WORKING DOCUMENT ON

Possible ecodesign requirements for low pressure compressor packages and oil-free compressor packages

DRAFT ECODESIGN REGULATION

Contents

COMMISSION WORKING DOCUMENT

implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for low pressure compressor packages and oil-free compressor packages

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[1] 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 low pressure compressor packages and oil-free compressor packages, belonging to the wider product group of electric motor systems. Electric motor systems were identified as a priority group in Article 16.2.a of Directive 2005/32/EC[2] which was replaced by Directive 2009/125/EC.

3) The Commission has carried out a preparatory study covering the technical, environmental and economic aspects of low pressure and oil-free compressor packages typically used in the Union. The study was devised together with stakeholders and interested parties from the Union and third countries, and the results have been made publicly available.

4) The preparatory study shows that the environmental aspect of both low pressure compressor packages and oil-free compressor packages considered significant for the purposes of this Regulation is energy consumption in the use phase and the study shows that the combined costs of purchasing and operating these products can be reduced by applying existing non-proprietary cost-effective technologies.

5) The annual energy consumption of low pressure and oil-free compressor packages combined in the European Union in 2010 was estimated to have been 24 TWh (216 PJ) corresponding to 9.6 Mt CO2 emissions. Unless specific measures are taken, the annual energy consumption related to use of low pressure compressor packages and oil-free compressor packages is expected to be 27 TWh (243 PJ) in 2020 and 29 TWh (261 PJ) in 2030. The electricity saving potential through mandatory minimum energy efficiency requirements has been estimated at 0.1 to 0.3 TWh by 2030 compared to a business-as-usual scenario. The implementation of such minimum energy efficiency requirements is however elaborate with modest savings, however the upper limit being characterised by significant

[1] OJ L 285, 31.10.2009, p. 10–35
[2] OJ L 191, 22.7.2005, p. 29.

impacts to the industries involved (affecting more than 40% of models placed on the market).

6) The preparatory study shows that the current test standards used to assess the (energy) performance of the products result in values that cannot be compared across technologies, whereas products based on these technologies can offer similar functionality and are in competition in several market segments.

7) Low pressure and oil-free compressor packages subject to this Regulation should therefore allow easier comparison of performance, especially of energy efficiency, which should lead to an overall improvement of energy efficiency of products placed on the market.

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) As highlighted in the Commission Communication "Closing the loop - An EU action plan for the Circular Economy" [3] resource efficiency of products needs to improve and this proposal therefore also includes resource efficiency requirements that are aligned with resource efficiency requirements that have been introduced or proposed for other motor driven systems such as pumps, fans and electric motors.

10) The introduction date of ecodesign requirements should provide a sufficient timeframe for manufacturers to re-design products, perform product tests and prepare information subject to this Regulation where necessary. The timing should take into account possible impacts for end-users and manufacturers, in particular small and medium-sized enterprises, while ensuring timely achievement of the objectives of this Regulation.

11) 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[4].

12) In accordance with Article 8(2) of Directive 2009/125/EC, this Regulation specifies the applicable conformity assessment procedures.

13) To improve the effectiveness of this Regulation and to protect consumers, products that automatically alter their performance in test conditions to improve the declared parameters should be prohibited from being placed on the market or put into service.

14) To facilitate verification testing, market surveillance authorities should be allowed to test, or witness the testing of, larger products at premises such as those of the manufacturer.

15) In order to facilitate compliance checks, manufacturers should provide 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.

16) 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.

