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Working Party on General Safety Provisions
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agenda item 4.)

REPORT OF THE INFORMAL GROUP OF GRSG ABOUT THE MEETINGS DEALING WITH THE DEVELOPMENT OF REGULATION No. 66

(Strength of superstructure)

Transmitted by the Expert from Hungary

Note: The text reproduced below was prepared by the expert from Hungary, in his function as Chairman of the Informal Group, with a view to receiving instructions from GRSG for future work. It is based on the text distributed without a symbol (informal document No. 6) during the seventy-third session of the Meeting of Experts (TRANS/WP.29/GRSG/53, para. 28).

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Note: This document is distributed to the Experts on General Safety Provisions only.

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I. The informal group was organized on the basis of GRSG's decision (see TRANS/WP.29/GRSG/52, para. 20). The participants were:

United Kingdom:	Mr. Donald MacDonald
	Dr. Dusan Keoman
	Mr. Ian Corfield
Germany:	Mr. Roland Niggestich
	Mr. Michael Becker
	Mr. Hubert Hummel
Spain:	Mr. Andrés Garcia
	Dr. Enrique Alcalá
Hungary:	Dr. Matolcsy Matyas
	Dr. Molnár Csaba
	Mr. Vincye Papp Sándor

Two meetings have been organized:

I. Budapest, 19-20 January 1998.

II. Cranfield, 23-24 March 1998.

This report contains the final results of both meetings. The basic document of the two meetings were:

- TRANS/WP.29/R.305 (Prepared by the United Kingdom, Spain and Hungary)
- Informal document No. 3 (73rd session GRSG)-German comments

During the two meetings a number of informal documents were distributed and discussed. The list of these documents is attached in annex 1.

II. With respect to document TRANS/WP.29/R.305 the Parties agreed on the following first priority subjects:

1. Scope
2. The mass of belted passengers
3. The mass of luggage located in the baggage compartment below the floor
4. Relation between manufacturers and Technical Service, the need of complete bus when applying for approval
5. Seating arrangements
6. Pendulum test
7. Residual space
8. Test results as Type Approval evidence
9. Depth of the ditch at rollover test
10. Direction of rollover test
11. Wheel support at rollover test (tilting platform)
12. Definition of types and number of bays
13. Energy concept, equations, shape of the bus, determination of "h"
14. Determination of the factor 0.75

15. Distribution of absorbed energy
16. Calculation method.

The GRSG standpoint and decision are needed on these subjects, on the basis of which the modifications of the text, and reformulation of Regulation No. 66 can be made.

III. During the discussion of document TRANS/WP.29/R.305, the Parties agreed that other relevant subjects, such as the consequences and related problems to the first priority questions listed above, should be also discussed. The following are some examples:

A. Definitions
B. Alternative test methods
C. How to test articulated buses
D. Specification of ditch surface
E. Quasi-statis bay test.

IV. Discussing the first priority subjects listed in chapter II, the Parties expressed their views as follows (the reference pertains to the list number in chapter II.)

General remark made by the United Kingdom and Germany:

The amendments to Regulation 66 have to be safety-led, but also assessed in terms of the detrimental environmental and cost effect of (too) heavy and (much) more expensive structures. The expert from Germany also pointed out that the structure of the present regulation should be maintained. If the delegations see a necessity for any fundamental change, it should be established on the basis of recent accident research.

ad 1. Scope

(a) The number of passengers is open until the final decision about minibuses (involved or not) is made;

(b) The extension of Regulation No. 66 to minibuses and double-deckers was commented by the Parties as follows:

- United Kingdom and Germany recommended to consider aligning the scope of Regulation No. 66 with the Regulation No. 36

- Spain proposed the extension for both categories, for the minibuses at least those in which the passenger capacity exceeds 16.

