

UN regulations considered under GRVA

GR	UN regulations considered in this work
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R.79 - Item 5A – Steering equipment

Overview

Item No: 5A

Subject: Steering equipment

Regulation: UN Regulation No 79

Series of amendments recommended for application: 03

Published in OJ: 03

Latest series adopted (excluding proposal documents): 03

Latest series in force: 03

Vehicle categories in scope of technical regulation: M, N and O

Introduction to the regulation: The intention of this regulation is to establish uniform provisions for the layout and performance of steering systems fitted to vehicles used on the road. It contains basic requirements for the steering system which include:

For human driver operation, steering characteristics such as a tendency to self-centre and steering effort limits.

To help reduce the likelihood of failure, adequate dimensioning of mechanical components and that they are readily accessible for maintenance.

In the event of non-mechanical failures, warnings to be provided to the driver, and for failures of the energy supply, how steering system shall be prioritised compared to other systems

It also contains requirements for Advanced Driver Assistance Systems (ADAS), 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. An example of ADAS is a corrective steering function that, for example, corrects the steering angle to prevent departure from the chosen lane. It explicitly states that systems, defined as 'Autonomous steering systems', which do not require the presence of a driver or where the driver will not necessarily be in primary control of the vehicle, are not within the scope of the regulation.

Requirements

Can regulation (or part of regulation) be waived altogether for passenger or goods LSAVs?:

By definition, LSAVs will be equipped with 'Autonomous steering systems', which fall outside the stated scope of UN Regulation 79 and should be regulated in the ADS part of the new regulation. On this basis, one could propose to waive this regulation altogether for LSAVs. However, some of the requirements, such as those related to the basic performance of the steering system (e.g. drive in a straight line without unusual steering correction ...) and those related to functional

safety are applicable, and so it is recommended that these requirements are kept, either in the non-ADS part of the regulation or in a new ADS part.

In terms of functional safety, for mechanical components the requirements are generally applicable to LSAVs and aim to ensure that they can be regarded as not liable to breakage. It is recommended that these requirements are transposed into the non-ADS part of the regulation. There are also other requirements for functional safety such as those related to failure of an energy supply common to the braking and steering systems and those related to the steering control systems such as the complex electronics (CEL) Annex 6. Some of these requirements are not easily transposed for LSAVs and, indeed, those related to failure of an energy supply common to the braking and steering systems which prioritise steering above braking, may not be applicable for LSAVs given their low maximum speed and thus their ability to be able to stop in very short distances (i.e. in this case it may be better to prioritise braking above steering). In view of this, it is recommended that functional safety, for non-mechanical steering parts, is fully addressed within the ADS part of a new regulation so that it can be treated as a whole.

UN Regulation 79 also contains other requirements related to Advanced Driver Assistance Systems (ADAS). These are not applicable to LSAVs because they assume the presence of a driver and will be taken care of by the ADS function (WP1 scope). Therefore, this part of the regulation can be waived for non-ADS requirements.

Analysis of technical requirements:

An analysis of the requirements from UN Regulation 79 has been performed to identify those recommended for inclusion into the non-ADS regulation. A summary of the review is given below

R79 ref.	Requirement	Analysis	Recommended Action
5.1.1.	<p>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 shall 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.</p>	<p>Self-centring is a requirement to help human drivers control the vehicle through the provision of a known characteristic which makes it easier to control and improves its directional stability. For example, it helps the driver steer out of a corner to straight ahead by the steering automatically tending to perform this action, i.e. the driver just has to feed the steering wheel through their hands rather than apply turning force. It is generally implemented through the steering geometry setup, namely positive castor angle and trail.</p> <p>For normal operation, it is not required for Phase I automated systems because the low vehicle speeds mean that directional stability should not be a significant issue and the ADS measures the steering angle at all times and does not need the steering ‘feel and returnability’ required by a human driver.</p> <p>In the event of failure, in terms of functional safety, a requirement to self-centre may restrict potential solutions. For example, if the steering motor drive failed one strategy could be to keep steering angle of the vehicle constant whilst the vehicle was braked to a stop. A worm drive could be used as part of a solution to implement this given that they can be made to be self-locking, i.e. the output cannot drive the input. This solution would not be possible with a self-centre tendency requirement because this would need the wheel steering angle (output) to drive the input.</p>	<p>Do not mandate this requirement. However, it can be included at the discretion of the manufacturer, for example, for the purposes of functional safety.</p>

