

21 April 2005

## **AGREEMENT**

### **CONCERNING THE ADOPTION OF UNIFORM TECHNICAL PRESCRIPTIONS FOR WHEELED VEHICLES, EQUIPMENT AND PARTS WHICH CAN BE FITTED AND/OR BE USED ON WHEELED VEHICLES AND THE CONDITIONS FOR RECIPROCAL RECOGNITION OF APPROVALS GRANTED ON THE BASIS OF THESE PRESCRIPTIONS \*/**

(Revision 2, including the amendments which entered into force on 16 October 1995)

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#### **Addendum 78: Regulation No. 79**

#### **Revision 2**

#### **Incorporating all valid text up to:**

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### **UNIFORM PROVISIONS CONCERNING THE APPROVAL OF VEHICLES WITH REGARD TO STEERING EQUIPMENT**



**UNITED NATIONS**

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\*/ Former title of the Agreement:

Agreement Concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts, done at Geneva on 20 March 1958.



Regulation No. 79

UNIFORM PROVISIONS CONCERNING THE APPROVAL OF VEHICLES  
WITH REGARD TO STEERING EQUIPMENT

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## 0. INTRODUCTION

The intention of the Regulation is to establish uniform provisions for the layout and performance of steering systems fitted to vehicles used on the road. Traditionally the major requirement has been that the main steering system contains a positive mechanical link between the steering control, normally the steering wheel, and the road wheels in order to determine the path of the vehicle. The mechanical link, if amply dimensioned, has been regarded as not being liable to failure.

Advancing technology, coupled with the wish to improve occupant safety by elimination of the mechanical steering column, and the production advantages associated with easier transfer of the steering control between left and right hand drive vehicles, has led to a review of the traditional approach and the Regulation is now amended to take account of the new technologies. Accordingly it will now be possible to have steering systems in which there is not any positive mechanical connection between the steering control and the road wheels.

Systems whereby the driver remains in primary control of the vehicle but may be helped by the steering system being influenced by signals initiated on-board the vehicle are defined as "Advanced Driver Assistance Steering Systems". Such Systems can incorporate an "Automatically Commanded Steering Function", for example, using passive infrastructure features to assist the driver in keeping the vehicle on an ideal path (Lane Guidance, Lane Keeping or Heading Control), to assist the driver in manoeuvring the vehicle at low speed in confined spaces or to assist the driver in coming to rest at a pre-defined point (Bus Stop Guidance). Advanced Driver Assistance Steering Systems can also incorporate a "Corrective Steering Function" that, for example, warns the driver of any deviation from the chosen lane (Lane Departure Warning), corrects the steering angle to prevent departure from the chosen lane (Lane Departure Avoidance) or corrects the steering angle of one or more wheels to improve the vehicle's dynamic behaviour or stability.

In the case of any Advanced Driver Assistance Steering System, the driver can, at all times, choose to override the assistance function by deliberate action, for example, to avoid an unforeseen object in the road.

It is anticipated that future technology will also allow steering to be influenced or controlled by sensors and signals generated either on or off-board the vehicle. This has led to several concerns regarding responsibility for the primary control of the vehicle and the absence of any internationally agreed data transmission protocols with respect to off-board or external control of steering. Therefore, the Regulation does not permit the general approval of systems that incorporate functions by which the steering can be controlled by external signals, for example, transmitted from roadside beacons or active features embedded into the road surface. Such systems, which do not require the presence of a driver, have been defined as "Autonomous Steering Systems".

This Regulation also prevents the approval of positive steering of trailers using energy supply and electrical control from the towing vehicle as there are not any standards applicable to energy supply connectors or to control transmission digital information interchange. It is expected that at some time in the future, the International Standards Organization (ISO) Standard, ISO11992, will be amended to take account of transmission of steering control data.

## 1. SCOPE

- 1.1. This Regulation applies to the steering equipment of vehicles of categories M, N and O. 1/
- 1.2. This Regulation does not apply to:
  - 1.2.1. Steering equipment with a purely pneumatic transmission;
  - 1.2.2. Autonomous Steering Systems as defined in paragraph 2.3.3;
  - 1.2.3. Full power steering systems fitted to trailers where the energy necessary for operation is transmitted from the towing vehicle;
  - 1.2.4. The electrical control of full power steering systems fitted to trailers, other than additional steering equipment as defined in paragraph 2.5.2.4.

## 2. DEFINITIONS

For the purposes of this Regulation:

- 2.1. "Approval of a vehicle" means the approval of a vehicle type with regard to its steering equipment.
- 2.2. "Vehicle type" means a vehicle which does not differ with respect to the manufacturer's designation of the vehicle type and in essential characteristics such as:
  - 2.2.1. type of steering equipment, steering control, steering transmission, steered wheels, and energy source.
- 2.3. "Steering equipment" means all the equipment the purpose of which is to determine the direction of movement of the vehicle.

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1/ As defined in Annex 7 of the Consolidated Resolution on the Construction of Vehicles (R.E.3) (TRANS/SC.1/WP.29/78/Rev.1).

The steering equipment consists of:

The steering control,

The steering transmission,

The steered wheels,

The energy supply, if any.

2.3.1. "Steering control" means the part of the steering equipment which controls its operation; it may be operated with or without direct intervention of the driver. For steering equipment in which the steering forces are provided solely or partly by the muscular effort of the driver the steering control includes all parts up to the point where the steering effort is transformed by mechanical, hydraulic or electrical means;

2.3.2. "Steering transmission" means all components which form a functional link between the steering control and the road wheels.

The transmission is divided into two independent functions:

The control transmission and the energy transmission.

Where the term "transmission" is used alone in this Regulation, it means both the control transmission and the energy transmission. A distinction is drawn between mechanical, electrical and hydraulic transmission systems or combinations thereof, according to the means by which the signals and/or energy is transmitted.

2.3.2.1. "Control transmission" means all components by means of which signals are transmitted for control of the steering equipment.

2.3.2.2. "Energy transmission" means all components by means of which the energy required for control/Regulation of the steering function of the wheels is transmitted.

2.3.3. "Autonomous Steering System" means a system that incorporates a function within a complex electronic control system that causes the vehicle to follow a defined path or to alter its path in response to signals initiated and transmitted from off-board the vehicle. The driver will not necessarily be in primary control of the vehicle.

2.3.4. "Advanced Driver Assistance Steering System" means a system, additional to the main steering system, that provides assistance to the driver in steering the vehicle but in which the driver remains at all times in primary control of the vehicle. It comprises one or both of the following functions:

2.3.4.1. "Automatically commanded steering function" means the function within a complex electronic control system where actuation of the steering system can result from

automatic evaluation of signals initiated on-board the vehicle, possibly in conjunction with passive infrastructure features, to generate continuous control action in order to assist the driver in following a particular path, in low speed manoeuvring or parking operations.

- 2.3.4.2. "Corrective steering function" means the discontinuous control function within a complex electronic control system whereby, for a limited duration, changes to the steering angle of one or more wheels may result from the automatic evaluation of signals initiated on-board the vehicle, in order to maintain the basic desired path of the vehicle or to influence the vehicle's dynamic behaviour.