- Hungary's opinion; the current scope is valid for high decker coaches too, but the test method and the requirements are not appropriate for this category, for approval. If this problem would be solved (see item 9) the modified test method could be acceptable for minibuses and double-deckers as well;

(c) The Parties do not see the necessity of any further limitation in the scope (e.g. speed and mass limits) and its footnote, on page 1 of Regulation No. 66.

ad 2. Mass of belted passengers

- Spanish experts gave some brief information about a bay test series simulating the following situations:

  - empty body without seats;
  - empty body with seats;
  - seated body with unbelted dummies;
  - seated body with lap-belted dummies;

  They promised a brief written report about the test result.

- The experts from the United Kingdom informed the group about a bay simulation series (computer simulation):

  - empty body with seats;
  - lap-belted passengers on the seats;
  - passengers with three point belts;
  - rigid masses in the centre of gravity of seating passengers.

  They presented a written report about the results of this study (see annex 1, para. 14)

- The Parties generally agreed to consider the mass of belted passengers, but further examination and research was needed on how to proceed.

- Germany pointed out, that consideration of belted passengers could only be justified if the regulation would be revised in line with the actual accident processes.

ad 3. Mass of luggage located in the baggage compartment

- German opinion: Consideration of mass of the baggage could only be justified, if the regulation would be revised in line with the actual accident processes. Taking into account the mass of the baggage will increase the height of the centre of gravity.

- Spain: they do not have specific opinion on this subject yet.

- United Kingdom opinion: involving this mass, the kinetic energy of the bus could be too high, the test could be too severe.

- Hungary: the volume of the baggage compartment has been considerably increased in recent years (high decker tourist coaches). The luggage mass could reduce the height of vehicle centre of gravity.

- Parties agreed that further study was necessary on this subject.

ad 4. Presentation of complete bus when applying for approval

The parties agreed that the reference data used for Approval requirements must be finally confirmed to the Technical Service by presentation of the whole vehicle which is either equal or “better” than the worst case approved, and specifically to check the mass, axle loads, and position of centre of gravity. The compliance of the manufactured structure with the approved design is part of the Conformance of Production Control.

ad 5. Seating arrangement

The Parties agreed that the manufacturer could ask for Approval independently from seating arrangement, on the basis of “worst case”. The “worst case” is to be defined by the Technical Service after consultation with the manufacturer. The “worst case” could be the body without seats (no supporting effect) but with seat masses and with the maximum possible seat number (maximum mass) or other combination of those.

ad 6. Pendulum test

- Hungarian, Germany and Spanish opinion: delete this test, but the buses which have been approved by the pendulum test should not need new approval.

- The United Kingdom had reservations concerning elimination of the pendulum bay test in view of its:

  (a) presence in all other rollover safety Regulations;
  (b) conservative nature;
  (c) close resemblance of the quasi-static calculations approval method.

ad 7. Residual space

Parties agreed on the following two principles:

- When determining the residual space it should be related to the body and not to the seats;

- The residual space should be extended to the driver's compartment as well as to the crew's compartment (seat).

Ad 8. Test results as type approval evidence

The Parties agreed that the Regulation has to describe exactly the data (test results, input and output data for calculation, etc.) which must be presented and documented as the evidences of Approval. But this demand should not harm the intellectual property rights of the manufacturers. Spain presented a proposal (see annex 1, para. 8) on this subject.

Ad 9. Depth of the ditch at rollover test

- The United Kingdom and Germany see the ditch dimensions as a fundamental reference in the Regulation, describing the "typical accident environment" and are hence in favour of keeping the current specification. The depth of the ditch was determined based on the findings of accident research and is a fundamental reference in the regulation. The basis of the present concept of the regulation is to have one figure for all buses/coaches included in the scope; to be able to change the figure, a large amount of accident research would be necessary.

- Germany pointed out that the higher the vehicle is, the more severe is the present Regulation No. 66 test.

