

## **Report on the status of work on the issue of electro-hydraulic systems, (ECE/TRANS/WP29/GRRF/2013/29)**

Based on the informal paper GRRF-76-24e.pdf presented on the 76.GRRF and a mandate from GRRF after the subsequent discussion an ad hoc group on the issue of annex 14 to R13 was founded. The first and so far the only session was on April 8. and 9. Under participation of industry, OICA, Netherlands, Japan and Germany. The text below reflects the status after that session and though some issues could be clarified (telltale, connector) it still leaves some questions unanswered (residual voltage, testing voltage, enabling of trailer braking via stop light signal or combination deceleration alone (1.3 and 2.5)). A few comments to those questions are at hand meanwhile but not worked in the text below. In the course of the discussion it was pointed out that the intended technology to be used requires energy reservoirs on the trailer and as such may differ from the technology that the current annex 14 is based on thus raising safety issues that have been already resolved in the field of O3/O4-trailers. Therefore it seemed appropriate to rely on some principle requirements to the latter and adapt them for the purpose of annex 14.

The text of R13 Rev.8 is used as starting point, the unchanged paragraphs of Annex 14 are kept in the proposal in order to have a better view on the end result:

- in blue the paragraphs which are amended with text to be deleted ~~crossed-out~~ and added text in **bold**,
- in dark red italic the justification for each amendment
- in black the unchanged paragraphs of Annex 14.
- \*) in green where comments are at hand meanwhile

### **Proposal:**

*par. 5.2.1.19.1.amend to read:*

5.2.1.19.1. The power supply (generator and battery) of the power-driven vehicle shall have a sufficient capacity to provide the current for an electrical braking system. With the engine running at the idling speed recommended by the manufacturer and all electrical devices supplied by the manufacturer as standard equipment of the vehicle switched on, the voltage in the electrical energy supply lines for the electrical braking system of the trailer shall at maximum current consumption of the electrical braking system (15 A) not fall below the value of 9,6 [??] V measured at the connection. The electrical lines shall not be capable of short circuiting even when overloaded;

*Justification:*

*Paragraph 5.2.1.19.1:*

*Text amended for clarification, proposed text makes clear that the electrical energy supply line is meant. The currently mentioned 9,6 V measured at the connection is unrealistic low and not necessary. The minimum voltage at the battery of the towing vehicle with running engine is 12 V although in practice voltages of 13,5 to 14,5 V are more common. The loss of voltage between the battery and the connector depends on the electrical resistance (section width)of the cable.*

*Voltage [??]; not yet known, depends on answer from OICA and further discussion. \*)*

*Remark: The same proposal applies mutatis mutandis to regulation no. 13-H par 5.2.17.1.*

Annex 10

*Annex 10, insert new paragraphs 5.3. to 5.3.3., to read:*

**"5.3. For full trailers with electric braking system**

**5.3.1. The requirements according to paragraph 5.1.1. apply also for full trailers with electric braking system.**

**5.3.2. For full trailers with electric braking system and with more than two axles the requirements according to paragraph 5.1.2. apply.**

**5.3.3. For the calculation to verify the compliance with the provisions of**

**paragraph 5.1.1.3. the influence of the drawbar can be ignored."**

*Justification:*

*Annex 10, paragraph 5.3, 5.3.1, 5.3.2 and 5.3.3:*

*The current scope of the UN Regulation No. 13 reads that it covers full trailers with an electrical braking system (5.2.2.2, last sentence). Annex 4 para. 1.3.2. requires O2- trailers, as to their behaviour on a low adhesion ground, to comply with the relevant provisions of Annex 10 but there are none (para. 5, resp. 5.1 covers only full trailers fitted with compressed-air braking systems).*

*These new paragraphs are in essence an import from an old proposal (ECE/TRANS/WP29/GRRF/2003/8) that was made to make some improvements to the inertia braked full trailer shortly before it was eliminated via ECE/TRANS/WP.29/GRRF/2004/11.*

Annex 14

*Annex 14 title amend to read:*

Test conditions for trailers **of categories O1 and O2** with electrical braking systems

*Justification:*

*Annex 14, Title:*

*"categories O1 and O2" are added for clarification.*

1. General

*Annex 14 par. 1.1 amend to read:*

1.1. For the purposes of the following provisions electrical braking systems are service braking systems consisting of a control device, an electromechanical, **electro-pneumatic or electrohydraulic** transmission device, and friction brakes. The electrical control device regulating the ~~voltage~~ **braking force** for the trailer shall be situated on the trailer.