Systems that do not themselves positively actuate the steering system but that, possibly in conjunction with passive infrastructure features, simply warn the driver of a deviation from the ideal path of the vehicle, or of an unseen hazard, by means of a tactile warning transmitted through the steering control, are also considered to be corrective steering.

- 2.3.5. "Steered wheels" means the wheels, the alignment of which may be altered directly or indirectly in relation to the longitudinal axis of the vehicle in order to determine the direction of movement of the vehicle. (The steered wheels include the axis around which they are rotated in order to determine the direction of movement of the vehicle);

- 2.3.6. "Energy supply" includes those parts of the steering equipment which provide it with energy, regulate that energy and where appropriate, process and store it. It also includes any storage reservoirs for the operating medium and the return lines, but not the vehicle's engine (except for the purpose of paragraph 5.3.2.1.) or its drive to the energy source.

- 2.3.6.1. "Energy source" means the part of the energy supply, which provides the energy in the required form.

- 2.3.6.2. "Energy reservoir" means that part of the energy supply in which the energy provided by the energy source is stored, for example, a pressurised fluid reservoir or vehicle battery.

- 2.3.6.3. "Storage reservoir" means that part of the energy supply in which the operating medium is stored at or near to the atmospheric pressure, for example a fluid reservoir.

## 2.4. Steering parameters

- 2.4.1. "Steering control effort" means the force applied to the steering control in order to steer the vehicle.

- 2.4.2. "Steering time" means the period of time from the beginning of the movement of the steering control to the moment at which the steered wheels have reached a specific steering angle.
- 2.4.3. "Steering angle" means the angle between the projection of a longitudinal axis of the vehicle and the line of intersection of the wheel plane (being the central plane of the wheel, normal to the axis around which it rotates) and the road surface.
- 2.4.4. "Steering forces" mean all the forces operating in the steering transmission.
- 2.4.5. "Mean steering ratio" means the ratio of the angular displacement of the steering control to the mean of the swept steering angle of the steered wheels for a full lock-to-lock turn;
- 2.4.6. "Turning circle" means the circle within which are located the projections onto the ground plane of all the points of the vehicle, excluding the external mirrors and the front direction indicators, when the vehicle is driven in a circle;
- 2.4.7. "Nominal radius of steering control" means in the case of a steering wheel the shortest dimension from its centre of rotation to the outer edge of the rim. In the case of any other form of control it means the distance between its centre of rotation and the point at which the steering effort is applied. If more than one such point is provided, the one requiring the greatest effort shall be used.
- 2.5. Types of steering equipment
- Depending on the way the steering forces are produced, the following types of equipment are distinguished:
- 2.5.1. For motor vehicles:
- 2.5.1.1. "Main steering system" means the steering equipment of a vehicle which is mainly responsible for determining the direction of travel. It may comprise:
- 2.5.1.1.1. "Manual steering equipment" in which the steering forces result solely from the muscular effort of the driver.
- 2.5.1.1.2. "Power assisted steering equipment" in which the steering forces result from both the muscular effort of the driver and the energy supply (supplies).
- 2.5.1.1.2.1. Steering equipment in which the steering forces result solely from one or more energy supplies when the equipment is intact, but in which the steering forces can be provided by the muscular effort of the driver alone if there is a fault in the steering (integrated power systems), is also considered to be power assisted steering equipment;



- 2.5.1.1.3. "Full-power steering equipment" in which the steering forces are provided solely by one or more energy supplies;
- 2.5.1.2. "Self-tracking steering equipment" means a system designed to create a change of steering angle on one or more wheels only when acted upon by forces and/or moments applied through the tyre to road contact.
- 2.5.1.3. "Auxiliary steering equipment (ASE)" means a system in which the wheels on axle(s) of vehicles of categories M and N are steered in addition to the wheels of the main steering equipment in the same or opposite direction to those of the main steering equipment and/or the steering angle of the front and/or the rear wheels may be adjusted relative to vehicle behaviour.
- 2.5.2. For trailers:
- 2.5.2.1. "Self-tracking steering equipment" means a system designed to create a change of steering angle on one or more wheels only when acted upon by forces and/or moments applied through the tyre to road contact.
- 2.5.2.2. "Articulated steering" means equipment in which the steering forces are produced by a change in direction of the towing vehicle and in which the movement of the steered trailer wheels is firmly linked to the relative angle between the longitudinal axis of the towing vehicle and that of the trailer;
- 2.5.2.3. "Self-steering" means equipment in which the steering forces are produced by a change in direction of the towing vehicle and in which the movement of the steered trailer wheels is firmly linked to the relative angle between the longitudinal axis of the trailer frame or a load replacing it and the longitudinal axis of the sub-frame to which the axle(s) is (are) attached;
- 2.5.2.4. "Additional steering equipment" means a system, independent of the main steering system, by which the steering angle of one or more axle(s) of the steering system can be influenced selectively for manoeuvring purposes.
- 2.5.3. Depending on the arrangement of the steered wheels, the following types of steering equipment are distinguished:
- 2.5.3.1. "Front-wheel steering equipment" in which only the wheels of the front axle(s) are steered. This includes all wheels which are steered in the same direction.
- 2.5.3.2. "Rear-wheel steering equipment" in which only the wheels of the rear axle(s) are steered. This includes all wheels which are steered in the same direction.
- 2.5.3.3. "Multi-wheel steering equipment" in which the wheels of one or more of each of the front and the rear axle(s) are steered;

- 2.5.3.3.1. "All-wheel steering equipment" in which all the wheels are steered;
- 2.5.3.3.2. "Buckle steering equipment" in which the movement of chassis parts relative to each other is directly produced by the steering forces.

## 2.6. Types of steering transmission

Depending on the way the steering forces are transmitted, the following types of steering transmission are distinguished:

- 2.6.1. "Purely mechanical steering transmission" means a steering transmission in which the steering forces are transmitted entirely by mechanical means.
- 2.6.2. "Purely hydraulic steering transmission" means a steering transmission in which the steering forces, somewhere in the transmission, are transmitted only by hydraulic means.
- 2.6.3. "Purely electric steering transmission" means a steering transmission in which the steering forces, somewhere in the transmission, are transmitted only through electric means.
- 2.6.4. "Hybrid steering transmission" means a steering transmission in which part of the steering forces is transmitted through one and the other part through another of the above mentioned means. However, in the case where any mechanical part of the transmission is designed only to give position feedback and is too weak to transmit the total sum of the steering forces, this system shall be considered to be purely hydraulic or purely electric steering transmission.
- 2.7. "Electric control line" means the electrical connection which provides the steering control function to the trailer. It comprises the electrical wiring and connector and includes the parts for data communication and the electrical energy supply for the trailer control transmission.

## 3. APPLICATION FOR APPROVAL

- 3.1. The application for approval of a vehicle type with regard to the steering equipment shall be submitted by the vehicle manufacturer or by his duly accredited representative.
- 3.2. It shall be accompanied by the undermentioned documents in triplicate, and by the following particulars:
  - 3.2.1. a description of the vehicle type with regard to the items mentioned in paragraph 2.2.; the vehicle type shall be specified;

- 3.2.2. a brief description of the steering equipment with a diagram of the steering equipment as a whole, showing the position on the vehicle of the various devices influencing the steering.
- 3.2.3. in the case of full power steering systems and systems to which Annex 6 of this Regulation applies, an overview of the system indicating the philosophy of the system and the fail-safe procedures, redundancies and warning systems necessary to ensure safe operation in the vehicle.

