Compatibility of heavy vehicle combinations. Supplementary Report. Recommendations and Justification.

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1 INTRODUCTION

TRL has completed a project for the UK Department of the Environment, Transport and the Regions, DETR, to investigate compatibility problems of articulated HGV's and a comprehensive report has been written (Fenn, 2000). Apart from giving full details and results of the testing and research, the report also gives recommendations for changes to Regulation 13, Annex 10. This brief report summarises the main recommendations with an explanation and reference to the supporting evidence in the main report. Both the main report and the recommendations are extensive and somewhat complex and it was considered necessary to provide this report to be read as a pre-cursor to the main report.

The main recommendations are given below, numbered, and in each case followed by a brief explanation with reference to the supporting evidence.

2 RECOMMENDATIONS

1. It is recommended that the compatibility corridors be narrowed. The research showed that, ideally, the corridors should be such that the threshold pressure difference be ±0.2 bar for coupling head pressures up to 2 bar and to ±0.4 bar for coupling head pressures greater than 2 bar. However, it may be difficult to meet this requirement and thus, a compromise was devised. Readily achievable compatibility corridors based upon the current requirements of Regulation 13 Annex 10, have been generated and are given below in figure 1, tractor unit unladen and laden. Figure 2 gives the recommended changes to the compatibility corridors for semi-trailers. The corridors have been narrowed at the check braking range (below 2 bar coupling head pressure) to improve the wear rate of the brake linings and to prevent glazing, and up to 4.5 bar coupling head pressure to improve stability and hence safety.

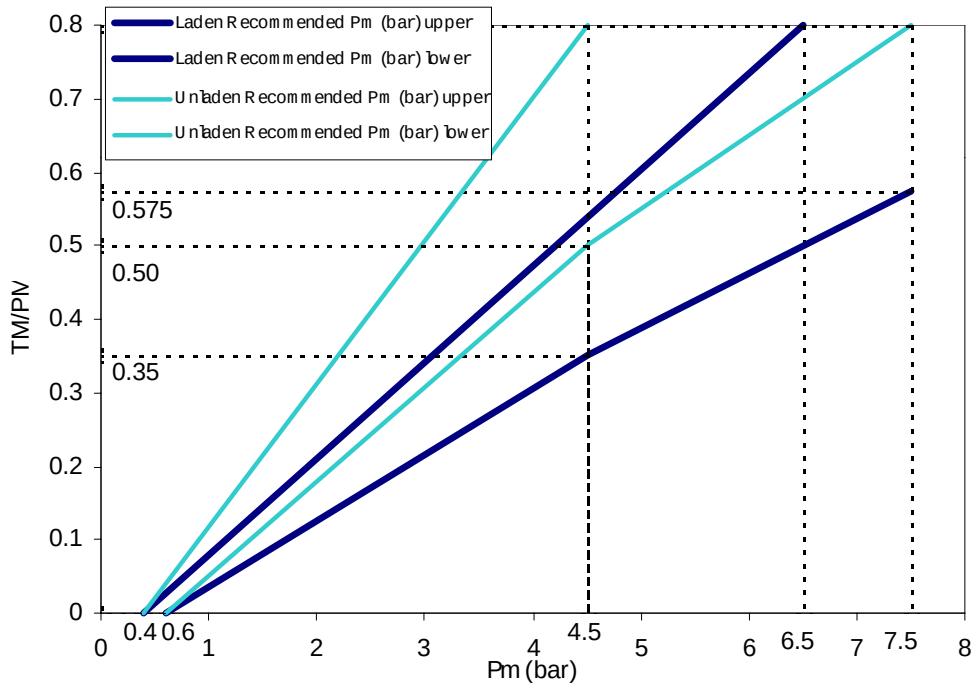

Figure 1: Recommended compatibility corridor for tractor units, laden and unladen

