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Item 5 (b) of the provisional agenda
Proposals for amendments to ATP:
New proposals

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

Transmitted by the Government of France

Background

1. Today, refrigerating units based on a thermodynamic cycle using liquefied gas are emerging as an alternative to compression units. They usually use a system of indirect release of liquid nitrogen (N_2) or carbon dioxide (CO_2).

2. ATP already covers certification of complete equipment but does not allow refrigerating appliances to be approved on their own.

3. This amendment proposes that ATP should include provisions for measuring the refrigeration capacity of these units and for dimensioning the equipment that uses them, taking an approach similar to that used for mechanical vapour-compression units.

Proposal

4. This proposal introduces a methodology to:

(a) Test both mono-temperature and multi-temperature liquefied gas refrigeration units;

(b) Dimension equipment using liquefied gas refrigeration units.

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5. The method applies to “indirect” units, i.e., it avoids any injection of gas into the insulated body.

Principles of the test methodology for liquefied gas refrigeration units

6. The test methodology is derived directly from the one described in annex 1, appendix 2, section 7, paragraph 2, of ATP, entitled “PROCEDURE FOR MEASURING THE CAPACITY OF MECHANICAL MULTI-TEMPERATURE REFRIGERATION UNITS AND DIMENSIONING MULTI-COMPARTMENT EQUIPMENT”, in the version approved on 30 September 2015.

7. In a new paragraph, it describes the adjustments made necessary by the specific features of the technique concerned:

- Specific definitions;
- Procedure for determining the individual refrigerating capacity of the refrigeration evaporators of a liquefied gas refrigeration unit;
- Procedure for determining the maximum nominal refrigerating capacity of a liquefied gas refrigeration unit;
- Procedure for determining the remaining effective refrigerating capacity of a liquefied gas refrigeration unit in multi-temperature operation at a reference heat load.

Impact

8. This proposal would provide a methodology for measuring the refrigerating capacity of liquefied gas refrigeration units. This methodology is based on the one already set down in ATP for refrigeration units.

Environmental impact

9. This proposal would make it possible to considerably reduce the number of tests and thus their environmental impact. It would also avoid penalizing a credible alternative to the use of vapour-compression units that use high global warming potential (GWP) refrigerants, which are targeted by international protocols aimed at limiting the greenhouse gas effect.

Economic impact

10. The cost of testing these materials will fall significantly once they are scheduled to be introduced into a broad range of refrigeration units. The cost for manufacturers and, in turn, their customers will be drastically reduced.

Proposed amendment to ATP

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

"9. PROCEDURE FOR MEASURING THE CAPACITY OF LIQUEFIED GAS UNITS AND DIMENSIONING THE EQUIPMENT THAT USES THESE UNITS

9.1 Definitions

(a) Primary evaporator: any minimal structure comprising a liquefied gas unit intended to absorb thermal capacity in an insulated compartment;

(b) Evaporator: any composition made up of primary evaporators located in an insulated compartment;

(c) Maximum nominal evaporator: any composition made up of primary refrigeration evaporators located in one or more insulated compartments;

(d) Mono-temperature liquefied gas unit: liquefied gas unit made up of a liquefied gas tank and a single evaporator for regulating the temperature of a single insulated compartment;

(e) Multi-temperature liquefied gas unit: liquefied gas unit made up of a liquefied gas tank and at least two evaporators, each regulating the temperature of a single, distinct insulated compartment in the same multi-compartment equipment;

(f) Mono-temperature operation: operation of a mono- or multi-temperature liquefied gas unit in which a single refrigeration evaporator is activated and maintains a single compartment in mono-compartment or multi-compartment equipment;

(g) Multi-temperature operation: operation of a multi-temperature liquefied gas refrigeration unit with two or more activated evaporators that maintain two different temperatures in insulated compartments in multi-compartment equipment;

(h) Maximum nominal refrigerating capacity (Pmax-nom): the maximum specified refrigerating capacity set by the manufacturer of the liquefied gas refrigeration unit;

(i) Nominal installed refrigeration capacity (Pnom-ins): the maximum refrigeration capacity within the maximum nominal refrigerating capacity that can be provided by a given configuration of evaporators in a liquefied gas refrigeration unit;

(j) Individual refrigerating capacity (Pind-evap): the maximum refrigerating capacity generated by each evaporator when the liquefied gas unit is operating as a mono-temperature unit;

(k) Effective refrigerating capacity (Peff-frozen-evap): the refrigerating capacity available to the lowest temperature evaporator when the liquefied gas unit is operating as described in paragraph 9.2.4.

9.2 Test procedure for liquefied gas units

9.2.1 General procedure

The test procedure shall be as specified in annex 1, appendix 2, section 4, of ATP, taking account of the following particularities.

The tests shall be conducted for the different primary evaporators. Each primary evaporator shall be tested on a separate calorimeter, if applicable, and placed in a temperature-controlled test cell.

For mono-temperature liquefied gas units, only the refrigeration capacity of the host unit with the maximum nominal capacity evaporator will be measured. A third temperature level is added in accordance with annex 1, appendix 2, section 4 of ATP.

For multi-temperature liquefied gas units, the individual refrigerating capacity shall be measured for all primary evaporators, each operating in mono-temperature mode as specified in paragraph 9.2.3.