The necessary technical files relating to such systems shall be made available for discussion with the type approval authority and/or technical service. Such files will be discussed on a confidential basis.

- 3.3. A vehicle representative of the vehicle type to be approved shall be submitted to the technical service responsible for conducting approval tests.

#### 4. APPROVAL

- 4.1. If the vehicle submitted for approval pursuant to this Regulation meets all relevant requirements given in this Regulation, approval of that vehicle type with regard to the steering equipment shall be granted.
- 4.1.1. The type approval authority shall verify the existence of satisfactory arrangements for ensuring effective control of the conformity of production as given in paragraph 7. of this Regulation, before type approval is granted.
- 4.2. An approval number shall be assigned to each type approved. Its first two digits (at present 02) shall indicate the series of amendments incorporating the most recent major technical amendments made to the Regulation at the time of issue of the approval. The same Contracting Party shall not assign this number to another vehicle type or to the same vehicle type submitted with different steering equipment from that described in the documents required by paragraph 3.
- 4.3. Notice of approval or of extension or refusal of approval of a vehicle type pursuant to this Regulation shall be communicated to the Parties to the 1958 Agreement which apply this Regulation, by means of a form conforming to the model in Annex 1 to this Regulation.
- 4.4. There shall be affixed, conspicuously and in a readily accessible place specified on the approval form, to every vehicle conforming to a vehicle type approved under this Regulation, an international approval mark consisting of:

- 4.4.1. a circle surrounding the letter "E" followed by the distinguishing number of the country which has granted approval; 2/
- 4.4.2. the number of this Regulation, followed by the letter "R", a dash and the approval number to the right of the circle prescribed in paragraph 4.4.1.
- 4.5. If the vehicle conforms to a vehicle type approved, under one or more other Regulations annexed to the Agreement, in the country which has granted approval under this Regulation, the symbol prescribed in paragraph 4.4.1. need not be repeated; in such a case the Regulation and approval numbers and the additional symbols of all the Regulations under which approval has been granted in the country which has granted approval under this Regulation shall be placed in vertical columns to the right of the symbol prescribed in paragraph 4.4.1.
- 4.6. The approval mark shall be clearly legible and shall be indelible.
- 4.7. The approval mark shall be placed close to or on the vehicle data plate affixed by the manufacturer.
- 4.8. Annex 2 to this Regulation gives examples of arrangements of approval marks.

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2/ 1 for Germany, 2 for France, 3 for Italy, 4 for the Netherlands, 5 for Sweden, 6 for Belgium, 7 for Hungary, 8 for the Czech Republic, 9 for Spain, 10 for Serbia and Montenegro, 11 for the United Kingdom, 12 for Austria, 13 for Luxembourg, 14 for Switzerland, 15 (vacant), 16 for Norway, 17 for Finland, 18 for Denmark, 19 for Romania, 20 for Poland, 21 for Portugal, 22 for the Russian Federation, 23 for Greece, 24 for Ireland, 25 for Croatia, 26 for Slovenia, 27 for Slovakia, 28 for Belarus, 29 for Estonia, 30 (vacant), 31 for Bosnia and Herzegovina, 32 for Latvia, 33 (vacant), 34 for Bulgaria, 35 (vacant), 36 for Lithuania, 37 for Turkey, 38 (vacant), 39 for Azerbaijan, 40 for The former Yugoslav Republic of Macedonia, 41 (vacant), 42 for the European Community (Approvals are granted by its Member States using their respective ECE symbol), 43 for Japan, 44 (vacant), 45 for Australia, 46 for Ukraine, 47 for South Africa, 48 for New Zealand, 49 for Cyprus, 50 for Malta and 51 for the Republic of Korea. Subsequent numbers shall be assigned to other countries in the chronological order in which they ratify or accede to the Agreement Concerning the Adoption of Uniform Technical Prescriptions for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these Prescriptions, and the numbers thus assigned shall be communicated by the Secretary-General of the United Nations to the Contracting Parties to the Agreement.

## 5. CONSTRUCTION PROVISIONS

### 5.1. General provisions

5.1.1. The steering system shall ensure easy and safe handling of the vehicle up to its maximum design speed or in case of a trailer up to its technically permitted maximum speed. There must be a tendency to self-centre when tested in accordance with paragraph 6.2. with the intact steering equipment. The vehicle shall meet the requirements of paragraph 6.2. in the case of motor vehicles and of paragraph 6.3. in the case of trailers. If a vehicle is fitted with an auxiliary steering system, it shall also meet the requirements of Annex 4. Trailers equipped with hydraulic steering transmissions shall comply also with Annex 5.

5.1.2. It must be possible to travel along a straight section of road without unusual steering correction by the driver and without unusual vibration in the steering system at the maximum design speed of the vehicle.

5.1.3. The direction of operation of the steering control shall correspond to the intended change of direction of the vehicle and there shall be a continuous relationship between the steering control deflection and the steering angle. These requirements do not apply to systems that incorporate an automatically commanded or corrective steering function, or to auxiliary steering equipment.

These requirements may also not necessarily apply in the case of full power steering when the vehicle is stationary and when the system is not energised.

5.1.4. The steering equipment shall be designed, constructed and fitted in such a way that it is capable of withstanding the stresses arising during normal operation of the vehicle, or combination of vehicles. The maximum steering angle shall not be limited by any part of the steering transmission unless specifically designed for this purpose. Unless otherwise specified, it will be assumed that for the purpose of this Regulation, not more than one failure can occur in the steering equipment at any one time and two axles on one bogie shall be considered as one axle.

5.1.5. The effectiveness of the steering equipment, including the electrical control lines, shall not be adversely affected by magnetic or electric fields. Conformity with the technical requirements of Regulation No. 10, to the amendment in force at the time of Type Approval shall be demonstrated.

5.1.6. Advanced driver assistance steering systems shall only be approved in accordance with this Regulation where the function does not cause any deterioration in the performance of the basic steering system. In addition they shall be designed such that the driver may, at any time and by deliberate action, override the function."

5.1.6.1. Whenever the Automatically Commanded Steering function becomes operational, this shall be indicated to the driver and the control action shall be automatically

disabled if the vehicle speed exceeds the set limit of 10 km/h by more than 20 per cent or the signals to be evaluated are no longer being received. Any termination of control shall produce a short but distinctive driver warning by a visual signal and either an acoustic signal or by imposing a tactile warning signal on the steering control.

5.1.7. Steering transmission

5.1.7.1. Adjustment devices for steering geometry must be such that after adjustment a positive connection can be established between the adjustable components by appropriate locking devices.

5.1.7.2. Steering transmission which can be disconnected to cover different configurations of a vehicle (e.g. on extendable semi-trailers), must have locking devices which ensure positive relocation of components; where locking is automatic, there must be an additional safety lock which is operated manually.

