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Item 5 (b) of the provisional agenda

PROPOSALS OF AMENDMENTS TO THE ATP

Pending issues

Proposal for an ATP Test Procedure for Multi-Temperature
Refrigeration Systems with Remote Evaporators

Transmitted by Transfrigoroute International (TI)

Note by the secretariat

The Programme of Work for 2006-2010 of the Inland Transport Committee adopted at its 68th session in 2006 (ECE/TRANS/166/Add.1, Item 2.11 (i)) requires the Working Party on the Transport of Perishable Foodstuffs (WP.11) to ensure the Harmonization of regulations and standards relating to the international transport of perishable foodstuffs and facilitation of its operations, *inter alia*, by the Consideration of amendment proposals relating to test methods and procedures for the approval of multi-compartment and multi-temperature vehicles, to take account of technical development. The present document is submitted in conformity with that mandate.

Introduction

1. Following a comprehensive discussion within WP.11 and the IIR subcommission CERTE, the WP.11, in 2001, postponed the adoption of ATP test regulations for multi-compartment, multi-evaporator and multi-temperature refrigerated vehicles until ATP test stations had collected enough experience with the test method proposed by France.

2. Although the proposed French test method allows the testing of a refrigeration unit with various additional evaporators at an acceptable cost, the ascertained ATP refrigeration capacities of the individual evaporators in solo continuous operation are significantly higher than the actual refrigeration capacities in multi-temperature operation when several evaporators with different temperatures are operating at the same time. Also, the ascertained ATP refrigeration capacity of the host unit in mono-temperature operation is, by far, not available in multi-temperature operation.

3. The Transfrigoroute International working group on the ATP – which includes both the transport refrigeration and body builder industry as well as interested ATP test stations – has now worked out a physically explicable reduction of these considerably too-high refrigeration capacities. The basis of this was comprehensive comparative measurements on a multi-temperature refrigeration unit of the latest design (Supra 950 MT) carried out in the ATP test laboratory of TÜV and at Cemafroid over a period of time exceeding 12 months, also financed by the refrigeration machine industry.

4. During the measurements, the refrigeration capacity of the individual evaporators in real multi-temperature operation dropped by up to 50% and the refrigeration capacity of the host unit dropped by up to 20%. The cause of this extreme drop in capacity was the physical fact that the evaporator used in the frozen compartment can only actively refrigerate until refrigeration capacity is demanded of a chilled evaporator at the same time.

5. In this respect, the working group proposed a new dimensioning method based on the principle of the theoretically available refrigeration capacity of the host unit (test No. 1) and of the theoretical refrigeration capacity of the evaporators in solo operation (test No. 2). The measurements which form the basis of the calculation are identical to the measurements of the test method proposed by France.

6. In future, the actual refrigeration capacity available in multi-temperature operation is to be calculated on the basis of the relative running time of the various evaporators. In each compartment this refrigeration capacity must exceed the maximum refrigeration requirement of each compartment – and this under the most unfavourable conditions (position of bulkheads, temperatures) – by the ATP design factor of 1.75.

7. However, in future, the type approval test is to also test the regulation and functionality of the overall system in real multi-temperature operation (test No. 3). Whilst the evaporator (1) works in the frozen compartment (-20°C), the available useful refrigeration capacity of the frozen evaporator (1) is ascertained for the chilled evaporator (2) (0°C) at 20% heat load. At the same time, the maximum possible heating capacity of the evaporator in the second chilled compartment (evaporator 3) (+12°C) is tested by cooling down this compartment by means of an additional cooling load heat exchanger.

8. With this, the control system and capacity of the multi-temperature system are tested under real circumstances for the first time. With variable bulkheads, the stream of the refrigeration capacity from the frozen compartment into the chilled compartment is frequently so high that chilled evaporators in multi-temperature operation even have to heat up during high summer in order to avoid frost damage.

9. Even smaller evaporators proven to have too-high refrigeration capacities according to the former testing method can be evaluated under real circumstances by means of the new proposed dimensioning method. The testing method is built on the formerly applied method, and all the results to date from type approvals according to the French testing method are applied. With almost the identical amount of testing, significantly more realistic measurements and results are gained during the newly determined test No. 3.

