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Item 5 (a) of the provisional agenda
Proposal for amendments to the Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be Used for such Carriage (ATP)

Pending proposals

Test and ATP certification procedures for mechanically refrigerated multi-temperature refrigeration units*

Transmitted by the Government of France

Introduction

1. The Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be Used for such Carriage (ATP), signed in 1970, relates to appliances which were on the market at that time. In the 1990s, manufacturers of mechanical refrigeration transport units began developing and marketing multi-temperature refrigeration units. Such appliances are designed to maintain different temperatures in different insulated compartments within the same insulated body.

2. ATP Test Stations tested these appliances in accordance with ATP. They measured refrigeration capacity using the method used for mono-temperature appliances.

3. It soon became clear, however, that although an overall refrigeration capacity measurement was necessary for dimensioning the appliance as a whole, it was insufficient for dimensioning the various compartments and evaporators fitted to each of them. From

* The present document is submitted in accordance with the Programme of Work for 2008–2012 of the Inland Transport Committee (ECE/TRANS/2008/11, Item 2.11 (a)) which calls for the “Consideration of amendment proposals to ATP to ensure it is updated as necessary”.

1994 to 1998, manufacturers and test stations thus worked together to design a procedure for testing these appliances.

4. They also designed a dimensioning method for multi-temperature equipment, and a model form of certificate of compliance for such equipment.

5. An initial proposal was submitted to the Working Party on the Transport of Perishable Foodstuffs in 1997. A revised version was submitted to — and approved by — the Working Party in 1998.

6. Unfortunately, when the amendment was submitted to Governments for adoption, there was no consensus and although the model form of certificate of compliance for multi-temperature equipment was approved, the test and dimensioning methods were not.

7. Since 1997, nearly all multi-temperature units on the market have been tested in accordance with the procedure approved by the Working Party in 1998. More than 100 multi-temperature unit test reports have been produced by three different ATP Test Stations for the four manufacturers supplying the market. Several ATP Contracting Parties use the 1998 test results and dimensioning method to issue ATP certificates for multi-temperature equipment. This test method has proved its worth, even if it could be improved in some particulars. The few flaws revealed in the dimensioning method can easily be corrected without making it more complex.

8. Since 1997, one manufacturer, dissatisfied with the test procedure, has been attempting to have it changed, but has not succeeded in obtaining unanimous approval from the other manufacturers. Technischer Überwachungs-Verein (TÜV) was asked to conduct new tests and seek a compromise, but without success. Cemafroid was eventually asked to attempt again to find a compromise.

9. This proposal is the result of work carried out in the first instance with TÜV and, subsequently, with the manufacturers who represent the bulk of the market.

10. This proposal has the support of:

- Sub-Commission D2 CERTE on Test Stations (Refrigerated Transport) of the International Institute of Refrigeration, which met in June 2009 in Castelo Branco, Portugal
- Manufacturers of mechanically refrigerated transport units representing more than 80% of the share of European and world markets for multi-temperature units

State of the art

11. As in the case of mono-temperature equipment, the aim is to measure the refrigerating capacity of a unit, verifying that the unit can meet the demand caused by heat loss from the body plus a safety coefficient.

Background to the tests

12. The 1998 method and all subsequent proposals require:

(a) For each evaporator:

- Measurement of the air flow

(b) For two- or three-compartment models:

- Measurements of:

    - The nominal capacity of the unit with a series of evaporators corresponding to the number of compartments
    - The individual capacity of each evaporator to be used (a combination of two evaporators fitted to the same compartment counts as one evaporator)
    - The effective capacity of a set of evaporators including the smallest and largest
- Calculation of the effective capacity of all the other evaporators to be used

13. The current method has shown, in more than 100 tests, that interpolation of effective capacities is both feasible and accurate and that testing just one set is sufficient.

14. Certain aspects of the test procedure were a little unclear; we propose clarifications. The presentation of the results of effective capacity tests has been improved over the years and we thus propose that a clearer format be used.

Background to dimensioning

15. The 1998 method involves verifying the unit's ability to provide sufficient capacity for the appliance as a whole and for each individual compartment.