5.1.8. Steered wheels

The steered wheels shall not be solely the rear wheels. This requirement does not apply to semi-trailers.

5.1.9. Energy supply

The same energy supply may be used for the steering equipment and other systems. However in the case of a failure in any system which shares the same energy supply steering shall be ensured in accordance with the relevant failure conditions of paragraph 5.3.

5.1.10. Control systems

The requirements of Annex 6 shall be applied to the safety aspects of electronic vehicle control systems that provide or form part of the control transmission of the steering function including advanced driver assistance steering systems. However, systems or functions, that use the steering system as the means of achieving a higher level objective, are subject to Annex 6 only insofar as they have a direct effect on the steering system. If such systems are provided, they shall not be deactivated during type approval testing of the steering system.

5.2. Special provisions for trailers

5.2.1. Trailers (with the exception of semi-trailers and centre-axle trailers) which have more than one axle with steered wheels and semi-trailers and centre-axle trailers which have at least one axle with steered wheels must fulfil the conditions given in paragraph 6.3. However, for trailers with self-tracking steering equipment a test

under paragraph 6.3. is not necessary if the axle load ratio between the unsteered and the self-tracking axles equals or exceeds 1.6. under all loading conditions.

However for trailers with self-tracking steering equipment, the axle load ratio between unsteered or articulated steered axles and friction-steered axles shall be at least 1 under all loading conditions.

5.2.2. If the towing vehicle of a vehicle combination is driving straight ahead, the trailer and towing vehicle must remain aligned. If alignment is not retained automatically, the trailer must be equipped with a suitable adjustment facility for maintenance.

### 5.3. Failure provisions and performance

#### 5.3.1. General

5.3.1.1. For the purposes of this Regulation the steered wheels, the steering control and all mechanical parts of the steering transmission shall not be regarded as liable to breakage if they are amply dimensioned, are readily accessible for maintenance, and exhibit safety features at least equal to those prescribed for other essential components (such as the braking system) of the vehicle. Where the failure of any such part would be likely to result in loss of control of the vehicle, that part must be made of metal or of a material with equivalent characteristics and must not be subject to significant distortion in normal operation of the steering system.

5.3.1.2. The requirements of paragraphs 5.1.2., 5.1.3. and 6.2.1. shall also be satisfied with a failure in the steering equipment as long as the vehicle can be driven with the speeds required in the respective paragraphs.

In this case paragraph 5.1.3. shall not apply for full power steering systems when the vehicle is stationary.

5.3.1.3. Any failure in a transmission other than purely mechanical must clearly be brought to the attention of the vehicle driver as given in paragraph 5.4. When a failure occurs, a change in the average steering ratio is permissible if the steering effort given in paragraph 6.2.6. is not exceeded.

5.3.1.4. In the case where the braking system of the vehicle shares the same energy source as the steering system and this energy source fails, the steering system shall have priority and shall be capable of meeting the requirements of paragraphs 5.3.2. and 5.3.3. as applicable. In addition the braking performance on the first subsequent application, shall not drop below the prescribed service brake performance, as given in paragraph 2. of Annex 3 of this Regulation.

5.3.1.5. In the case where the braking system of the vehicle shares the same energy supply as the steering system and there is a failure in the energy supply, the steering system shall have priority and shall be capable of meeting the requirements of

paragraphs 5.3.2. and 5.3.3. as applicable. In addition the braking performance on the first subsequent application shall comply with the prescriptions of paragraph 3. of Annex 3 of this Regulation.

5.3.1.6. In the case of trailers the requirements of paragraphs 5.2.2. and 6.3.4.1. shall also be met when there is a failure in the steering system.

5.3.2. Power assisted steering systems

5.3.2.1. Should the engine stop or a part of the transmission fail, with the exception of those parts listed in paragraph 5.3.1.1., there shall be no immediate changes in steering angle. As long as the vehicle is capable of being driven at a speed greater than 10 km/h the requirements given in paragraph 6., relating to a system with a failure, shall be met.

5.3.3. Full power steering systems

5.3.3.1. The system shall be designed such that the vehicle cannot be driven indefinitely at speeds above 10 km/h where there is any fault which requires operation of the warning signal referred to in paragraph 5.4.2.1.1.

5.3.3.2. In case of a failure within the control transmission, with the exception of those parts listed in paragraph 5.1.4., it shall still be possible to steer with the performance laid down in paragraph 6. for the intact steering system.

5.3.3.3. In the event of a failure of the energy source of the control transmission, it shall be possible to carry out at least 24 "figure of eight" manoeuvres, where each loop of the figure is 40 m diameter at 10 km/h speed and at the performance level given for an intact system in paragraph 6. The test manoeuvres shall begin at an energy storage level given in paragraph 5.3.3.5.

5.3.3.4. In the event of a failure within the energy transmission, with the exception of those parts listed in paragraph 5.3.1.1., there shall not be any immediate changes in steering angle. As long as the vehicle is capable of being driven at a speed greater than 10 km/h the requirements of paragraph 6. for the system with a failure shall be met after the completion of at least 25 "figure of eight" manoeuvres at 10 km/h minimum speed, where each loop of the figure is 40 m diameter.

The test manoeuvres shall begin at an energy storage level given in paragraph 5.3.3.5.

5.3.3.5. The energy level to be used for the tests referred to in paragraphs 5.3.3.3. and 5.3.3.4. shall be the energy storage level at which a failure is indicated to the driver.

In the case of electrically powered systems subject to Annex 6, this level shall be the worst case situation outlined by the manufacturer in the documentation submitted in



connection with Annex 6 and shall take into account the effects of e.g. temperature and ageing on battery performance.

#### 5.4. Warning signals

##### 5.4.1. General provisions

- 5.4.1.1. Any fault which impairs the steering function and is not mechanical in nature must be signalled clearly to the driver of the vehicle.

Despite the requirements of 5.1.2. the deliberate application of vibration in the steering system may be used as an additional indication of a fault condition in this system.

In the case of a motor vehicle, an increase in steering force is considered to be a warning indication; in the case of a trailer, a mechanical indicator is permitted.

- 5.4.1.2. If the same energy source is used to supply the steering system and other systems, an acoustic or optical warning shall be given to the driver, when the stored energy/fluid in the energy/storage reservoir drops to a level liable to cause an increase in steering effort. This warning may be combined with a device provided to warn of brake failure if the brake system uses the same energy source. The satisfactory condition of the warning device must be easily verifiable by the driver.

##### 5.4.2. Special provisions for full-power steering equipment

- 5.4.2.1. Power-driven vehicles shall be capable of providing steering failure and defect warning signals, as follows:

- 5.4.2.1.1. A red warning signal, indicating failures defined in paragraph 5.3.1.3. within the main steering equipment.

- 5.4.2.1.2. Where applicable, a yellow warning signal indicating an electrically detected defect within the steering equipment, which is not indicated by the red warning signal.

- 5.4.2.1.3. If a symbol is used, it must comply with symbol J 04, ISO/IEC registration number 7000-2441 as defined in ISO 2575: 2000.