[3] COM(2015) 614 final, 2.12.2015
[4] 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 *low pressure compressor packages* that provide a *maximum volume flow rate* between 1 to 4150 l/s (≥ 1 l/s and ≤ 4150 l/s), and *oil-free compressor packages* that provide a *maximum volume flow rate* between 1 to 3500 l/s (≥ 1 l/s and ≤ 3500 l/s), when supplying air at their *average discharge pressure*.
2. This Regulation shall not apply to *low pressure compressor packages* and *oil-free compressor packages*:
    a. with *input power* (P_{real}) less than 0.75 kW or more than 1 MW when they provide maximum volume flow rate of air at average discharge pressure (i.e. test condition '4' as described in Annex III to this regulation);
    b. the *stages* of which are driven by single-phase electric motors;
    c. designed and specified to function in potentially explosive atmospheres as defined in Directive 94/9/EC of the European Parliament and of the Council[5];
    d. designed and specified to function at inlet air temperatures, the daily average value of which is below 15ºC or above 50ºC;
    e. designed and specified to function at ambient pressures prevailing at altitudes exceeding 1000 metres above sea-level.

Article 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. *'Low pressure compressor package'* means an air compressor specified and capable to supply air, drawn in from the ambient, with an *average discharge pressure* between 1.1 bar(a) and 5 bar(a) (≥ 1.1 and < 5 bar(a)) for *standard inlet conditions*;
2. *'Oil-free compressor package'* means an air compressor specified and capable to supply air, drawn in from the ambient, with an *average discharge pressures* between 5 bar(a) and 15 bar(a) (≥ 5 and ≤ 15 bar(a)) for *standard inlet conditions*, and in which the air that is compressed does not come into contact with any intentionally added sealant, cooling medium and/or lubricant except water;
3. *'Air compressor'* means a machine or apparatus that converts electric energy into the potential energy of air pressure, for displacement and compression of air to any higher pressure values above atmospheric pressure with a pressure ratio exceeding 1.1;
4. *'Stage'* means the smallest discernible section of an air compressor in which the pressure of the air drawn in is increased by mechanical motions of one or more working members;

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

5. 'Input power' (P_{real}) means the electric input power supplied to the basic package of a low pressure compressor package or oil-free compressor package, when supplying air into a compressed air system, expressed in kW;
6. *'Inlet pressure'* (p_1) means the absolute pressure of air aspirated at the inlet of the product, expressed in bar(a);
7. *'Discharge pressure'* (p_2) means the absolute pressure of air measured at the discharge port of the product when supplying air, expressed in bar(a);
8. *'Rated discharge pressure'* (p_{2rated}) means any discharge pressure at which the compressor package can typically be operated as specified by the manufacturer, expressed in bar(a).
9. *'Minimum discharge pressure'* (p_{2min}) means:
    a. for oil-free compressor packages a discharge pressure of 5 bar(a) if at least one rated discharge pressure(s) is less than 5 bar(a) or the lowest of rated discharge pressure(s) between 5 bar(a) and 15 bar(a), that can be supplied safe, continuously (without interruption of air delivery or unloading) and reliably by the compressor package and with air at standard inlet conditions, expressed in bar(a);
    b. for low pressure compressor packages, a discharge pressure of 1.1 bar(a) if at least one rated discharge pressure(s) is less than 1.1 bar(a) or the lowest of rated discharge pressure(s) between 1.1 bar(a) and 5 bar(a), that can be supplied safe, continuously (without interruption of air delivery or unloading) and reliably by the compressor package and with air at standard inlet conditions, expressed in bar(a);
10. *'Maximum discharge pressure'* (p_{2max}) means:
    a. for oil-free compressor packages, a discharge pressure of 15 bar(a) if at least one rated discharge pressure exceeds 15 bar(a) or the highest of rated discharge pressures between 5 bar(a) and 15 bar(a), that can be supplied safe, continuously (without interruption of air delivery or unloading) and reliably by the compressor package, and the realisation of which involves no active reduction of the inlet volume flow rate (for instance through inlet throttling, etc.), with air at standard inlet conditions, expressed in bar(a); *if only one rated discharge pressure within 5 bar(a) to 15 bar(a) is specified, the maximum discharge pressure, the minimum discharge pressure and the rated discharge pressure are identical*;
    b. for low pressure compressor packages, the highest of rated discharge pressure(s) between 1.1 bar(a) and 5 bar(a), that can be supplied safe, continuously (without interruption of air delivery or unloading) and reliably by the compressor package, and the realisation of which involves no active reduction of the inlet volume flow rate (for instance through inlet throttling, etc.), with air at standard inlet conditions, expressed in bar(a); *If only one rated discharge pressure within 1.1 bar(a) to 5 bar(a) is specified, the maximum discharge pressure, the minimum discharge pressure and the rated discharge pressure are identical*;
11. *'Average discharge pressure'* (p_{2avg}) means the arithmetic mean of the *maximum discharge pressure* and *minimum discharge pressure*,
12. *'Maximum volume flow rate'* (V_{1max}) means the highest *inlet volume flow rate* that can be supplied safe, continuously and reliably by the *compressor package*, for a given *discharge pressure* (indicated in the context of the use of the term), expressed in l/s or as 100% when expressed as % of the *maximum volume flow rate* for that same discharge pressure;