16. For each compartment, the K coefficient is considered to be equal to that of the entire appliance. Other dimensioning rules are the same as for ATP mono-temperature appliances.

17. This method underrates the refrigerating demand of each compartment in certain configurations and uses. It can result in insufficient capacity in some cases. It should thus be improved.

18. The main changes involve the way in which the refrigerating demand of each compartment is calculated. The K coefficient of the entire appliance would no longer be used. The K coefficient of the compartment would be calculated using the K coefficient of the whole body and the K coefficient of the [internal dividing] walls.

Certificates

19. No changes would be made to the model form of certificate of compliance with ATP, which can easily be used. It could be refined alongside work on the model form of certificate for mono-temperature equipment.

The proposal

20. This proposal comprises three sections:

- Title and definitions
- Test procedure for multi-temperature units
- Dimensioning method for multi-temperature equipment

21. The ATP model form of certificate was adopted in 1998. No change would be made to the model form.

Definitions

22. New terms introduced into ATP will be defined.

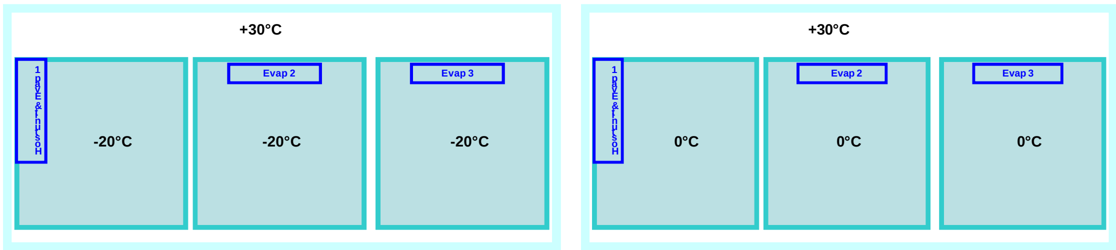
Test procedure

23. This test will be conducted under the same conditions as for mono-temperature units. Each evaporator is fitted onto a separate calorimeter.

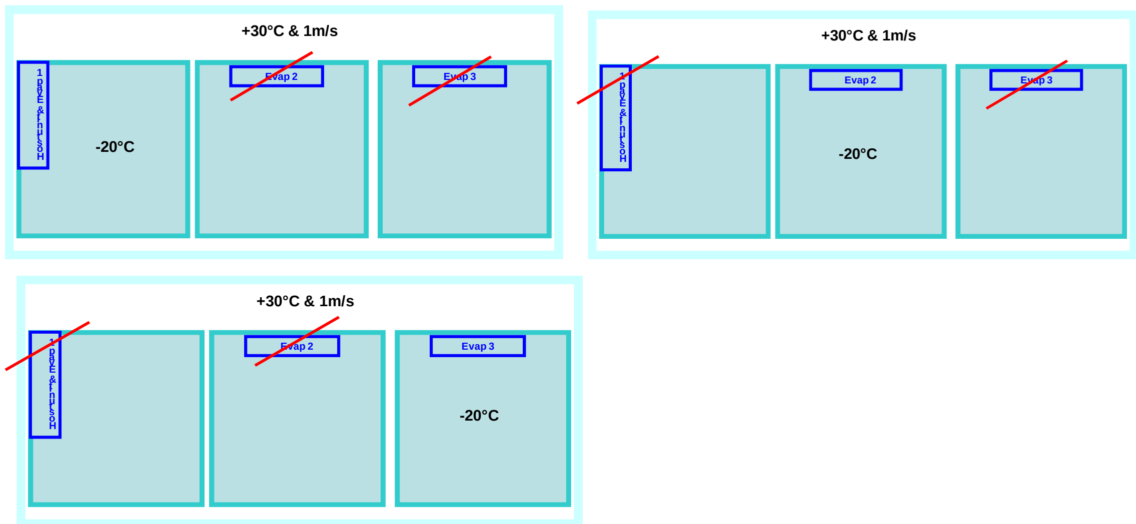
24. The air flow is measured for each evaporator.