- 5.4.2.1.4. The warning signal(s) mentioned above shall light up when the electrical equipment of the vehicle (and the steering system) is energised. With the vehicle stationary, the steering system shall verify that none of the specified failures or defects is present before extinguishing the signal.

Specified failures or defects which should activate the warning signal mentioned above, but which are not detected under static conditions, shall be stored upon

detection and be displayed at start-up and at all times when the ignition (start) switch is in the "on" (run) position, as long as the failure persists.

5.4.3. In the case where additional steering equipment is in operation and/or where the steering angle generated by that equipment has not been returned to normal driving position a warning signal must be given to the driver.

5.5. Provisions for the periodic technical inspection of steering equipment

5.5.1. As far as practicable and subject to agreement between the vehicle manufacturer and the type approval authority, the steering equipment and its installation shall be so designed that, without disassembly, its operation can be checked with, if necessary, commonly used measuring instruments, methods or test equipment.

5.5.2. It must be possible to verify in a simple way the correct operational status of those Electronic Systems, which have control over steering. If special information is needed, this shall be made freely available.

5.5.2.1. At the time of Type Approval the means implemented to protect against simple unauthorized modification to the operation of the verification means chosen by the manufacturer (e.g. warning signal) shall be confidentially outlined.

Alternatively this protection requirement is fulfilled when a secondary means of checking the correct operational status is available.

6. TEST PROVISIONS

6.1. General provisions

6.1.1. The test shall be conducted on a level surface affording good adhesion.

6.1.2. During the test(s), the vehicle shall be loaded to its technically permissible maximum mass and its technically permissible maximum load on the steered axle(s).

In the case of axles fitted with ASE, this test shall be repeated with the vehicle loaded to its technically permissible maximum mass and the axle equipped with ASE loaded to its maximum permissible mass.

6.1.3. Before the test begins, the tyre pressures shall be as prescribed by the manufacturer for the mass specified in paragraph 6.1.2. when the vehicle is stationary.

6.1.4. In the case of any systems that use electrical energy for part or all of the energy supply, all performance tests shall be carried out under conditions of actual or simulated electrical load of all essential systems or systems components which share the same energy supply. Essential systems shall comprise at least lighting systems, windscreen wipers, engine management and braking systems.

6.2. Provisions for motor vehicles

6.2.1. It must be possible to leave a curve with a radius of 50 m at a tangent without unusual vibration in the steering equipment at the following speed:

Category M1 vehicles: 50 km/h

Category M2, M3, N1, N2 and N3 vehicles: 40 km/h or the maximum design speed if this is below the speeds given above.

6.2.2. When the vehicle is driven in a circle with its steered wheels at approximately half lock and a constant speed of at least 10 km/h, the turning circle must remain the same or become larger if the steering control is released.

6.2.3. During the measurement of control effort, forces with a duration of less than 0.2 seconds shall not be taken into account.

6.2.4. The measurement of steering efforts on motor vehicles with intact steering equipment.

6.2.4.1. The vehicle shall be driven from straight ahead into a spiral at a speed of 10 km/h. The steering wheel control effort shall be measured at the nominal radius of the steering control until the position of the steering control corresponds to turning radius given in the table below for the particular category of vehicle with intact steering. One steering movement shall be made to the right and one to the left.

6.2.4.2. The maximum permitted steering time and the maximum permitted steering control effort with intact steering equipment are given in the table below for each category of vehicle.

6.2.5. The measurement of steering efforts on motor vehicles with a failure in the steering equipment.

6.2.5.1. The test described in paragraph 6.2.4. shall be repeated with a failure in the steering equipment. The steering effort shall be measured until the position of the steering control corresponds to the turning radius given in the table below for the particular category of vehicle with a failure in the steering equipment.

6.2.5.2. The maximum permitted steering time and the maximum permitted steering control effort with a failure in the steering equipment are given in the table below for each category of vehicle.

Table

STEERING CONTROL EFFORT REQUIREMENTS

Vehicle Category	INTACT			WITH A FAILURE		
	Maximum effort (daN)	Time(s)	Turning radius (m)	Maximum effort (daN)	Time(s)	Turning radius (m)
M1	15	4	12	30	4	20
M2	15	4	12	30	4	20
M3	20	4	12 <sup>**/</sup>	45 <sup>*/</sup>	6	20
N1	20	4	12	30	4	20
N2	25	4	12	40	4	20
N3	20	4	12 <sup>**/</sup>	45 <sup>*/</sup>	6	20

<sup>\*/</sup>/ 50 for rigid vehicles with 2 or more steered axles excluding self tracking equipment

<sup>\*\*/</sup>/ or full lock if 12m radius is not attainable.

6.3. Provisions for trailers

6.3.1. The trailer must travel without excessive deviation or unusual vibration in its steering equipment when the towing vehicle is travelling in a straight line on a flat and horizontal road at a speed of 80 km/h or the technically permissible maximum speed indicated by the trailer manufacturer if this is less than 80 km/h.

6.3.2. With the towing vehicle and trailer having adopted a steady state turn corresponding to a turning circle radius of 25 m (see paragraph 2.4.6.) at a constant speed of 5 km/h, the circle described by the rearmost outer edge of the trailer shall be measured. This manoeuvre shall be repeated under the same conditions but at a speed of 25 km/h ± 1 km/h. During these manoeuvres, the rearmost outer edge of the trailer travelling at a speed of 25 km/h ± 1 km/h shall not move outside the circle described at a constant speed of 5 km/h by more than 0.7 m.

6.3.3. No part of the trailer shall move more than 0.5 m beyond the tangent to a circle with a radius of 25 m when towed by a vehicle leaving the circular path described in paragraph 6.3.2. along the tangent and travelling at a speed of 25 km/h. This requirement must be met from the point the tangent meets the circle to a point 40 m along the tangent. After that point the trailer shall fulfil the condition specified in paragraph 6.3.1.

6.3.4. The annular ground area swept by the towing vehicle/trailer combination with an intact steering system, driving at no more than 5 km/h in a constant radius circle with the front outer corner of the towing vehicle describing a radius of 0.67 x vehicle combination length but not less than 12.5 m is to be measured.

- 6.3.4.1. If, with a fault in the steering system, the measured swept annular width is  $> 8.3$  m, then this must not be an increase of more than 15 per cent compared with the corresponding value measured with the intact steering system. There shall not be any increase in the outer radius of the swept annular width.
- 6.3.5. The tests described in paragraphs 6.3.2., 6.3.3. and 6.3.4. shall be conducted in both clockwise and anti-clockwise directions.

## 7. CONFORMITY OF PRODUCTION

The Conformity of Production Procedures shall comply with those set out in the 1958 Agreement, Appendix 2 (E/ECE/324–E/ECE/TRANS/505/Rev.2), with the following requirements:

- 7.1. The holder of the approval must ensure that results of the conformity of production tests are recorded and that the annexed documents remain available for a period determined in agreement with the approval authority or technical service. This period must not exceed 10 years counted from the time when production is definitely discontinued.
- 7.2. The type approval authority or technical service which has granted type approval may at any time verify the conformity control methods applied in each production facility. The normal frequency of these verifications shall be once every two years.

