TRAILER ANTI-LOCK BRAKING SYSTEM APPROVAL REPORT

Approval Report No : **RDW-71/320-0350**

1. Identification

1.1. Manufacturer of the anti-lock braking system (name and address) : WABCO Fahrzeugbremsen
Am Lindener Hafen 21
D-30453 Hannover
Germany

1.2. System name/model : Vario Compact Trailer ABS (VCS)

2. System(s) and installation(s) approved

2.1. ABS configuration(s) approved :
- 2S/2M two sensors and two modulators,
- 4S/2M four sensors and two modulators,
- 4S/3M four sensors and three modulators.

2.2. Range of application (type of trailer and number of axles) :

2S/2M:
- semi-trailer 1- or 2- or 3-axle(s).
- centre-axle trailer 1- or 2- or 3-axle(s).

4S/2M:
- semi-trailer 2- or 3-axles.
- centre-axle trailer 2- or 3-axles.

4S/3M:
- full trailer 2- or 3-axles.
- semi-trailer 2- or 3-axles.
- centre-axle trailer 2- or 3-axles.

2.3. Methods of powering :

24 volt:
- ISO 7638-1
- ISO 1185 (24N)
- ISO 3731 (24S)

12 volt:
- ISO 7638-2

2.4. Identification of approved sensor(s), controller(s) and modulator(s) :

Sensors:
See manufacturer's Information Document, paragraph 2.1.3.1.

Controllers:
See manufacturer's Information Document, paragraph 2.1.3.2.

Modulators:
See manufacturer's Information Document, paragraph 2.1.3.3.

2.5.	Energy consumption - equivalent number of static brake applications and the ratio of actuator stroke against brake lever length	: Drum brake: $n_e = 14$ $R_l = s_T / l_T = 25 / 150 = 0{,}166$ Disc brake: $n_e = 16$ Remark concerning only disc brakes: Annex XIV requires a safety factor of 1,2 for the energy consumption test (see 6.2.1.1 of Annex XIV) and proposes to increase the brake chamber stroke. In case of disc brakes this is not possible in all cases due to the design of this brake type. The above given value for n_e is including this safety factor of 1,2 (20% increase in delivery volume). Therefore the procedure defined in paragraph 6.2.1.2. of Annex XIV is to be carried out without any increase in actuator stroke as defined in paragraph 6.2.1.1. of Annex XIV.
2.6.	Additional features e.g. retarder control, lift axle configuration etc	: See section 2.1.3.2. of manufacturer's Information Document.

3. Test data and results

3.1.	Test vehicle data	: See Appendix 2.
3.2.	Test surface information	: See Appendix 3.
3.3.	Test results	
3.3.1.	Utilisation of adhesion	: See Appendix 4.1.
3.3.2.	Energy consumption	: See Appendix 4.2.
3.3.3.	Split-friction test	: See Appendix 4.3.
3.3.4.	Low speed performance	: Test done on wet blue basalt with a speed of 40 km/h. Observations: - no locking of the direct controlled wheels. - full stability of the vehicle.
3.3.5.	High speed performance	: Test done on wet asphalt with a speed of 80 km/h. Observations: - no locking of the direct controlled wheels. - full stability of the vehicle.
3.3.6.	Additional checks	
3.3.6.1	Transition from high to low-adhesion surfaces	: Test done on dry asphalt/wet blue basalt with a speed of 40 km/h and 80 km/h. Observations: - no inadmissible locking of the direct controlled wheels. - full stability of the vehicle.
3.3.6.2	Transition from low to high-adhesion surfaces	: Test done on wet blue basalt/wet asphalt with a speed of 50 km/h. Observations: - no inadmissible locking of the direct controlled wheels. - full stability of the vehicle.

3.3.7.	Failure mode simulation	: See Appendix 5.
3.3.8.	Functional checks of optional connections	: N.A.
3.3.9.	Electro-magnetic compatibility	: See section 2.1.4. of manufacturers Information Document, certificate no e1*72/245*95/54*1058*..

