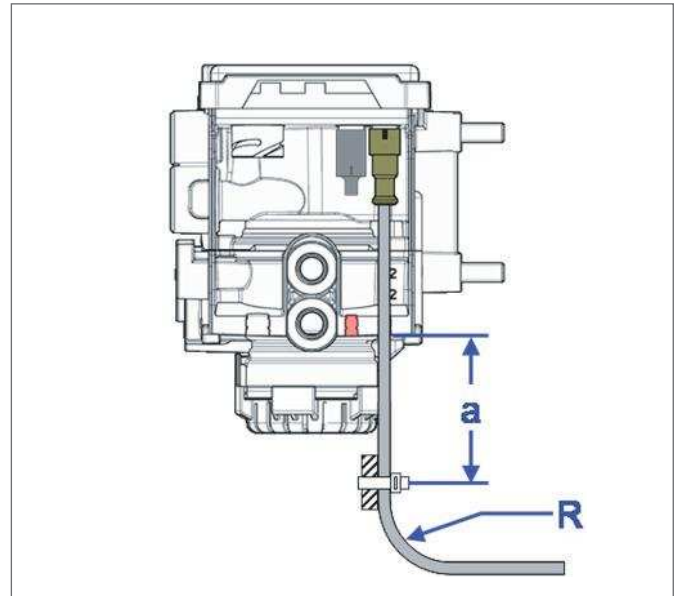


<sup>1)</sup> The description of the wheel speed sensor cable assembly also applies for the lining wear connection cable (K019786).

### Cable fixation and routing<sup>1)</sup>

- The wheel speed sensor cables have to be fixed to a suitable fixation point on the chassis in the range 80 to 120 mm (a) of the cable exit from the bottom of the TEBS G2 brake module.
- The cable shall run vertically from the brake module until the first fixation point.
- After the fixation point, routing of the cable can be as required, however the minimum bend radius (R) of 50 mm must be observed.

Refer to the power cable section for cover assembly and disassembly options.



## 6.8 TEBS G2 brake module parameterisation

Before a trailer can be used on the road its braking performance must have been verified by a Technical Service and type approved. Part of this process is the requirement to fulfil the prescribed compatibility requirements which means a number of braking parameters must be specified. This is normally realised by means of a brake calculation taking into account the physical characteristics of the trailer and the recorded performance of braking components defining the respective brake chamber pressures to fulfil laden and unladen requirements. For the TEBS G2 equipped trailer this would be carried out using the Knorr-Bremse brake calculation program BSD which has been specifically developed for this purpose. The main parameters which control the braking performance of the trailer are:

- Laden and unladen air spring pressures
- Laden and unladen axle loads
- Dynamic tyre size
- Coupling head pressure when braking should commence.
- In-shot pressure generated when braking should commence.

- Laden and unladen brake actuator delivery pressures for a control line pressure of 6.5 bar.

The diagnostic program ECUTalk® is the primary means by which the parameters can be written to the TEBS G2 brake module. This can be realised by either entering individual parameters into the required fields or by reading the parameter values from a file produced by the brake calculation program BSD; the latter option being more reliable as the possibility of error has been removed. When a TEBS G2 module is produced, default parameters are defined so that, in the event that a trailer is inadvertently not parameterised, a level of braking performance will always be available. When a data set of parameters is written to the TEBS G2 brake module the operators PIN will also be written and stored as a finger print to who carried out the parameterisation.

Knorr-Bremse makes available four levels of PC Diagnostics as follows:

- Full version for OEMs
- EOL version for OEMs
- Service Plus for workshops
- Service Version for workshops

<sup>1)</sup> The description of the wheel speed sensor cable assembly also applies for the lining wear connection cable (K019786).