*Justification:*

*Annex 14 par. 1.1:*

*The original text of the Regulation gives constructive requirements for the transmission to be electromechanical. New innovative electrohydraulic and electro-pneumatic systems should not be excluded. The wording "voltage" has to be replaced by "braking force" to remove the design restriction.*

1.2. The electrical energy required for the electrical braking system is supplied to the trailer by the towing vehicle.

1.3. Electrical braking systems shall be actuated by operating the service braking system of the towing vehicle.

1.4. The nominal voltage rating shall be 12 V.

*Annex 14, insert new paragraph 1.4.1 to read:*

**During the tests of paragraph 3 the electrical braking system shall be supplied with a test voltage of [12] V, measured at the energy supply connector.**

*Justification:*

*Annex 14, paragraph 1.4.1:*

*The voltage during the test and the place where it should be measured is an important parameter for the braking performance of the trailer.*

*The current text is not clear, what means "nominal 12 V" (paragraph 1.4) with regard to the voltage to be used during the test described in paragraph 3. Nor is it clear where during the tests the voltage has to be measured.*

*The proposed text brings the necessary clarity. The actual value for voltage is not yet decided and has to be discussed further.*

*Annex 14, paragraph 1.5 amend to read:*

1.5. The maximum current consumption **measured in the energy supply line between the towing vehicle and the trailer** shall not exceed 15 A.

*Justification:*

*Annex 14, paragraph 1.5:*

*The proposed text clarifies where the current has to be measured.*

*Annex 14, paragraph 1.6 amend to read:*

1.6. The electrical connection of the electrical braking system to the towing vehicle shall be effected by means of a special plug and socket connection corresponding to ...,1/ which shall not be compatible with the sockets of the lighting equipment of the vehicle. **In the case of articulated vehicle combinations, the plug together with the cable shall be situated on the trailer a part of the power-driven vehicle. In all other cases, the plug together with the cable shall be a part of the trailer.**

*Justification:*

*Annex 14, paragraph 1.6:*

*To bring the requirements for the electrical braking system in line with the requirements for the air braking systems, paragraph 5.1.3.8. Electric braking systems are relatively often used on semi-trailers.*

*1/ Under study. Until the characteristics of this special connection have been determined, the type to be used will be indicated by the National Type Approval Authority granting the approval.*

**The connection however shall at least fulfil the following requirements:**

- the plug and the socket shall have sealings, to prevent liquids or dirt to get into,**
- the plug and the socket shall have a robust locking mechanism to hold the plug with a connection in the socket,**
- at least two terminals at the rear of the pins and tubes shall be capable of accepting cables with a cross-sectional area of at least [5,5] mm<sup>2</sup> (energy supply lines)**
- the socket shall have a cover which closes automatically when the plug is disconnected.**

*Justification:*

*Annex 14, footnote to paragraph 1.6:*

*At this moment it is not yet possible to specify a standard for the connection. However for safety reasons the most important basic requirements are proposed to be added to the footnote. For the energy supply of the electrical braking system at least two pins and tubes are specified to be capable of accepting cables with a cross section of [5,5] mm<sup>2</sup> in order to provide the possibility of using cables with a low resistance to restrict the loss of voltage and not to restrict the design of the electric braking system with regard the energy supply.*

## 2. Conditions concerning the trailer

*Annex 14, par. 2.1 amend to read:*

2.1. If there is a battery on the trailer, **which is not used for the service braking system and** fed by the power supply unit of the towing vehicle, it shall be separated from its supply line during service braking of the trailer.