		On this basis, it is recommended that requirement of tendency to self-centre should not be mandated, but it can be included at the discretion of the manufacturer, for example, for the purposes of functional safety.	
5.1.2.	It shall 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	Requirement applicable to all vehicles whether automated or not, because although for non-automated requirement is mainly related to driver comfort, it is also related to vehicle stability and wear of steering components.	Mandate this requirement; for driver read Automated Driving System (ADS)
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	Requirement needed to provide manual steering control for human driver, therefore not needed for automated vehicle.	Do not mandate this requirement
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.	Requirement applicable to all vehicles whether automated or not. Note that third part of requirement in sentence starting, 'Unless otherwise specified ...', is related to functional safety assessment, which may not be part of non-ADS requirements.	Mandate this requirement. Note that third part should be highlighted in part of regulation related to functional safety assessment of steering system.
5.1.5	The effectiveness of the steering equipment, including the electrical control lines, shall not be adversely affected by magnetic or electric fields. This shall be demonstrated by fulfilling the technical requirements and respecting the	Requirement for EMC applicable to all vehicles whether automated or not.	Mandate this requirement

	<p>transitional provisions of Regulation No. 10 by applying:</p> <p>(a) The 03 series of amendments for vehicles without a coupling system for charging the Rechargeable Electric Energy Storage System (traction batteries);</p> <p>(b) The 04 series of amendments for vehicles with a coupling system for charging the Rechargeable Electric Energy Storage System (traction batteries).</p>		
5.1.6	<p>Advanced driver assistance steering systems (ADASS) 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.</p>	<p>For LSAVs new requirements will be needed for the ADS, which will supersede all ADASS requirements and hence make them redundant.</p>	<p>Do not mandate this requirement or sub-requirements related to ADASS because will be covered by ADS part of regulation.</p>
5.1.7.	<p>Towing vehicles equipped with a connection to supply electrical energy to the steering system of the trailer and trailers that utilise electrical energy from the towing vehicle to power the trailer steering system shall fulfil the relevant requirements of Annex 7.</p>	<p>LSAVs that tow trailers are not anticipated in the near future. If LSAVs are developed to tow trailers in the longer term future, additional requirements would also be required for the ADS. Therefore, to minimise potential confusion, it is proposed that this requirement is not mandated at this time but could be added in conjunction with ADS requirements if and when regulation of LSAVs that tow trailers is needed.</p>	<p>Do not mandate this requirement at this time.</p>
5.1.8.	<p>5.1.8.1. Adjustment devices for steering geometry shall be such that after adjustment a positive connection can be established between the adjustable components by appropriate locking devices.</p> <p>5.1.8.2. Steering transmission which can be disconnected to cover different configurations of a vehicle (e.g. on extendable semi-trailers), shall have locking devices which ensure positive relocation of components; where locking is</p>	<p>The paragraph 5.1.8.1 requirement is applicable to all vehicles whether automated or not. Regarding paragraph 5.1.8.2, it is foreseeable that LSAVs could have different configurations which may involve changing the steering configuration, but this would almost definitely have knock-on effects for the ADS. Therefore, to minimise potential confusion, it is proposed that this requirement is not mandated at this time</p>	<p>Mandate paragraph 5.1.8.1 requirement.</p> <p>Do not mandate paragraph 5.1.8.2 requirement at this time.</p>

	automatic, there shall be an additional safety lock which is operated manually	but could be added in conjunction with ADS requirements at a later date if required.	
5.1.9	The steered wheels shall not be solely the rear wheels. This requirement does not apply to semi-trailers.	Requirement to provide a steering characteristic which helps human drivers and is not necessarily required for automated vehicles. LSAV category will include three wheeled vehicles, some of which will likely have rear wheel steering. Also, in the case of bi-directional vehicles this requirement could result in restrictions, e.g. it would not be possible to steer one axle only. On basis of above recommend that this requirement is not mandated.	Do not mandate this requirement
5.1.10	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.	This requirement or an equivalent is needed for automated vehicles. It is related to the functional safety case for the steering system. However, the provisions of paragraph 5.3 which are referred to, such as priority of the steering system over the braking systems may not necessarily be appropriate for all LSAVs. Therefore, it is proposed that this requirement (or appropriate equivalent) should be included in the ADS requirements, so that functional safety is addressed as a whole. Hence this requirement should not be included here in non-ADS requirements.	Do not mandate this requirement in non-ADS part of regulation. However, mandate this requirement or an appropriate equivalent in ADS part of regulation.
5.1.11.	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	This requirement or an appropriate equivalent is needed for automated vehicles. It is related to the functional safety case for the steering system. It is proposed that this should be included in the ADS requirements, so that it is addressed as a whole and hence this requirement should not be included here in non-ADS requirements.	Do not mandate this requirement in non-ADS part of regulation. However, mandate this requirement or an appropriate equivalent in ADS part of regulation.