- Hungarian experts pointed out and proved with documents that the recent depth value (800 mm) is not appropriate in the case of high decker coaches, because the deformation of the structure could be limited by the geometrical configuration even in the case of a very weak superstructure (see annex 2). The floor height (or waistrail height) above which this limitation takes place cannot be defined easily, while it depends on the shape of the body as well as the inner height of the passenger compartment, etc. Therefore Hungarian experts propose a modified rollover test method (changing depth of the ditch, or using shaped ditch, or their combination). Annex 3 shows the principle of these possibilities. Annex 4 gives an idea about the technical arrangement of this test facility, which is not essentially a new principle. This modified test method could solve the problem of testing (and approving) mini buses and double-deckers in the frame of one regulation if necessary.

- Spain wanted to have one regulation for all kinds (classes) of buses, but they do not see the necessity for a change in the depth of the ditch.

ad 10. Direction of rollover test

The Parties agreed that the decision (which direction should be used in the rollover test or simulation) belongs to the Technical Service and not to the manufacturer. Only one direction rollover test can be required.

ad 11. Wheel support at rollover test (tilting platform)

The Parties agreed that some parameters of the tilting platform (e.g. wheel support, axis position of rotation, etc.) have a great influence on the rollover test results (and in their comparison). Therefore this should be well defined in the regulation, using fixed values and not ranges for the geometry. Annex 5 gives some proposals. The dimensions of the wheel support is agreed as follows:

height	80 mm
width	20 mm
edge radius	[10 mm]
length, min.	500 mm

The exact position of the axis of tilting should also be defined.
The values shown in annex 5 in brackets are not yet agreed; they represent a fixed value from the existing ranges.
There is also a need to specify the tilting rig for bay tests.

Ad 12. Definition of types and number of bays to be tested

Discussing this subject, the Parties expressed their common view that:

- the bay test should be connected with the calculation of the whole body;

- the bay test alone is not acceptable as well as calculation alone - without laboratory test - cannot be used.

Technical Service should determine the number and types of sections, bays to be tested. The expert from the United Kingdom presented a document (see annex 1, para. 13) also emphasizing the importance of the roll moment of inertia.

Ad 13. Energy concept equations, shape of the bus, determination of "h"

The Parties agreed on the following:

- only one formula should be given for determining energy $E^* = 0,75\ Mgh$. (This is needed in the case of quasi-static calculation, dynamic simulation, and pendulum test);

- the real shape (in cross section) of the bus should be used when determining the value of "h";

- determining the real value of "h", the further deformation (after the impact of cant rail) should be considered. The way of this must be studied in the future.

Germany expressed the opinion that the current determination of "h" should be maintained.
The United Kingdom suggested that the final aim of E* energy and its "0.75" and "h" components is to reproduce the consequences of a full-scale rollover test, without erring on the unsafe side. It is the final figure that eventually counts.

ad 14. Determination of the factor 0.75

- The United Kingdom informed the experts that in the ADR (Australian Design Rule) this energy factor is lower (0.62);

- Hungarian experts emphasized that for the appropriate rollover simulation: the structure, the phenomena influencing the factor 0.75 and its components should be clarified and defined.

ad 15. Distribution of absorbed energy

On the basis of the proposal of the United Kingdom the Parties agreed on the following principle: it is necessary that the distribution of the absorbed energy should broadly follow the mass distribution along the bus. Spain proposed to put this requirement into the main text (instead of the annex).

ad 16. Calculation method

The Parties agreed on the principle outlined in document TRANS/WP.29/R.305 that:

"Annex 6 needs a significant review to establish a common interpretation of the regulation and set requirements that will narrow as much as may be reasonable the variation within which the Technical Services may operate, not to compromise the comparative quality of Approvals."

The Parties agreed that two kinds of calculations should be considered:

- dynamic simulation: computer simulation of rollover test with masses, mass forces, etc.;

- quasi-static calculation: forces acting on the cant rail detected deformations until energy E* is absorbed.