## 6.9 Pneumatic connections

To fulfil the requirements of the trailer manufacturer a number of TEBS G2 brake modules are produced each with a different specification of pneumatic port connection, some have only threaded ports to allow any tube size fitting to be used, others with dedicated push-to-connect (PTC) fittings as follows:

Port No.	Qty.	Function	Connection					
			K019300 (OE)	K019302 (OE)	K019309 (AM)	K019340 (OE)	K019342 (OE)	
1	2	Supply	M22 x 1.5	PTC fitting 15 x 1.5	M22 x 1.5	M22 x 1.5	PTC fitting 15 x 1.5	M22 x 1.5
12	1	From park/shunt valve	M22 x 1.5	PTC fitting 12 x 1.5	M22 x 1.5	M22 x 1.5	PTC fitting 12 x 1.5	M22 x 1.5
21	3	Delivery to brake actuators	M16 x 1.5	PTC fitting 12 x 1.5	M16 x 1.5	M16 x 1.5	PTC fitting 12 x 1.5	M16 x 1.5
22	3	Delivery to brake actuators	M16 x 1.5	PTC fitting 12 x 1.5	M16 x 1.5	M16 x 1.5	PTC fitting 12 x 1.5	M16 x 1.5
23	4	To spring brakes	M16 x 1.5	PTC fitting 8 x 1	M16 x 1.5	M16 x 1.5	PTC fitting 8 x 1	M16 x 1.5
4	1	Control line	M16 x 1.5	PTC fitting 8 x 1	M16 x 1.5	M16 x 1.5	PTC fitting 8 x 1	M16 x 1.5
42	1	Air springs	M16 x 1.5	PTC fitting 8 x 1	M16 x 1.5	M16 x 1.5	PTC fitting 8 x 1	M16 x 1.5
28	1	Pneumatic AUX	M16 x 1.5	PTC fitting 8 x 1	M16 x 1.5	N/A	N/A	N/A
28	1	Test point	N/A	N/A	N/A	M16 x 1.5	PTC fitting 8 x 1	M16 x 1.5

The combined park/shunt valve AE431. has the following pneumatic port connections:

Port No.	Qty.	Function	Connections		
			K015849	K015380	K020123
1	1	Supply line	M16 x 1.5	M16 x 1.5	PTC fitting 8 x 1
1-2	1	Brake system reservoir	M16 x 1.5	M16 x 1.5	PTC fitting 8 x 1
2	1	To TEBS G2 module	M22 x 1.5	M22 x 1.5	PTC fitting 12 x 1
21-22	2	Auxiliary reservoir *	N/A	M16 x 1.5	PTC fitting 8 x 1

\* Optional connection



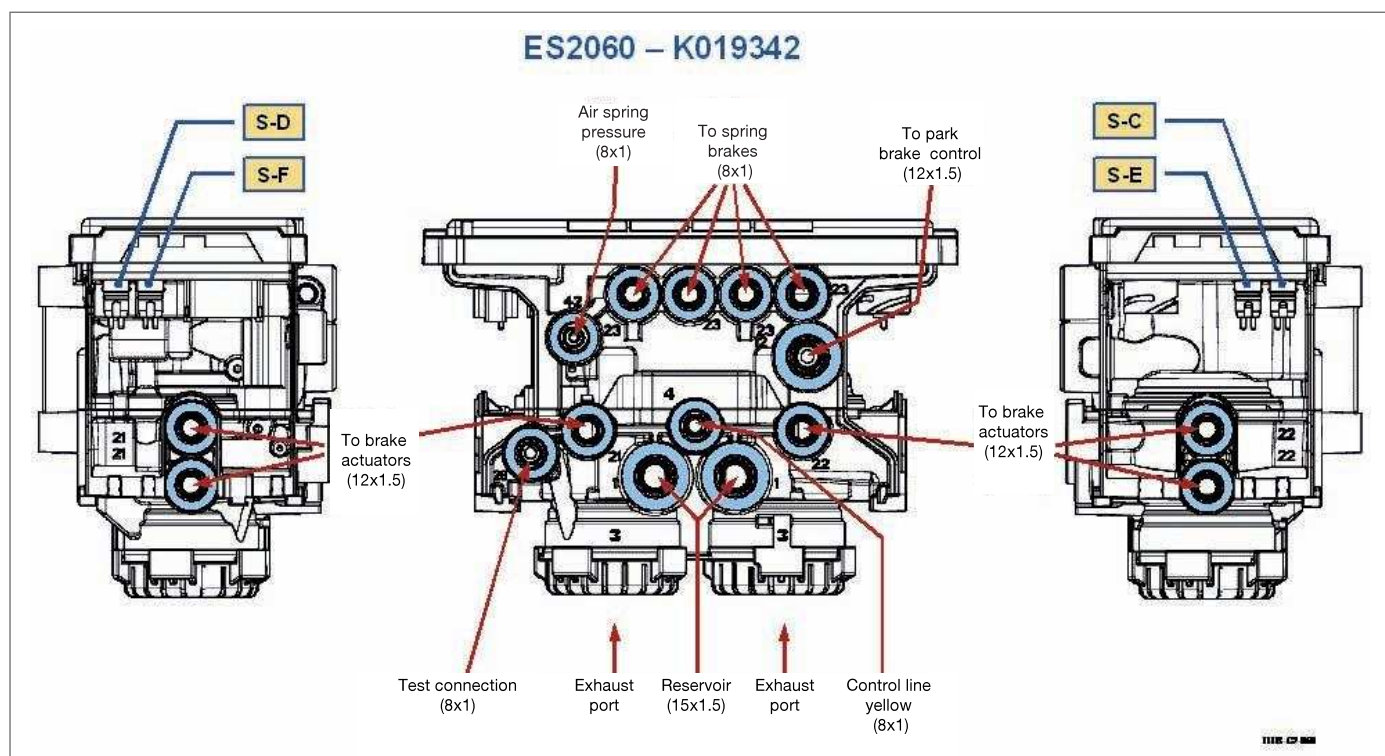
### 6.9.1 Fitting recommendations for push-to-connect (PTC) fittings