	deactivated during type approval testing of the steering system.		
5.3.1.1	<p>Failure provisions and performance: 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.</p>	<p>The precise meaning of this requirement is difficult to understand because it mixes elements of functional safety and measures to achieve this. However, the authors understand underlying requirement without functional safety elements to be:</p> <p>In order that they are not liable to breakage, the steered wheels, the steering control and all mechanical parts of the steering transmission shall be amply dimensioned, be 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.</p>	<p>Mandate this requirement in non-ADS part of regulation as below:</p> <p>In order that they are not liable to breakage, the steered wheels, the steering control and all mechanical parts of the steering transmission shall be amply dimensioned, be 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.</p>
5.3.1.2	<p>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.</p> <p>In this case paragraph 5.1.3. shall not apply for full power steering systems when the vehicle is stationary.</p>	<p>This requirement is related to functional safety. Given that paragraph 5.3.1.1 effectively says that the steered wheels, steering control and mechanical parts of the steering transmission are assumed not to fail, this requirement is mainly related to failure of steering power assistance and that if/when this occurs the vehicle can still be driven in a straight line (5.1.2), and can still be steered with the steering behaving in the usual manner (5.1.3 and 6.2.1), i.e. turn a little right, vehicle goes a little right, etc., but with much greater steering effort required. An LSAV could likely use rack and pinion steering driven by an electric motor. To meet this functional safety requirement, one solution could be to fit redundant electric</p>	<p>Do not mandate this requirement in non-ADS part of the regulation, but instead include it in ADS part of regulation as part of functional safety assessment.</p>

		motors. Another solution could be to perform a MRM and bring the vehicle to a halt quickly in whatever direction it is pointing in. This functional safety requirement should be included in the non-ADS regulation.	
5.3.1.3.	Any failure in a transmission other than purely mechanical shall 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	This requirement is related to functional safety. The first part is relevant to automated vehicles in that action should be taken in response to the failure, but clearly the driver cannot be warned. The second part is not relevant as it relates to driver steering effort. Action proposed for LSAV in response to failure is to initiate a minimum risk manoeuvre (MRM) and clearly bring to attention of operator.	Mandate first part of requirement as follows: In the event of any failure in a transmission other than purely mechanical an electronic signal shall be sent to the ADS.
5.3.1.4. to 5.3.1.6	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.	Requirements 5.3.1.4 (written in full), 5.3.1.5 and 5.3.1.6 are all related to functional safety and the case where the steering and braking systems share the same energy source. These requirements are based on the concept that the steering system should have priority over the braking one and sets minimum requirements in the event that failure occurs. However, LSAVs will have a maximum speed of 20 mph and some may have a lower maximum speed. Therefore, because the vehicle could be braked to a stop from this speed in a relatively short distance to mitigate risk if the brakes were fully operational, the concept that steering should have priority over braking for these vehicles may not be appropriate.	Do not mandate these requirements in non-ADS part of regulation, but instead include relevant parts as appropriate in ADS part of regulation as part of functional safety assessment.
5.3.1.7	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.	LSAVs that tow trailers are not anticipated in the near future. If LSAVs are developed to tow trailers in the longer term future, additional requirements would also be required for the ADS. Therefore, to minimise potential confusion, it is proposed that this requirement is not mandated at this time but could be added in conjunction with ADS requirements if and	Do not mandate this requirement at this time.

		when regulation of LSAVs that tow trailers is needed.	
5.3.2	Power assisted steering systems	N/A because no driver	Do not mandate
5.3.3	<p>Full power steering systems</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>The test manoeuvres shall begin at an energy storage level given in paragraph 5.3.3.5.</p>	<p>These requirements relate to functional safety. They are somewhat appropriate in that they relate to full power steering systems¹⁰ which by definition automated steering systems will be, but they also assume that a driver is present and the vehicle travels at speeds which make the 'steering should have priority over braking' concept valid, so this makes some requirements somewhat inappropriate. However, some of the safety concepts mandated are appropriate such as the 'fail operational'¹¹ for a failure within the control transmission (5.3.3.2.) and the 'fail safe'¹² for a failure of the energy source of the control transmission (5.3.3.3.) are most likely appropriate for LSAVs. Therefore, it is recommended that these are noted and incorporated into the ADS part of regulation as part of functional safety assessment.</p>	<p>Do not mandate these requirements in non-ADS part of regulation, but instead include relevant parts (mainly concepts) as appropriate in ADS part of regulation as part of functional safety assessment.</p> <p>Safety concepts to note:</p> <ul style="list-style-type: none"> • Fail operational for failure within the control transmission • Fail safe for failure of the energy source