*Justification:*

*Annex 14, paragraph 2.1:*

*In this proposal provisions are introduced for an energy storage device on the trailer providing the energy for the electric service brake. It does not make sense to separate this energy storage device from the supply line. However batteries used for auxiliary equipment and/or the automatic braking should be separated from the supply line to supply the service braking system with the maximum available energy.*

*The text is amended in order to restrict the requirement to the batteries not used for the electric service brake.*

2.2. With trailers whose unladen mass is less than 75 per cent of their maximum mass, the braking force shall be automatically regulated as a function of the loading condition of the trailer.

*Annex 14, par. 2.3 amend to read:*

2.3. Electrical braking systems shall be such that even when the voltage in the ~~connection lines~~ **energy supply line between the towing vehicle and the trailer** is reduced to a value of 7 V, **measured at the energy supply connector** a braking effect of 20 per cent of the (sum of the) maximum stationary axle load(s) is maintained.

*Justification:*

*Annex 14, paragraph 2.3:*

*For clarification, the current text does not make clear where the voltage has to be measured.*

*Annex 14, par. 2.4 amend to read:*

2.4. Control devices for regulating the braking force, which react to the inclination in the direction of travel (pendulum, spring-mass-system, liquid-inertia-switch) shall, if the trailer has more than one axle and a vertically adjustable towing device, be attached to the chassis. In the case of single-axle trailers and trailers with close-coupled axles where the axle spread is less than 1 metre, these control devices shall be equipped with a mechanism indicating its horizontal position (e.g., spirit level) and shall be manually adjustable to allow the mechanism to be set in the horizontal plane in line with the direction of travel of the vehicle. **Alternatively, devices which are self leveling to the horizontal plane are allowed on the condition that a warning is given in the case of a failure. Such a warning shall be provided within the driver's indirect field of vision and shall be flashing (not constant). The warning signal may be given by flashing the tell tale specified in paragraph 2.7. The satisfactory condition of the signals shall be easily verifiable.**

*Justification:*

*Annex 14, paragraph 2.4:*

*At the time the current version of Annex 14 was written there were not yet highly reliable micro-electronic devices to detect the deceleration of the combination. These devices often appear as a sensor-cluster which is able to detect the acceleration on all three axes at the same time. With these sensors it is relatively easy to generate a self-leveling system which does not need to be adjusted by the user. The text of par. 2.4 is amended to allow these new devices.*

*Because the driver leaves the automatic adjustment to the device he assumes the adjustment is correct. For that reason the driver shall be warned in the case there is a failure in the device.*

*Annex 14, par. 2.5 amend to read:*

2.5. The relay for actuating the ~~braking current~~ **service braking system** in accordance with paragraph 5.2.1.19.2. of this Regulation, which is connected to the actuating line, shall be situated on the trailer.

*Justification:*

*Annex 14, paragraph 2.4:*

*Text is amended in order to delete the design restriction.*

2.6. A dummy socket shall be provided for the plug.

*Annex 14, par 2.7 amend to read:*

2.7. A tell-tale shall be provided ~~at the control device~~, **within the driver's indirect field of vision, [exclusively]** lighting up at any brake application and indicating the proper functioning of the trailer electrical braking system.

*Justification:*

Annex 14, paragraph 2.7:

*The text assures that the tell tale is visible for the driver from his driving seat.*

*Annex 14, insert a new par. 2.8 to 2.8.3.1 to read:*

**2.8. The trailer's braking system may be equipped with one or more energy storage device(s) (energy accumulators), fed direct or indirect by the electric energy supplied by the towing vehicle, provided that all of the following requirements are fulfilled:**

**2.8.1. Capacity**

**2.8.1.1. The energy storage device (energy accumulator) of the trailer shall be such that after eight actuations of the service brake, under the condition prescribed in par. 2.8.1.2. below, it shall still be possible to achieve on the ninth application a braking force of at least 25 % of the maximum total axle load and without actuating the self braking device.**

**2.8.1.2. Testing shall be performed in conformity with the following requirements:**

- the initial energy level in the energy storage device (energy accumulator) may be specified by the manufacturer but is not more than the minimum level occurring during normal operation of the system,
- the energy storage device shall not be fed, in addition, any energy storage device (energy accumulator) for auxiliary equipment shall be isolated,
- each brake actuation shall be equivalent to a braking from 60 km/h to 0 km/h with the maximum achievable braking force,
- where the duration of the braking has influence on the energy consumption each brake actuation shall last at least 4,4 seconds (corresponding to a braking from 60 km/h to 0 km/h).

