WORKING DOCUMENT ON

Possible requirements for compressors for standard air applications

DRAFT ECODESIGN REGULATION

COMMISSION WORKING DOCUMENT

implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for compressors for standard air applications

THE COMMISSION OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products, and in particular Article 15(1) thereof,

After consulting the Ecodesign Consultation Forum,

Whereas:

(1) Under Directive 2009/125/EC ecodesign requirements are to be set by the Commission for energy-related products, representing significant volumes of sales and trade, having a significant environmental impact and presenting significant potential for improvement in terms of their environmental impact without entailing excessive costs.

(2) Article 16(2), first indent, of Directive 2009/125/EC provides that in accordance with the procedure referred to in Article 19(3) and the criteria set out in Article 15(2), and after consulting the Ecodesign Consultation Forum, the Commission will, as appropriate, introduce an implementing measure for standard air compressors. The product group has been incurred in the indicative list of the Working Plan for the period 2009-2011 (COM 2008 660).

(3) The Commission has carried out a preparatory study covering the technical, environmental and economic aspects of standard air compressors typically used in the Union. The studies were devised together with stakeholders and interested parties from the Union and third countries, and the results have been made publicly available.

(4) The environmental aspect of standard air compressors that has been identified as significant for the purposes of this Regulation is energy consumption in the use phase

(5) The preparatory study shows that requirements regarding other ecodesign parameters referred to in Annex I, Part 1, of Directive 2009/125/EC are not necessary as energy consumption of standard air compressors in the use phase is by far the most important environmental aspect.

(6) The annual energy consumption related to standard air compressors was estimated to have been 59 TWh (529 PJ) in the European Union in 2010 corresponding to 52.7 Mt CO2 emissions. Unless specific measures are taken, the annual energy consumption related to standard air compressors is expected to be 57 TWh (513 PJ) in 2020 and 60 TWh (541 PJ) for 2030. The cost effective energy saving potential through more efficient design has been estimated at 0.7 TWh by 2020 and 1.6 TWh by 2030 compared to a business-as-usual scenario.

(7) Standard air compressors subject to this Regulation should be made more efficient by applying existing non-proprietary cost-effective technologies that can reduce the combined costs of purchasing and operating these products.

(8) The ecodesign requirements should not affect functionality from the end-user's perspective and should not negatively affect health, safety or the environment. In particular, the benefits of reducing energy consumption during the use phase should more than offset any additional environmental impacts during the production phase and the disposal.

(9) The ecodesign requirements should be introduced gradually in order to provide a sufficient timeframe for manufacturers to re-design products subject to this Regulation. The timing should be such as to avoid negative impacts on the functionalities of equipment on the market, and to take into account cost impacts for end-users and manufacturers, in particular small and medium-sized enterprises, while ensuring timely achievement of the objectives of this Regulation.

(10) Measurements of the relevant product parameters should be performed through reliable, accurate and reproducible measurement methods, which take into account the recognised state of the art measurement methods including, where available, harmonised standards adopted by the European standardisation organisations, as listed in Annex I to Regulation (EU) 1025/2012 of the European Parliament and of the Council of 25 October 2012 on European standardisation[1].

(11) In accordance with Article 8 of Directive 2009/125/EC, this Regulation should specify the applicable conformity assessment procedures.

(12) In order to facilitate compliance checks, manufacturers should provide information in the technical documentation referred to in Annexes IV and V of Directive 2009/125/EC insofar as this information relates to the requirements laid down in this Regulation.

(13) Benchmarks for currently available standard air compressors with high energy efficiency should be identified. This will help to ensure the wide availability and easy accessibility of information which will further facilitate the integration of best design technologies and facilitate the development of more efficient products for reducing energy consumption.

(13) The measures provided for in this Regulation are in accordance with the opinion of the Committee established by Article 19(1) of Directive 2009/125/EC.

