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Procedures for the approval of multi-compartment multi-temperature vehicles

Submitted by the Federal Republic of Germany

Draft amendment of the ATP Concerning test and approval procedures for multi-compartment and multi temperature equipment's

E. Test procedures, test report and certification for multi-compartment and multi-temperature equipment's

(61) Definitions

Multi-compartment equipment: Insulated equipment with two or more compartments for only one regulated temperature in one compartment or in all compartments

Multi-temperature equipment: Insulated equipment with two or more compartments for different temperatures in each compartment.

Multi-temperature refrigeration unit: Cooling or heating (thermal) appliances for a multi-temperature Equipment

Multi-temperature mechanical refrigeration unit: Cooling or heating (thermal) appliances with compressor (one condensing unit with one ore more evaporator units or one condensing unit with one evaporator unit and one or more fans for the different compartments) for a multi-temperature equipment.

Nominal cooling capacity: Cooling capacity determined with the condensing unit and one or more evaporator units which have a maximum surface at same conditions.

Useful cooling capacity: Cooling capacity of each possible evaporator unit in conjunction with the condensing unit operating separately multiplied with the factor U or V.

(62) Test procedure for multi-compartment and multi-temperature equipment with thermal appliances.

The tests can be carried out :

a) Combined testing

On the complete insulated equipment equipped (as the case may be) with one or several thermal appliances.

After measuring the insulating capacity of the insulated equipment (K-coefficient) according to the procedure in paragraphs 7-27 and 30 a check of the efficiency of the thermal appliances as described in paragraphs 31 of this appendix has to follow.

b) Separated testing

If the multi-temperature mechanically refrigerated unit is to test separately for the insulated equipment (according to the procedure described in paragraph 2 (c) (iii) (b) of Annex 1, Appendix 1 of ATP), then the insulating capacity of the insulated equipment (k coefficient) is measured as described in 7-27 and 30 of this appendix. The effective and the nominal cooling capacity of the multi-temperature mechanically refrigeration unit shall be measured according to the procedures described in paragraph 65 of this appendix.

When installing the mechanical refrigeration unit on the insulated equipment the distribution system of pipes and cables which pass through insulated walls must be insulated so as to limit the losses through the thermal bridges caused by the installation.

(63) K coefficient.

The overall K coefficient of the complete multi-temperature/multi-compartment equipment must be measured as in the procedures described in paragraphs1 to 15 for the equipment with movable bulkheads, and paragraphs 1 to 15 plus 20 and 21 (b) for equipment with fixed bulkheads.

(64) Bulkheads

For multi-temperature or multi-compartment equipment, internal bulkheads which separate compartments shall be treated as follows:

Bulkhead type	Minimum insulation thickness	Assumed K-coefficient
Fixed transverse	40 mm	1,0 W/m²K
Movable transverse	40 mm	2,0 W/m²K
Fixed longitudinal	25 mm	1,5 W/m²K
Movable longitudinal	25 mm	2,5 W/m²K

It is also assumed that manufacturers of these internal bulkheads will use the most effective insulation material available, as they would use to insulate the external side-walls of the equipment.

Use of inferior insulation material in the construction of internal bulkheads will disqualify the manufacturer from using the above facility. Under such circumstances the competent authorities will have to test a complete vehicle according to the provisions described in paragraph 62.

Note:
The above figures have been introduced to facilitate the necessary calculations required to match evaporator cooling capacities to the maximum thermal losses of each compartment.
They are an assumption and must not be used as a rule to correlate the K-coefficient against insulation thickness.

(65) Procedure for testing of multi-temperature mechanically refrigerated units.

Testing may be carried out on a complete equipment or by using the appropriate number of calorimeters.

The tests to determine the K-coefficient of the complete equipment or the calorimeters must be tested according to the provisions described in the paragraphs 51 to 59.

Test conditions of nominal cooling capacity are 30/-20 °C and 30/0 °C. Interpolation will provide 30/-10 °C and 30/12 °C is accepted as equivalent to 30/0 °C for evaporator unit/compartment performance matching purposes.

The following series of tests shall be completed:

1) The nominal cooling capacities of the condensing unit equipped with one or more evaporators for a maximum operating surface shall be measured.