4. Limitations of installation

4.1.	Relationship of tyre circumference to the resolution of the exciter	: See section 2.1.2.3. of manufacturer's Information Document.
4.2.	Tolerance on tyre circumference between one axle and another fitted with the same exciter	: See section 2.1.2.4. of manufacturer's Information Document.
4.3.	Suspension type	: - mechanical suspension. - pneumatic suspension. See also Appendix 7 of manufacturer's Information Document.
4.4.	Differential(s) in brake input torque within a trailer bogie	: Allowed is a maximum of 15% brake input torque differential within a trailer bogie. This is tested on vehicles SA2 and ZA1. See also section 2.1.2.6. of manufacturer's Information Document.
4.5.	Wheelbase of full trailer	: $E_r \geq 3{,}2$ m.
4.6.	Brake type	: - cam brakes (drum brakes). - disc brakes.
4.7.	Tube sizes and lengths	: See section 2.1.3.5. of manufacturer's Information Document.
4.8.	Load sensing device application	: See section 2.1.2.1. and 2.1.3.5. (brake diagrams) of manufacturer's Information Document.
4.9.	Warning lamp sequence	: See section 2.1.3.4. of manufacturer's Information Document.
4.10.	Other recommendations/limitations (e.g. locations of sensors, modulator(s), lift axle(s), steering axle(s).)	
4.10.1.	Installation limitations	: See section 2.1.2.2. and Appendix 1 of manufacturer's Information Document.
4.10.2.	Category A performance	: The configurations described in Appendix 1 of the manufacturer's Information Document fulfils the requirements of category A, paragraph 6.3.2., Annex X of Directive 98/12/EC.

5. **Date of test**

The anti-lock braking system described above complies with the requirements of Annex XIV of Directive 71/320/EEC as last amended by Directive 98/12/EC.

Technical service and approval authority conducting the test:

RDW
Europaweg 205
2700 AT Zoetermeer
The Netherlands

W.R. Hartman 26 January 2000.

Approval Authority if different from the Technical Service:

J. Bierman 26 January 2000.

Attachment : - Appendix 1 Symbols and definitions.
- Appendix 2. Test vehicle data.
- Appendix 3. Test surface information
- Appendix 4.1. Utilisation of adhesion.
- Appendix 4.2. Energy consumption.
- Appendix 4.3. Split friction.
- Appendix 5. Safety assessment.
- Appendix 6. Cross-referencing test results.
- Manufacturer's Information Document BESAN141.DOC (36 pages).
Date: 06.12.99

Appendix 1

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Symbols and definitions

Symbol	Notes
s_T	Brake chamber push rod travel of reference test trailer in mm
l_T	Brake lever length of reference test trailer in mm
R_1	Ratio of s_T/l_T
n_e	Number of equivalent static brake applications
l_v	Brake lever length of trailer to be approved in mm
s_v	Brake chamber push rod travel of trailer to be approved in mm
L	Sensors on axle, axle controlled by modulator(s)
X	Not equipped with sensors
Z	Sensors on axle, wheels on the same side controlled by modulator(s)
H	Sensors on axle, wheels on the same side controlled by modulator(s)
VR	Front right wheel sensored
HL	Rear left wheel sensored

Appendix 2.

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Test vehicle data

	DA1	**DA2**	**DA3**	**SA1**
make	Kolberg	Kässbohrer	Schmitz	Bartoletti
type	A18	D17B	WF18	HKA-140
variety	Full trailer	Full trailer	Full trailer	Semi-trailer
no of axles	2	3	2	3
brake type	S-cam (drum)	S-cam (drum)	S-cam (drum)	S-cam (drum)
suspension type	mechanical	mechanical	pneumatic	pneumatic
air reservoir V_0	60 dm^3	80 dm^3	80 dm^3	100 dm^3
axle 1, BC/lT	30”/127 mm	24”/127 mm	30”/150 mm	30”/135 mm
axle 2, BC/lT	20”/127 mm	20”/127 mm	24”/150 mm	30”/135 mm
axle 3, BC/lT	-	20”/127 mm	-	30”/135 mm
unladen weight	7.140 kg	6.400 kg	3.000 kg	9.870 kg
weight axle 1	3.130 kg	2.480 kg	1.400 kg	2.460 kg
weight axle 2	4.010 kg	3.920 kg	1.600 kg	2.415 kg
weight axle 3	-		-	2.440 kg
wheelbase	2.940 mm	7.145 mm	4.750 mm	4.810 mm
tyre size front	365/80 R 20	385/65 R 22.5	385/65 R 22.5	-
tyre size rear	365/80 R 20	385/65 R 22.5	385/65 R 22.5	485/65 R 22.5
remarks	-	-	-	-