	<p>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.</p> <p>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.</p>		
5.4	Warning signals	<p>These requirements relate to the type of warning that should be provided to the driver, hence they are not appropriate. However, action does need to be taken in response to faults which may impair the steering function. A proposal to cover this is included in the modifications to paragraph 5.3.1.3. – see above.</p>	<p>Do not mandate these requirements. Note: see paragraph 5.3.1.3. above.</p>
5.5	<p>Provisions for the Periodic Technical Inspection of steering equipment</p> <p>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.</p> <p>5.5.2. It shall 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.</p> <p>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</p>	<p>Requirement 5.5.1. is probably appropriate for LSAVs for ensuring the roadworthiness of mechanical components of the steering system using PTI.</p> <p>Requirement 5.5.2 is based around the electronic systems self-checking themselves and indicating faults to the driver via a Malfunction Indicator Light (MIL). The driver is expected to take appropriate action in response to the MIL. The status of the MIL is checked at PTI, either visually or by the use of a scan tool. By itself, this type of requirement is probably not sufficient to ensure the roadworthiness of the steering control of an ADS for LSAVs. The main reasons for this are:</p> <p>There is no human driver present, so a more continuous method to monitor the roadworthiness of the system is probably needed to act as a replacement for them. The</p>	<p>It is recommended that vehicle provisions to enable inspection of the roadworthiness of LSAVs, in particular the ADS, should be developed at a more holistic level and not be included in the regulation at the level of individual ‘mechanical’ systems, such as steering. For the moment a simple requirement that periodic roadworthiness testing shall be feasible has been included in the cross-cutting prescriptions (Section 5.1) as a placeholder, and the specific requirements of the steering regulation are not applied. Additionally, in the interim it is proposed to include at least the provisions for inspection of mechanical components.</p>

	<p>manufacturer (e.g. warning signal) shall be confidentially outlined.</p> <p>Alternatively, this protection requirement is fulfilled when a secondary means of checking the correct operational status is available.</p>	<p>idea of Continuous Technical Inspection (CTI) to supplement Periodic Technical Inspection (PTI) has been proposed by vehicle inspection organisations.</p> <p>Because of the complexity of the ADS, methods to check its roadworthiness in a more holistic manner are probably needed.</p> <p>For these reasons, it is recommended that vehicle provisions to enable inspection of the roadworthiness of LSAVs, in particular the ADS, should be developed at a more holistic level and not be included in the regulation at the level of individual ‘mechanical’ systems, such as steering. However, inclusion of provisions for inspection of mechanical components at this level should be considered, once an overall approach has been developed.</p>	
5.6	Provisions for ACSF	For LSAVs new requirements will be needed for the ADS, which will supersede all ACSF requirements and hence make them redundant.	Do not mandate this requirement or sub-requirements related to ACSF
6	<p>Test Provisions</p> <p>6.2.1. It shall 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:</p> <p>Category M1 vehicles: 50 km/h</p> <p>Category M2, M3, N1, N2 and N3 vehicles: 40 km/h or the maximum design speed if this is below the speeds given above.</p> <p>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 shall remain the same or become larger if the steering control is released</p> <p>6.2.3. to 6.2.4. Requirements related to steering control effort</p>	<p>Analysis shows applicability of the test provisions as follows:</p> <p>6.2.1 assesses behaviour of the steering system for normal driving, thus applicable for LSAVs. Prescribed test speed is higher than vehicle maximum speed but regulation already allows lower speed in this case. Nevertheless, clarification with regard to the vehicle categories and speeds shall be introduced.</p> <p>6.2.2 assesses ‘tendency to self-centre’ capability of the steering system thus only applicable for LSAVs if this requirement is mandated.</p> <p>6.2.2 to 6.2.4 assesses steering control effort for human driver therefore not applicable for LSAVs</p>	<p>Mandate the following test requirement:</p> <p>It shall be possible to leave a curve with a radius of 50 m at a tangent without unusual vibration in the steering equipment at 30 km/h or the maximum design speed if this is below 30 km/h.</p> <p>Requirements related to a tendency to self-centre (6.2.2) and steering control effort (6.2.3 to 6.2.4) should not be mandated.</p>

Potential to ease requirements or give derogations for certain subgroups of LSAVs:

- None foreseen at present

Sources for requirements to cover additional risks/considerations:

- n/a

Other notes/considerations:

- Currently, it is intended that functional safety of the steering system, with the exception of its mechanical components, should be addressed within the ADS part of the regulation. Therefore, it is critical that the relevant parts of UN Regulation 79 are captured for this purpose. The analysis above begins this process.

Proposed application of technical regulation to LSAV categories:

- Passenger LSAV: Applicable
- Goods LSAV: Applicable

Proposed text for 'definitions, exemptions and modifications' (requirements):

1. Only the following provisions, some of which have been modified, shall be applied:
 1. Paragraph 5.1.1.: The steering system shall ensure easy and safe handling of the vehicle up to its maximum design speed.
 2. Paragraph 5.1.2.: It shall be possible to travel along a straight section of road without unusual steering correction by the Automated Driving System (ADS) and without unusual vibration in the steering system at the maximum design speed of the vehicle.
 3. Paragraph 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. The maximum steering angle shall not be limited by any part of the steering transmission unless specifically designed for this purpose.
 4. Paragraph 5.1.5.: The effectiveness of the steering equipment, including the electrical control lines, shall not be adversely affected by magnetic or electric fields. This shall be demonstrated by fulfilling the technical requirements and respecting the transitional provisions of UN Regulation No 10 by applying:
 1. (a) The 03 series of amendments for vehicles without a coupling system for charging the Rechargeable Electric Energy Storage System (traction batteries);
 2. (b) The 04 series of amendments for vehicles with a coupling system for charging the Rechargeable Electric Energy Storage System (traction batteries).
 5. Paragraph 5.1.8.1.: Adjustment devices for steering geometry shall be such that after adjustment a positive connection can be established between the adjustable components by appropriate locking devices.