Exact, detailed requirements should be fixed in the regulation about the tools (e.g. program), methods (e.g. modelling, assumptions, input data, etc.) and their documentation. Ideally, it should be possible for one Technical Service to reproduce the Approval calculations, produced by another service. However, in view of the organizational and technical difficulties that may arise, this may not always be possible. It would be useful to agree, in principle, how such disagreements may be dealt with. All of the parties gave a short presentation to show that the calculation method which is used in their countries for approval (in addition Hungary and the United Kingdom presented a dynamic simulation too, which is used now in development). In the light of these presentations, the Parties established the main subjects which have the utmost importance in the calculation and methodology used by the countries. The summary of this study is given in annex 6.

V. When discussing the subjects listed in chapter III the Parties mentioned the following common opinions:

ad A. Definitions.

The definitions should be reviewed when discussing the individual subjects and not independently.

ad B. Alternative test methods.

It should be seriously considered during the future discussions whether the Technical Services are able to decide that a new test or calculation method (not specified in the regulation) is acceptable or not. The United Kingdom was explicitly against offering further options for approval.

ad C. Rollover test of articulated bus.

According to the existing regulation, the two parts of articulated buses have to be tested (simulated) and approved independently. However, there is no fixed requirement about the theoretical (e.g. masses) and technical (e.g. support of the part having one axle) disconnection of the two parts.

ad D. Specification of ditch surface.

Assuring the similar, reproducible testing circumstances, the quality of the surface (e.g. dry, rigid, smooth) should be specified.

ad E. Quasi-static bay test

Clarify the position of this option before concluding the formulation, e.g. is the quasi-static bay test:

(a) part of a calculation process (annex 6)?
(b) a new test procedure introduced under para. 6.2.?

Also, in terms of load application and specimen mounting conditions, this test looks very similar to the strongly criticised pendulum test, less the dynamic loading aspects.

VI. The report of the two meetings of the informal group were presented during the seventy-fourth Meeting of GRSG in April 1998 for further discussion. GRSG should decide about the fruther procedure.

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Annex 1

LIST OF INFORMAL TECHNICAL DOCUMENTS

1. Documents for ad hoc meeting dealing with Regulation No. 66 (Hungarian material, 1997, December).

2. Minutes of GRSG ad hoc meeting, Budapest 19-20 January 1998.

3. German comment on the Minutes of Budapest meeting.

4. ECE Regulation No. 66 - German position.

5. The United Kingdom comments on the Minutes of Budapest meeting.

6. The United Kingdom stand on the priority issues agreed in Budapest.

7. ECE Regulation No. 66 - the Spanish stand on the priorities agreed in Budapest.

8. Specimens of certification of superstructures approved by Regulation No. 66 of Geneva (Spanish material 23.03.98).

9. Summary of AUTÓKUT rollover simulation method for approval (Hungarian material 23.03.98).

10. Information to GRSG ad hoc group from AUTÓKUT (Hungary) containing the following:

    - Pendulum test on bus cross sectional rings;
    - Supporting of wheels on tilting device;
    - Numerical calculation at AUTÓKUT.

11. Block diagram of Spanish calculation method (23.03.98).

12. Strength calculation of bus superstructures in the light of international legislation (Hungarian dynamic simulation method used in the development practice, not in official legislation 23.03.98).

13. The United Kingdom procedure for type-approval of the PSV structures for rollover safety by calculation with component tests. (Detailed report by Dr. D. Keoman, CIC 23.03.98).

14. Large PSV-Strength of superstructure-ECE Regulation No. 66 (Final report, made by CIC on the order of DETR-UK February 1998). Main subjects: standard accident, pendulum bay test, energy to be absorbed by the structure, effect of the roll moment of inertia, and of belted passengers.

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Annex 6

MAIN SUBJECTS OF THE CALCULATION METHOD

On the basis of four plus two presentations on the Approval and development calculation methods, the ad hoc group established the most important features of the alternative approaches used in the four countries represented. These are summarized below as an illustrative evidence, without qualification.