The following table give the insertion depth and maximum force for Raufoss PTC fittings:

External Tube Diameter (mm)	Push in Length (mm)	Push in Force (N)	Raufoss Release tool Part Number	Raufoss Closing plug Part Number
6	19.5	80	96606000	96210006
8	20.5	90	96608000	96210008
10	24.0	100	96610000	96210010
12	25.0	110	96612700	96210012
15	27.0	125	96616000	96210015
16	27.0	130	96616000	96210016

Raufoss provides an adapter for rubber hoses which can be inserted into the R12 x 1.5 PTC fitting. The part number is 94311012.

Table based on information contained in Kongsberg Automotive Raufoss couplings product catalogue 2006.



The term '*Diagnostics*' is an all embracing name which may be applied to any device or program which is able to provide status information in a format that is understandable to the user. With respect to the TEBS G2 brake module the following options provide different levels of diagnostics:

- Warning signals
- Magic Eye
- TIM G2
- ECUtalk® diagnostic program

Initial indication of a potential error or condition is generally displayed to the driver by means of a warning lamp(s) in the cab of the towing vehicle. This includes detectable faults within the braking system and auxiliary functions or a predefined condition has been detected e.g. pad wear.

## 7.1 Warning lamp signals

It is a requirement that towing vehicles shall have a yellow warning lamp that is controlled by the trailer braking system or anti-lock braking system via Pin 5 of the ISO 7638 connector. This is used to display the system's status at initial power up, drive away and during driving. In principle a permanently illuminated yellow warning lamp means that a fault in the braking system is present or has been stored.

The yellow warning lamp may also be used to indicate faults or status conditions in auxiliary functions but certain restrictions apply since the primary use of this signal is to provide the driver with information on the status of the braking system.

On vehicles equipped with an 'electric control line' (CAN) i.e. EBS equipped vehicles, there is also the possibility of transmitting additional information to the towing vehicle. In this case it is required for the trailer to provide information via the data communications to illuminate a red warning lamp in the cab of the towing vehicle in parallel to transmission of the yellow warning lamp. The following information is provided:

### Illumination of yellow warning lamp:

Braking system fault but maximum braking performance is still available.

### Illumination of yellow and red warning lamps:

Braking system fault where the available braking performance may be reduced.

For more information on warning signals see section 3.3.

## 7.2 Magic Eye

The Magic Eye is a display device that is generally mounted on the outside of the trailer in a visually accessible position-see Figure 44, and is connected to the TEBS G2 brake module by means of the pins 3 (AUXIO 3), 12 and 6 of the In-Out connector. Information is transmitted via this connection and interpreted by the Magic Eye so that, if a preconfigured condition is recorded, the display will change colour.