6. Paragraph 5.3.1.1.: In order that they are not liable to breakage, the steered wheels, the steering control and all mechanical parts of the steering transmission shall be amply dimensioned, be 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.
7. Paragraph 5.3.1.3.: In the event of any failure in a transmission other than purely mechanical an electronic signal shall be sent to the ADS.
8. Paragraph 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.
9. Paragraph 6.2.1: It shall be possible to leave a curve with a radius of 50 m at a tangent without unusual vibration in the steering equipment at 30 km/h or the maximum design speed if this is below 30 km/h.

Test procedures

Technical aspects incompatible with LSAVs:

- For the requirements deemed applicable to LSAVs the following comments relate to the associated assessment or verification procedures:
 - Paragraph 5.1.2. Unusual correction or vibration: This requirement is normally covered by a subjective assessment conducted by the driver as part of a driven test. For LSAVs, the technical service would expect the vehicle to be operated at the maximum design speed and because there is no driving position or steering control, they may require additional evidence that the requirement is met (such as manufacturer design criteria, CAN data, video feed during dynamic driving, etc.) as part of the test. As there is no test procedure defined in regulation currently, there is no need to introduce modifications.
 - Paragraph 5.1.4. Steering equipment stresses: This requirement is normally a subjective assessment by the technical service of the material and construction features of the steering system. The wheel-to-wheel articulation of the steered axles is checked for method of steering angle limitation. The required standard can be applied to LSAVs without any modification.
 - Paragraph 5.1.5. Steering equipment not adversely affected by magnetic or electric fields: The required standard can be applied to LSAVs without any modification. The practical issues of testing will be discussed under Item 10A.
 - Paragraph 5.1.8.1. Adjustment devices: The required standard can be applied to LSAVs without any modification.
 - Paragraph 5.3.1.1. Breakage: The required standard can be applied to LSAVs without any modification.

- Paragraph 5.3.1.3. Signal to ADS in case of steering equipment failure: The technical service may require design documentation from the manufacturer as evidence that this requirement is fulfilled. As for many other aspects in this regulation, the technical service is well placed to decide how this requirement is best evidenced and there is no need to introduce an explicit test procedure into the regulation.
- Paragraph 6.2.1. Leave a 50 metre radius curve: In order to demonstrate that it is possible to leave the specified curve without unusual vibration in the steering equipment, the LSAV will require an automated programme or (equivalent method) allowing it to perform the manoeuvre on a test track. This is covered by a cross-cutting prescription (see Section 5.1).

Proposed text for 'definitions, exemptions and modifications' (test procedures):

1. No modifications apply.

R.13-H - Item 9B – Braking of passenger cars

Overview

Item No: 9B

Subject: Braking of passenger cars

Regulation: UN Regulation No 13-H

Series of amendments recommended for application: 01

Published in OJ: Original version of the regulation

Latest series adopted (excluding proposal documents): 01

Latest series in force: 01

Vehicle categories in scope of technical regulation: M₁, N₁

Introduction to the regulation: This regulation defines requirements relating to the characteristics and performance of the braking system for passenger cars and light good vehicles. Note that Brake Assist Systems are contained in a separate Item (Item 108).

Requirements

Can regulation (or part of regulation) be waived altogether for passenger or goods LSAVs?:

- This braking regulation must ensure, for passenger and goods LSAVs, that the braking system design is safe and that the vehicle is technically capable of achieving sufficient deceleration for safe operation, whereas the ADS regulation (WP1) should ensure that the available brake performance is used adequately when driving.
- Most of the specifications for braking equipment and functions shall therefore continue to apply for LSAVs to ensure, inter alia, durability, resistance to magnetic or electrical field, sufficient brake performance even in case of failure of the service braking system, the ability to inspect the braking equipment, shared components and failure detection.
- Aspects relating driver controls and tell-tales are not applicable to driverless vehicles and should therefore be modified or waived. This is addressed with cross-cutting prescriptions applicable for various regulations (see Section 1).

Technical aspects incompatible with LSAVs:

- Complex electronic systems requirements (Paragraph 5.1.3. and Annex 8): A safety assessment of complex electronic systems, including the braking system, continues to be necessary. However, for automated vehicles it is proposed to allow one combined assessment of the safety of all complex electronic systems rather than dividing the braking and steering assessment, because there might be interdependencies between the systems (e.g., differential braking to control failed steering, shared energy reserves) which can be better analysed in a combined assessment. WP1 will address this aspect, which is why the requirements and assessments of the braking regulation shall not apply. The manufacturer should have the option to split this assessment into smaller sub-assessments as desired.
- Provisions for the periodic technical inspection of braking system (Paragraph 5.1.4.): It is recommended that vehicle provisions to enable inspection of the

roadworthiness of LSAVs, in particular the ADS, should be developed at a more holistic level and not be included in the regulation at the level of individual 'mechanical' systems, such as braking. However, once an overall approach has been developed, inclusion of provisions for inspection of mechanical components at this level should be considered. For the moment a simple requirement that periodic roadworthiness testing shall be feasible has been included in the cross-cutting prescriptions (Section 5.1) as a placeholder, and the specific requirements of the braking regulation are not applied. Additionally, in the interim it is proposed to include at least the provisions for a possibility to assess the wear condition.