1. Types of calculation method

Both quasi-static calculation and dynamic simulation approaches are used for approval.

Quasi-static method: relies on the elastic and plastic properties of the complete structure, and replaces the inertia effects and dynamic loading by quasi-static cant rail loading and underfloor support conditions. The total energy absorbed before contacting the residual space is compared with the energy E* in the Regulation, or its equivalent established by rolling representative bays.

Dynamic simulations: simulate the rollover process, involving the structural and inertia effects using a wide range of model complexities. Both approaches presented include the E* energy and monitor that the residual space is not intruded.

In principle both methods are acceptable.

2. Determination of CG height

Wide variety in the practice:

- Manufacturer declaration without test at the application stage (with possible experimental checking of the complete vehicle)

- Measuring by the Technical Service using different methods:

    - with rigid (fixed) axle suspension or with working one, with rigid wheels or original wheels, etc.;

    - tilting side-ways or lifting at front (or rear) the vehicle;

    - By calculation with some experimental data.

The principles of the acceptable methods should be given in Regulation No. 66.

3. Determination of masses

Axle loads are measured, or calculations with some experimental data are used. The roll moment of inertia also has a significant effect on the roll-over dynamics and the energy absorbed. It should be included into the Regulation, following some additional research.

4. Test evidences of calculation

Great number of test variations are used now.

- component test only (both static and dynamic) with or without dynamic factor (1.2);
- static bay test (combined with component test);
- bay rollover test;
- using results of former tests;
- substitution and interpolation using the results of similar, but not the same component test.

5. Modelling of the structure

- generally the real cross section shape is used;
- the complexity of the structural models varies greatly;
- between the main structural elements (rings) the intermediate effect is simulated by different ways: rigid beam, elastic springs, elastic structural elements, etc.);
- different methods are used for determining the location of plastic hinges;
- the effect of certain structural elements, like wheel arches, partitions, toilets etc. are mostly neglected;
- determination of rigid structural elements, like underframe structure, roof (sometimes), rods between the plastic hinges, etc.

6. Loading and supporting conditions

Different methods are used in the tests of quasi-static calculations:

- loading only at the cant rail, with equal displacements giving a reaction at 25° to the floor and designing the structure so that the distributions of the mass and energy absorbed along the structure are similar;

- the angle of the load is adjusted to the real geometry of the cross section shape;

- loading at the cant rail first and after a certain deformation putting load on the waistrail too (simulating when wastrel touches the ground);

- the (simple) supports of the structure under static calculation are usually at the joints between the main underfloor cross beams and upper and lower longitudionals and chassis connections (if any).

In case of dynamic simulation the loads are determined by mass forces. Questions to be studied are:

- the supporting conditions at the wheels;

- simulation of friction;

- the build up of dynamic reaction forces.

7. Evaluation of the results

Different criteria are used in the countries. The common features of the evaluation are the following:

- loading until the required energy (E*) is absorbed by the structure;

- checking the energy absorption whether it is proportional to the mass distribution along the length of the bus (the dynamic simulation does not need this checking);

- checking the individual ring deformations whether the survival space is untouched.

8. Calculation checks

The experts agreed that in case of sophisticated, non-linear calculations, certain calculation checks should be built into the program which can check e.g. the order of the internal loads, the validity of the plastic hinge characteristics etc.

9. Interpretation of test results

Different methods are used in existing practice. The followings subjects were mentioned, as part of the documentation:

- basic principles of the calculation;
- drawing of the bus, especially of its superstructure with all the required geometry;
- structural analysis and its result: the model of the bus;
- masses, their location, position of centre of gravity;
- test results (static and dynamic): deformation curves of bays, plastic hinge characteristics;
- determination of E* and energy distribution;
- absorbed energies;
- ring deformations, distances from the survival space;
- the whole file of the calculation.

The experts of the ad hoc meeting agreed that the documentation of the calculation should provide the transparency of the calculation. There was a discussion about the conditions of the reproducibility.