**Figure 44:** Magic Eye

When a configured display condition is not present the display will be black. When any one of the configured display conditions is recorded by the Magic Eye the display will switch to red. The TEBS G2 brake module must be powered to transmit the relevant information and for the Magic Eye to recognise a condition to be displayed however even when the power is turned off, or the trailer is uncoupled, the Magic Eye will continue to display the condition present at the time the ignition is turned off. This state will remain valid until the condition to be displayed is rectified and the TEBS G2 brake module re-powered – then the Magic Eye will return to a black display. Any of

the following conditions may be configured by using the diagnostics program ECUTalk®:

- Display prescribed braking errors, i.e. faults within the braking system that would generate a warning signal.
- Display non-prescribed error i.e. electrical faults within auxiliary control systems connected and controlled by the TEBS G2 brake module.
- Display pad wear limit, i.e. when the wear of the linings or pads has reached a predefined limit.
- Display programmed ADL event.
- Display service interval exceeded.

The Magic Eye will indicate any of the above conditions by means of the red display. To find the reason for the red display it is necessary to check the TEBS G2 brake module status using the diagnostic program ECUTalk® and rectify any fault condition(s) or note specific events that have been recorded.

**Tip – ‘Magic Eye’:**

The most suitable location for the Magic Eye is on the trailer headboard where it will be readily visible. An 11 m extension cable is available from Knorr-Bremse for this purpose.

ECUTalk® is available from Knorr-Bremse by a download from the Knorr-Bremse internet at:

<http://www.knorr-bremseCVS.com>

Before the program can be run to configure a TEBS G2 brake module it is necessary for the user to attend a training course and be issued with a PIN code. This is directly associated with the user's name or company name and is stored within the TEBS G2 brake module whenever the user writes a configuration file to the ECU.

For more detailed information on ECUTalk® and configuration of TEBS G2 please refer to the Knorr-Bremse ‘User Manual’ Y051496.

### 7.3 Diagnostic Program ECUTalk®

ECUTalk® is a software platform produced specifically to assist the user in the configuration, fault diagnosis and system check of the TEBS G2 brake module and other Knorr-Bremse trailer electronically controlled products. Its functionality includes:

- System parameterisation
- Reading and writing configuration data to and from the TEBS G2 brake module.
- End of Line (EOL) test
- Fault diagnosis
- Trouble shooting by use of the “System Check” function
- Reading of “Operational Data”
- Creation and storing of EOL test reports, fault records and load sensing plate labels.

This section provides important information associated with the replacement of a TEBS G2 brake module and the interchangeability between the different part numbers associated with the product.

## 8.1 Replacement of the TEBS G2 brake module in the event of a failure

In the unlikely event that it is necessary to replace the TEBS G2 brake module due to an irreparable fault within the original TEBS G2 brake module it is important to save the trailer configuration file before removing the faulty module from the trailer unless the file is already available for that specific trailer. Saving the file stored within the TEBS G2 brake module can be realised by connection of the diagnostic program ECUTalk® and saving the file to a directory in a computer for future use – for more information refer to the “Online-help” system of ECUTalk® for TEBS G2.

If for any reason it is not possible to read and save the file from the failed TEBS G2 brake module it is recommended that a copy of the original configuration file is obtained from the trailer manufacturer.

Once the replacement TEBS G2 brake module has been installed the saved file should be used to configure the module and an EOL test should always be performed – for more information refer to the “Online-help” system of ECUTalk® for TEBS G2.

## 8.2 File format of the configuration file

With the introduction of the TEBS G2 brake module it was necessary to change the file format of the configuration

files used to parameterise the module. This format uses the file extension *\*.dpv* whereas the original TEBS\*\* (see note) used a file extension *\*.cfg*. These file formats are not interchangeable therefore a TEBS G2 brake module cannot be parameterised using a file created for the original TEBS.

\*\* Also known as TEBS4.

## 8.3 Fault detection and effect

### 8.3.1 Interface connections

A trailer equipped with the TEBS G2 brake module can receive brake demands from towing vehicles which have different interface connections at the coupling head as follows:

- Pneumatic supply line and pneumatic control line
- Pneumatic supply line, pneumatic control line and electric control line (ISO 11992 (CAN))
- Pneumatic supply line and electric control line (ISO 11992 (CAN)) \*

\* This option is currently prohibited by ECE Regulation 13. However to ensure compatibility with towing vehicles of the future, the TEBS G2 brake module has been designed to operate with this specification of vehicle.

Provisions are defined within ECE Regulation 13 that ensure the safe operation of towing vehicles and trailers irrespective of their specification. The table below defines the reaction of either the towing vehicle or trailer to certain failures/conditions relative to the brake demands and electrical power availability at the towing vehicle/trailer interface.

