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Proposals of amendments to ATP: new proposals

Methodology for the approval of a liquefied gas-refrigerating unit separately from the transport vehicle

Transmitted by the governments of France and the Netherlands

Summary	
Executive summary:	<p>Today, refrigerating units based on a thermodynamic cycle using liquefied gas are emerging as an alternative to compression units.</p> <p>Three proposals are presented below:</p> <ul style="list-style-type: none"> (a) The possibility for refrigerating units working with liquefied gas to be tested separately from the vehicle body; (b) A test methodology for measuring the capacity of liquefied gas units, whether mono-temperature or multi-temperature operation, and a dimensioning methodology for vehicle fitted with liquefied gas unit; (c) A test report for liquefied gas unit.
Action to be taken:	Amend annex 1, appendice 2
Related documents:	

Introduction

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 (N₂) or carbon dioxide (CO₂).
2. A vehicle with liquefied gas unit can already be certified with the ATP but it's yet not possible for a liquefied gas unit to be certified separately from the vehicle body.
3. This amendment offers a methodology to measure the refrigerating capacity of a liquefied gas unit and for dimensioning the transport equipment using a liquefied gas unit.

I. Proposals

4. The three following proposals are presented below:
 - (a) The possibility for refrigerating units working with liquefied gas to be tested separately from the vehicle body;
 - (b) A test methodology for measuring the capacity of liquefied gas units, whether mono-temperature or multi-temperature operation, and a dimensioning methodology for vehicle fitted with liquefied gas unit;
 - (c) A test report for liquefied gas unit.
5. These proposals are applicable to "indirect" refrigerating units, meaning without any gas injection inside the insulated body.

Amendment N°1 proposed for agreement

6. Proposition to add to Appendix 2, Annex 1 of ATP three new paragraphs 3.1.7, 3.1.8 and 3.1.9 as follows:

"3.1.7 If a refrigerating appliance of paragraph 3.1.3 (c) with all its accessories has undergone separately, to the satisfaction of the competent authority, the test in section 9 of this appendix to determine its effective refrigerating capacity at the prescribed reference temperatures, the transport equipment may be accepted as refrigerated equipment without undergoing an efficiency test if the effective refrigerating capacity of the appliance in continuous operation exceeds the heat loss through the walls for the class under consideration, multiplied by the factor 1,75.

3.1.8 If the refrigerating appliance is replaced by a unit of a different type, the competent authority may:

- (a) Require the equipment to undergo the determinations and verifications prescribed in paragraphs 3.1.3 to 3.1.5; or
- (b) Satisfy itself that the effective refrigerating capacity of the new refrigerating appliance is, at the temperature prescribed for equipment of the class concerned, at least equal to that of the unit replaced; or
- (c) Satisfy itself that the effective refrigerating capacity of the new refrigerating appliance meets the requirements of paragraph 3.1.7.

3.1.9 A refrigerating unit working with liquefied gas is regarded as being of the same type as the unit tested if:

- The same refrigerant is used;

- The evaporator has the same capacity;
- The regulation system has the same characteristics;
- The liquefied gas tank has the same design and its capacity is equal or upper to the capacity stated in the test report;
- The diameters and the technology of the supply lines are identical.”.

Amendment N°2 proposed for agreement

7. Proposition to add to Appendix 2, Annex 1 of ATP a new paragraph 9 as follows:

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

9.1 Definitions

- (a) A liquefied gas unit is composed of a tank containing liquefied gas, a regulating system, an interconnection system, a muffler if applicable and one or more evaporator;
- (b) Primary evaporator: any minimal structure comprising a liquefied gas unit intended to absorb thermal capacity in an insulated compartment;
- (c) Evaporator: any composition made up of primary evaporators located in an insulated compartment;
- (d) Maximum nominal evaporator: any composition made up of primary evaporators located in one or more insulated compartments;
- (e) Mono-temperature liquefied gas unit: liquefied gas unit made up of a liquefied gas tank connected to a single evaporator for regulating the temperature of a single insulated compartment;
- (f) Multi-temperature liquefied gas unit : liquefied gas unit made up of a liquefied gas tank connected to at least two evaporators, each regulating the temperature of a single, distinct insulated compartment in the same multi-compartment equipment;
- (g) Mono-temperature operation: operation of a mono- or multi-temperature liquefied gas unit in which a single evaporator is activated and maintains a single compartment in mono-compartment or multi-compartment equipment;
- (h) Multi-temperature operation: operation of a multi-temperature liquefied gas unit with two or more activated evaporators that maintain two different temperatures in insulated compartments in multi-compartment equipment;
- (i) Maximum nominal refrigerating capacity ($P_{\max-nom}$): the maximum specified refrigerating capacity set by the manufacturer of the liquefied gas unit;
- (j) Nominal installed refrigeration capacity ($P_{nom-ins}$): the maximum refrigeration capacity within the maximum nominal refrigerating capacity that can be provided by a given configuration of evaporators in a liquefied gas unit;
- (k) Individual refrigerating capacity ($P_{ind-evap}$): the maximum refrigerating capacity generated by each evaporator when the liquefied gas unit is operating as a mono-temperature unit;

- (l) Effective refrigerating capacity ($P_{\text{eff-frozen-evap}}$): 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 regulating unit with the maximum nominal capacity evaporator will be measured. A third temperature level is added in accordance with annex 1, appendix 2, para. 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 $30 \pm 0,5$ °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 (i.e. fan...).