## 8. PENALTIES FOR NON-CONFORMITY OF PRODUCTION

- 8.1. The approval granted in respect of a vehicle type pursuant to this Regulation may be withdrawn if the requirement laid down in paragraph 7.1. is not complied with or if sample vehicles fail to comply with the requirements of paragraph 6. of this Regulation.
- 8.2. If a Contracting Party to the Agreement applying this Regulation withdraws an approval it has previously granted, it shall forthwith so notify the other Contracting Parties applying this Regulation, by means of a communication form conforming to the model in Annex 1 to this Regulation.

## 9. MODIFICATION AND EXTENSION OF APPROVAL OF THE VEHICLE TYPE

- 9.1. Every modification of the vehicle type shall be notified to the approval authority which granted the approval. The approval authority may then either:
- 9.1.1. Consider that the modifications made are unlikely to have an appreciable adverse effect and that in any case the vehicle still complies with the requirements; or

- 9.1.2. Require a further test report from the technical service responsible for conducting the tests.
- 9.2. Confirmation or extension or refusal of approval, specifying the alterations, shall be communicated by the procedure specified in paragraph 4.3. to the Parties to this Regulation.
- 9.3. The approval authority issuing the extension of approval shall assign a series number for such an extension and inform thereof the other Parties to the 1958 Agreement applying this Regulation by means of a communication form conforming to the model in Annex 1 to this Regulation.

#### 10. PRODUCTION DEFINITELY DISCONTINUED

If the holder of the approval completely ceases to manufacture a type of vehicle approved in accordance with this Regulation, he shall so inform the authority which granted the approval. Upon receiving the relevant communication that authority shall inform thereof the other Parties to the 1958 Agreement applying this Regulation by means of a communication form conforming to the model in Annex 1 to this Regulation.

#### 11. NAMES AND ADDRESSES OF TECHNICAL SERVICES RESPONSIBLE FOR CONDUCTING APPROVAL TESTS AND OF ADMINISTRATIVE DEPARTMENTS

The Parties to the 1958 Agreement applying this Regulation shall communicate to the United Nations Secretariat the names and addresses of the technical services responsible for conducting approval tests and of the administrative departments which grant approval and to which forms certifying approval or extension or refusal or withdrawal of approval, issued in other countries, are to be sent.

Annex 1

COMMUNICATION

(Maximum format: A4 (210 x 297 mm))



issued by :

Name of administration:

.....  
.....  
.....

concerning: 2/

APPROVAL GRANTED  
APPROVAL EXTENDED  
APPROVAL REFUSED  
APPROVAL WITHDRAWN  
PRODUCTION DEFINITELY DISCONTINUED

of a vehicle type with regard to steering equipment pursuant to Regulation No. 79

Approval No. ....

Extension No. ....

1. Trade name or mark of vehicle .....
2. Vehicle type .....
3. Manufacturer's name and address .....
4. If applicable, name and address of manufacturer's representative .....
5. Brief description of the steering equipment .....
- 5.1. Type of steering equipment .....
- 5.2. Steering control .....
- 5.3. Steering transmission .....
- 5.4. Steered wheels .....
- 5.5. Energy source .....

6. Results of tests, vehicle characteristics .....
- 6.1. Steering effort required to achieve a turning circle of 12 m radius with an intact system and 20 m radius with a system in the failed condition .....
- 6.1.1. Under normal conditions .....
- 6.1.2. After failure of special equipment .....
- 6.2. Other tests required by this Regulation ..... pass/fail 2/
- 6.3. Adequate documentation in accordance with Annex 6 was supplied in respect of the following parts of the steering system: .....
7. Vehicle submitted for approval on .....
8. Technical service responsible for conducting approval tests .....
9. Date of report issued by that service .....
10. Number of report issued by that service .....
11. Approval granted/extended/refused/withdrawn 2/
12. Position of approval mark on vehicle .....
13. Place.....
14. Date.....
15. Signature .....
16. Annexed to this communication is a list of documents in the approval file deposited at the administration services having delivered the approval and which can be obtained upon request.

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1/ Distinguishing number of the country which has granted/extended/refused/withdrawn approval (see approval provisions in the Regulation).

2/ Strike out what does not apply.

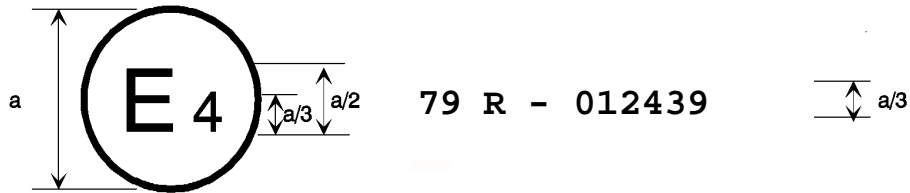


Annex 2

ARRANGEMENTS OF APPROVAL MARKS

Model A

(See paragraph 4.4. of this Regulation)

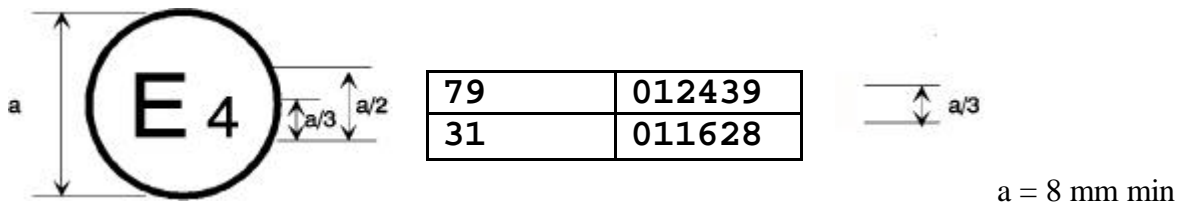


a = 8 mm min

The above approval mark affixed to a vehicle shows that the vehicle type concerned has, with regard to steering equipment, been approved in the Netherlands (E4) pursuant to Regulation No. 79 under approval No. 012439. The approval number indicates that the approval was granted in accordance with the requirements of Regulation No. 79 incorporating the 01 series of amendments.

Model B

(See paragraph 4.5. of this Regulation)



a = 8 mm min

The above approval mark affixed to a vehicle shows that the vehicle type concerned has been approved in the Netherlands (E4) pursuant to Regulations Nos. 79 and 31 \*/. The approval numbers indicate that, at the dates when the respective approvals were given, Regulation No. 79 incorporating the 01 series of amendments and Regulation No. 31 included the 01 series of amendments.

\*/ The second number is given merely as an example.

Annex 3

**BRAKING PERFORMANCE FOR VEHICLES USING THE SAME ENERGY SOURCE TO SUPPLY STEERING EQUIPMENT AND BRAKING DEVICE**

1. For tests carried out in accordance with this annex the following vehicle conditions shall be met:
  - 1.1. The vehicle shall be loaded to its technically permissible maximum mass distributed between the axles as declared by the vehicle manufacturer. Where provision is made for several arrangements of the mass on the axles, the distribution of the maximum mass between the axles shall be such that the mass on each axle is proportional to the maximum permissible mass for each axle. In the case of tractors for semi-trailers, the mass may be repositioned approximately half way between the kingpin position resulting from the above loading conditions and the centreline of the rear axle(s);
  - 1.2. The tyres shall be inflated to the cold inflation pressure prescribed for the mass to be borne by the tyres when the vehicle is stationary;
  - 1.3. Before the start of the tests the brakes shall be cold, that is, with a disc or outer brake drum surface temperature less than 100°C.
2. If an energy source failure occurs, service braking performance on the first brake application shall achieve the values given in the table below.