[1] OJ L 316, 14.11.2012, p. 12

HAS ADOPTED THIS REGULATION:

Article 1 Subject matter and scope

1. This Regulation establishes ecodesign requirements for the placing on the market and/or putting into service of rotary standard air compressors with a volume flow rate between 5 to 1280 l/s and piston standard air compressors with a volume flow rate between 2 to 64 l/s, when driven by a three-phase electric motor.
2. This Regulation shall not apply to rotary standard air compressors or piston standard air compressors which are:
    a. designed to handle gas mixtures (or single constituent gases) other than filtered ambient air, such as hazardous gases;
    b. designed specifically to operate in potentially explosive atmospheres as defined in Directive 94/9/EC of the European Parliament and of the Council[2];
    c. designed to function where ambient temperatures exceed 40°C and/or where average inlet air temperatures are below -15°C or above 100°C; Chapter 2 Definitions

In addition to the definitions set out in Article 2 of Directive 2009/125/EC, the following definitions shall apply for the purpose of this Regulation:

1. Rotary standard air compressor means a standard air compressor in which air admission, forced expansion, and diminution of its successive volumes or its forced discharge are performed cyclically by rotation of one or several rotors in an oil-injected compressor casing;
2. Piston standard air compressor means a standard air compressor in which air admission, forced expansion and diminution of its successive volumes or its forced discharge are performed cyclically by a piston reciprocating in an oil-lubricated cylinder;
3. Standard air compressor means a basic package compressor designed to supply air, sucked in from the surrounding environment, at outlet pressure levels between 7 to 14 bar(g) and which may have been in contact with substances inserted in the compression chamber for cooling, lubrication and sealing of that chamber and the moving components contained therein;
4. Outlet pressure level means the pressure level at the discharge port of the basic package compressor, expressed in bar(g);
5. Basic package compressor means a compressor made up of compression element ('air end'), electric motor(s) and transmission or coupling to drive the compression element, and which is fully piped and wired internally, including ancillary and auxiliary items of equipment that is considered essential for safe operation and required for functioning as intended;
6. Compressor means a machine or apparatus converting different types of energy into the potential energy of gas pressure for displacement and compression of gaseous

[2] OJ L 100, 19.4.1994, p. 1.

media to any higher pressure values above atmospheric pressure with pressure-increase ratios exceeding 1.11;

7. Volume flow rate (V_1) means the volume flow of compressed air at standard inlet conditions, expressed in l/sec;
8. Standard inlet conditions means air is aspirated at an inlet pressure of 100 kPa (1 bar(a)), a temperature of 20°C and a relative water vapour pressure of 0 (zero);
9. Fixed speed rotary standard air compressor means a rotary standard air compressor which is not equipped with a variable speed drive when placed on the market;
10. Variable speed rotary standard air compressor means a rotary standard air compressor which is equipped with a variable speed drive when placed on the market;
11. Hazardous gas means a gas or vapour with chemical, radioactive or biological properties (such as flammable, explosive, unstable, pyrogenic, corrosive, caustic, toxic, carcinogenic), which generate hazards by reactions inside the compressor or through dispersal or through reactions with the environment. A hazardous gas may be a mixture of gases with these properties;

Article 3 Ecodesign requirements and timetable

1. The ecodesign requirements for rotary and piston standard air compressors are set out in Annex I. They shall apply in accordance with the following timetable:
2. from 01/01/2018 as indicated in Annex I, point 2 and point 3;
3. from 01/01/2020 as indicated in Annex I, point 2;
4. Compliance with ecodesign requirements shall be measured and calculated in accordance with methods set out in Annex II

Article 4 Conformity assessment

The conformity assessment procedure referred to in Article 8(2) of Directive 2009/125/EC shall be the internal design control set out in Annex IV to that Directive or the management system for assessing conformity set out in Annex V to that Directive.

Article 5 Verification procedure for market surveillance purposes

When performing the market surveillance checks referred to in Directive 2009/125/EC, Article 3(2), member States authorities shall apply the verification procedure set out in Annex III of this working document.