25. Since several measurements are made for each unit, the refrigerating capacities of multi-temperature units will only be measured at 0° C and -20° C. The refrigerating capacity test is structured as follows:

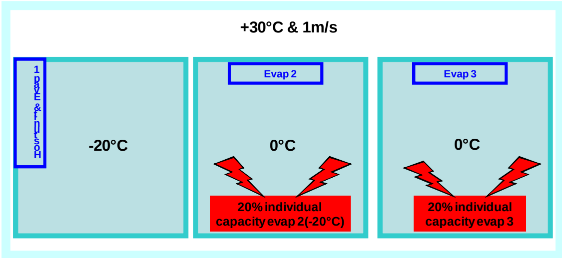
- **Determination of nominal capacity**

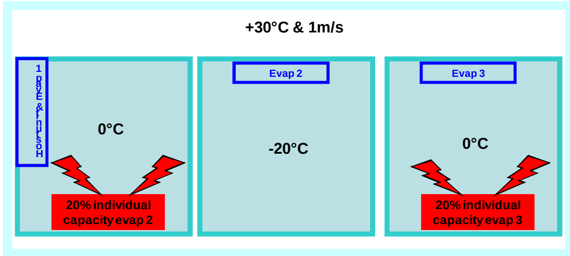


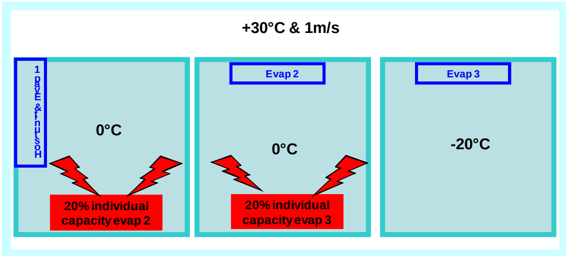
- **Measurement of individual capacity for each evaporator or combination of evaporators**



- Operating with other evaporators (Nos. 4, 5 …) and
- For each individual evaporator, the test will also be repeated at 0° C
- **Measurement of the effective capacity of a sample set of evaporators:** the smallest, largest and, if necessary, a mid-sized evaporator







26. These tests should be carried out on combinations of two and three evaporators if both are possible. In all cases, measurements of nominal and individual capacities will be made at 0° C and -20° C. The capacities at -10° C will be calculated by linear interpolation.

27. The effective capacities of the other evaporators will be calculated based on the fact that they are proportional to the individual capacity at -20° C of an evaporator with the same coefficient.

28. All tests will be conducted in on-road and sector mode if applicable.

29. The results will be presented in a table as in the following model:

Temperature	*Total nominal capacity of unit (W)*	*Effective capacity of evaporator (W) Evaporator 1*			*Effective capacity of evaporator (W) Evaporator 2*			*Effective capacity of evaporator (W) Evaporator 3*		
		Individual	*2 compartments*	*3 compartments*	*Individual*	*2 compartments*	*3 compartments*	*Individual*	*2 compartments*	*3 compartments*
Engine driven										
-20/+30° C										
-10/30° C (*)										
0/30° C										
Driven by electrical motor										
-20/+30° C										
-10/+30° C (*)										
0/+30° C										

(*) The capacities at -10° C are interpolated from the capacities at -20° C and 0° C.

Key

(light blue)	Total nominal capacity of unit
(light green)	Individual capacity of evaporator
(orange)	Effective capacity of evaporator with two compartments
(green)	Effective capacity of evaporator with three compartments

Dimensioning method

30. Dimensioning is carried out in two stages:

- Overall dimensioning of the appliance
- Dimensioning of each compartment

31. The overall dimensioning of the appliance is carried out as for mono-temperature equipment based on:

- The nominal capacity of the unit
- The K coefficient of the unit as a whole
- The mean outside surface area of the unit as a whole

32. The dimensioning of each compartment is carried out as for mono-temperature equipment based on:

- The maximum size and surface area of the compartment
- The effective capacity of the compartment's evaporator
- The K coefficient of the compartment as measured or calculated. The K coefficient of the outside walls is considered equal to the K coefficient of the whole body. The K coefficient of the [internal dividing] wall may be measured by an officially-recognized ATP testing station using the difference method or taken from the table below:

