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COMMITTEE OF EXPERTS ON THE TRANSPORT OF DANGEROUS GOODS

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agenda item 5 a))**

PROGRAMME OF WORK

Programme of work for the 2001/2002 biennium and related proposals

Amendments to Chapter 6.7 of the Model Regulations on the Transport of Dangerous Goods

Transmitted by the expert from Germany

Introduction

At the beginning of 1995 the final report on the research project THESEUS (Tankfahrzeuge mit höchst erreichbarer Sicherheit durch experimentelle Unfall-Simulation = Tank-vehicles with maximum attainable safety through experimental accident simulation) was presented to the German public.

One of the essential conclusions Germany draws from this report refers to the equivalence wall thickness formula in accordance with para. 6.7.2.4.6 of the Recommendations on the Transport of Dangerous Goods in its 11th revised edition. The present equivalence wall thickness formula - which has to be applied if the required minimum wall thickness of tanks has to be determined for any metal other than the reference metal (mild steel) - cannot be derived from the laws of mechanics according to the results of the THESEUS research project.

Therefore it will be proposed to replace this formula by an equivalence formula in accordance with the laws of mechanics like it had been adopted by the UN/ECE/WP.15 for ADR purposes, already.

Furthermore, it will be proposed to introduce an evaluation system for the different tank designs (reference tank) as it is still not possible to completely evaluate different tank types with the criteria contained in Chapter 6.7 even with a changed equivalence formula. In this connection, reference can be made to the UN Model Regulations in para. 6.7.1.2 according to which alternative designs (alternate arrangements) can be permitted on certain conditions and in consideration of scientific and technological progress.

Proposals

1. Adequate equivalence wall thickness formula

The present equivalence wall thickness formula in para. 6.7.2.4 e.g. should be replaced by the following formula:

$$e_1 = \frac{464 \cdot e_0}{\sqrt[3]{(R_m \cdot A_1)^2}}$$

2. Alternative arrangements - Description of a reference tank

In addition to the requirements on alternative arrangements according to para. 6.7.1.2 the characteristics of a reference tank should be defined, representing the basic level of safety of tanks intended for the transport or a certain quantity of dangerous goods with certain hazardous properties.

Justification

1. Adequate equivalence wall thickness formula

The determination of minimum wall thicknesses according to the requirements prescribed in para. 6.7.2.4. “Minimum shell thickness” results for test and design pressures between 4 and 10 bar in wall thicknesses of about 3 up to 5 mm and more related to mild steel depending on the pressure vessel code being applied. Nevertheless, a sufficient level of safety of the tanks against the effects of internal and external (accidental) loads shall be ensured. This will be done by fulfilling the requirements laid down in the present para. 6.7.2.4.2 respectively by defining absolute minimum thicknesses related to mild steel as follows e.g.:

The walls, ends and cover plates of shells of circular cross-section not more than 1,80 m in diameter shall not be less than 5 mm thick if of mild steel, or of equivalent thickness if of another metal. Where the diameter is more than 1,80 m this thickness shall be increased to 6 mm except in the case of shells intended for the carriage of powdery or granular substances, if the shell is of mild steel, or to an equivalent thickness if the shell is of another metal. According to para. 6.7.2.4.6. the equivalent thickness of a metal other than the thickness prescribed for the reference steel shall be determined using the following formula:

$$e_1 = \frac{21{,}4 \cdot e_0}{\sqrt[3]{R_{m1} \cdot A_1}}$$

The above-mentioned formula - the so called “cubic root formula” - is inadequate in regard of internal or external loads affected to the tank shell. The main disadvantages of the cubic root formula are as follows:

- Its application to metals with properties less than those of mild steel (aluminium alloys e.g.) results in thinner wall thicknesses than needed to cover the same amount of loads the equivalent shell made of mild steel is able to do.

- Its application to metals with properties better than those of mild steel (austenitic steels e.g.) results in thicker wall thicknesses than needed to cover the same amount of loads the equivalent shell made of mild steel is able to do.

The above-mentioned figures for minimum wall thickness may be reduced if additional protection compensating the loss of properties of the tank wall because of the reduction of the wall thickness will be provided (see para. 6.7.4.3)

Thus follows, tanks (shells) intended for the transport of dangerous substances related to test or design pressures up to 4 bar or even more

- may be designed on an inadequate basis (cubic root formula), if aluminium alloys or austenitic steels are used instead of mild steels;
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- may be fitted with insufficient additional protection, because the reduction of wall thickness should be compensated completely.

Therefore, the third root formula should be replaced by an adequate one like proposed before.

For further technical justification see the attached document like it was presented to and adopted by the UN/ECE/WP.15 during its 68th session in May 2000, already.

2. Description of a reference tank

Where protection of the shell is provided, the required basic wall thickness of 6 or 5 mm e.g. related to mild steel may be reduced in the proportion to the protection provided (up to a maximum reduction of 2 mm related to mild steel). So, reduction of the wall thickness is permitted only if the remaining wall thickness and the protection added will reach an equivalent level of safety with regard to the safety level of the shell wall not being reduced, in principle. In other words, the combination of the remaining wall thickness with the protection added shall offer a level of safety not less than that given by the wall thickness not being reduced.

The decrease of the level of safety caused by the reduction of the wall thickness can be compensated completely only by double-wall designs of certain characteristics (vacuum-insulation or intermediate layer of solid materials)

But, the material/wall thickness combination is only one important detail of the totality of measures influencing the overall level of safety of a certain kind of tank, as long as no real accident-proof tank is required, however. Among other things the level of safety depends as well on the

- choice of material and wall thickness,
- kind of additional protection

as on the

- accidental behaviour of the whole structure,
- effects of details of the design (equipment e.g.),

- quantity of the substances being released during an accident, probably,
- hazardous properties/characteristics of the substances being released
- level of safety of the vehicle tanks are fixed on.

Therefore, the decrease of the level of safety caused by the reduction of the wall thickness may be compensated not only by tank wall related measures but also by measures increasing the structure of the whole tank, eliminating the effects of bad design and weak service equipment, completed by knowledge about the accidental behaviour of the whole tank and its components.

Against this background it is advisable to introduce a system which comprises all possibilities of compensation with regard to the reduction of wall thickness

- directly by increasing the properties of the tank shell,
- indirectly by increasing the level of safety of the whole tank.

The basic level of safety should be indirectly defined by fixing a set of characteristics of a reference tank which could be looked at as a solution safe enough to be intended for the transport of a certain quality of dangerous goods with certain hazardous properties.

Thus follows, tanks may be put into service only, if they represent the same or a multiple level of safety like the level of safety of the reference tank, depending on the hazards of the substances to be transported a.s.o.

Conclusion

Because of the complexity of the matter it would be envisaged to discuss the above mentioned items during the next biennium of the Committee of Experts on the Transport of Dangerous Goods, perhaps in a portable tank working group which could be established at the 21st session of the Committee. If these items were adopted for the future work program, the expert from Germany would distribute the necessary additional information to the countries participating in such working group or to the Sub-Committee, as appropriate.

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