Article 6 Indicative benchmarks

The indicative benchmarks for the best-performing standard air compressors technologically possible at the time of entry into force of this Regulation are set out in Annex IV

Article 7 Revision

1. The Commission shall review this Regulation in the light of technological progress of standard air compressors and present the result of this review to the Consultation Forum no later than five years after its entry into force.
2. The revision shall in particular address the widening of scope to other types of compressors.

Article 8 Entry into force

This Regulation shall enter into force on the twentieth day following that of its publication in the Official Journal of the European Union.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels ……

Annex I –Ecodesign requirements

1. Definitions for the purposes of Annex I

1) Fixed speed rotary standard air compressor means a rotary standard air compressor which is not equipped with a variable speed drive when placed on the market;
2) Variable speed rotary standard air compressor means a rotary standard air compressor which is equipped with a variable speed drive when placed on the market;
3) Variable speed drive means an electronic power converter integrated — or functioning as one system — with the motor(s) driving the compression element(s), that continuously adapts the electrical power supplied to the electric motor in order to control the mechanical power output of the motor according to the torque-speed characteristic of the load being driven by the motor, excluding variable voltage controllers where only the supply voltage for the motor is varied;
4) Isentropic efficiency means the power that is theoretically required to compress under constant entropy a given volume flow rate of air (treated as an ideal gas), from a given inlet pressure and temperature to a given discharge pressure, divided by the actual electric input power to the standard air compressor basic package compressing the same volume flow rate of air from the same inlet pressure and temperature to the same discharge pressure, expressed as percentage;
5) Ideal gas means a hypothetical gas whose molecules occupy negligible space and have no interactions, and which consequently obeys the gas laws exactly;
6) Entropy means a quantitative measure of disorder in a thermodynamic system;
7) Proportional loss factor (d) means, when combined with an appropriate formula to calculate the minimum isentropic efficiencies, the factor signifying the proportional change in efficiency from average to theoretical optimum efficiency (i.e. 100%);
8) Inlet pressure (p_1) means the pressure of air aspirated at the inlet, expressed in bar(a) for calculation of isentropic efficiency, or as (Pa) for inclusion in product information;
9) Input power (P_{real}) means the electric input power supplied to the basic package compressor, expressed in kW;
10) Cycle energy requirement means the energy consumption for a full cycle from standstill over start-up to full load and back via venting and idling to standstill, expressed in seconds of full load power consumption (s);
11) Cooling method means the method applied to cool the compression element within the basic package compressor;
12) Compression stages means the number of successive compression stages within the basic package compressor;
13) Sound pressure level means the sound pressure emitted by the basic package compressor (dB)
14) Total package compressor means a basic package compressor plus its additional components, such as components for air treatment (drying or filtering) or oil treatment, etc., included in the configuration when placed on the market;

2. Specific ecodesign requirements

The minimum energy efficiency requirements for standard air compressors are set out in Tables 1 and 2.

Table 1

First tier minimum energy efficiency requirements for standard air compressors from 01/01/2018

Standard air compressor type	**Formula to calculate the <u>minimum</u> isentropic efficiency, depending on flow rate (V_1) and proportional loss factor (d)**	**Proportional loss factor (d) to be used in formula**
Fixed speed rotary standard air compressor	$(-0.928 \ln^2 (V_1) + 13.911 \ln (V_1) + 27.110) +$ $(100 - (-0.928 \ln^2 (V_1) + 13.911 \ln (V_1) + 27.110) * d/100$	-5
Variable speed rotary standard air compressor	$(-1.549 \ln^2 (V_1) + 21.573 \ln (V_1) + 0.905) +$ $(100 - (-1.549 \ln^2 (V_1) + 21.573 \ln (V_1) + 0.905) * d/100$	-5
Piston standard air compressor	$(8.931 \ln (V_1) + 31.477) +$ $(100 - (8.931 \ln (V_1) + 31.477) * d/100$	-5

Table 2

Second tier minimum energy efficiency requirements for standard air compressors from 01/01/2020