	K coefficient – [W/m²K]		*Minimum foam thickness [mm]*
	Fixed	*Removable*	
Longitudinal	2.5	3.5	25
Transversal	1.5	2.5	40

33. In all cases, the safety coefficient will be the same as for mono-temperature equipment provided in ATP.

34. The maximum air flow from each compartment should comply with ATP requirements for mono-temperature equipment.

Examples of unit testing and equipment dimensioning

Testing of a multi-temperature unit

35. Testing of a multi-temperature unit on the market with five evaporator models E1, E2, E3, E4 and E5, in ascending order of size.

Nominal and individual capacities

36. The nominal capacity and individual capacities were measured at -20° C and at 0° C; the capacities at -10° C were interpolated. The following results were obtained:

Capacities	*Nominal*	*Individual E1*	*Individual E2*	*Individual E3*	*Individual E4*	*Individual E5*
-20° C/+30° C	5 000	4 500	4 200	4 000	3 500	3 000
-10° C/+30° C	7 500	7 000	6 300	6 000	5 250	4 500
0° C/+30° C	10 000	9 500	8 400	8 000	7 000	6 000

Measurement of effective capacities and relative refrigeration rate R for a configuration of two evaporators

37. Evaporators E1 and E5 (the smallest and largest) were mounted on two separate **calorimeters**; the effective capacities were measured at -20° C. The results are given below:

	Effective capacity E1 (2 evaporators)	*Effective capacity E5 (2 evaporators)*	
-20° C/0° C	**3 717**	1 035	Thermostat set at 0° C
0° C/-**20° C**	678	**2 466**	Thermostat set at 0° C

i.e. Calculating Ri coefficients as a percentage of individual capacities at -20° C:

$R_1 = P_{U\_1}/P_{I\_1}$ = 3,717/4,500 = 0.826

$R_2 = P_{U\_2}/P_{I\_2}$ = 2,466/3,000 = 0.822

38. The results are given in the table below:

	Effective capacity E1 (2 evaporators)	*Effective capacity E5 (2 evaporators)*
-20° C/0° C	**82.6%**	23.0%
0° C/-**20° C**	22.6%	**82.2%**

39. The mean R coefficient was then calculated for two evaporators. The R coefficient for a configuration of two evaporators (R_{2evap}) is thus:

R_{2evap} = mean (R_1, R_2) = (82.6 + 82.2)/2,

i.e. R_{2evap} = 82.4%

Measurement of effective capacities and relative refrigeration rate R for a configuration of three evaporators

40. Evaporators E1, E3 and E5 (the smallest, mid-sized and largest) were mounted on **three** separate **calorimeters**; the effective capacities were measured at -20° C.

41. With two evaporators set at 0° C with a fixed heat load of 20% of their individual capacity, the third evaporator was tested at -20° C; each evaporator was tested in turn in this way. The results were as follows:

	Effective capacity E1 (3 evaporators)	*Effective capacity E3 (3 evaporators)*	*Effective capacity E5 (3 evaporators)*	
-20° C/0°C/0° C	**3 290**	900	700	Thermostat set at 0° C
0° C/-20° C/0° C	950	**2 920**	650	Thermostat set at 0° C
0° C/0° C/-**20° C**	980	850	**2 200**	Thermostat set at 0° C

i.e. Calculating Ri coefficients as a percentage of individual capacities at -20° C:

$R_1 = P_{U\_1}/P_{I\_1}$ = 3,290/4,500 = 0.731

$R_2 = P_{U\_2}/P_{I\_2}$ = 2,920/4,000 = 0.730

$R_3 = P_{U\_3}/P_{I\_3}$ = 2,200/3,000 = 0.733

42. The capacities are given in the table below:

	Effective capacity E1 (3 evaporators)	*Effective capacity E3 (3 evaporators)*	*Effective capacity E5 (3 evaporators)*
-20° C/0° C/0° C	**73.1%**	22.50%	23.33%
0° C/-20° C/0° C	21.11%	**73.0%**	21.67%
0° C/0° C/**-20° C**	21.78%	21.25%	**73.3%**