For the unladen tractor, the compatibility corridor, shown in figure 1 above, has been calculated by moving the x axis intercept, for the upper boundary, from 0.2 bar to 0.4 bar. The gradient has altered slightly because a brake efficiency of 0.8 at 4.5 bar coupling head pressure has remained the same. This has ensured that there will be no perceived loss in brake efficiency, because this rate can be achieved by current vehicle designs. The lower boundary has been moved from an intercept, on the x axis, of 1.0 bar coupling head pressure to 0.6 bar. The gradient for the first part of the lower boundary (between 0.6 bar and 4.5 bar) has changed, but the second part (above 4.5 bar) has remained the same. This is due to using the current R13 co-ordinate (4.5, 0.575) which will mean a comprehensive narrowing of the corridors at coupling head pressures below 4.5 bar. The overall narrowing of the compatibility corridor has altered the pressure difference at 2 bar and 4.5 bar coupling head pressures. Based upon the lower boundary and moving horizontally, the difference is 0.68 bar and 1.54 bar respectively. The current Annex 10 of Regulation 13 permits 1.03 bar and 1.66 bar for coupling head pressures of 2 and 4.5 bar.

The laden tractor unit corridors were calculated in the same manner as those for the unladen. Regulation 13 allows a pressure difference of 1 bar and 1.5 bar for coupling head pressures of 2 bar and 4.5 bar. The recommended corridors have a pressure difference of 0.64 and 1.43 for coupling head pressures of 2 and 4.5 bar.

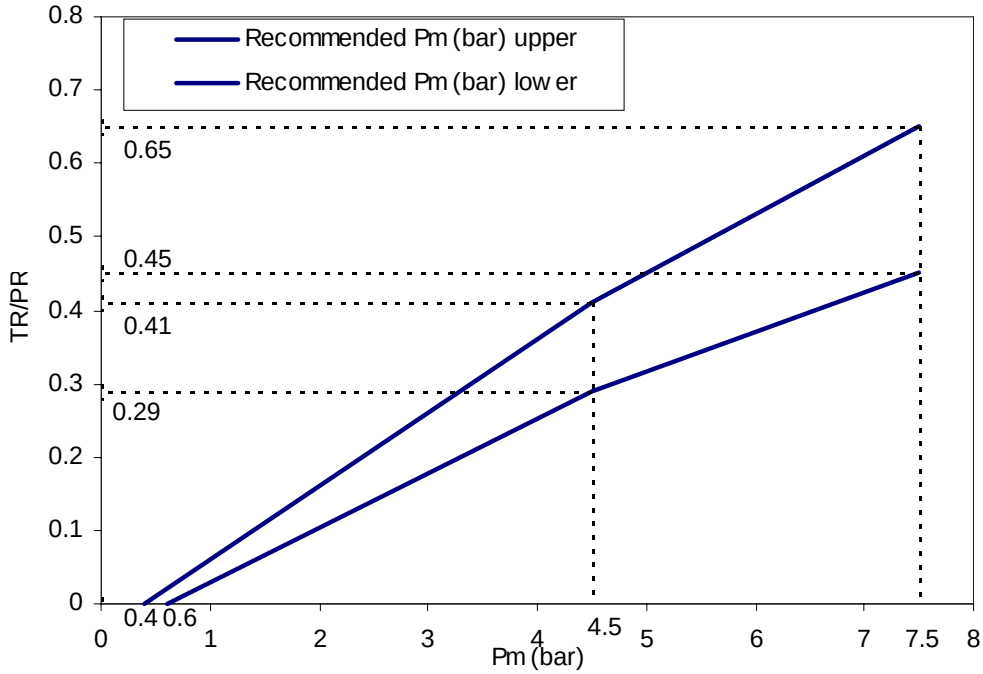

Figure 2: Recommended compatibility corridor for semi-trailers

The recommended corridors for the semi-trailer were similarly calculated. For the boundary before the elbow the gradients were changed, whereas the gradients after the elbow (after 4.5 bar coupling head pressure) were kept the same as in Regulation 13. The upper boundary was moved from an intercept, on the x axis, of 0.2 bar to a new intercept 0.4 bar. The lower boundary was moved to 0.6 bar. In an unmodified state, where K_c =1.00, the pressure difference for 2 bar coupling head pressure is 0.56 bar, whereas in Regulation 13 it is 0.93 bar. At 4.5 bar coupling head pressure, the recommended

corridors have a pressure difference of 1.20 bar which compares to a pressure difference of 1.26 bar currently permitted by Regulation 13.

It should be noted that the corridors described above will not bring about the full range of benefits, identified from the research, that may be possible with the "ideal" corridors.