Pneumatic Control Line	Electric Control Line	Failure Condition	Failure Reaction
Not present	Signalled from two independent circuits	Data bus (ISO 11992) or electrical power failure (ISO 7638)	Condition recognised by the towing vehicle which subsequently exhausts the supply line. (See ECE Regulation 13 paragraph 5.2.1.18.3 )
Signalled from one circuit	Signalled from one circuit	Data bus failure (ISO 11992)	Automatic switch to pneumatic control line by the TEBS G2 brake module with full system functionality retained
Signalled from one circuit	Signalled from one circuit	Electrical power failure (ISO 7638)	Reverts to pneumatic backup with load sensing function and ABS control from stop lamp circuit (when connected)
Signalled from one circuit	Not present	Electrical power failure (ISO 7638)	Reverts to pneumatic backup with load sensing function and ABS control from stop lamp circuit (when connected)
Signalled from one circuit	Signalled from one circuit	Pneumatic control signal not present	Utilises electric control line signal and transmits signals for illumination of yellow and red warning signals. Full system functionality is retained

### 8.3.2 Failure detection

The following table defines the possible failures that may occur and the reaction of the TEBS G2 brake module to those failure conditions.

Component	Fault	Effect
Wheel Speed Sensors		
2S/2M and 4S/2M Sensors S-C and S-D	Short circuit	No ABS Function Yellow failure warning
	Open circuit	
	Short to B+	
	Low output	
	Plausibility	
4S/2M Sensors S-E or S-F	Short circuit	ABS configuration reduced to 2S/2M using sensors S-C and S-D. Yellow failure warning
	Open circuit	
	Short to B+	
	Low output	
	Plausibility	
Trailer Brake Module Solenoid Faults		
Backup solenoid	Short circuit	No EBS or RSP function, revert to pneumatic backup, with ABS retained on the unaffected pressure modulators. Yellow failure warning.
	Open circuit	
	Short to B+	
Inlet solenoid	Short circuit	No EBS or RSP function, revert to pneumatic backup with ABS. Yellow failure warning.
	Open circuit	
	Short to B+	
Exhaust solenoid	Short circuit	No EBS or RSP function, revert to pneumatic backup, with ABS retained on the unaffected pressure modulators. Yellow failure warning.
	Open circuit	
	Short to B+	



Component	Fault	Effect
Trailer Brake Module Faults		
Internal hardware or software faults	Low voltage	No EBS, ABS or RSP function, revert to pneumatic backup. Yellow & Red failure warning.
	High voltage	
	Internal error	
	Incorrect installation configuration	
Pressure Transducer Faults		
Demand pressure	Electrical or plausibility error	EBS function disabled, revert to pneumatic backup with ABS function. Yellow failure warning
Air spring pressure	Electrical or plausibility error	Reverts to laden pressure relationship irrespective of vehicle load. Yellow failure warning
Reservoir pressure	Electrical or plausibility error	EBS function disabled, revert to pneumatic backup with ABS function. Yellow failure warning
Delivery pressure	Electrical or plausibility error	EBS function disabled, revert to pneumatic backup with ABS function. Yellow failure warning
Auxiliary Functions		
Auxiliary input and outputs on the “In Out” connectors	Short circuit	Operation/monitoring of Auxiliary function suspended. Yellow “flashing” warning
	Open circuit	
	Short to B+	
Internal auxiliary solenoid	Short circuit	Operation/monitoring of Auxiliary solenoid suspended. Yellow “flashing” warning
	Open circuit	
	Short to B+	
Lateral acceleration sensor	Electrical fault or plausibility error	No RSP or Tilt Angle function. Yellow failure warning

## 8.4 Information plates and labels

Following installation and parameterisation of the TEBS G2 brake module it is possible to generate a load sensing plate by using the diagnostic program ECUTalk®. This plate will not only contain information to carry out a check of the load sensing settings but also define additional TEBS G2 brake module configuration data and trailer related information – Figure 45 illustrates an example:


