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Proposals of amendments to the ATP: New proposals

Procedure for measuring the capacity of mono-temperature and multi-temperature refrigeration units using liquefied gas

Transmitted by the Government of France

Background

1. Most of the refrigeration units currently carrying perishable foodstuffs by road operate with the use of mechanical vapour compression. Three different types of drive are now in use when such compressors are in on-road mode:

- Driven by on-board internal combustion engines of self-contained units on semi-trailers and, generally, on rigid vehicles;
- Driven by the internal combustion engine of the vehicle, in the case of non-self-contained, pulley-driven units used on small vehicles;
- Driven by the on-board electric motor of a non-self-contained, pulley-driven unit used on small vehicles.

2. Today, new refrigerating technologies are emerging or reappearing. Some use an open thermodynamic cycle: a liquefied gas is used as the source of cold. There are machines with “direct” injection into the temperature-controlled chamber and also machines with “indirect” injection through a ventilated exchanger. They use either liquid nitrogen (N_2) or liquid carbon dioxide (CO_2).

3. These units are clearly identified in the section of ATP on “Refrigerated equipment”. Testing of this equipment is performed using the same protocol as for units with eutectic plates. This method is reliable and tested, but for a given type of unit it requires a large number of tests, owing to the number of bodies on which such units can be installed.

4. This testing method is ill-suited to the market reality and places this technology at a disadvantage compared with the competing and comparable technology of fan-cooled vapour-compression units.

5. Such open-cycle cryogenic solutions:

- are functionally different from mechanical vapour compression techniques, and
- are in use on road equipment designed for carrying perishable foodstuffs.

6. They should thus be included in the series of tests proposed in ATP, to measure their refrigeration capacity and simplify the dimensioning of the equipment that uses them.

Proposal

7. This proposal introduces the testing methodology for liquefied gas refrigeration units of both mono-temperature and multi-temperature types.

8. The method applies to the “direct” and “indirect” units described above.

Principles of the test methodology for liquefied gas refrigeration units

9. The test methodology is derived directly from the one described in section 8 of appendix 2 to annex 1 of ATP, entitled “PROCEDURE FOR MEASURING THE CAPACITY OF MECHANICAL MULTI-TEMPERATURE REFRIGERATION UNITS AND DIMENSIONING MULTI-COMPARTMENT EQUIPMENT”, in the version approved on 23 September 2013.

10. However, some adjustments to the procedure for mechanical refrigeration units are required:

New definitions

11. For the purposes of this paragraph, it is necessary to define the following terms:

Refrigeration unit: Individual refrigerating appliance, or appliance serving several units of transport equipment, which, using a source of cold (by evaporation of a liquefied gas, etc.) is capable, with a mean outside temperature of + 30° C, of lowering the temperature T_i inside the empty body and thereafter maintaining it continuously as defined for mechanically refrigerated equipment in annex 1 of the ATP.

Refrigeration evaporator: The term refrigeration evaporator is used to refer to any evaporative component of a liquefied gas refrigeration unit that absorbs thermal energy and operates in an open cycle.

Maximum refrigerating capacity: Defines the maximum refrigerating capacity set by the manufacturer of the liquefied gas refrigeration unit in terms of dimensioning.

Effective refrigerating capacity: The effective refrigerating capacity is established using the same methodology as in section 8.2.4 of appendix 2 of annex 1 to ATP on testing the remaining effective refrigerating capacities of a set of evaporators in multi-temperature operation at a reference heat load. However, given the specific nature of liquefied gas refrigeration units, it is necessary to distinguish between the measured refrigerating capacities.

Adaptation of the method

12. For mono-temperature liquefied gas refrigeration units, only the maximum refrigerating capacities should be determined. The refrigerating capacity should be estimated for each refrigeration evaporator.

13. The refrigerating capacities should be estimated for:

- the individual capacity of each refrigeration evaporator, with the smallest liquefied gas tank that can be fitted with the liquefied gas refrigeration unit, and
- the maximum capacity of the liquefied gas refrigeration unit when used with a larger one, subject to checking that the individual refrigerating capacity of the smaller refrigeration evaporator is the same from one tank to another.

14. Each refrigeration evaporator should be installed in an individual calorimeter box and placed in a test cell at a controlled temperature.

15. For each test, the following will also be recorded:

- the flow, consumption and pressure of the liquefied gas used,
- the unit's supply voltage.

Determining the maximum refrigerating capacity of a liquefied gas refrigeration unit

16. The maximum refrigerating capacity of a liquefied gas refrigeration unit is estimated using the most powerful configuration sold by the manufacturer of the unit.