2) The cooling capacity of each possible evaporator unit to be used in conjunction with the condensing unit shall be measured separately in operating.

Measurements of refrigeration capacity shall follow the procedures described in paragraphs 51 to 59.

3) The tests must be carried out on a complete operating multi-temperature unit with two or three evaporators. The air temperatures at the inlet to the condensing unit shall be controlled at 30 ± 0,5 °C with internal temperatures of each compartment reduced to 0 °C. The temperature of one compartment is reduced to –20 °C and maintained at that temperature by the addition of balance heat which is measured and recorded. At the same time a heat load equal to 20 % of the separately measured cooling capacity at –20 °C of each corresponding evaporator unit is added to the compartments which remain controlled to 0 °C.

The above process is repeated for all other evaporator units/compartments in the multi-temperature unit on test.

This cooling capacity measured under point 3) by the condition 30/-20 °C of each evaporator unit is represented as a percentage (U for two evaporator units and V for three evaporator unit) of the evaporator unit operating alone cooling capacity.
An average evaporator unit mean percentage factor U for two compartment and V for three compartment configurations, must be calculated.

4) Calculation of the useful capacities of the evaporator units in order to apply paragraph 41 of Annex 1 Appendix 2

The cooling capacity measured under point 3) by the condition 30/-20 °C of each evaporator units is represented as a percentage (U for two evaporator units and V for three evaporator unit) of the evaporator unit operating alone cooling capacity.

An average evaporator unit mean percentage factor U for two compartments and V for three compartments configurations, must be calculated.

The useful capacities to be used to match multi-temperature refrigeration unit to multi-compartment equipment's bodies are considered to be U % or V % multiplied by the individual evaporator capacity as operating in conjunction with the condensing unit.

5) Evaporator airflow

Each alternative evaporator's fan delivery volume and mean airspeed will be measured using an internationally recognised method (such as BS 848, ANSI/AMCA 210-85 etc.).

6) Test report

A test report (Model 11) shall be completed to include the results of the above testing of the multi-temperature mechanical refrigeration unit.

7) Certification

Using the test report (Model 11), calculations shall be made to ensure that the measured nominal refrigeration capacity unit at 30/-20 °C conditions is at least 1.75 times the thermal losses through the sidewalls, floor, front bulkhead, roof an doors of the vehicle when operating at -20 °C internal temperature in 30 °C external temperature. Similarly for 30/-10 °C, and 30/0 °C conditions.

Secondly, the useful capacity of each evaporator operating alone at 30/-20 °C conditions,must be at least 1,75 times the calculated thermal losses through the sidewalls, floor, bulkheads/doors and roof of the compartment in which the evaporator operates. Similarly for 30/-10 °C and 30/0 °C conditions.

Thirdly the measured evaporator delivery volume in m 3 /hr divided by the maximum volume of the compartment in which the evaporator operates must be at least 60 (air changes per hour).

Finally a ATP certificate can be issued for the multi-temperature/multi-compartment according annex 1, appendix 3, model B.

(66) Procedure for testing of multi-temperature mechanically refrigerated units, where cold air is blown by fans from the low temperature compartment to control the temperature in the second compartment.

Testing of this type of equipment can only be carried out on a complete vehicle. For this the following tests shall be completed:

1) The K-coefficient of the complete vehicle must be measured. If the vehicle is fitted with a movable bulkheads, the bulkheads shall be placed in its out-of-use horizontally stored at roof level position.

2) The refrigeration capacity of the complete mechanical refrigeration unit is measured according to paragraphs 51 to 59, at 30/-20 °C and 30/0 °C conditions.

3) The movable bulkhead is positioned in place to maximise the size of the higher temperature compartment. The mechanical refrigeration unit is then operated at 30/-20 °C conditions. Bulkhead fans are operated continuously, and if necessary balance heat is added to the rear compartment to maintain its temperature at -20 °C. Similarly these tests are repeated at 30/0 °C conditions.

4) Airflow

Evaporator fan and bulkhead fan delivery volumes and airspeeds shall be measured.

5) Test report

A test report (Model 12) shall be produced from the results of testing.