<div></div> <div><b>KNORR-BREMSE</b></div> <div>ECUtalk® for TEBS G2 (v.1.0.0.7)</div>		TEBS G2		ES2060		K019302		<div>E11 13R-</div>	
		SW Version		ET6A.0000700.0000068		KB Help Centre		+ 49 (0) 180 566 77 05	
		Type		Semi-trailer		Manufacturer		test customer	
		Brake calculation no.		test BSD filename		VIN		test VIN	
ABS Configuration		2S/2M		Unladen	Laden	<div>Axle</div> <div>Max. load [kg]</div> <div></div> <div></div>			
Bogie load unladen [kg]	3300	Airspring pressure [bar]	0.6	4.8					
Bogie load laden [kg]	27000	Suspension press. [bar]	-	-	1		9000	24	152
Sensing ring teeth	100	Ext. Sensor Voltage [V]	-	-	2		9000	24	152
Tyre diameter [mm]	1034	LS. Lever Length	-		3		9000	24	152
SENS_IN1		Disabled	Spring Deflection [mm]	-		4	-	-	-
SENS_SUP		Disabled	Module turned	No		5	-	-	-
						Pneumatic (CAN) [bar]			
AUXIO1	LAC1	INPUT_E	Disabled	Control pressure [bar]		0.80	1.6	4.5	6.5
AUXIO2	SP	INPUT_F	Disabled	Brake press. unladen [bar]		0.40	0.6	1.5	2.1
AUXIO3	Disabled	Pneu. output	Disabled	Brake press. laden [bar]			1.3	4.4	6.5

Figure 45: Typical load sensing plate generated by ECUTalk®

This load sensing/information plate should be affixed in a visible location on the trailer.

The ISO 7638 interface between towing vehicle and trailer provides at least the electrical energy to power the TEBS G2 brake module and all such vehicles must be equipped with this connector. In service however, it can be the case, for whatever reason, that the ISO 7638 connector is not connected, in which case the electrical control of the trailer brakes and operation of auxiliary functions will not be available. To ensure that drivers are aware of the

consequences of not using the ISO 7638 connector it is required that a label is attached to the trailer in the vicinity of the ISO 7638 connector which clearly defines the functionality when the connector is not connected – see Figure 46.



**Figure 46:** ISO 7638 functionality label (II39796F)

Note:

The above label is required irrespective of whether the TEBS G2 brake module is wired to receive electrical energy from any other source, e.g. stop lamp circuit.

The following two labels – see Figures 47 and 48 – are optional but provide an indication as to the functionality of the trailer:



**Figure 47:** EBS functionality label (II39799F)



**Figure 48:** EBS and RSP functionality label (II40392F)

## 9.1 ABS and EBS approval

Before any vehicle is permitted to run on the road it must fulfil the requirements of many EC Directives and/or ECE Regulations. With respect to braking the associated legislative instruments are:

- Directive 71/320/EEC as last amended by Directive 2002/78/EC
- ECE Regulation 13 including the 10 series of amendments

Due to the diversity of the trailer industry, where there are many manufacturers producing trailers to a wide range of specifications, the burden of type approval is both onerous and costly. Two of the most difficult and time consuming elements of braking type approval relate to the assessment of the ABS performance and electronics. This has been recognised by the authorities and provisions have been made, both in Directive 71/320/EEC and ECE Regulation 13, to enable independent performance assessment for which a test report is generated. The requirements associated with this procedure are defined in Annex XIV of the EC Directive and Annex 19 of the ECE Regulation.

The Knorr-Bremse TEBS G2 brake module has been subject to the test procedures defined within these Annexes and test reports have been produced. Additionally, to verify

the functionality of the electronics in normal and failed modes an independent assessment has been carried out with Technical Services in accordance with the provisions of ECE Regulation 13, in particular Annex 17 (ISO 11992 compatibility) and Annex 18 (Special requirements to be applied to the safety aspects of complex electronic vehicle control systems). The following documentation provides the required system information and the results associated with each of the assessments:

ABS Assessment	Document
TEBS G2 brake module ABS Information Document	Y038142
'TÜV Nord' test report	EB.154

Electronics Assessment	Document
TEBS G2 brake module Electronics Information Document	Y038143
'TÜV Nord' test report	EB.155
'UTAC' test report	07/02387