	SA2	**SA3**	**SA4**	**SA 6**
make	Blumhardt	Kögel	Kögel	Renders
type	Cont.SAL40.18E	SN 24 P 100	SN 22	CS 40/45 GV
variety	Semi-trailer	Semi-trailer	Semi-trailer	Semi-trailer
no of axles	2	3	3	3
brake type	S-cam (drum)	disc	S-cam (drum)	S-cam (drum)
suspension type	mechanical	pneumatic	mechanical	pneumatic
air reservoir V_0	80 dm^3	80 dm^3	80 dm^3	100 dm^3
axle 1, BC/lT	30”/120 mm	16”/88 mm	24”/150 mm	24”/127 mm
axle 2, BC/lT	30”/150 mm	16”/88 mm	24”/150 mm	24”/127 mm
axle 3, BC/lT	-	16”/88 mm	24”/150 mm	24”/127 mm
unladen weight	4.850 kg	7.920 kg	7.570 kg	7.620 kg
weight axle 1	3.915 kg	5.880 kg	5.630 kg	5.840 kg
weight axle 2				
weight axle 3	-			
wheelbase	5.310 mm	7.900 mm	7.300 mm	7.500 mm
tyre size front	-	-	-	-
tyre size rear	365/85 R 20	385/65 R 22.5	385/65 R 22.5	385/65 R 22.5
remarks	-	-	**SA5** with 1st axle lifted	**SA7** with 2nd axle lifted, **SA8** with 1st and 2nd axle lifted, 3rd axle is self steering (can be blocked)

Appendix 2.

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Test vehicle data (continued)

	SA9	**SA10**	**ZA1**
make	Viberti	Benalu	Obermaier
type	*ZOVS06105PV0S0002*	88/1850 SA3	ETN 6,5
variety	Semi-trailer	Semi-trailer	Centre-axle trailer
no of axles	3	1	2
brake type	S-cam (drum)	disc	S-cam (drum)
suspension type	pneumatic	pneumatic	mechanical
air reservoir V_0	80 dm^3	30 dm^3	40 dm^3
axle 1, BC/lT	24”/150 mm	18”/86 mm	9”/120 mm
axle 2, BC/lT	24”/150 mm	-	12”/120 mm
axle 3, BC/lT	24”/150 mm	-	-
unladen weight	3.720 kg	4.720 kg	2.940 kg
weight axle 1	3.280 kg	3.120 kg	2.520 kg
weight axle 2		-	
weight axle 3		-	-
wheelbase	6.000 mm	7.450 mm	5.230 mm
tyre size front	-	-	215/75 R 17.5
tyre size rear	385/65 R 22.5	385/65 R 22.5	215/75 R 17.5
remarks	**SA11** with 1st axle lifted	with 1st and 3rd axle lifted	-

General remarks on used variants:					
variant	**base vehicle**	**description**	**wheelbase**	**total weight**	**remarks**
SA5	SA4	2-axle semi-trailer	7.955 mm	7.320 kg	1st axle lifted
SA7	SA6	2-axle semi-trailer	7.500 mm	7.640 kg	2nd axle lifted
SA8	SA6	1-axle semi-trailer	8.500 mm	7.400 kg	1st and 2nd axle lifted
SA11	SA9	2-axle semi-trailer	6.660 mm	3.720 kg	1st axle lifted

Appendix 3.

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Test surface information

1.1.	Surface with high adhesion	:	Dry and wet asphalt.
1.2.	Surface with low adhesion	:	Wet blue basalt, the characteristics of this surface were obtained in accordance with the requirements of Appendix 4 of Annex X to Directive 98/12/EC.
1.3.	Results	:	- k_{peak} : 0,40 - k_{lock} : 0,28 - ratio “R” : 1,4

Appendix 4.1.

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Utilisation of adhesion, ε values