17. Tests are conducted on all evaporators which:

- are activated and functional, and
- if applicable, have the same air intake temperature (for "indirect" units) or, if applicable, the same air temperature inside the body (for "direct" units).

18. The maximum refrigeration capacity of the cryogenic unit should be evaluated at two temperatures:

- -20° C, and
- 0° C.

19. Where necessary, the maximum refrigerating capacity of the cryogenic unit should be calculated by linear interpolation of the maximum refrigerating capacities at -20° C and 0° C.

Determining the individual refrigerating capacity of the refrigeration evaporators of a liquefied gas refrigeration unit

20. The individual capacity of each refrigeration evaporator should be evaluated on its own, without any other activated or functional refrigeration evaporator.

21. This refrigeration capacity should be determined at two temperatures:

- -20° C, and
- 0° C.

22. Where necessary, the refrigerating capacity of each refrigeration evaporator should be calculated by linear interpolation of the refrigerating capacities measured and calculated at -20° C and 0° C.

Determining the remaining effective refrigerating capacity of a liquefied gas refrigeration unit in multi-temperature operation at a reference heat load

23. Determining the effective capacity of a liquefied gas refrigeration unit requires the simultaneous use of two or three refrigeration evaporators, as follows:

- For a two-compartment unit, the refrigeration evaporators with the highest and lowest individual refrigerating capacities,
- For a three-compartment unit, the same refrigeration evaporators as above and a third with an intermediate refrigerating capacity.

24. For a cryogenic unit with three compartments:

- Thermostat setting:
    - The set points of all but one of the refrigeration evaporators should be set in such a way as to obtain an air intake temperature, or, if not applicable, an air temperature inside the body, of 0° C.
    - A heat load is applied to each calorimeter/refrigeration evaporator pair under control of the thermostat.
    - The heat load must be equal to 20 per cent of the individual refrigerating capacity of each refrigeration evaporator at -20° C.
- The effective capacity of the remaining refrigeration evaporator should be estimated to obtain an air intake temperature or, if not applicable, an air temperature inside the body, of -20° C.

25. Once the effective capacity of the remaining evaporator has been determined, the test should be repeated after conducting a circular permutation of the calorimeter/refrigeration evaporator pairs, which must be at -20° C.

26. For refrigeration units with three compartments, the effective refrigerating capacity should be tested in a two-compartment configuration.

Impact

27. This proposal would provide a methodology for measuring the refrigerating capacity of the new cold-producing technologies employed by liquefied-gas-based refrigeration units. This methodology is based on the methodology already in ATP for mono-temperature and multi-temperature refrigeration units, which has proven itself; it was finalized in 1998 and incorporated in the version of ATP approved on 23 September 2013.

28. The proposal requires amendment of the Agreement in order for it to be fully and directly usable.

Environmental impact

29. This proposal would make it possible to considerably reduce the number of tests and thus their environmental impact.

Economic impact

30. The cost of testing for these materials will be reduced considerably once they are introduced on a large range of insulated units. The cost for manufacturers and, in turn, their customers will be drastically reduced.

Proposed amendment to the Agreement

31. It is proposed that a new section 9 should be added to appendix 2 of annex 1 to ATP, as follows:

"**9. Procedures for measuring the capacity of liquefied gas mono-temperature and multi-temperature refrigeration units and dimensioning multi-compartment equipment**

9.1 Definitions

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

(b) Refrigeration evaporator: any evaporative component of a liquefied gas refrigeration unit that absorbs thermal energy and operates in an open cycle;

(c) Multi-temperature liquefied gas refrigeration unit: Liquefied gas refrigeration unit with liquefied gas tank and two or more evaporators set at different temperatures in the various compartments of multi-compartment equipment;

(d) Multi-temperature operation: Operation of a multi-temperature liquefied gas refrigeration unit with two or more evaporators operating at different temperatures in multi-compartment equipment;

(e) Maximum refrigerating capacity: maximum refrigerating capacity set by the manufacturer of the liquefied gas refrigeration unit in terms of dimensioning;

(f) Individual refrigerating capacity ($P_{ind\text{-}evap}$): The maximum refrigerating capacity of each evaporator in solo operation with the host unit;

(g) Effective refrigerating capacity ($P_{eff\text{-}frozen\text{-}evap}$): The refrigerating capacity available to the lowest temperature evaporator when two or more evaporators are each operating in multi-temperature mode, as prescribed in paragraph 8.3.5.

9.2 Test procedure for multi-temperature refrigeration units

9.2.1 General procedure

The test procedure shall be as defined in section 4 of appendix 2 of annex 1 to ATP, except for the type of unit.