10. Hence this proposal has been accepted by the majority of test stations, the transport refrigeration and body builder industry as well as the concerned associations (TI, Liaison Committee of the Body and Trailer Building Industry (CLCCR)). The proposal was also discussed anew at this year's meeting of the IIR subcommission CERTE in Piestany and has been modified according to the decisions of that meeting.

11. The acceptance of the proposal by WP.11 and the updating of the ATP as soon as possible is proposed.

E. Procedure for measuring cooling and heating capacity and dimensioning the cooling and heating demand of multi-temperature mechanical refrigeration units for multi-compartment equipment

I. Definitions

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1) **Multi-compartment equipment:** Equipment with two or more insulated compartments for different temperatures in each compartment.

2) **Multi-temperature mechanical refrigeration unit:** Mechanical refrigeration unit with compressor, condenser and two or more evaporators for the control (cooling and/or heating) of different temperatures in the different compartments of a multi-compartment equipment.

3) **Multi-temperature operation:** Operation of a multi-temperature mechanical refrigeration unit with two or more evaporators working at different temperatures in multi-compartment equipment.

4) **Nominal cooling capacity:** Maximum cooling capacity of the condensing unit in mono-temperature operation with two or three evaporators operating simultaneously at the same temperature.

5) **Individual cooling capacity:** Maximum cooling capacity of each individual evaporator operating alone with the condensing unit.

6) **Individual heating capacity:** Maximum heating capacity of each individual evaporator operating alone with the condensing unit.

7) **Useful cooling capacity:** Cooling capacity of each evaporator with the condensing unit in multi-temperature operation with two or more evaporators at different temperatures.

8) **Relative cooling time:** Useful capacity / individual capacity.

9) **Useful heating capacity:** Heating capacity of each evaporator with the condensing unit in multi-temperature operation with two or more evaporators at different temperatures.

10) **Condensing unit:** …

II. Test procedures for multi-temperature mechanical refrigeration units

62) General procedure

The test procedure is according to ATP Annex 1, Appendix 2, D.

Accuracy according to ATP Annex 1, Appendix 2, D and Annex 1, Appendix 2, paragraph 10. [Where the internal cooling method is applied, one or more heat exchangers shall be placed inside the body. The surface area of these exchangers shall be such that, if a fluid at a temperature not lower than 0 °C passes through them, the mean inside temperature of the body remains below +12°C when continuous operation has been established.] Accuracy of the heating capacity must be equal or lower than 5 %.

The condensing unit can be tested in combination with a varying number of evaporators. Each evaporator shall be tested in a separate calorimeter.

The nominal cooling capacity of the condensing unit in multi-temperature operation as prescribed in paragraph 63 is tested with only one combination with two or three evaporators including the smallest and the biggest.

The individual cooling capacity is measured for all evaporators, each in single operation with the condensing unit as described in paragraph 64.

The useful cooling capacities of the evaporators in multi-temperature operation as prescribed in paragraphs 65 and 66 are tested with two or three evaporators.

If the number of tested evaporators is higher than three, condensing units for a maximum of two evaporators are tested with the largest and smallest evaporator and condensing units for three or more evaporators with the largest, the smallest and a mid-sized evaporator.

63) Nominal cooling capacity tests of the condensing unit

Nominal cooling capacity of the condensing unit in mono-temperature operation with all evaporators operating simultaneously at the same temperature:

Tests at -20°C and at 0°C air inlet temperature of the evaporator unit, +30°C air inlet temperature of the condensing unit.

64) Individual capacity tests of each evaporator

a) **Individual cooling capacity of each individual evaporator** operating alone with the condensing unit:

Test at –20°C and 0°C air inlet temperature of the evaporator unit and +30°C air inlet temperature of the condensing unit. The individual capacities at -10°C can be calculated by linear interpolation of the capacities at -20°C and 0°C.

b) **Optional: Individual heating capacity of each individual evaporator** operating alone with the condensing unit:

Test at +12°C air inlet temperature of the evaporator unit and -20°C air inlet temperature of the condensing unit.