6) Calculations and certification

Using the test report, calculations must show that the refrigeration capacity of the complete refrigeration unit is at least 1.75 times the thermal losses through the floor, roof, sidewalls, front bulkhead and rear doors of the complete vehicle at 30/-20 °C and 30/0 °C conditions.

Similarly, for the high temperature compartment at its maximum size, the test report will provide the maximum available refrigeration effect. By calculation this effect must be at

least 1.75 times the thermal losses of this compartment under 30/-20 °C, 30/-10 °C or 30/0 °C conditions.

For equipment with fixed bulkheads, the K coefficient of the complete body must be measured according to paragraphs 1 to 15, plus paragraphs 20 and 21(b). Refrigeration testing must follow the procedures outlined in the beginning of this paragraph.

Finally a ATP certificate can be issued for the multi-temperature/multi-compartment according this annex 1, appendix 3, model C.

(67) Control of the operation of a complete new multi-compartment / multi-temperature equipment

This test shall be carried out on site by the competent authority.
Its objective is to check that the multi-temperature refrigeration unit controls the temperature set-point to within a tolerance within +/- 1.0 K each compartment

For example, at the following temperature for the equipment with three temperature-controlled compartments:

-25/-25-25 °C 0/12/-25 °C 12/-25/0 °C

§ 65 - 7) Certification and § 66 - 6) Calculation and certification

At present a safety factor of 1,75 (thermal losses through the walls etc) is stated in the paper for testing multi-temperature vehicles. We suggest to chnange the safety factor change from 1.75 to at least 2.5.

This suggestion has also been made by

- Transfrigeroute International (TRANS/WP.11/1997CRP.1/Add.1)

- Carrier „TRANSCOLD (THERMOKING - MULTI UNIT TESTING ATPCERTIFICATION PROPOSAL“, 24 avril 1997) - In this document is written a safety factor of from 2,5 till 3.

- CRT CJB/JEC/T4, 27April 1995 - In this document is the mentioned safety factor also more then 1,75.

  In our opinion the safety factor of 2.5 is necessary, better is the value 3.0 for the following reasons:

- In modern types of multi-temperature mechanically driven refrigeration units the evaporator fans are continuously operating. Therefore there is an additional heat load because of the power of all evaporators fans. So it is necessary to increase the safety factor for the cooling capacity.

- The amount of air leakage's between the compartments is unknown. Depending on this also the realistic heating respective cooling capacity are not known. In our experience the influence of air leakage's is very high in bodies which have been in use for some years. Up to now these facts have not been considered with regard to the safety factor.

- The cooling capacity of the mechanically driven refrigeration units can have a capacity deviation of up to 20 % compared to the ATP type approval values. (Vergleichende Untersuchungen an wärmegedämmten Aufbauten und Fahrzeugen und Kältemaschinen, TÜV Süddeutschland Bau und Betrieb, ATP-Prüfstelle, 1996).Tests in 1999 confirmed these results.

§ 65 - 3)

In (65) 3) it says, that the test has to be done at different temperatures in the compartments. At this test procedure, a the heat load equal to 20 % is added to the chilled compartment(s). This heat load of 20 % is only in relation to the capacity of a single evaporator at –20 °C instead of in relation to the cooling capacity of the complete unit. During the pro-posed test procedure refrigeration units with relatively powerful evaporators which are able to manage the complete refrigeration capacity of the host unit are loaded very highly by the additional load so that a relatively low capacity remains for the evaporator in the deep frozen compartment. On the other hand units with less powerful evaporators are not sufficiently loaded by the suggested additional heat load and a relatively big capacity remains for the evaporator in the deep frozen compartment. For this reason we think that the additional heat lost must be related to the capacity of the host unit.

Also there are no logical and physical reasons for the introduction of this completely new value of 20 % (up to now the ATP demands a minimum of 35 % or 75 %). During the IRR-meeting D2/D3 in Lisbon in 1998, it was not possible to explain this unusual value of 20 % for the determination of the cooling capacities. Therefore, this test procedure should be cancelled incl. the values U respective V until an internationally binding agreement with regard to the heat load has been reached.