43. The mean R coefficient was then calculated for three evaporators (R_{3evap}):

R_{3evap} = mean (R_1, R_2, R_3) = (73.1 + 73.0 + 73.3)/3,

i.e. R_{3evap} = 73.1%

Calculation of effective capacities of all evaporators

44. For a configuration of two evaporators, the effective capacity for each evaporator is calculated as follows:

$P_{U\_n}(-20° C) = R_{2evap} \times P_{I\_n}(-20° C)$

where P_{U_n}(-20° C) is the effective capacity of the evaporator at -20° C and P_{I_n} (-20° C) is the individual capacity of the same evaporator operating at -20° C. The same calculation is made at 0° C:

$P_{U\_n} (0° C) = R_{2evap} \times P_{I\_n} (0° C)$

45. The effective capacities of each evaporator at -10° C are then interpolated for a configuration of two evaporators:

	Effective capacities E1 (2 evaporators)	*Effective capacities E2 (2 evaporators)*	*Effective capacities E3 (2 evaporators)*	*Effective capacities E4 (2 evaporators)*	*Effective capacities E5 (2 evaporators)*
-20° C/+30° C	3 708	3 461	3 296	2 884	2 472
-10° C/+30° C	5 768	5 191	4 944	4 326	3 708
0° C/+30° C	7 828	6 922	6 592	5 768	4 944

46. The same calculations are made for a configuration of three evaporators using coefficient R_{3evap} and the individual capacities at -20° C and 0° C for each evaporator:

Capacities	*Effective capacities E1 (3 evaporators)*	*Effective capacities E2 (3 evaporators)*	*Effective capacities E3 (3 evaporators)*	*Effective capacities E4 (3 evaporators)*	*Effective capacities E5 (3 evaporators)*
-20° C/+30° C	3 290	3 070	2 924	2 559	2 193
-10° C/+30° C	5 117	4 605	4 386	3 838	3 290
0° C/+30° C	6 945	6 140	5 848	5 117	4 386

Impact of the proposal

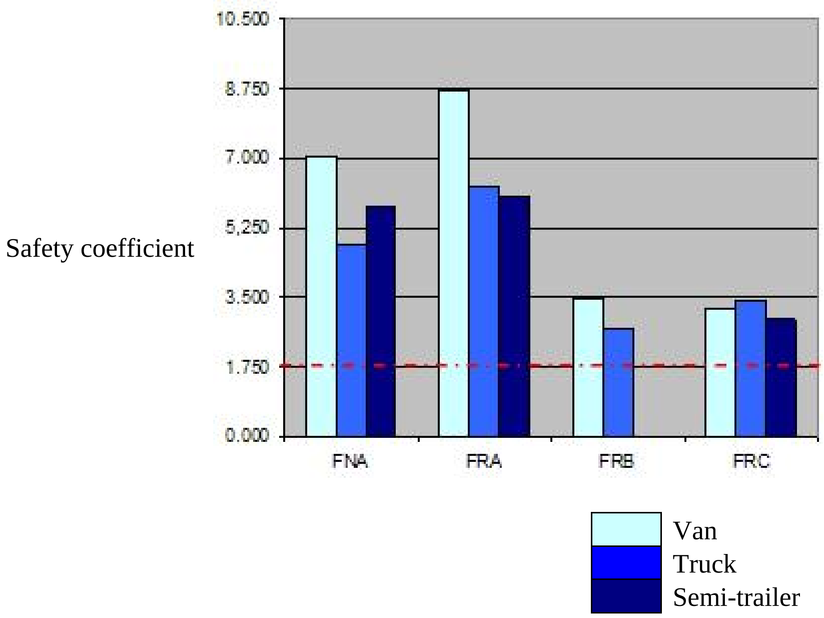
Technical impact

47. The new test procedure will not alter the number or length of the tests. It will not directly affect products — units or appliances — already on the market.