Standard air compressor type	**Formula to calculate the <u>minimum</u> isentropic efficiency, depending on flow rate (V_1) and proportional loss factor (d)**	**Proportional loss factor (d) to be used in formula**
Fixed speed rotary standard air compressor	$(-0.928 \ln2 (V_1) + 13.911 \ln (V_1) + 27.110) +$ $(100 - (-0.928 \ln2 (V_1) + 13.911 \ln (V_1) + 27.110) * d/100$	0
Variable speed rotary standard air compressor	$(-1.549 \ln2 (V_1) + 21.573 \ln (V_1) + 0.905) +$ $(100 - (-1.549 \ln2 (V_1) + 21.573 \ln (V_1) + 0.905) * d/100$	0

Piston standard air compressor	$(8.931 \ln (V_1) + 31.477) +$ $(100 - (8.931 \ln (V_1) + 31.477) * d/100$	0

3. Generic ecodesign requirements

From 01/01/2018 the information:

(a) Referred to in points 1 to 19 below shall be visibly displayed in the technical documentation provided with the standard air compressor;

(b) Referred to in points 1-6, 13 and 14 below shall be visibly displayed on the free access websites of the manufacturers of the standard air compressor;

(c) Referred to in points 1, 5 and 6 below shall be durably marked on or near the rating plate of the standard air compressor.

Information to be provided in accordance with the above items (a), (b) and (c).

1. Isentropic efficiency of the standard air compressor (%)
2. Cycle energy requirement (s)
3. Cooling method (water or air cooled)
4. Compression stages (-)
5. Volume flow rate at full load outlet pressure[3] (m^3/s)
6. Full load outlet pressure (Pa)[4]
7. Maximum full flow outlet pressure (see note: a) (Pa)
8. Drive motor rated output power (kW)
9. Drive motor nominal efficiency (%)
10. Fan motor electric input power (if applicable) (kW)
11. Fan motor overall efficiency (%)
12. Basic package input power at zero volume flow rate (kW)
13. Basic package input power at full load outlet pressure (kW) (see note: b) (kW)
14. Emitted sound pressure level (dB)
15. Year of manufacture;
16. Manufacturer's name or trade mark, commercial registration number and place of manufacturer;
17. Product's model number;

[3] Note: the calculation of isentropic efficiency follows a formula using (l/s) as unit, measured at inlet.
[4] Note: the calculation of isentropic efficiency follows a formula using (bar(a)) as unit.

18. Information relevant to minimise impact on the environment and ensure optimal life expectancy as regards installation, use and maintenance of the compressor;

19. Information relevant for facilitating disassembly, recycling or disposal at end-of-life;

Notes:

a) Maximum pressure attainable at full flow, usually the unload pressure setting for load/no load control or the maximum pressure attainable before capacity control begins. May require additional power.

b) Basic package input power at other than reported operating points will vary with control strategy. For variable speed products the basic package input power and capacity should be stated for a volume flow of 100%, 70% and 40% of the volume flow at full load outlet pressure

The exact wording used in the list does not need to be repeated. It may be displayed using graphs, figures or symbols rather than text.

Annex II - Measurements and calculations

1. Calculation of isentropic efficiency of fixed speed rotary and piston standard air compressors

The isentropic efficiency of a rotary or piston standard air compressor is calculated at full load conditions, using the formula shown below. This formula assumes that air is compressed from atmospheric inlet conditions and the units are as indicated below.

$$\eta_{isen} = \frac{0.35 * V_1 * ({p_2}^{0.2857} - 1)}{P_{real}}$$

Where:

η_{isen} = isentropic efficiency of the standard air compressor (-), multiplied by 100 gives percentages (%);

V_1 = inlet volume flow rate (l/s), at full load;

p_2 = outlet pressure (bar[a]), at full load;

P_{real} = basic package compressor electric input power (kW), at full load.

2. Calculation of isentropic efficiency of variable speed rotary standard air compressors

The isentropic efficiency of a variable speed rotary standard air compressor is calculated as the weighted averaging of the isentropic efficiency at 100%, 70% and 40% of the nominal volume flow rate.

$$\eta_{isen} = \sum_{i=1}^{n} (\eta_{isen,i} * fi)$$

Where:

η_{isen} = isentropic efficiency of the standard air compressor (-), multiplied by 100 gives percentages (%);

$\eta_{isen,i}$ = isentropic efficiency of the basic package compressor (-), at volume flow rate of 100%, 70% or 40% of volume flow rate at full load outlet pressure, multiplied by 100 gives percentages (%);

f_i = weighing factor, according to table 3.