13. *'Minimum volume flow rate'* (V_{1min}) means the *lowest inlet volume flow rate* that can be supplied safe, continuously and reliably by the compressor package, for a given discharge pressure, expressed in l/s or in percentage of the *maximum volume flow rate* for that same *discharge pressure*;
14. *'Inlet volume flow rate'* (V1) means the volume of compressed air per unit of time supplied by the *compressor package* to a connected system, expressed in l/s and with inlet air at *standard inlet conditions*;
15. *'Standard inlet conditions'* means the air aspirated by the compressor package has an *inlet pressure* of 1 bar(a) (100 kPa), a temperature of 20°C and a relative water vapour pressure of 0 (zero), and the cooling water is (where applicable) supplied to the compressor package has a supply temperature of 20 ºC and a temperature difference between cooling water inlet and outlet not exceeding 25 K;
16. *'equivalent model'* means a model which has the same technical characteristics relevant for the technical information to be provided, but which is placed on the market or put into service by the same manufacturer, importer or authorised representative as another model with a different model identifier;
17. *'model identifier'* means the code, usually alphanumeric, which distinguishes a specific product model from other models with the same trade mark or the same manufacturer's, importer's or authorised representative's name.

Article 3 Ecodesign requirements

1. The ecodesign requirements for low pressure compressor packages and oil-free compressor packages set out in Annex II shall apply from the dates indicated therein.
2. Compliance with ecodesign requirements shall be measured and calculated in accordance with methods set out in Annex III

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.

For the purposes of the conformity assessment pursuant to Article 8 of Directive 2009/125/EC, the technical documentation of low pressure compressor packages and oil-free compressor packages shall contain a copy of the product information provided in accordance with point 1 of Annex II to this Regulation, and the details and results of calculations set out in Annex III to this Regulation.

Where the information included in the technical documentation for a particular model has been obtained:

(a) from a model that has the same technical characteristics relevant for the technical information to be provided but is produced by a different manufacturer; or

(b) by calculation on the basis of design or extrapolation from another model of the same or a different manufacturer, or both,

the technical documentation shall include the details of such calculation, the assessment undertaken by the manufacturer to verify the accuracy of the calculation and, where appropriate, the declaration of identity between the models of different manufacturers.

The technical documentation shall include a list of all equivalent models, including the model identifiers.

Article 5 Verification procedure for market surveillance purposes

Member States shall apply the verification procedure set out in Annex III when performing the market surveillance checks referred to in Directive 2009/125/EC, Article 3(2).

Article 6 Circumvention and software updates

The manufacturer, importer or authorised representative shall not place on the market products designed to be able to detect they are being tested (e.g. by recognising the test conditions or test cycle), and to react specifically by automatically altering their performance during the test with the aim of reaching a more favourable level for any of the parameters specified in this Regulation or declared by the manufacturer, importer or authorised representative in the technical documentation or included in any of the documentation provided .