The host unit shall be tested in combination with different refrigeration evaporators. Each refrigeration evaporator shall be tested on a separate calorimeter, if applicable, and placed in a temperature-controlled test cell.

The maximum refrigeration capacity of the host unit in mono-temperature operation, as prescribed in paragraph 9.2.2, shall be measured with a single combination of two or three evaporators, including the smallest and largest.

For mono-temperature liquefied gas refrigeration units, only the maximum refrigerating capacities shall be measured, as prescribed in paragraph 9.2.2.

The individual refrigerating capacity shall be measured for all refrigeration evaporators, each in mono-temperature operation with the host unit, as prescribed in paragraph 9.2.3.

The refrigerating capacity shall be estimated for:

- the individual capacity of each refrigeration evaporator, with the smallest liquefied gas tank that can be fitted with the liquefied gas refrigeration unit, and
- the maximum refrigerating capacity of the liquefied gas refrigeration unit when used with a larger one, subject to checking that the individual refrigerating capacity of the smaller refrigeration evaporator is the same from one tank to another.

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

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

- The host unit shall be tested with a combination of three refrigeration evaporations: the smallest, the largest and a mid-sized evaporator;
- In addition, on demand of the manufacturer, the host unit can be tested optionally with a combination of two evaporators: the largest and the smallest.

For each test, the following shall also be recorded:

- the flow, consumption and pressure of the liquefied gas used,
- the unit’s supply voltage.

The tests shall be conducted in the modes prescribed by the manufacturer.

9.2.2 Determination of the maximum refrigerating capacity of the host unit

The maximum refrigerating capacity of the host unit in mono-temperature operation shall be measured with a single combination of two or three refrigeration evaporators operating simultaneously at the same temperature. This test shall be conducted at -20° C and 0° C.

The maximum refrigerating capacity of a liquefied gas refrigeration unit shall be measured using the most powerful configuration sold by the manufacturer of the unit.

Tests shall be conducted using all evaporators which:

- are activated and functional, and
- if applicable, have the same air intake temperature (for “indirect” units) or, if applicable, the same air temperature inside the body (for “direct” units).

The average air temperature outside the calorimetric boxes shall be between +25° C and +35° C.

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

9.2.3 Determination of the individual refrigerating capacity of each refrigeration evaporator of a liquefied gas refrigeration unit

The individual refrigerating capacity of each refrigeration evaporator shall be measured in solo operation with the host unit. The test shall be conducted at -20° C and 0° C.

The average temperature outside the calorimetric box shall be between +20° C and +35° C.

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

9.2.4 Determining the remaining effective refrigerating capacity of a liquefied gas refrigeration unit in multi-temperature operation at a reference heat load

The determination of the remaining effective capacity of a liquefied gas refrigeration unit requires the simultaneous use of two or three refrigeration evaporators, as follows:

- For a two-compartment unit, the refrigeration evaporators with the highest and lowest individual refrigerating capacities,
- For a three-compartment unit, the same refrigeration evaporators as above and a third evaporator with an intermediate refrigerating capacity.

For cryogenic units with three compartments:

- Thermostat setting:
    - The set points of all but one of the refrigeration evaporators shall be set in such a way as to obtain an air intake temperature, or, if not applicable, an air temperature inside the body, of 0° C.
    - A heat load equivalent to 20 per cent of the individual refrigerating capacity of each refrigeration evaporator at -20° C shall be applied to each calorimeter/refrigeration evaporator pair under control of a thermostat.
- The effective capacity of the remaining refrigeration evaporator shall be measured at an air inlet temperature or, if not applicable, at an air temperature inside the body, of -20° C.

Once the effective capacity of the remaining evaporator has been determined, the test shall be repeated after conducting a circular permutation of the calorimeter/refrigeration evaporator pairs, which must be at -20° C.

For refrigeration units with three compartments, a test shall be conducted of the effective refrigerating capacity with a two-compartment configuration.

The average air temperature outside the calorimetric boxes shall be between +25° C and +35° C.

9.3 Dimensioning and certification of refrigerated multi-temperature liquefied gas equipment

The dimensioning and certification of refrigerated equipment using liquefied gas refrigeration units shall be as prescribed in section 8.3, “Dimensioning and

certification of refrigerated multi-temperature equipment", of appendix 2 of annex 1 to ATP, with the following capacity equivalents:

$P_{maximum} = P_{nominal}$

$P_{eff\ frozen\text{-}evap} = P_{eff\ frozen\ evap}$

$P_{eff\ chilled\text{-}evap} = P_{eff\ chilled\text{-}evap}$."