- Paragraph 5.2.2.8. (two completely independent energy reserves) shall continue to apply even though the service brake system is not 'controlled by the driver' as stipulated in the paragraph.
- Failures or defects that result in a red warning signal according to the requirements in UN R 13-H are critical and should compel the driver to bring the vehicle to a safe stop. In the absence of on-board warning signals (cross-cutting prescription) and driver, it is proposed that an electronic signal shall be sent to the ADS. This should enable the ADS to react as appropriate for the situation, which could be for instance be initiating a minimum risk manoeuvre (MRM) to bring the vehicle to a state of relative safety or other reactions appropriate to the situation and in-line with the safety concept applied. Note that if and how the ADS should react will not be defined in the context of the non-ADS regulation but will be a relevant topic for WP1 to consider.
- Anti-lock braking systems (ABS):
 - Vehicles are currently not explicitly required to be fitted with anti-lock systems for type approval, but the fitment of electronic stability control (ESC) for unlimited series approvals in practice requires anti-lock brakes. As discussed in the approach on vehicle stability (Sections 3.3.1 and 3.3.2), it is proposed to not mandate ESC for LSAVs but to require ABS functionality, either through a dedicated ABS system or equivalent functionality integrated in other systems such as the ADS. ESC could ensure directional stability and mitigate the risk of rollovers in highly dynamic swerving situations.
 - Annex 6 (Test requirements for vehicles fitted with anti-lock systems): Paragraph 5.3.7. permits rotation of the steering control during split mu tests, but limits the degree to which it may be turned to a level within general human ability. As the ADS would perform steering corrections, it is proposed to remove this limitation.
- Three-wheeled vehicles: UN Regulation No 13-H is designed for vehicles with four or more wheels. If the decision is taken to include three-wheeled vehicles in the scope of the GB scheme, UN Regulation No 78 should be considered as an alternative source for requirements. This Regulation is expected to require substantial modifications because it does not cover braking systems which exclusively rely on the use of an energy reserve (i.e. no muscular force).
- Pneumatic braking systems: Manufacturers may potentially desire to equip some higher-weight LSAVs with pneumatic braking systems, for which no provision is made

in UN R13-H. It is proposed in this case to apply the corresponding requirements from UN R13.

Wording/definition aspects incompatible with LSAVs:

- Driver controls for any of the braking systems are not required for LSAVs; instead the ADS and potentially other automated systems shall control the brake systems ("automatically commanded braking").
 - Interpretation of the 'moment when the control device begins to be actuated' is required and is clarified in a cross-cutting prescription applicable for various regulations (see Section 5.1).
 - 'Full-stroke actuation' and 'full application' of brake controls, which is referred to throughout the regulation, is not possible in the absence of controls and requires clarification. It is proposed to interpret this as 'automatically commanded maximum braking demands by the ADS'. Similarly, 'release' shall be interpreted as 'no automatically commanded braking demand'.

Potential to ease requirements or give derogations for certain subgroups of LSAVs:

- UN Regulation No 13-H does not apply to vehicles with a maximum speed ≤ 25 km/h. Equally, UN Regulation No 78 (Braking of L-category vehicles), which was investigated as a possible alternative for very-low-speed vehicles, does not apply < 25 km/h. Currently, vehicles falling outside the scope of these UN regulations are required only to comply with Construction and Use requirements, Regulation 16, which sets out basic design requirements and requires 'efficient' braking systems. No specific performance requirements (MFDD or stopping distance) are set by this regulation and compliance would not be tested by VCA. A later project task will consider if Construction and Use requirements, Regulation 15 setting out more demanding requirements, should be applied instead for LSAVs. If the decision is taken to include very-low-speed vehicles in the scope of the GB scheme, braking is one of the fundamental aspects for safe operation which should be checked by a technical service. Taking this into consideration and based on the equivalent safety principle it is proposed to permit for vehicles with a maximum speed ≤ 25 km/h (15.6 mph) to either undergo type-approval testing according to UN Regulation 13-H or demonstrate, to the satisfaction of VCA, that the applicable Construction and Use requirements are fulfilled.