The weighing factors for the specified volume flow rates are presented in the following table.

Table 3

Weighing factors for variable speed rotary standard air compressors

Volume flow rate ($V_{1,i}$, expressed as % of full load volume flow V_i)	**Weighing factor (f_i)**
100%	25%

70%	50%
40%	25%

The isentropic efficiency at the volume flow rates specified is calculated using the formula shown below. This formula assumes that air is compressed from atmospheric inlet conditions and the units are as indicated below.

$$\eta_{isen,i} = \frac{0.35 * V_{1,i} * \left({p_{2,i}}^{0.2857} - 1\right)}{P_{real,i}}$$

Where:

$V_{1,i}$ = inlet volume flow rate (l/s), at volume flow rate at 100%, 70% or 40% of volume flow rate at full load outlet pressure;

$p_{2,i}$ = outlet pressure (bar[a]), at volume flow rate at 100%, 70% or 40% of volume flow rate at full load outlet pressure;

$P_{real,i}$ = basic package compressor electric input power (kW), at volume flow rate of 100%, 70% or 40% of volume flow rate at full load outlet pressure.

3. Standard inlet conditions

The isentropic efficiency of the basic package compressor shall be calculated assuming standard inlet conditions, which means that inlet air pressure, inlet air temperature and water vapour pressure (and cooling water temperature if applicable) are as described in the following Table.

Table 3

Standard inlet conditions

Inlet condition parameter	Value
Inlet air pressure	100 kPa [1 bar] (a)
Inlet air temperature	20 °C
Relative water vapour pressure	0
Cooling water temperature	20 °C

4. Basic package compressor configuration

The electric input power (P_{real}) shall be measured for the basic package compressor. The table below gives a minimum configuration or product boundaries of the basic package compressor for fixed speed rotary standard air compressors, variable speed rotary standard air compressors and piston standard air compressors.

Table 4

Configuration of the basic package compressor

Type	**Fixed speed rotary standard air compressor**	**Variable speed rotary standard air compressor**	**Piston standard air compressor**
Indicated power input	kW	kW	kW
Oil	oil-injected	oil-injected	oil-lubricated
Stages	single stage	single stage	two-stage
Speed	fixed speed	variable speed	fixed speed
Cooling	air-cooled	air-cooled	air-cooled
Electric Motor	Yes	Yes	Yes
Cooling fan	Yes	Yes	if applicable [3]
Compression element	Yes	Yes	Yes
Transmission (belt, gear, coupling, ...)	Yes (if applicable) [3]	Yes (if applicable) [3]	Yes
Inlet filter	Yes	Yes	Yes
Inlet valve	Yes	Yes	No
Minimum pressure check valve / backflow check valve	Yes	Yes	yes (as "check valve")
Oil separator	Yes	Yes	No
Air piping	Yes	Yes	Yes
Oil piping	Yes	Yes	No
Oil pump	if applicable [3]	if applicable [3]	No
Oil filter	Yes	Yes	No
Oil cooler	Yes	Yes	No
Thermostatic valve	Yes	Yes	No
Electrical switchgear	Yes [1]	No [1]	If applicable [3]
Frequency converter	No [1]	Yes [1]	No
Compressed air after cooler	Yes	Yes	No
Compressor control device (pressure switch, pressure transducer etc...)"	Yes	Yes	Yes
Pressure regulator	No	No	Yes
Pressure vessel	No	No	No [2]
Drain	No	No	Yes

[1] Electrical switchgear and frequency converter only concern the main electric drive motor, other motors (i.e. fans, pumps) may still be driven by a variable speed drive and/or include electrical switchgear and/or frequency converter.