*Justification:*

Annex 14, paragraph 2.8:

*New paragraph allowing energy storage devices on the trailer for the service brake. This allowance is necessary to open new possibilities for innovative improvements of the functioning of the electric braking systems.*

Annex 14, paragraph 2.8.1:

*To guarantee sufficient energy in the energy accumulator requirements for the capacity are necessary. This is analogous to the air brake system.*

Annex 14, paragraph 2.8.1.1:

- Text based on par.1.2.1 of Annex 7 part C. Text is adapted to be general.
- The 25%-requirement is based on the common practice in R13 to specify the secondary braking performance in combination with energy storage devices. In the case of pneumatic braking systems R13 Annex 7 specifies after eight full stroke actuations half the pressure after a first full stroke actuation. This value implies also about half of the braking forces after a certain amount of full stroke applications. Generally the prescribed secondary braking performance is half the service braking performance. In the case of electric braking systems Annex 14 prescribes braking forces of 50% of the maximum axle load.
- A provision with regard to the actuation of the self braking device is added (text based on par. 1.3 of Annex 7)

Annex 14, paragraph 2.8.1.2:

- The initial energy level has to be at the cut-in pressure. That is the worst case during normal operation of the system..
- Text analogous to e.g. text par. 1.2.1.2.2. of Annex 7 Part C.
- Specification of "a braking from 60 km/h to 0 km/h with the maximum achievable braking force" in stead of the in regulation no.13 commonly used "full stroke actuations of towing vehicle's service braking system" is necessary to take into account that the control of the electric braking system is on

*the trailer.*

*- In some cases the used energy depends also on the time the brakes are applied, e.g. in the case electromagnets are used to generate the braking power. To avoid different interpretations the time is fixed at 4,4 s. This time is derived from the 50 % braking force and 60 km/h (Annex 14 par. 3.4 and 3.5) and the type 0 test of M2, M3, N2 and N3 vehicles:  $v = 60 \text{ km/h}$ ,  $a = 5,0 \text{ m/s}^2$  and  $s = 0,15 v + v^2/130$  (Annex 4 par. 2.1.1). These givens lead to a braking time of 4,4 seconds.*

## **2.8.2. Warnings**

**2.8.2.1 A warning shall be given when the stored energy falls to a value at which without recharging of the energy storage device (energy accumulator) and irrespective of the load conditions of the trailer, it is possible to brake for a fifth time from 60 km/h to 0 km/h and obtain a braking force of at least 25 % of the maximum total axle load after four actuations of the service brake each equivalent to a braking from 60 km/h to 0 km/h with the maximum achievable braking force. Where the duration of the braking has influence on the energy consumption each brake actuation shall last at least 4,4 seconds (corresponding to a braking from 60 km/h to 0 km/h).**

**2.8.2.2. The warning signal shall be provided within the driver's indirect field of vision and shall be flashing (not constant). The warning signal may be given by flashing the tell tale specified in paragraph 2.7. The satisfactory condition of the signals shall be easily verifiable.**

*Justification:*

### Annex 14, par. 2.8.2.1:

*- Based upon par. 5.2.1.13.1. Text is adapted to the electric trailer braking system. Secondary brake braking performance is generally half of the service braking performance. A similar requirement can be found in par. 5.2.2.16.1.*

*- Specification of "a braking from 60 km/h to 0 km/h with the maximum achievable braking force" in stead of the in regulation no.13 commonly used "full stroke actuations of towing vehicle's service braking system" is necessary to take into account that the control of the electric braking system is on the trailer.*