Sources for requirements to cover additional risks/considerations:

- n/a

Other notes/considerations:

- n/a

Proposed application of technical regulation to LSAV categories:

- Passenger LSAV: Applicable

- Goods LSAV: Applicable

Proposed text for ‘definitions, exemptions and modifications’ (requirements):

1. For vehicles with a maximum design speed of 25 km/h or less, as an alternative to type approval in accordance with UN Regulation No 13-H, manufacturers may demonstrate to the satisfaction of the Technical Service and the Approval Authority, that the applicable Construction and Use requirements are fulfilled.
2. Vehicles with a maximum design speed of more than 25 km/h shall fulfil the requirements for a category 1 anti-lock system set out in Annex 6 (Test requirements for vehicles fitted with anti-lock systems). The angular steering control rotation limits set out in Annex 6, Paragraph 5.3.7. shall not apply, i.e. unlimited steering input by the ADS is permitted. As stipulated in Annex 6, Paragraph 1.2., the required performance may be achieved by a conventional anti-lock system or, alternatively, integrated into another system (e.g. the ADS). For vehicles with a maximum design speed of 25 km/h or less, Annex 6 shall continue to apply on an if-fitted basis.
3. The safety of complex electronic systems with regard to braking, Paragraph 5.1.3. and Annex 8, shall not be assessed as part of the brake systems approval but instead as part of an overall assessment of the Automated Driving System.
4. Of the provisions for the periodic technical inspection of braking systems set out in Paragraph 5.1.4., only Paragraph 5.1.4.1. shall apply.
5. All muscular generated performances in conventional vehicles (e.g. secondary brake) shall be replaced by alternative energy sources.
6. Paragraph 5.2.2.8. (two completely independent energy reserves) shall continue to apply even though the service brake system is not "controlled by the driver" as stipulated in the regulation.
7. In the event of any failure or defect that would result in a red warning signal according to the regulatory requirements an electronic signal shall be sent to the ADS.
8. References to ‘full-stroke actuation’ and ‘full application’ of brake controls shall be interpreted as ‘automatically commanded maximum braking demand’ by the ADS; references to ‘release’ of the brake controls shall be interpreted as ‘applying no automatically commanded braking demand’.
9. Vehicles equipped with compressed-air braking systems shall fulfil, in addition to the requirements of UN Regulation No 13-H as modified above, the requirements for compressed-air braking systems set out in UN Regulation No 13 (11 series of amendments), Paragraph 5.1.3., Annex 6, Annex 7 and Annex 10.

Test procedures

Technical aspects incompatible with LSAVs:

- Testing to UN R13-H will require dynamic and driven tests. LSAVs will therefore require a method for human control or enabled automated test modes in order to perform the various dynamic and static tests. This is covered by a cross-cutting prescription (see Section [5.1](#)).

- For bi-directional vehicles, it is expected that the technical service will consider the test requirements as part of a worst-case assessment. This is covered by a cross-cutting prescription
- Annex 3 Braking tests and performance:
 - Bi-directional vehicles should comply in both directions. This is covered by a cross-cutting prescription.
 - It is assumed that LSAVs will not have a towing capability, and so any requirements related to trailer and towing will not apply.
 - Paragraph 1.2.2. confirms that testing can be conducted at the vehicles maximum speed if it cannot meet the prescribed speeds of the regulation.
 - Paragraph 1.2.3. Brake control applied force: Limit values for applied forces for service, secondary or parking brake systems should not apply. This is covered by a cross-cutting prescription.
- Annex 5 Braking distribution among axles:
 - Bi-directional vehicles not equipped with ABS should comply in both directions, in which case the references to front and rear should be reversed. This is covered by a cross-cutting prescription.
 - Appendix 1 and 2: Limit values for applied forces for service brake systems should not apply. This is covered by a cross-cutting prescription.
- Annex 6 Anti-lock systems:
 - Bi-directional vehicles should comply in both directions. This is covered by a cross-cutting prescription.
 - Limit values for applied forces for service brake systems should not apply. This is covered by a cross-cutting prescription.
- For the elements of the regulation not mentioned, the required test procedures can be applied to LSAVs without modification.

Proposed text for ‘definitions, exemptions and modifications’ (test procedures):

1. No modifications apply.

R.155 -Item 91 – Protection of vehicle against cyberattacks

Overview

Item No: 91

Subject: Protection of vehicle against cyberattacks

Regulation: UN Regulation No 155

Series of amendments recommended for application: Original version of the Regulation

Published in OJ: Original version of the Regulation

Latest series adopted (excluding proposal documents): Original version of the Regulation

Latest series in force: Original version of the Regulation

Vehicle categories in scope of technical regulation: M, N, O, L6, L7

Introduction to the regulation: This regulation requires vehicle manufacturers to have a cyber security management system in place and to demonstrate that each vehicle type has been designed in accordance with this management system.

Requirements

Can regulation (or part of regulation) be waived altogether for LSAVs?:

Cyber security is a pertinent aspect for modern vehicles that can lead to safety risks if not adequately addressed by the manufacturer. UN R155 is not currently required for the GB type approval of conventional vehicles based on retained legislation.