The refrigerating capacities are determined by using a liquefied gas tank provided by the manufacturer that allows a complete test to be carried out without intermediate refilling.

All the elements of the liquefied gas refrigeration unit shall be placed in a thermostatic enclosure maintained at an ambient temperature of 30 ± 0.5 °C.

For each test, the following shall also be recorded:

- The flow, temperature and pressure of the liquefied gas emerging from the tank in use;
- The voltage, electrical current and total electrical consumption absorbed by the liquefied gas unit.

The test shall last at least three hours.

The gas flow is equal to the mean mass consumption of fluid throughout the test in question.

Except when determining the liquefied gas flow, each quantity must be physically captured for a fixed period equal to or less than 10 seconds and each quantity must be recorded for a fixed maximum period of 2 minutes, subject to the following:

Each temperature recorded at the air intake of the ventilated evaporator or each air temperature recorded inside the body of the non-ventilated evaporator must comply with the expected class temperature ±1K.

The test shall be conducted for all the electrical power supply modes provided by the manufacturer.

If the tests show equivalent maximum nominal refrigerating capacities, regardless of the operating mode of the liquefied gas refrigeration unit, then the tests may be restricted to a single electrical power supply mode, taking into account the potential impact on the air flow expelled by the evaporators, where applicable. Equivalence is demonstrated if:

$$2 * \frac{\left|P_{\max-nom,1} - P_{\max-nom,2}\right|}{P_{\max-nom,1} + P_{\max-nom,2}} \leq 0.035$$

Where:

$P_{\max-nom,1}$: The maximum nominal capacity of the eutectic liquefied gas unit for a given electrical power supply mode.

$P_{\max-nom,2}$: The second maximum nominal capacity of the eutectic liquefied gas unit for a different electrical power supply mode.

9.2.2 Determination of the maximum nominal refrigerating capacity of the host unit

The test shall be conducted at reference temperatures of -20 °C and 0 °C.

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

The maximum nominal refrigerating capacity of the host unit in mono-temperature operation shall be measured with the maximum nominal evaporator offered by the manufacturer. This evaporator is formed of the primary refrigeration evaporator(s).

The test shall be conducted with the unit operating at a single reference temperature, corresponding to the temperature of the air intake in the case of ventilated evaporators or the temperature of the air inside the body in the case of non-ventilated evaporators.

The maximum nominal refrigerating capacity shall be estimated using a variation of the procedure described in section 7 of ATP:

(a) The set point of the liquefied gas unit shall be set to the chosen test temperature with a set point shift if necessary, in accordance with the instructions of the test sponsor;

(b) The electrical power dissipated in the calorimeter box shall be adjusted throughout the test to ensure that the reference temperature remains constant.

The refrigerating capacity drift during the tests must be lower than a rolling average of 5% per hour and shall not exceed 10% during the course of the test. If this is the case, the refrigeration capacity obtained corresponds to the minimum refrigeration capacity recorded during the course of the test.

Only when the maximum nominal refrigerating capacity of the host unit is being measured, a single additional test of 1 hour shall be conducted with the smallest tank sold with the unit to quantify the impact of its volume on the regulation of the refrigerating capacity. The new refrigerating capacity obtained shall not vary by more than 5% from the lower value or compared to the value found with the tank used for the tests of 3 hours or more. Where the impact is greater, a restriction on the volume of the tank shall be included in the official test report.

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

The individual refrigerating capacity of each primary refrigeration evaporator shall be measured in solo operation. The test shall be conducted at -20 °C and 0 °C, as prescribed in paragraph 9.2.2.

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

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 evaporators with the highest and lowest individual refrigerating capacities;
- For a unit with three or more compartments, the same evaporators as above and as many others as needed, with intermediate refrigerating capacity.

Setting of the reference heat load:

- 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 shall be applied to each calorimeter/refrigeration evaporator pair under control of the thermostat, except the one not selected;
- The heat load shall be equal to 20% of the individual refrigerating capacity of each refrigeration evaporator at -20 °C.

The effective capacity of the remaining evaporator shall be determined at an air intake temperature, or, if not applicable, 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 temperature classes.

9.3 Refrigerating capacity of evaporators

Refrigeration evaporators can be created on the basis of refrigeration capacity tests carried out on primary evaporators. The refrigeration capacity and liquefied gas consumption of the evaporators equal the arithmetic sum of the refrigeration capacity and of the liquefied gas consumption, respectively, of the primary refrigeration evaporators within the limit of the maximum nominal refrigerating capacity and of the associated flow of liquefied gas.

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

The dimensioning and certification of refrigerated equipment using liquefied gas refrigeration units shall be carried out as prescribed in section 3.2.6 for mono-temperature equipment, with the following capacity equivalents:

$$P_{nom\text{-}ins} = P_{eff} \text{ (effective refrigerating capacity)}$$

or section 7.3 for multi-temperature refrigerating equipment, with the following capacity equivalents:

$$P_{max\text{-}nom} = P_{nominal}$$

In addition, the usable volume of liquefied gas tanks shall be such as to permit the liquefied gas unit to maintain the temperature for that class of equipment for a minimum of 12 hours.”