vehicle	ABS	configuration	no of axles	surface	k_f	k_r	k_R	ε LSD + 1 bar	ε LSD 1:1
DA1	4S/3M	L-H	2	dry asphalt	0,758	0,757	0,758	0,75	0,78
DA2	4S/3M	L-H-X	3	wet asphalt	0,593	0,429	0,499	0,91	0,87
DA3	4S/3M	H-L	2	wet asphalt	0,465	0,506	0,486	0,75	0,80
SA1	4S/3M	L-X-H	3	dry asphalt	-	-	0,760	-	0,83
SA2	2S/2M	X-H	2	dry asphalt	-	-	0,790	-	0,88
SA6	2S/2M	H-X-X	3	wet asphalt	-	-	0,499	0,75	0,81
	2S/2M	X-H-X	3	wet asphalt	-	-	0,499	0,83	0,77
	4S/2M	Z-H-X	3	wet asphalt	-	-	0,499	0,86	0,76
	4S/2M	Z-X-H	3	wet asphalt	-	-	0,499	0,83	0,81
	4S/3M	X-H-L	3	wet asphalt	-	-	0,499	0,81	0,75
	4S/3M	H-X-L	3	wet asphalt	-	-	0,499	0,82	0,81
	4S/3M	L-X-H	3	wet asphalt	-	-	0,499	0,75	-
SA7	2S/2M	H-X	2	wet asphalt	-	-	0,499	0,83	-
	2S/2M	X-H	2	wet asphalt	-	-	0,499	0,83	-
	4S/2M	H-Z	2	wet asphalt	-	-	0,499	0,96	0,89
	4S/3M	H-L	2	wet asphalt	-	-	0,499	0,83	0,83
	4S/3M	L-H	2	wet asphalt	-	-	0,499	0,76	0,75
SA8	2S/2M	H	1	wet asphalt	-	-	0,570	0,78	0,80
SA9	4S/3M	L-H-X	3	wet asphalt	-	-	0,499	0,84	0,95
SA11	2S/2M	H-X	2	wet asphalt	-	-	0,499	-	0,96
ZA1	2S/2M DAR	VR-HL	2	wet asphalt	-	-	0,499	0,83	0,83

Appendix 4.2.

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Energy consumption

1. Vehicle weights concerning energy consumption : For the worst case concerning vehicle test-weights see section 2.1.2.7. of manufacturer's Information Document.

2. Measured values

Vehicle	**ABS**	**configuration**	**weight on axles P_R (kg)**	**total weight (kg)**	**V_0 (dm^3)**	**p_0 (bar)**	**p_{15s} (bar)**	**p_{15s+5} (bar)**	**n_e**	**n_e +20 %**	**cylinder type on axle no**			**R_l**
											1	**2**	**3**	
DA1	4S/3M	L-H	7.140	7.140	60	8,0	3,6	2,6	14	-	30	20	-	0,166
DA2	4S/3M	L-H-X	10.340	10.340	80	8,0	3,9	3,1	14	-	24	16	16	0,166
SA10	2S/2M	H	3.620	5.220	30	8,0	4,9	3,1	14	16	18	-	-	-
SA5	2S/2M	H-X	5.630	7.320	60	8,0	4,6	3,6	11	-	24	24	-	0,166
SA2	2S/2M	X-H	5.915	6.850	80	8,0	4,4	3,4	14	-	30	30	-	0,166
SA5	4S/2M	H-Z	5.630	7.320	60	8,0	4,4	3,4	12	-	24	24	-	0,166
SA5	4S/3M	H-L	5.630	7.320	60	8,0	4,4	3,3	13	-	24	24	-	0,166
SA4	2S/2M	H-X-X	10.630	12.570	80	8,0	4,4	3,1	12	-	24	24	24	0,166
SA4	4S/2M	H-Z-X	10.630	12.570	80	8,0	4,1	3,0	13	-	24	24	24	0,166
SA3	4S/2M	X-Z-H	10.880	12.920	80	8,0	4,5	3,5	12	14	16	16	16	-
SA4	4S/2M	Z-X-H	10.630	12.570	80	8,0	4,3	3,1	12	-	24	24	24	0,166
SA4	4S/3M	H-X-L	10.630	12.570	80	8,0	4,1	3,1	12	-	24	24	24	0,166
ZA1	2S/2M	VR-HL	4.220	4.640	40	8,0	4,4	3,4	13	-	9	12	-	0,166

Appendix 4.3.