48. The new dimensioning method will have an impact on equipment with a very low safety coefficient, of 1.75 or thereabouts. According to a study of appliances sold in France in 2007 and 2008, mean safety coefficients for all types of appliances are well over 1.75, as shown in the figure below. The new provisions will affect an extremely limited number of configurations.

F. Safety coefficient f (type)

Figure 1
Mean safety coefficient of appliances sold in France from 2007 to 2008



Economic impact

49. There will be no economic impact of this proposal on testing since the duration and number of the tests are the same as under the current procedure. Moreover, the old tests could still be used.

50. The impact on the price of appliances will be negligible in most cases. In the case of poorly dimensioned appliances, the improvement in performance and reduction in risk will offset any price increase resulting from the new dimensioning.

Conclusion and proposal

51. Based on the above, we propose three additional amendments to ATP annex 1, appendix 2, to be inserted in a new sub-section E:

- **Amendment No. 1**: Title and definitions
- **Amendment No. 2**: Test method for multi-temperature units
- **Amendment No. 3**: Dimensioning method for ATP multi-temperature appliances

Proposed amendments to the ATP

Amendment No. 1

E. Procedure for measuring the capacity of mechanical refrigeration units and dimensioning multi-compartment appliances

I. Definitions

61.

(a) **Multi-compartment equipment**: Equipment with two or three insulated compartments for maintaining different temperatures in each compartment;

(b) **Multi-temperature mechanical refrigeration unit**: Mechanical refrigeration unit with compressor, condenser and two or three evaporators to set different temperatures in the various compartments of multi-compartment equipment;

(c) **Multi-temperature operation**: Operation of a multi-temperature mechanical refrigeration unit with two or three evaporators operating at different temperatures in multi-compartment equipment;

(d) **Nominal refrigerating capacity**: Maximum refrigerating capacity of the condensing unit in mono-temperature operation with two or three evaporators operating simultaneously at the same temperature;

(e) **Individual refrigerating capacity**: Maximum refrigerating capacity of each evaporator operating on its own with the condensing unit;

(f) **Effective refrigerating capacity:** Refrigerating capacity of each evaporator with the condensing unit in multi-temperature operation with two or three evaporators set at different temperatures;

(g) **Relative refrigeration rate**: Effective capacity/Individual capacity.

Amendment No. 2

II. Test procedure for multi-temperature mechanical refrigeration units

62. General procedure

The test procedure shall be as defined in ATP annex 1, appendix 2 D.

At issue are ATP annex 1, appendix 2 D and ATP annex 1, appendix 2, paragraph 10.

The condensing unit shall be tested in combination with different evaporators. Each evaporator shall be tested on a separate calorimeter.

The nominal capacity of the condensing unit in multi-temperature operation, as prescribed in paragraph 63, shall be measured with a single combination of two or three evaporators including the smallest and largest.

The individual capacity shall be measured for all evaporators, each in mono-temperature operation with the condensing unit, as prescribed in paragraph 64.

The effective capacity of the evaporators in multi-temperature operation, as prescribed in paragraphs 65 and 66, shall be measured with combinations of two or three evaporators including the smallest and largest.

If the multi-temperature unit can be operated with more than two evaporators:

- The combination of the condensing unit and two evaporators shall be tested with a combination of two evaporators: the largest and smallest;
- The combination of the condensing unit and three evaporators shall be tested with a combination of three evaporators: the smallest, the largest and a mid-sized evaporator.

The effective capacities shall be calculated for each evaporator in a combination of two evaporators and, if necessary, in a combination of three evaporators.

63. Determination of the nominal capacity of the condensing unit

The nominal capacity of the condensing unit in mono-temperature operation shall be measured with a single combination of two or three evaporators operating simultaneously at the same temperature. This test shall be conducted at -20° C and at 0° C. The air inlet temperature of the condensing unit shall be +30° C.

The nominal capacity at -10° C shall be calculated by linear interpolation from the capacities at -20° C and 0° C.

64. Determination of the individual capacity of each evaporator

The individual capacity of each evaporator shall be measured in solo operation with the condensing unit. The test shall be conducted at -20° C and 0° C. The air inlet temperature of the condensing unit shall be +30° C.