Category	V (km/h)	m/s <sup>2</sup>	FdaN
M1	80	5.8	50
M2 and M3	60	5.0	70
N1	80	5.0	70
N2 and N3	60	5.0	70

3. After any failure in the steering equipment, or the energy supply, it shall be possible after eight full stroke actuations of the service brake control, to achieve at the ninth application, at least the performance prescribed for the secondary (emergency) braking system (see table below).

In the case where secondary performance requiring the use of stored energy is achieved by a separate control, it shall still be possible after eight full stroke actuations of the service brake control to achieve at the ninth application, the residual performance (see table below).

SECONDARY AND RESIDUAL EFFICIENCY

Category	V km/h	Secondary braking m/s <sup>2</sup>	Residual braking m/s <sup>2</sup>
M1	80	2.9	1.7
M2	60	2.5	1.5
M3	60	2.5	1.5
N1	70	2.2	1.3
N2	50	2.2	1.3
N3	40	2.2	1.3

Annex 4

ADDITIONAL PROVISIONS FOR VEHICLES EQUIPPED WITH ASE

1. General Provisions

Vehicles fitted with auxiliary steering equipment (ASE) in addition to the requirements given in the body of this Regulation shall also comply with the provisions of this Annex.

2. Specific Provisions

2.1. Transmission

2.1.1. Mechanical steering transmissions  
Paragraph 5.3.1.1. of this Regulation applies.

2.1.2. Hydraulic steering transmissions

The hydraulic steering transmission must be protected from exceeding the maximum permitted service pressure T.

2.1.3. Electric steering transmissions

The electric steering transmission must be protected from excess energy supply.

2.1.4. Combination of steering transmissions

A combination of mechanical, hydraulic and electric transmissions shall comply with the requirements specified in paragraphs 2.1.1., 2.1.2. and 2.1.3. above.

2.2. Testing requirements for failure

2.2.1. Malfunction or failure of any part of the ASE (except for parts not considered to be susceptible to breakdown as specified in paragraph 5.3.1.1. of this Regulation) shall not result in a sudden significant change in vehicle behaviour and the relevant requirements of paragraph 6. of this Regulation shall still be met. Furthermore, it must be possible to control the vehicle without abnormal steering correction. This shall be verified by the following tests:

2.2.1.1. Circular test

The vehicle shall be driven into a test circle with a radius "R" m and a speed "v" km/h corresponding to its category and the values given in the table below:

Vehicle category	R <u>3/</u>	v <u>1/</u> <u>2/</u>
M1 and N1	100	80
M2 and N2	50	50
M3 and N3	50	45

The failure shall be introduced when the specified test speed has been reached. The test shall include driving in a clockwise direction, and in a counter-clockwise direction.

2.2.1.2. Transient test

2.2.1.2.1. Until uniform test procedures have been agreed, the vehicle manufacturer shall provide the technical services with their test procedures and results for transient behaviour of the vehicle in the case of failure.

2.3. Warning signals in case of failure.

2.3.1. Except for parts of ASE not considered susceptible to breakdown as specified in paragraph 5.3.1.1. of this Regulation, the following failure of ASE shall be clearly brought to the attention of the driver.

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1/ If the ASE is in a mechanically locked position at this specified speed, the test speed will be modified to correspond to the maximum speed where the system is functioning. Maximum speed means the speed when the ASE becomes locked minus 5 km/h.

2/ If the dimensional characteristics of the vehicle imply an overturning risk, the manufacturer shall provide to the Technical Service behaviour simulation data demonstrating a lower maximum safe speed for conducting the test. Then the Technical Service will choose this test speed.

3/ If, due to the configuration of the test site, the values of the radii cannot be observed, the tests may be carried out on tracks with other radii, (maximum variation:  $\pm 25$  per cent) provided that the speed is varied to obtain the transverse acceleration resulting from the radius and speed indicated in the table for the particular category of vehicle

- 2.3.1.1. A general cut-off of the ASE electrical or hydraulic control.
- 2.3.1.2. Failure of the ASE energy supply.
- 2.3.1.3. A break in the external wiring of the electrical control if fitted.

Annex 5

PROVISIONS FOR TRAILERS HAVING HYDRAULIC STEERING TRANSMISSIONS

1. General provisions

Vehicles fitted with hydraulic steering transmission, in addition to the requirements given in the body of this Regulation shall also comply with the provisions of this annex.

2. Specific provisions

2.1. Performance of hydraulic lines and hose assemblies.

2.1.1. The hydraulic lines of hydraulic transmission shall be capable of a burst pressure at least four times the maximum normal service pressure (T) specified by the vehicle manufacturer. Hose assemblies shall comply with ISO Standards 1402:1994, 6605:1986 and 7751:1991.

2.2. In systems dependent on an energy supply;

2.2.1. the energy supply must be protected from excess pressure by a pressure limiting valve which operates at the pressure T.

2.3. Protection of steering transmission;

2.3.1. the steering transmission must be protected from excess pressure by a pressure limiting valve which operates at between 1.5 T and 2.2 T.

## Annex 6

### SPECIAL REQUIREMENTS TO BE APPLIED TO THE SAFETY ASPECTS OF COMPLEX ELECTRONIC VEHICLE CONTROL SYSTEMS

#### 1. GENERAL

This annex defines the special requirements for documentation, fault strategy and verification with respect to the safety aspects of Complex Electronic Vehicle Control Systems (paragraph 2.3. below) as far as this Regulation is concerned.

This annex may also be called, by special paragraphs in this Regulation, for safety related functions which are controlled by electronic system(s).

This annex does not specify the performance criteria for "The System" but covers the methodology applied to the design process and the information which must be disclosed to the technical service, for type approval purposes.

This information shall show that "The System" respects, under normal and fault conditions, all the appropriate performance requirements specified elsewhere in this Regulation.

#### 2. DEFINITIONS

For the purposes of this annex,

2.1. "Safety concept" is a description of the measures designed into the system, for example within the electronic units, so as to address system integrity and thereby ensure safe operation even in the event of an electrical failure. The possibility of a fall-back to partial operation or even to a back-up system for vital vehicle functions may be a part of the safety concept.

2.2. "Electronic control system" means a combination of units, designed to co-operate in the production of the stated vehicle control function by electronic data processing. Such systems, often controlled by software, are built from discrete functional components such as sensors, electronic control units and actuators and connected by transmission links. They may include mechanical, electro-pneumatic or electro-hydraulic elements. "The System", referred to herein, is the one for which type approval is being sought.

2.3. "Complex electronic vehicle control systems" are those electronic control systems which are subject to a hierarchy of control in which a controlled function may be over-ridden by a higher level electronic control system/function. A function which is over-ridden becomes part of the complex system.