The energy consumption of the product and any of the other declared parameters shall not deteriorate after a software or firmware update when measured with the same test standard originally used for the declaration of conformity, except with explicit consent of the end-user prior to the update. No deterioration of performance shall occur as result of rejecting the update.

A software update shall never have the effect of changing the product's performance in a way that makes it non-compliant with the ecodesign requirements applicable for the declaration of conformity.

Article 7 Benchmarks

The benchmarks of package efficiency for low pressure compressor packages and oil-free compressor packages at the time of entry into force of this Regulation are set out in Annex IV.

Article 8 Review

1. The Commission shall review this Regulation in the light of technological progress and shall present the result of this review to the Consultation Forum no later than [five] years after its entry into force.
2. The review shall in particular address:
    a. The appropriateness of introducing minimum energy efficiency requirements for low pressure compressor packages and oil-free compressor packages;
    b. The appropriateness of introducing additional resource efficiency requirements for products in accordance with the objectives of the circular economy;
    c. The appropriateness of expanding the scope to include air compressors designed for other application ranges than the ones covered by low pressure or oil-free compressor packages.

Article 9 Entry into force and application

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

It shall apply from 1 June 2022

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

Done at Brussels [date]

Annex I - Definitions

For the purposes of Annex I, II and III of this Regulation and in addition to the definitions set out in Directive 2009/125/EC, the following definitions apply:

1. *'Compressor package'* means a *basic package* or a *feature package*;
2. *'Basic package'* means an *air compressor* that contains not more than the minimum number of components required for safe, continuous and reliable operation and is used for verification of its performance. The minimum number of components shall include those indicated in point 5 of Annex III.
3. *'Feature package'* means an *air compressor* that comprises a basic package and any number of additional components, for instance for drying or filtering of compressed air and/or noise attenuation etc.;
4. *'Package efficiency'* (η_{pack}) means the energy efficiency of the *basic package* of *low pressure or oil-free compressor packages*, calculated in accordance with the procedures laid down in Annex III - Measurement and Calculation;
5. *'Volume flow control category'* means the category used to characterise the control over the *inlet volume flow rate* that can be supplied by *compressor package*, and which is either *'wide flow control range'*, *'limited flow control range'* or *'zero flow control range'*;
6. 'Wide flow control range' (WFCR) means the *compressor package* belongs to a category of products which allows changing the *inlet volume flow rate* independent of the *discharge pressure* whereby:
    a. for **low pressure compressor packages** the *minimum volume flow rate* at each *discharge pressure* between (and including) *minimum* and *maximum discharge pressure* the *minimum volume flow rate* is equal to or less than **50%** of the maximum volume flow rate at that same discharge pressure;
    b. for **oil-free compressor packages** the *minimum volume flow rate* at each *discharge pressure* between (and including) *minimum* and *maximum discharge pressure* the *minimum volume flow rate* is equal to or less than **60%** of the maximum volume flow rate at that same discharge pressure;
7. 'Limited flow control range' (LFCR) means the *compressor package* belongs to a category of products which allows changing the *inlet volume flow rate* independent of the *discharge pressure* whereby:
    a. for **low pressure compressor packages** the *minimum volume flow rate* at each *discharge pressure* between (and including) *minimum* and *maximum discharge pressure* the *minimum volume flow rate* is higher than **50%** of the maximum volume flow rate at that same discharge pressure;
    b. for **oil-free compressor packages** the *minimum volume flow rate* at each *discharge pressure* between (and including) *minimum* and *maximum discharge pressure* the *minimum volume flow rate* is higher than **60%** of the maximum volume flow rate at that same discharge pressure;
8. 'Zero flow control range' (ZFCR) means the *compressor package* belongs to a category of *compressor packages* that do not allow changing the *inlet volume flow rate* independent of the *discharge pressure*;
9. 'Pressure peak capability' means the product can:

a. supply air to a connected system the pressure in which exceeds the *maximum discharge pressure* of the *compressor package* by 200 mbar for a duration of 15 seconds or more, while;

b. keeping any reduction of the *inlet volume flow rate* of the *compressor package* within 2% of the *maximum volume flow rate* for the *maximum discharge pressure*, per 100 mbar increase of system pressure, within one second the conditions mentioned under (a) are established;

c. Fulfil the conditions under (a) and (b) eight or more times per hour.