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 shall be physically captured for a fixed period equal to or less than 10 seconds and each quantity shall 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 shall comply with the expected class temperature ± 1 K.

If the electrical components of the liquefied gas unit can be fed by more than one electrical power supply, the tests shall be repeated accordingly.

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:

$$\frac{2 \left| P_{\text{nom-max},1}^{\square} - P_{\text{nom-max},2}^{\square} \right|}{P_{\text{nom-max},1}^{\square} + P_{\text{nom-max},2}^{\square}} \leq 0,035$$

Where:

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

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

9.2.2 Determination of the maximum nominal refrigerating capacity of the liquefied gas 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 regulating 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 at each level of temperature as follows:

A first test shall be carried out, for at least four hours, under control of the thermostat (of the refrigeration unit) to stabilize the heat transfer between the interior and exterior of the calorimeter box.

After re-filling of the tank (if needed), a second test shall be carried out for at least three hours for the measurement of the maximum nominal refrigerating capacity in which:

- (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 this second test shall 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 for the measurement of the maximum nominal refrigerating capacity of the liquefied gas unit, a single additional test of one 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 three 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 evaporator of a liquefied gas unit

The individual refrigerating capacity of each primary evaporator shall be measured in mono-temperature 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 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 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 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/ 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 at -20 °C of each evaporator.

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 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:

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

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

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

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.”.

Amendment N°3 proposed for agreement

8. Proposition to add to Appendix 2, Annex 1, Paragraph 8 of ATP the following model:

“Model No. zy

TEST REPORT

Prepared in conformity with the special provisions of the Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be used for such carriage (ATP)

Test Report No.....

Determination of the effective refrigeration capacity of a refrigeration unit in accordance with section 9 of ATP Annex 1, Appendix 2

Tests carried out from mm/dd/yyyy to mm/dd/yyyy

Approved testing station

Name:

Address:

Refrigerating unit presented by:

[(a declaration by the manufacturer shall be provided if the applicant is not the manufacturer)]

(a) Technical specifications of the unit:

- Make/Brand :
- Type designation :
- Type of liquefied gas :
- Serial number :

Date of manufacture (month/year):(The tested unit shall not have been built more than 1 year prior to ATP tests.)

Description:

.....

Regulating valve (if different types of fans are used repeat information below for each type)

- Make/Brand :
- Type :
- Serial number :

Tank (if different types of fans are used repeat information below for each type)

Make/Brand :
 Type :
 Serial number:
 Capacity [l] :
 Gas pressure at tank outlet :

 Method of insulation :
 Material of inner tank :
 Material of outer tank :
 Supply of liquefied gas : (internal pressure, pressure by heat exchanger,
 pump)¹

Pressure regulator

Make/Brand :
 Type :
 Serial number :
 Gas pressure at pressure outlet :

Supply liquefied gas line (on the test bench)

Diameter :
 Length :
 Material :
 Number of connections :

Defrosting device (Electric / Combustion unit)¹

Make/Brand :
 Type :
 Supply :
 Declared heating capacity :

Regulator

Make/Brand :
 Type :
 Hardware version :
 Software version :
 Serial number :
 Power supply :

Possibility for Multi-temperature operation : (yes/no)¹

Number of compartments able to work in multi-temperatures:

HEAT EXCHANGERS

		<i>Condenser</i>	<i>Evaporator</i>
Make-Type			
Number of circuits			
Number of rows			
Number of blankets			
Number of tubes			
Fin pitch [mm]			
Tube : nature and diameter [mm]			
Total exchange surface [m ²]			
Face area [m ²]			
FANS	Make-Type		
	Number		
	Blade per fan		
	Diameter [mm]		
	Power [W]		
	Nominal speed [rpm]		
	Total nominal output airflow [m ³ /h] at a pressure of 0 Pa		
	Method of drive (Description direct current / alternative, frequency, etc.)		

(b) Test method and results:

Test method¹: Heat balance method/enthalpy difference method

In a calorimeter box of mean surface area of = m²

Measured value of the U-value of the calorimeter box fitted with the liquefied gas unit: W/°C,

At a mean wall temperature: °C.

In a transport equipment

Measured value of the U-value of the transport equipment fitted with the liquefied gas unit: W/°C,

At a mean wall temperature: °C.

The formula employed for the correction of the U-value of the calorimeter box as a function of the mean wall temperature is:

.....

Maximum errors of determination of:

U-value of the body:

Refrigerating capacity of the liquefied gas unit:

Mean air temperature at the tank outside: °C								
Electric power supply:								
Liquefied gas consumption	Electrical consumption	Pressure at the tank outlet	Temperature of the liquid at the evaporator	External temperature	Internal temperature	Heating power	Evaporator air intake temperature	Useful refrigerating capacity
[kg/h]	[Vdc] and [A]	[bar abs]	[°C]	[°C]	[°C]	[W]	[°C]	[W]

Corrected cooling capacity [W]:

(c) Checks:

Temperature regulator: Setting °C
 Differential°C

Functioning of the defrosting device¹: satisfactory / unsatisfactory

Airflow volume leaving the evaporator:

Value measured: m³/h
 At a pressure of Pa
 At a temperature of °C
 At a rotation speed of tr/min.

Minimum capacity tank:

(d) Remarks

.....

This test report is valid for a maximum duration of six years after the date of the end of the tests.

Done at:

On:

Testing officer

.....”

¹ Delete where applicable.

² Value indicated by the manufacturer

II. Justification

9. This proposals 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.

III. Environmental impact

10. This proposals 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.

IV. Economical impact

11. 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.