## 9.2 Trailer brake performance requirements

Test	Directive / Regulation	Requirement	Procedure
Brake system response requirements	Directive 98/12/EC – Annex III.  ECE Regulation 13/10 – Annex 6  <i>Note: Only ECE Regulation 13 defines requirements for CAN response time measurement.</i>	The elapsed time from 0.65bar at the coupling head to 75% of the asymptotic brake actuator pressure shall be <0.4secs (maximum permitted value = 0.44secs)	<ul style="list-style-type: none"> <li>• Pneumatic and CAN simulator required.</li> <li>• Brakes to be adjusted as closely as possible.</li> <li>• Initial supply line pressure = 6.5bar</li> <li>• Shut off the supply line</li> <li>• Use simulator to produce the defined signal (pneumatic and CAN) at the coupling head.</li> <li>• Determine the system response time</li> </ul>
Anti-lock energy consumption	Directive 71/320/EEC as amended – Annex XIV paragraph 6.2  ECE Regulation 13 as amended – Annex 20 paragraph 7.3	To ensure that, after 15 secs of ABS cycling followed by 4 static brake applications, the residual reservoir pressure is then able to generate a braking force on the next application of 22.5% of the static axle load.	<ul style="list-style-type: none"> <li>• Adjust brakes according to specified requirements</li> <li>• The load sensing shall be set to the laden position - see Chapter 4.10</li> <li>• Pressurise the trailer reservoir to 8.0 bar then isolate the supply.</li> <li>• Apply a pressure of 6.5 bar via the pneumatic control line and then reduce it to zero. Continue this procedure until the defined number of static applications <math>n_g</math> have been completed.</li> <li>• (For the value <math>n_g</math> see TÜV Nord test report EB154.)</li> <li>• On the last application the pressure in the brake actuator should be noted and verified that it is able to generate a braking force equivalent to at least 22.5% of the static laden axle/bogie load of the trailer – see brake calculation.</li> <li>• The above shall be fulfilled without the spring brakes generating a braking force.</li> </ul>
Spring brake energy consumption	Directive 98/12/EC – Annex V paragraph 2.4  ECE Regulation 13/10 – Annex 8 paragraph 2.4	To ensure that it is possible to release the spring brakes at least 3 times after the trailer has been uncoupled.	<ul style="list-style-type: none"> <li>• The supply line shall be pressurised to 6.5 bar (EC) / 7.5 bar (ECE) and then disconnected.</li> <li>• The automatic brake shall be released prior to the following check.</li> <li>• Using the park brake control release the spring brakes 3 times.</li> <li>• After the third release it shall still be possible to rotate the wheels equipped with spring brakes.</li> </ul>
Application of the spring brakes after operation of the service braking system	Directive 98/12/EC – Annex V paragraph 2.5 ECE Regulation 13/10 – Annex 8 paragraph 2.5	After the supply line has been isolated the service brakes shall be fully actuated 4 times after which it must still be possible to rotate the wheels equipped with spring brakes.	<ul style="list-style-type: none"> <li>• The supply line shall be pressurised to 6.5 bar (EC) / 7.0 bar (ECE) and then isolated.</li> <li>• Fully apply and release the service brakes 4 times.</li> <li>• After the fourth application it shall be still possible to rotate the wheels equipped with spring brakes.</li> </ul>



Test	Directive / Regulation	Requirement	Procedure
Capacity of service braking reservoir	Directive 98/12/EC – Annex IV paragraph 1.3  ECE Regulation 13/10 – Annex 7 paragraph 1.3	After the supply line has been isolated the service brakes shall be fully actuated eight times. The pressure in the brake actuators on the eighth application shall not be less than half of the brake actuator pressure recorded on the first application.	<ul style="list-style-type: none"> <li>• The service braking system reservoir(s) shall be pressurised to 8.5 bar and the supply line isolated.</li> <li>• Fully apply and release the service brakes eight times, record the pressure in the brake actuators on the first and eighth application.</li> <li>• Ensure the relationship between these pressures meets the requirement.</li> </ul>
Service brake protection	Directive 98/12/EC – paragraph 2.2.2.15.  ECE Regulation 13/10 – paragraph 5.2.2.14.	During operation of, or a leakage from, the auxiliary equipment (air suspension) it shall be ensured that the braking system is protected to enable at least 80% of the prescribed service braking performance to be fulfilled.	<ul style="list-style-type: none"> <li>• Pressurise the service braking reservoir(s) and auxiliary equipment to a pressure &gt;7.0 bar.</li> <li>• Produce a leakage from the auxiliary equipment.</li> <li>• Wait until leakage stops</li> <li>• Measure the pressure in the service braking reservoir and check that it does not fall below a pressure of 5.2 bar or the residual pressure is able to produce a braking force of at least 80% of the prescribed value.</li> </ul>



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