10. 'Minimum volume flow rate' (V_{1min}) means the lowest *inlet volume flow rate* that can be supplied safe, continuously and reliably by the *compressor package*, while providing the *maximum, minimum or average discharge pressure*, as declared by the manufacturer, expressed in l/s or in % of the *maximum volume flow rate* at that same *discharge pressure*;

11. 'Average volume flow rate' (V_{1avg}) means the arithmetic mean of the *maximum volume flow rate* and *minimum volume flow rate*, calculated as: $V_{1avg} = (V_{1max} + V_{1min})/2$ for each maximum, minimum or average discharge pressure, as declared by the manufacturer, expressed in l/s or in % of the *maximum volume flow rate* at that same *discharge pressure*;

12. 'Isentropic efficiency' means the division of the power that is theoretically required to compress under constant entropy a given *inlet volume flow rate* of air (treated as an ideal gas), from a given *inlet pressure* and temperature to a given *discharge pressure*, by the actual electric *input power* P_{real} to the *basic package* of the *low pressure compressor package* or *oil-free compressor package* compressing the same *inlet volume flow rate* from the same *inlet pressure* and temperature to the same *discharge pressure*, expressed as percentage;

13. 'Ideal gas' means a hypothetical gas whose molecules occupy negligible space and have no interactions, and which consequently obeys the gas laws exactly;

14. 'Entropy' means a quantitative measure of disorder in a thermodynamic system;

15. 'Idle power' (P_{idle}) means the input power of the *basic package*, when running in unloaded mode and delivering zero inlet volume flow rate, expressed in kW;

16. 'Cycle energy requirement' means the energy consumption of a compressor package when completing an operating cycle from standstill over start-up to full load and back via venting and idling to standstill, expressed in seconds of full load power (s);

17. 'Cooling method' means the method applied to cool the stage(s) of the compressor package and which can either be 'air-cooled' or 'water-cooled' depending on the medium used;

18. 'Sound power level' (L_{WA}) means the sound power of a compressor package (expressed in dB);

19. *Heat recovery option* means a technical solution for the recovery of heat produced by the *compressor package* with the aim of energy saving within the *compressor package* (i.e. heat-driven drying processes, etc.) or in processes to which the recovered heat is delivered (i.e. space and/or water heating or (pre)heating of various media, etc.).

20. *customer* means a natural or legal person who buys, hires or receives a product for own use whether or not acting for purposes which are outside its trade, business, craft or profession;

21. ‘witnessed testing’ means actively observing the physical testing of the product under investigation by another party, to draw conclusions on the validity of the test and the test

results. This may include conclusions on the compliance of testing and calculations methods used with applicable standards and legislation;

22. ‘factory acceptance test’ means a test on an ordered product where the customer uses witnessed testing to verify the product’s full accordance with contractual requirements, before they are accepted or put into service.

Annex II - Ecodesign requirements

1. Product information requirements

a) From 1 June 2022, the instruction manuals for installers and end-users, and free access websites of manufacturers, importers and authorised representatives shall provide the following product information:

i) For all compressor packages:

(1) *Package efficiency* of the basic package of the *low pressure compressor package* or oil-free compressor package, in %;

(2) Category of volume flow control which can be: *wide flow control range*, *limited flow control range* or *zero flow control range*;

(3) Number of *stages* [count];

(4) the *maximum discharge pressure* (p_{2max}), in bar(a);

(5) the *minimum discharge pressure* (p_{2min}), in bar(a);

