



**Economic and Social
Council**

Distr.
GENERAL

ECE/TRANS/WP.11/2008/4
25 July 2008

Original: ENGLISH

ECONOMIC COMMISSION FOR EUROPE

INLAND TRANSPORT COMMITTEE

Working Party on the Transport of Perishable Foodstuffs

Sixty-fourth session
Geneva, 14-17 October 2008
Item 6 of the provisional agenda

**AGREEMENT ON THE INTERNATIONAL CARRIAGE OF PERISHABLE FOODSTUFFS
AND ON THE SPECIAL EQUIPMENT TO BE USED FOR SUCH CARRIAGE (ATP)**

HANDBOOK

**Fuel consumption measurement method for vehicle-powered refrigeration units based on the
concept of a standard vehicle engine***

Transmitted by the Government of the Czech Republic

Purpose and scope

1. This procedure describes the measurement method for determining the fuel consumption of vehicle powered refrigeration units, or in other words the increase in diesel engine fuel consumption when the refrigeration unit is on.

* 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 (f)) which calls for the "Elaboration of an ATP Handbook".

2. The measurement method is based on standard operating conditions of refrigeration units tested and excludes the influence of all random effects such as particular truck and engine types, different test roads and driving styles, the real load (capacity) of the unit, etc. The basic principle of the method is the test laboratory measurement of the total input power needed to drive the unit and its recalculation for the fuel consumption of a standard engine.

Proposed amendment to the ATP Handbook

3. The description of the procedure which appears in italics should be added to the ATP Handbook as a comment to Annex 1, Appendix 2, paragraph 54 (b):

54. Instrumentation

Test stations shall be equipped with instruments to measure the U value to an accuracy of $\pm 5\%$. Heat transfer through air leakage should not exceed 5 % of the total heat transfer through the calorimeter box or through the unit of transport equipment. The refrigerating capacity shall be determined with an accuracy of $\pm 5\%$.

The instrumentation of the calorimeter box or unit of transport equipment shall conform to paragraphs 3 and 4 above. The following are to be measured:

(a) *Air temperatures:* At least four thermometers uniformly distributed at the inlet to the evaporator;

At least four thermometers uniformly distributed at the outlet to the evaporator;

At least four thermometers uniformly distributed at the air inlet(s) to the refrigeration unit;

The thermometers shall be protected against radiation.

The accuracy of the temperature measuring system shall be ± 0.2 K.

(b) *Energy consumption:* Instruments shall be provided to measure the electrical energy or fuel consumption of the refrigeration unit.

The electrical energy and fuel consumption shall be determined with an accuracy of $\pm 0.5\%$.

Comment to paragraph 54 (b):

This procedure describes the measurement method for determining the fuel consumption of vehicle powered refrigeration units, or in other words the increase in diesel engine fuel consumption when the refrigeration unit is on.

Three standards have been introduced and used to determine the increase in fuel consumption as a result of the operation of the refrigeration unit:

- *Standard diesel engine with standard specific fuel consumption: $c_s = 165$ g/(kW. h).*
- *Standard vehicle alternator efficiency: $\epsilon = 50\%$.*

- *Standard diesel fuel specific density: $\rho = 836$ g/l.*

The most frequent arrangement is assumed: the refrigeration compressor or a special electric generator supplying the refrigeration unit is driven from the vehicle engine crankshaft (usually by a belt drive). Using a suitable design of power pack in the test station, the torque τ [N.m] and operating rotational speed n [s^{-1}] are measured and the input power P_1 [W] on the shaft of the compressor or generator is calculated.

$$P_1 [W] = 2\pi n \tau \quad \dots \text{ where } \pi = 3.141593$$

There are also vehicle-powered units taking in addition electric current from the standard (or auxiliary) vehicle alternator, or from vehicle batteries, usually to drive electric fans and blowers. Regarding the shaft power P_2 [W] of a standard or auxiliary alternator determined from electric measurement, the efficiency of such vehicle alternators has to be considered (usually 24 V dc, 100 A to 150 A). Alternator efficiency ε for these calculations is postulated at 50 % (see the second of the three standards mentioned above). Accordingly, if P_{fans} is the total electric input needed to drive the fans, the alternator shaft input is:

$$P_2 = 2 \times P_{fans}$$

In this case the total input power P [W] that the vehicle engine has to deliver to the refrigeration unit consists of the compressor input P_1 and of the alternator input P_2 for the fans:

$$P = P_1 + P_2$$

If P [W] is the total refrigeration unit input power at specific operating conditions, then the fuel consumption by weight C_{fw} [g/h] of the tested refrigeration unit can be calculated as:

$$C_{fw} [g/h] = P \times c_s = 0.165 \times P.$$

The consumption by weight (measured in g/h) can be converted to consumption by volume (measured in l/h) if the specific density ρ of the diesel fuel is known. This density varies from 830 kg/m³ (winter) to 842 kg/m³ (summer). The standard (mean) value of the specific density $\rho = 836$ kg/m³ = 836 g/l has been used for the purposes of this procedure (see the third of the standards mentioned above).

$$C_{fvol} [l/h] = C_{fw} / 836$$

It is beneficial to introduce specific fuel consumption; it is the quantity which can be used to compare the economy of units with different refrigeration capacities. Specific fuel consumption c_{fvol} (consumption by volume reduced to 1 kW of refrigeration capacity Q) is defined in this way:

$$c_{fvol} [l/(h. kW)] = 1000 C_{fvol} / Q$$

- (c) *Speed of rotation*: Instruments shall be provided to measure the speed of rotation of the compressors and circulating fans or to allow these speeds to be calculated where direct measurement is impractical.

The speed of rotation shall be measured to an accuracy of ± 1 %.

- (d) *Pressure*: High precision pressure gauges (accurate to ± 1 %) shall be fitted to the condenser and evaporator and to the compressor inlet when the evaporator is fitted with a pressure regulator.
- (e) *Heat quantity*: The heat dissipated by the internal fan heaters fitted with electrical resistances shall not exceed a flow of $1\text{W}/\text{cm}^2$ and the heater units shall be protected by a casing of low emissivity.

The electrical energy consumption shall be determined with an accuracy of ± 0.5 %.