*- In some cases the used energy depends also on the time the brakes are applied, e.g. in the case electromagnets are used to generate the braking power. To avoid different interpretations the time is fixed at 4,4 s. This time is derived from a the 50 % braking force (Annex 14 par. 3.4 and 3.5) and the type 0 test of M2, M3, N2 and N3 vehicles:  $v = 60 \text{ km/h}$ ,  $a = 5,0 \text{ m/s}^2$  and  $s = 0,15 v + v^2/130$  (Annex 4 par. 2.1.1). These givens lead to a braking time of 4,4 seconds.*

### Annex 14, par. 2.8.2.2:

*Text based upon paragraph 5.2.1.29. The flashing is not specified in detail since that may be too restrictive. From which position the signal has to be verifiable is not specified either because the tell tale (warning) is on the trailer. It is not necessary to specify such in detail.*

## **2.8.3. Self braking**

**2.8.3.1. The trailer shall be equipped with a system which applies the service brake or the parking brake and locks the brake mechanically when the energy level in the energy storage device (energy accumulator) is such that a braking with the performance prescribed in paragraph 3.3. of Annex 4 to this Regulation can no longer be ensured. This requirement also applies when the trailer is not connected to the towing vehicle.**

**2.8.3.2. It shall be possible to release the braking system, if necessary by the use of tools and/or an auxiliary device carried/fitted on the vehicle.**

*Justification:*

- The term “self braking” is proposed since “automatic braking” refers by definition (par. 2.11) only to braking in the case of separation of components of the combination including such separation through the breakage of a coupling.

Par. 2.8.3.1:

- Requirement based upon par. 5.2.2.15.2.

- This requirement is uniquely for an electric trailer braking system and not for all the other trailer braking systems. However air brake systems of trailers O3 and O4 have in practice a system which keeps the trailer brakes applied as long as there is insufficient pressure in the reservoirs although there has to be some pressure otherwise the trailer is not braked in the case the trailer is not equipped with spring brakes.

- This provision is inserted also to safeguard that a trailer with electrical brakes and without sufficient energy in the storage device is coupled to a towing vehicle and driven away. It is necessary because there are no requirements with regard to the time necessary to bring the energy level of the storage device to a sufficient high level. E.g. the recharging of an empty battery can take a rather long time. Mechanical locking is necessary to assure the trailer is also braked when no energy is left e.g. after a certain time being parked.

Par. 2.8.3.2:

Text based on paragraph 5.2.1.26.2.1, adapted to the electric trailer brake. It is necessary to have a possibility to release the brakes since it could happen that the trailer comes to a standstill at a place where it endangers the other traffic.

### 3. Performance

3.1. Electrical braking systems shall respond at a deceleration of the tractor/trailer combination of not more than 0.4 m/s<sup>2</sup>.

3.2. The braking effect may commence with an initial braking force, which shall not be higher than 10 per cent of the (sum of the) maximum stationary axle load(s) nor higher than 13 per cent of the (sum of the) stationary axle load(s) of the unladen trailer.

3.3. The braking forces may also be increased in steps. At higher levels of the braking forces than those referred to in paragraph 3.2. of this annex these steps shall not be higher than 6 per cent of the (sum of the) maximum stationary axle load(s) nor higher than 8 per cent of the (sum of the) stationary axle load(s) of the unladen trailer. However, in the case of single-axle trailers having a maximum mass not exceeding 1.5 tonnes, the first step shall not exceed 7 per cent of the (sum of the) maximum stationary axle load(s) of the trailer. An increase of 1 per cent of this value is permitted for the subsequent steps (example: first step 7 per cent, second step 8 per cent, third step 9 per cent, etc; any further step should not exceed 10 per cent). For the purpose of these provisions a two-axle trailer having a wheelbase shorter than 1 m will be considered as a single axle trailer.