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Split friction LSD 1:1

Vehicle	ABS	configu ration	no of axles	z_{RALH}	z_{RALL}	z_{RALS}	requirements for z_{RALS}			
							A	B	C	D
DA1	4S/3M	L-H	2	0,42	0,12	0,22	0,17	0,15	0,54	3,50
DA3	4S/3M	H-L	2	0,40	0,09	0,18	0,15	0,11	0,50	4,24
DA2	4S/3M	L-H-X	3	0,44	0,11	0,21	0,15	0,13	0,52	4,42
SA8	2S/2M	H	1	0,46	0,13	0,27	0,18	0,16	0,58	3,66
SA11	2S/2M	H-X	2	0,48	0,13	0,29	0,16	0,14	0,50	3,62
SA2	2S/2M	X-H	2	0,44	0,15	0,29	0,20	0,17	0,55	2,93
SA7	4S/2M	H-Z	2	0,45	0,11	0,23	0,15	0,12	0,50	4,07
SA7	4S/3M	H-L	2	0,42	0,12	0,19	0,16	0,14	0,50	3,56
SA7	4S/3M	L-H	2	0,38	0,11	0,24	0,16	0,15	0,50	3,49
SA6	2S/2M	H-X-X	3	0,40	0,12	0,24	0,16	0,15	0,50	3,49
SA6	2S/2M	X-H-X	3	0,38	0,12	0,25	0,17	0,16	0,50	3,11
SA6	4S/2M	X-H-Z	3	0,44	0,12	0,25	0,16	0,14	0,50	3,59
SA6	4S/2M	Z-H-X	3	0,38	0,11	0,23	0,16	0,14	0,50	3,45
SA6	4S/2M	Z-X-H	3	0,40	0,11	0,24	0,16	0,14	0,50	3,68
SA6	4S/3M	X-H-L	3	0,38	0,10	0,21	0,16	0,13	0,50	3,63
SA9	4S/3M	L-H-X	3	0,43	0,12	0,26	0,16	0,13	0,50	3,64
SA6	4S/3M	H-X-L	3	0,42	0,11	0,20	0,15	0,14	0,50	3,64
SA1	4S/3M	L-X-H	3	0,45	0,11	0,24	0,16	0,13	0,54	4,09
ZA1	2S/2M DAR	VR-HL	2	0,45	0,13	0,24	0,17	0,16	0,55	3,54

Test-surface:
- surface for z_{RALH} : dry or wet asphalt
- surface for z_{RALL} : wet blue basalt

Requirements for z_{RALS}:

A	$z_{RALS} \geq \frac{0,75}{\varepsilon_H} \times \frac{(4 \times z_{RALL} + z_{RALH})}{5}$	(if $\varepsilon_H > 0,95$ use $\varepsilon_H = 0,95$)
B	$z_{RALS} > \frac{z_{RALL}}{\varepsilon_H}$	
C	$\frac{z_{RALH}}{\varepsilon_H} \geq 0,5$	
D	$\frac{z_{RALH}}{z_{RALL}} \geq 2$	

Appendix 4.3.

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Split friction LSD + 1 bar

Vehicle	ABS	configu ration	no of axles	z_{RALH}	z_{RALL}	z_{RALS}	requirements for z_{RALS}			
							A	B	C	D
DA1	4S/3M	L-H	2	0,43	0,12	0,22	0,20	0,16	0,79	5,02
DA3	4S/3M	H-L	2	0,38	0,08	0,17	0,14	0,11	0,50	4,81
DA2	4S/3M	L-H-X	3	0,45	0,10	0,21	0,15	0,11	0,52	4,42
SA8	2S/2M	H	1	0,45	0,12	0,28	0,18	0,15	0,57	3,81
SA7	2S/2M	H-X	2	0,42	0,10	0,21	0,15	0,12	0,50	4,22
SA7	2S/2M	X-H	2	0,42	0,11	0,22	0,15	0,13	0,50	3,88
SA7	4S/2M	H-Z	2	0,48	0,11	0,25	0,14	0,12	0,51	4,50
SA7	4S/3M	H-L	2	0,42	0,10	0,19	0,15	0,12	0,50	4,00
SA7	4S/3M	L-H	2	0,38	0,10	0,23	0,15	0,13	0,50	3,79
SA6	2S/2M	H-X-X	3	0,38	0,09	0,19	0,15	0,12	0,50	4,07
SA6	2S/2M	X-H-X	3	0,41	0,12	0,24	0,16	0,14	0,50	3,58
SA6	4S/2M	X-H-Z	3	0,46	0,11	0,25	0,15	0,12	0,50	4,01
SA6	4S/2M	Z-H-X	3	0,43	0,11	0,23	0,15	0,13	0,50	3,98
SA6	4S/2M	Z-X-H	3	0,42	0,10	0,22	0,15	0,12	0,50	4,29
SA6	4S/3M	X-H-L	3	0,40	0,11	0,20	0,15	0,14	0,50	3,80
SA9	4S/3M	L-H-X	3	0,42	0,11	0,22	0,16	0,13	0,50	3,68
SA6	4S/3M	H-X-L	3	0,41	0,09	0,18	0,14	0,11	0,50	4,57
SA6	4S/3M	L-X-H	3	0,38	0,10	0,21	0,16	0,13	0,50	3,65
ZA1	2S/2M DAR	VR-HL	2	0,45	0,13	0,23	0,18	0,16	0,55	3,38