To ensure a sufficient level of protection against cyberattacks through adequate technical and procedural means, which is particularly pertinent for highly automated vehicles, it is proposed to apply UN R155 for all LSAVs.

Technical aspects incompatible with LSAVs:

n/a

Wording/definition aspects incompatible with LSAVs:

n/a

Potential to ease requirements or give derogations for certain subgroups of LSAVs:

n/a

Sources for requirements to cover additional risks/considerations:

n/a

Other notes/considerations:

The regulation requires an assessment of the manufacturer to issue a certificate of compliance for their cyber security management system. A UK approval authority would need to be appointed for this purpose (Paragraph 6.1).

Proposed application of technical regulation to LSAV categories:

Passenger LSAV: Applicable

Goods LSAV: Applicable

Proposed text for 'definitions, exemptions and modifications' (requirements):

1. No modifications apply.

Test procedures**Technical aspects incompatible with LSAVs:**

The required standards of this regulation can be applied to LSAVs without any modification.

Proposed text for 'definitions, exemptions and modifications' (test procedures):

1. No modifications apply.

R.156 - Item 114 – Software update and software updates management system

Overview

Item No: 114

Subject: Software update and software updates management system

Regulation: UN Regulation No 156

Series of amendments recommended for application: Original version of the Regulation

Published in OJ: n/a (not currently applied for EU type approval)

Latest series adopted (excluding proposal documents): Original version of the Regulation

Latest series in force: Original version of the Regulation

Vehicle categories in scope of technical regulation: M, N, O, R, S, T (vehicles that permit software updates)

Introduction to the regulation: This regulation sets out requirements for a manufacturer's software update management system (SUMS) and requirements for vehicle types being approved.

The term SUMS describes a systematic approach defining organizational processes and procedures to comply with the requirements for delivery of software updates according to the regulation. To obtain a Certificate of Compliance for SUMS, manufacturers must demonstrate by documents to the satisfaction of the approval authority or the technical service that they have the necessary processes in place to:

Document and securely hold information relevant to the regulation

Uniquely identify information regarding all initial and updated software versions

Access and update information regarding the RX Software Identification Number (RXSWIN) before and after an update (applicable for vehicle types that have an RXSWIN)

Verify that the software versions present on a component of a type approved system are consistent with those defined by the relevant RXSWIN (applicable for vehicle types that have an RXSWIN)

Identify interdependencies of the updated system with other systems

Identify target vehicles for a software update

Confirm the compatibility of a software update with the target vehicle

Assess, identify and record whether a software update will affect any type approved systems

Assess, identify and record whether a software update will add, alter or enable any functions that were not present, or enabled, when the vehicle was type approved

Assess, identify and record if a software update will affect any other system required for the safe and continued operation of the vehicle or if the update will add or alter functionality of the vehicle compared to when it was registered

Enable the vehicle user to be informed about updates

Make certain information available to authorities and technical services

The vehicle manufacturer is furthermore required to record and store information for each update applied to a given vehicle, including configurations of type approved systems, software relevant to every RXSWIN, target vehicles and compatibility, and other aspects.

Vehicle manufacturers must demonstrate that they fulfil the following requirements:

Hold a valid Certificate of Compliance for SUMS

Protect the software update delivery mechanism and ensure integrity and authenticity

Protect software identification numbers

Ensure the software identification number is readable from the vehicle

Over the air software updates must:

Restore function if the update fails

Execute the update only if there is sufficient power

Ensure safe execution

Inform users about each update and its completion

Ensure the vehicle is capable of conducting an update

Inform the user when a mechanic is needed

Requirements

Can regulation (or part of regulation) be waived altogether for LSAVs?:

The continued safety of LSAVs in operation may be strongly dependent on in-use software updates (for the ADS and other vehicle systems) to address issues identified in real-world operation, improve overall driving capabilities or extend the ODD. To ensure the safety of software updates and their delivery, as well as traceability of software versions it is proposed to require the vehicle manufacturer and in particular the manufacturer of the ADS (if different to the vehicle manufacturer) to comply with UN R156.

This regulation should apply for both, passenger and goods LSAVs.

Technical aspects incompatible with LSAVs:

n/a

Wording/definition aspects incompatible with LSAVs:

n/a

Potential to ease requirements or give derogations for certain subgroups of LSAVs:

n/a

Sources for requirements to cover additional risks/considerations:

n/a

Other notes/considerations:

In order to implement UN R156, the UK will need to appoint an Approval Authority to carry out the assessment of the manufacturer and to issue a Certificate of Compliance for Software Update Management System.

Proposed application of technical regulation to LSAV categories:

Passenger LSAV: Applicable

Goods LSAV: Applicable

Proposed text for 'definitions, exemptions and modifications' (requirements):

No modifications apply.

Test procedures

Technical aspects incompatible with LSAVs:

The required standards of this regulation can be applied to LSAVs without any modification.

Proposed text for 'definitions, exemptions and modifications' (test procedures):

1. No modifications apply.