- 2.4. "Higher-Level control" systems/functions are those which employ additional processing and/or sensing provisions to modify vehicle behaviour by commanding variations in the normal function(s) of the vehicle control system. This allows complex systems to automatically change their objectives with a priority which depends on the sensed circumstances.
- 2.5. "Units" are the smallest divisions of system components which will be considered in this annex, since these combinations of components will be treated as single entities for purposes of identification, analysis or replacement.
- 2.6. "Transmission links" are the means used for inter-connecting distributed units for the purpose of conveying signals, operating data or an energy supply. This equipment is generally electrical but may, in some part, be mechanical, pneumatic or hydraulic.
- 2.7. "Range of control" refers to an output variable and defines the range over which the system is likely to exercise control.
- 2.8. "Boundary of functional operation" defines the boundaries of the external physical limits within which the system is able to maintain control.

### 3. DOCUMENTATION

#### 3.1. Requirements

The manufacturer shall provide a documentation package which gives access to the basic design of "The System" and the means by which it is linked to other vehicle systems or by which it directly controls output variables. The function(s) of "The System" and the safety concept, as laid down by the manufacturer, shall be explained. Documentation shall be brief, yet provide evidence that the design and development has had the benefit of expertise from all the system fields which are involved. For periodic technical inspections, the documentation shall describe how the current operational status of "The System" can be checked.

##### 3.1.1. Documentation shall be made available in two parts:

- (a) The formal documentation package for the approval, containing the material listed in paragraph 3. (with the exception of that of paragraph 3.4.4.) which shall be supplied to the technical service at the time of submission of the type approval application. This will be taken as the basic reference for the verification process set out in paragraph 4. of this annex.

(b) Additional material and analysis data of paragraph 3.4.4. which shall be retained by the manufacturer, but made open for inspection at the time of type approval.

3.2. Description of the functions of "The System" A description shall be provided which gives a simple explanation of all the control functions of "The System" and the methods employed to achieve the objectives, including a statement of the mechanism(s) by which control is exercised.

3.2.1. A list of all input and sensed variables shall be provided and the working range of these defined.

3.2.2. A list of all output variables which are controlled by "The System" shall be provided and an indication given, in each case, of whether the control is direct or via another vehicle system. The range of control (paragraph 2.7.) exercised on each such variable shall be defined.

3.2.3. Limits defining the boundaries of functional operation (paragraph 2.8.) shall be stated where appropriate to system performance.

3.3. System layout and schematics

3.3.1. Inventory of components.

A list shall be provided, collating all the units of "The System" and mentioning the other vehicle systems which are needed to achieve the control function in question.

An outline schematic showing these units in combination, shall be provided with both the equipment distribution and the interconnections made clear.

3.3.2. Functions of the units

The function of each unit of "The System" shall be outlined and the signals linking it with other units or with other vehicle systems shall be shown. This may be provided by a labelled block diagram or other schematic, or by a description aided by such a diagram.

3.3.3. Interconnections

Interconnections within "The System" shall be shown by a circuit diagram for the electric transmission links, by a piping diagram for pneumatic or hydraulic transmission equipment and by a simplified diagrammatic layout for mechanical linkages.

3.3.4. Signal flow and priorities

There shall be a clear correspondence between these transmission links and the signals carried between Units. Priorities of signals on multiplexed data paths shall be stated wherever priority may be an issue affecting performance or safety as far as this Regulation is concerned.

3.3.5. Identification of units

Each unit shall be clearly and unambiguously identifiable (e.g. by marking for hardware and marking or software output for software content) to provide corresponding hardware and documentation association.

Where functions are combined within a single unit or indeed within a single computer, but shown in multiple blocks in the block diagram for clarity and ease of explanation, only a single hardware identification marking shall be used. The manufacturer shall, by the use of this identification, affirm that the equipment supplied conforms to the corresponding document.

3.3.5.1. The identification defines the hardware and software version and, where the latter changes such as to alter the function of the Unit as far as this Regulation is concerned, this identification shall also be changed.

3.4. Safety concept of the manufacturer

3.4.1. The manufacturer shall provide a statement which affirms that the strategy chosen to achieve "The System" objectives will not, under non-fault conditions, prejudice the safe operation of systems which are subject to the prescriptions of this Regulation.

3.4.2. In respect of software employed in "The System", the outline architecture shall be explained and the design methods and tools used shall be identified. The manufacturer shall be prepared, if required, to show some evidence of the means by which they determined the realisation of the system logic, during the design and development process.

3.4.3. The Manufacturer shall provide the technical authorities with an explanation of the design provisions built into "The System" so as to generate safe operation under fault conditions. Possible design provisions for failure in "The System" are for example:

- (a) Fall-back to operation using a partial system.
- (b) Change-over to a separate back-up system.

(c) Removal of the high level function.

In case of a failure, the driver shall be warned for example by warning signal or message display. When the system is not deactivated by the driver, e.g. by turning the ignition (run) switch to "off", or by switching off that particular function if a special switch is provided for that purpose, the warning shall be present as long as the fault condition persists.

- 3.4.3.1. If the chosen provision selects a partial performance mode of operation under certain fault conditions, then these conditions shall be stated and the resulting limits of effectiveness defined.
- 3.4.3.2. If the chosen provision selects a second (back-up) means to realise the vehicle control system objective, the principles of the change-over mechanism, the logic and level of redundancy and any built in back-up checking features shall be explained and the resulting limits of back-up effectiveness defined.
- 3.4.3.3. If the chosen provision selects the removal of the Higher Level Function, all the corresponding output control signals associated with this function shall be inhibited, and in such a manner as to limit the transition disturbance.
- 3.4.4. The documentation shall be supported, by an analysis which shows, in overall terms, how the system will behave on the occurrence of any one of those specified faults which will have a bearing on vehicle control performance or safety.

This may be based on a Failure Mode and Effect Analysis (FMEA), a Fault Tree Analysis (FTA) or any similar process appropriate to system safety considerations.

The chosen analytical approach(es) shall be established and maintained by the Manufacturer and shall be made open for inspection by the technical service at the time of the type approval.

- 3.4.4.1. This documentation shall itemize the parameters being monitored and shall set out, for each fault condition of the type defined in paragraph 3.4.4. of this annex, the warning signal to be given to the driver and/or to service/technical inspection personnel.

4. VERIFICATION AND TEST

4.1. The functional operation of "The System", as laid out in the documents required in paragraph 3., shall be tested as follows:

4.1.1. Verification of the function of "The System"

As the means of establishing the normal operational levels, verification of the performance of the vehicle system under non-fault conditions shall be conducted against the manufacturer's basic benchmark specification unless this is subject to a specified performance test as part of the approval procedure of this or another Regulation.

4.1.2. Verification of the safety concept of paragraph 3.4.

The reaction of "The System" shall, at the discretion of the type approval authority, be checked under the influence of a failure in any individual unit by applying corresponding output signals to electrical units or mechanical elements in order to simulate the effects of internal faults within the unit.

4.1.2.1. The verification results shall correspond with the documented summary of the failure analysis, to a level of overall effect such that the safety concept and execution are confirmed as being adequate.

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