Test-surface:
- surface for z_{RALH} : dry or wet asphalt
- surface for z_{RALL} : wet blue basalt

Requirements for z_{RALS}:

A	$z_{RALS} \geq \frac{0,75}{\varepsilon_H} \times \frac{(4 \times z_{RALL} + z_{RALH})}{5}$	(if $\varepsilon_H > 0,95$ use $\varepsilon_H = 0,95$)
B	$z_{RALS} > \frac{z_{RALL}}{\varepsilon_H}$	
C	$\frac{z_{RALH}}{\varepsilon_H} \geq 0,5$	
D	$\frac{z_{RALH}}{z_{RALL}} \geq 2$	

Appendix 5.

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Safety assessment

1. Assessment of the development systematic and the safety concept

1.1.	Documentation and evaluation of the system concept	: The manufacturer presented documentation in which the configurations of the ABS system VCS with its functions and the safety philosophy are described.
1.2.	Safety assessment	: An audit with respect to the safety philosophy of this system was carried out with respect to the following subjects: - Project management and course of development. - Safety concept. - System specification. - Development methods and tools. - Block diagrams. - Circuit diagrams. - Monitoring functions. - System FMEA. - ECU FMEA. The presented documents were satisfactory. It is anticipated that the measures taken are sufficient to attain the desired level of safety.
1.3.	Analysis regarding possible failures	: It was evident in a documented analysis regarding the possible failures (FMEA) that the safety concept presented had been realised. Practical tests of the efficiency of the failure monitoring at the periphery were carried out during driving and rig tests (see section 4 below).The specified safety and failure concept was confirmed

2. Peripheral fault detection and system reaction

	The following failures outside of the controller (ECU) were simulated and analysed:	: - Open circuits. - Short circuits. - Sensor failures. - Under-voltage in supply power. - Over-voltage in supply power. Measures have been taken within the ECU that enable detection of corrupted input signals. Depending on the type of failure and system configuration the controller passes into a defined state in which partial functions are maintained. Or the system is switched of completely. In all cases the ECU is able to detect failures external to the controller and provides a failure warning. See also the following table.

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3. Operational and environmental influences

General : The manufacturer demonstrated that the ECU was specified and developed for those service and environmental influences that would be appropriate to a vehicle-mounted electronic system. (climatic test, protection class test, vibration and shock test).

EMC : See section 3.3.9. of this report

4. Safety assessment, table of failure-mode simulation

Component	Introduced failure	Failure-mode
Wheel speed sensor c (H2)	Cable fracture	Warning lamp on
Wheel speed sensor d (H1)	Short circuit	Warning lamp on
Modulator C (H2)	Cable fracture	Warning lamp on
Modulator B (H1)	Short circuit	Warning lamp on
Electronic control unit (ECU)	Low voltage	Warning lamp on
Electronic control unit (ECU)	High voltage	Warning lamp on

Appendix 6.

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1. Cross-referencing test results.

1.1. In accordance with the provisions of 4.1. of Annex XIV the following cross-references were considered appropriate and equivalent.

1.1.1. Concerning the utilisation of adhesion :

Full trailer			
Equivalent ABS type and configuration		*Tested ABS type and configuration*	
4S/3M	L-X-H	4S/3M	L-H-X
The bogie of a 3-axle full trailer can be considered as one axle, therefore these ABS configurations are equivalent.			

Semi-trailer or centre-axle trailer			
Equivalent ABS type and configuration		*Tested ABS type and configuration*	
2S/2M	X-X-H	2S/2M	X-H-X
Due to suspension reactivity, sensor-configuration X-H-X is considered worst case compared to sensor-configuration X-X-H.			
Equivalent ABS type and configuration		*Tested ABS type and configuration*	
4S/2M	H-Z-X	4S/2M	Z-H-X
4S/2M	Z-H	4S/2M	H-Z
4S/2M	X-Z-H	4S/2M	X-H-Z
The ABS control logic considers sensors Z and H equivalent.			

1.1.2. Concerning the energy consumption : For every configuration one representative test was conducted because the location of the sensors is considered not to have a significant influence on the energy consumption.