3.4. The prescribed braking force of the trailer (including semi-trailers) of at least 50 per cent of the maximum total axle load shall be attained - with maximum mass - in the case of a mean fully developed deceleration of the tractor/trailer combination of not more than 5.9 m/s<sup>2</sup> with single-axle trailers and of not more than 5.6 m/s<sup>2</sup> with multi-axle trailers. Trailers with close-coupled axles where the axle spread is less than 1 m are also considered as single-axle trailers within the meaning of this provision. Moreover, the limits as defined in the appendix to this annex shall be observed. If the braking force is regulated in steps, they shall lie within the range shown in the appendix to this annex.

*Justification:*

Par. 2.8.3.1:

- “Including semi-trailers” added for clarity.

3.5. The test shall be carried out with an initial speed of 60 km/h.

3.6. Automatic braking of the trailer shall be provided in accordance with the conditions of paragraph 5.2.2.9. of this Regulation. If this automatic braking action requires electrical energy, a trailer braking force of at least 25 per cent of the maximum total axle load shall be achieved for at least 15 minutes to satisfy the above-mentioned conditions.

**Annex 14 - Appendix**  
**Compatibility of the braking rate of the trailer and the**  
**mean fully developed deceleration of the tractor/trailer**  
**combination (trailer laden and unladen)**

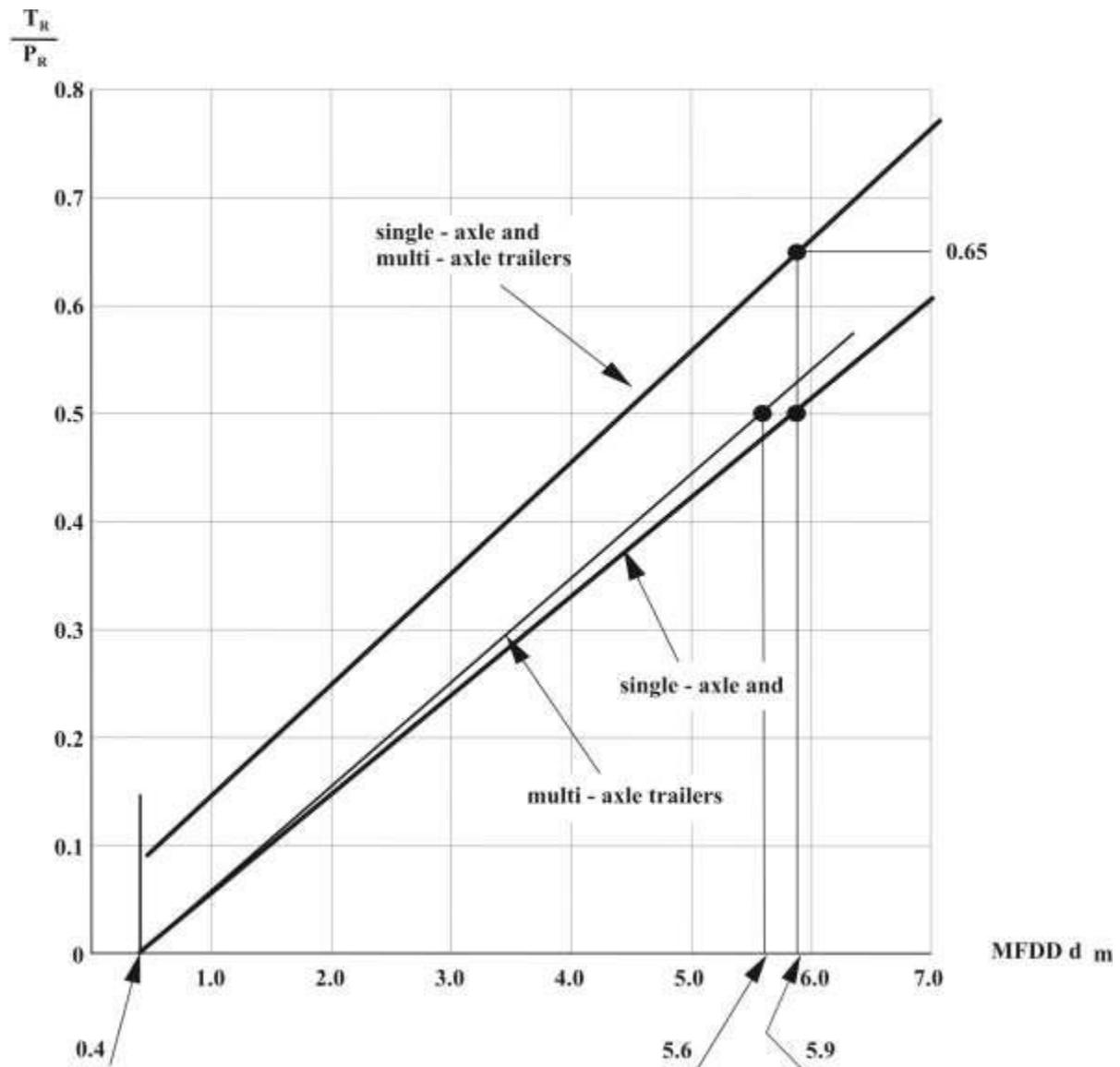
*Annex 14, Appendix text in the diagram amend to read:*