2. Recommendation 1) above defines new narrower corridors for the tractor and semi-trailer. However, to ensure that the compatibility lies within the limits indicated by the research then the tractor and semi-trailer corridors must be closely aligned. It is thus further recommended that the values of Kc and Kv should be limited and a tolerance established. This means that manufacturers will necessarily need to declare a centre of gravity height for a laden trailer corresponding to a particular type of use, or load, and that type of use, or load, should then be declared on the vehicle. For example, it is not possible for a vehicle that has been designed to carry a dense load, such as metal, also to be suitable for carrying a container, fully loaded by weight and volume, and remain compatible with a given tractor.

3. Narrowing of the compatibility corridors means, from the outset, that tractor units and semi-trailers will have normal operating threshold pressures that are initially very close. With this in mind, it would mean that adjustment to a relay valve, by a vehicle operator, would be unnecessary. Therefore, phasing out of predominance valves is recommended. A relay valve would still be required, but it should be designed such that it is 'tamperproof'. Furthermore, the phasing out of predominance valves with large adjustment capabilities will eliminate the hazard of a trailer control valve that has significant predominance reverting to zero predominance, leading to unbalanced braking between tractor and semi-trailer, if one of the two tractor brake circuits fail.

4. The work done profiles show that balancing temperature across all axles does not necessarily produce balanced braking. Balanced braking is achieved by sharing work done by the equivalent ratio of the static load with an allowance for load transfer under severe braking. Manufacturers of vehicles, semi-trailers and/or axles could produce simple tables indicating to vehicle operators the correct temperature distribution applicable to each loading condition, thereby improving the lining wear and vehicle downtime.

5. Although the theoretical braking rate for unladen semi-trailers is based on sound mathematics, there is a need to verify that the vehicle can match the predicted braking rate later in the vehicle life, for example ten years after vehicle manufacture. Good maintenance is essential to ensure that optimum braking is sustained. Evidence should be provided to show that the theoretically derived regulatory requirements are met in practice.

3 JUSTIFICATION

3.1 RECOMMENDATION 1

This recommendation was formulated based on the results from the work, which states that the permitted threshold pressure difference should be ±0.2 bar. Sections 3.5 and 4.2, in the main report, on wear rates have shown that a pressure difference in excess of ±0.4 bar produces unacceptably high wear rates. Furthermore, if either the tractor unit or trailer has an excessive wear rate then other brake linings are likely to suffer glazing, and hence a loss in braking performance. This relationship between wear rate and glazing is an important safety issue and so the overall recommended threshold pressure difference is ±0.2 bar.

Unbalanced braking can effect stability of the vehicle. Section 4.4, and specifically table 9 in section 3.9.2, shows that a low coefficient of friction surface can lead to an undesirable order of wheel locking and hence jack-knife or trailer swing is possible.

3.2 RECOMMENDATION 2

To ensure the compatibility corridors between the tractor and trailer are coincident it is recommended that the values of Kc and Kv be set and a tolerance established. Kc and Kv are related to the height of the Centre of Gravity and the wheelbase of the semi-trailer. Therefore, it is essential that the semi-trailer is designed for the correct purpose, that is the type of loads it will be carrying. Section 4.5 gives details of the potential problems that may occur if the corridors are not coincident.

3.3 RECOMMENDATION 3

Current regulations permit a large difference in threshold pressure, therefore, the use of predominance between the tractor and trailer can be of benefit. However, because it is recommended that the corridors be narrowed, the predominance valve that is adjustable by an operator becomes obsolete. Sections 3.8 and 4.7 show results from testing and discuss potential disadvantages.

3.4 RECOMMENDATION 4

When a vehicle brakes, the kinetic energy will be dissipated mainly as heat. The share of heat, or work done, is proportional to the braking effort, but balancing the temperatures across the vehicle does not achieve balanced braking. Sections 3.4 and 4.3, in the main report, detail the distribution of braking effort and hence brake drum temperature.

3.5 RECOMMENDATION 5

Tests have shown that the braking efficiency of a vehicle may be different to what has been theoretically predicted. It may also vary if the vehicle is incorrectly maintained, therefore, proof is required to show that the actual braking rate matches the theoretical braking rate, as discussed in sections 3.10 and 4.8.

4 REFERENCES

Fenn B N, *Compatibility of heavy vehicle combinations. Final report*, TRL Project report PR/SE/605/99. 2000.