65) Useful cooling capacity tests of the evaporators in multi-temperature operation

Measurement of the maximum useful cooling capacity of each evaporator at -20°C while the other evaporators are cooling under thermostatic control at 0°C with a fixed heat load of 20% of the nominal cooling capacity of the host unit at -20°C. The air inlet temperature of the condensing unit is +30°C (two tests for condensing units with two evaporators, three tests for condensing units with three or more evaporators).

66) Useful cooling and useful heating capacity tests of the evaporators in multi-temperature operation

Parallel measurement of the maximum useful cooling capacity at -20°C of one evaporator and of the maximum useful heating capacity at +12°C of another evaporator. The cooling and heating capacities shall be tested for each evaporator. The air inlet temperature of the condensing unit is +30°C.

In the case of condensing units with three evaporators the third evaporator is cooling under thermostatic control at 0°C with a fixed heat load of 20% of the nominal cooling capacity of the host unit at -20°C. The cooling and heating capacities have to be tested for each evaporator (two tests for condensing units with two evaporators, three tests for condensing units with three evaporators).

67) Calculation of the useful cooling capacities of the evaporators in multi-temperature operation

The useful cooling capacities of each evaporator in multi-temperature operation can be calculated with the individual capacities of the evaporators operating alone with the condensing unit at -20°C and the relative cooling times of the evaporators. The calculation is based on the fact that the evaporator does not cool at -20°C while another evaporator is cooling at 0°C.

Useful cooling capacity = relative cooling time x individual cooling capacity at -20°C.

Relative cooling time of frozen evaporator = 1 - relative cooling time of all chilled evaporators.

III. Dimensioning and certification of multi-temperature mechanical refrigeration units for multi-compartment equipment

68) General procedure

The cooling and heating capacity demand for multi-compartment equipment is based on ATP Annex 1, Appendix 2 for mono-temperature equipment.

For multi-compartment equipment a K coefficient lower or equal to 0.40 W/m²K (IR) for the body has to be approved according to ATP Annex 1, Appendix 2, paragraphs 7 - 25.

69) Calculation of the cooling and heating demand

The calculation of the maximum cooling and heating capacity for each compartment must be based on the maximum possible temperature for the maximum cooling and heating demand. In the case of movable bulkheads, the calculation must be based on the most unfavourable position of the bulkhead and the maximum size of each compartment.

The insulation capacities of the internal bulkheads can be measured within an insulated body or calculated based on the K coefficient table in paragraph 71.

The cooling demands have to be calculated for +30°C ambient temperature and +30°C in the dry freight compartments and at -20°C in the frozen compartment and at 0°C in the chilled compartment.

The heating demands have to be calculated for a temperature of -20°C ambient and +12°C in the chilled compartment.

70) Check of the test results in multi-temperature operation and certification

The nominal cooling or heating capacity of all the appliances installed must be at least equal to or higher than the calculated heat loss through the walls of the complete equipment by a factor of 1.75.

The calculated useful cooling or heating capacities of the evaporators in each compartment in multi-temperature operation with the condensing unit (paragraph 67) must be at least equal to or higher than the calculated maximum cooling or heating demand of the compartments multiplied by a factor of 1.75.

For certification, the measured useful cooling capacities of the frozen evaporators in paragraphs 65 and 66 shall be on average higher than 90% of the calculated cooling capacities in paragraph 67.

71) Internal bulkheads

The thermal losses of the internal bulkheads can be calculated with the K coefficents in the following table. Alternatively, the insulation capacity (K coefficient) of the internal bulkheads can be measured on a complete vehicle according to ATP Annex 1, Appendix 2, paragraphs 7-25.

	K coefficient [W/m²K]		minimum foam thickness in average [mm]
	Fixed	Movable	
longitudinal	2.5	3.5	25
transversal	1.5	2.5	40

Notes:

a) The K coefficients of the internal bulkheads are based on calculations including thermal bridges in walls, roof, floor, protection plates, load lock bars and sealings.