The individual capacity at -10° C shall be calculated by linear interpolation from the capacities at 0° C and -20° C.

65. Determination of the effective capacities of a set of evaporators in multi-temperature operation

The maximum effective capacity of each evaporator shall be measured at -20° C with the other evaporator(s) operating under control of a thermostat set at 0° C with a heat load of 20% of the individual capacity at -20° C of the evaporator in question. The air inlet temperature of the condensing unit shall be +30° C.

This test shall be conducted with two or three evaporators including the smallest, the largest and, if necessary, a mid-sized evaporator.

66. Determination of the effective capacity of each evaporator in multi-temperature operation

The effective capacity of each evaporator in multi-temperature operation shall be calculated using the individual capacity at -20° C of the evaporator in solo operation with the condensing unit, and the unit’s relative refrigeration rate.

The relative refrigeration rate (R) shall be determined for a configuration of two evaporators and for a configuration of three evaporators where applicable.

Determination of the relative refrigeration rate of the unit for a configuration of two evaporators

- R = mean (Ri)

- Ri = Ui / Ii

where:

- Ui is the effective capacity at -20° C of evaporator (i)
- Ri is the relative refrigeration rate of evaporator (i)
- R is the mean relative refrigeration rate for a configuration of two evaporators
- Ii is the individual capacity of evaporator (i) operating at -20° C

Determination of the effective capacity of each evaporator for a configuration of two evaporators:

- At -20° C: Un(-20°C) = R × In(-20° C)
- At 0° C: Un (0°C) = R × In(0° C)

where:

- Un(-20° C) and Un(0° C) are the effective capacities of evaporator (n) at -20° C and 0° C respectively
- R is the relative refrigeration rate
- In(-20° C) and In(0° C) are the individual capacities of evaporator (n) at -20° C and 0° C respectively

The effective capacities at -10° C shall be calculated by linear interpolation from the effective capacities at 0° C and -20° C.

The same calculation shall be made for configurations with three evaporators. This involves determining the relative refrigeration rate for configurations with three evaporators as well as the effective capacity of each evaporator operating with a configuration of three evaporators.

Amendment No. 3

III. Dimensioning and certification of refrigerated multi-temperature equipment

67. General procedure

The refrigerating capacity demand of multi-temperature equipment shall be based on the refrigerating capacity demand of mono-temperature equipment as defined in ATP annex 1, appendix 2.

For multi-compartment equipment, a K coefficient less than or equal to 0.40W/m²K (IR) for the body as a whole shall be approved in accordance with ATP annex 1, appendix 2, paragraphs 7 to 25.

For issuance of an ATP certificate, the nominal capacity of all the appliances installed shall at least be equal to the heat loss through the [internal dividing] walls of the equipment as a whole multiplied by the same factor as in paragraph 41.

For issuance of an ATP certificate, in each compartment, the effective capacity of the evaporator in multi-temperature operation shall be greater than or equal to the maximum refrigeration demand of the compartment multiplied by the same factor as in paragraph 41.

68. Calculation of the refrigerating demand

Calculation of the maximum refrigerating capacity demand for each compartment shall be based on the minimum class temperature. In the case of removable [internal dividing] walls, the calculation shall be based on the most unfavourable position of the wall for each compartment.

The insulation capacities of the [internal dividing] walls may be measured inside an insulated unit or calculated using the coefficients in the table in paragraph 69.

The K coefficient of the compartment shall be the mean of the K coefficients on the various sides weighted by the inside surfaces of the panels.

The outside temperature of the compartment shall be considered equal to +30° C on each side of the compartment both for both inside and outside panels.

69. Internal dividing walls

Thermal losses through internal dividing walls may be calculated using the coefficients in the following table. Alternatively, the K coefficient of the internal dividing walls may be measured on a complete insulated body in accordance with ATP annex 1, appendix 2, paragraphs 7–25.

	K coefficient - [W/m²K]		Minimum foam thickness
	Fixed	Removable	[mm]
Longitudinal	2.5	3.5	25
Transversal	1.5	2.5	40