**In the diagram the terms “centre-axle trailer” and “semi-trailer” shall be used instead of “single-axle trailer”. The term “full trailer” shall be used instead of “multi-axle trailer”**

*Justification:*

*Annex 14, paragraph 2.4:*

*For clarification, in the past terms as multi axle trailer and single axle trailer were use. In the meantime these terms are replaced by full trailer, centre-axle trailer and semi-trailer.*



*Notes:*

1. Limits indicated in the diagram refer to laden and unladen trailers. When the trailer unladen mass exceeds 75 per cent of its maximum mass, limits shall be applied only to "laden" conditions.
  2. Limits indicated in the diagram do not affect the provisions of this annex regarding the minimum braking performances required. However, if braking performances obtained during test - in accordance with provisions indicated in paragraph 3.4. of this annex - are greater than those required, said performances shall not exceed the limits indicated in the above diagram.
- TR = sum of braking forces at periphery of all wheels of trailer.

PR = total normal static reaction of road surface on wheels of trailer.  
dm = mean fully developed deceleration of tractor/trailer combination.

### **Comments presently at hand \*):**

As to par. 5.2.1.19.1 from OICA:

- OICA is ready to increase the voltage from 9.6V up to 11.1V, provided the following amendment are made:

"5.2.1.19.1. The power supply (generator and battery) of the power-driven vehicle shall have a sufficient capacity to provide the current for an electrical braking system.

**At the time of type approval, it shall be checked that, with the engine running at the idling speed recommended by the manufacturer and the ~~all~~ electrical devices **required during normal vehicle use** ~~supplied by the manufacturer as standard equipment of the vehicle~~ switched on, the voltage in the electrical **energy supply line lines for the electrical braking system of the trailer** shall at maximum current consumption of the electrical braking system (15 A) not fall below the value of **11.1 V** measured at the connection.**

The electrical lines shall not be capable of short circuiting even when overloaded;"

### **Comment on the appendix to annex 14 with regard to multi axle trailers i.e. full trailers**

1. In the course of the debate around annex 14 an issue was also the allowable drawbar forces. The appendix allows drawbar forces that are comparable to those for multi axle overrun braked trailers. The documents 2004/10 and 2004/11 differ in the wording of 5.2.2.2 as to the applicability of annex 14 for full trailers resulting in the current state of 5.2.2.2 which implies the use of annex 14 to full trailers.
2. Allowable drawbar forces of full trailer are smaller than those of centre axle trailers both in annex 12 and annex 14 which suggests that the regulation had already made up for the situation of drawbar forces in case of full trailers.

Both aspects suggest that drawbar forces were at least not the primary reason for the elimination of the multi axle overrun braked trailers.

3. The current state of annex 14 does not require any particular brake force distribution. This proposal makes an adaption to the level of annex 10, par. 5.1 that was also used for O3/O4-trailers (high drawbar forces possible) in times when ABS was not mandatory.

These are some aspects that in the course of the discussions to annex 14 led to the belief that it was appropriate to reconsider the case of the overrun braked O1/O2 full trailer on the basis of the document 2003/8.