[2] The pressure vessel is in most cases supplied as part of the whole package, but is not a necessary component of the package (performance measurement may be done on equipment without the pressure vessel).

[3] The term "if applicable" should be understood as if by design the functionality of the basic package is achieved without the component, then it doesn't have to be included.

Annex III - Verification procedure for market surveillance purposes

When performing the market surveillance checks referred to in Article 3(2) of Directive 2009/125/EC, the authorities of the Member States shall apply the following verification procedure for the requirements set out in Annex I.

1. The authorities of the Member State shall test one single unit per model.
2. The model shall be considered to comply with the applicable requirements set out in Annex I of this Regulation if the values in the technical documentation comply with the requirements set out in Annex I, and if the measured parameters meet the requirements set out in Annex I within the verification tolerances indicated in Table 1 of this Annex;
3. For models that are produced (on average) in quantities of five or more per year, if the result referred to in point 2 is not achieved, the market surveillance authority shall randomly test three additional units.
4. The model shall be considered shall be considered to comply with the applicable requirements set out in Annex I of this Regulation if the arithmetic average of the values of the three additional units in the technical documentation comply with the requirements set out in Annex I, and if the arithmetic average of the measured parameters of the three additional units meet the requirements set out in Annex I within the verification tolerances indicated in the Table 1 of this Annex.
5. If the results referred to in point 4 are not achieved, the model shall be considered not to comply with this Regulation. The Member States authorities shall provide all relevant information, including the test results if applicable, to the authorities of the other Member States and the Commission within one month of the decision being taken on the non-compliance of the model.
6. For models that are produced in lower quantities than five per year, if the result referred to in point 2 is not achieved, the model shall be considered not to comply with this Regulation. The Member States authorities shall provide all relevant information, including the test results if applicable, to the authorities of the other Member States and the Commission within one month of the decision being taken on the non-compliance of the model.

Member States authorities shall use the measurement methods and calculation methods set out in Annex II.

Given the weight and size limitations in the transportation and testing of certain models of standard air compressors, Member States authorities may decide to undertake the verification procedure at the premises of manufacturers, before they are put into service in their final destination.

The tolerances for verification purposes set out in this Annex relate only to the verification of the measured parameters by Member States authorities and shall not be used by the manufacturer or importer as an allowed tolerance to establish the values in the technical documentation.

Table 1

Tolerances for verification purposes only

Volume flow rate (l/s)	**Maximum deviation from declared values**			
	Volume flow rate	Isentropic efficiency	Input power at zero volume flow	Outlet pressure
$0 < V_1 \leq 8.3$	± 7%	± 8%	± 10%	± 2%
$8.3 < V_1 \leq 25$	± 6%	± 7%	± 10%	± 2%
$25 < V_1 \leq 250$	± 5%	± 6%	± 10%	± 2%
$V_1 > 250$	± 4%	± 5%	± 10%	± 2%

Annex IV – Indicative benchmarks

At the time of adoption of this Regulation, the best available technology on the market for compressors is as indicated in Table 1. These benchmarks may not always be achievable in all applications or for the full load volume flow rate range covered by the Regulation.

Table 1

Indicative benchmarks of standard air compressors

Standard air compressor type	**Formula to calculate the benchmark isentropic efficiency, depending on flow rate (V_1) and proportional loss factor (d)**	**Proportional loss factor (d) to be used in formula for indicative benchmark**
Fixed speed rotary standard air compressor	$(-0.928 \ln^2(V_1) + 13.911 \ln(V_1) + 27.110) +$ $(100 - (-0.928 \ln^2(V_1) + 13.911 \ln(V_1) + 27.110) * d/100$	+25
Variable speed rotary standard air compressor	$(-1.549 \ln^2(V_1) + 21.573 \ln(V_1) + 0.905) +$ $(100 - (-1.549 \ln^2(V_1) + 21.573 \ln(V_1) + 0.905) * d/100$	+25
Piston standard air compressor	$(8.931 \ln(V_1) + 31.477) +$ $(100 - (8.931 \ln(V_1) + 31.477) * d/100$	+25