(6) the *maximum volume flow rate* (V_{1max}) of the *basic package* at *average discharge pressure* (p_{2avg}), in l/s;

(7) the *input power* (P_{real}) of the *basic package*, when supplying the *maximum volume flow rate* at the *maximum discharge pressure*, in kW;

(8) the *idle Power* (P_{idle}) of *basic package*, in kW;

(9) the *cycle energy requirement* of the *basic package*, in s;

(10) the *cooling method* of the compression stage [water-cooled or air-cooled];

(11) the *sound power level*, in dB;

(12) Description of at least one *heat recovery option* that can be applied in or in conjunction with the *compressor package*;

(13) Specific precautions that must be taken when the product is assembled, installed or maintained;

(14) Information related to improving resource efficiency:

(a) Information relevant for facilitating disassembly, recycling or disposal at end-of-life;

(b) Information relevant for the installation, use and maintenance of the compressor package.

ii) For all compressor packages that belong to the *wide flow control range* or *limited flow control range* category:

(1) the *maximum volume flow rate* (V_{1max}) of the basic package at maximum discharge pressure (p_{2max}), in l/s;

(2) the *maximum volume flow rate* (V_{1max}) of the *basic package* at *minimum discharge pressure* (p_{2min}), in l/s;

iii) For *low pressure compressor packages* only:

(1) Whether the product has 'pressure peak capability' [yes/no]

b) The manufacturer, authorised representatives and importers of low pressure compressor packages and oil-free compressor packages shall provide market surveillance authorities, upon request, the necessary information on the setting of the unit, as applied for the establishment of package efficiencies, minimum, average and maximum discharge pressure, volume flow rate, and provide contact information for obtaining such information.

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

2. Resource efficiency requirements

From 1 June 2022, manufacturers, importers or authorised representatives shall ensure that low pressure compressor packages and oil-free compressor packages are designed in such a way that the materials and components referred to in Annex VII to Directive 2012/19/EU can be removed with the use of commonly available tools.

Manufacturers, importers or authorised representatives shall fulfil the obligations laid down in Article 15, Point 1 of Directive 2012/19/EU.

Annex III - Measurement methods and calculations

For the purposes of compliance and verification of compliance with the requirements of this Regulation, measurements and calculations shall be made using harmonised standards the reference numbers of which have been published for this purpose in the Official Journal of the European Union, or other reliable, accurate and reproducible methods, which takes into account the generally recognised state-of-the-art, and in line with the following provisions:

1) Standard inlet conditions

The isentropic efficiency of the basic package 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 Table 1.

Table 1 Standard inlet conditions

Inlet condition parameter	Value
Inlet air pressure	1 bar(a) [100 kPa]
Inlet air temperature	20 °C
Relative water vapour pressure of air	0
Cooling water inlet temperature (if applicable)	20 °C
Temperature difference inlet/outlet	< 25 K

2) Test conditions

The package efficiencies are calculated based on the isentropic efficiency of the basic package in multiple test conditions. These test conditions are different for low pressure compressor packages and oil-free compressor packages and for each category of volume flow rate control (wide volume flow control, limited volume flow control or zero volume flow control).

Tables 2 and 3 show the designation (number between 1 to 9) of the test conditions to be considered for the combinations indicated.

Table 2: Test conditions and their reference number for low pressure compressors

	Wide flow control range				Limited flow control range				Zero flow control range
	40% of maximum	70% of maximum volume flow rate	100% of maximum volume flow rate		minimum volume flow rate	average volume flow rate	maximum volume flow rate		maximum volume flow rate

	volume flow rate[6]								
p_{2max}	3	2	1		3	2	1		1
p_{2avg}	6	5	4		6	5	4		4
p_{2min}	9	8	7		9	8	7		7

Table 3: Test conditions and their reference number for oil-free compressor packages

	Wide flow control range				Limited flow control range				Zero flow control range
	50% of maximum volume flow rate[7]	75% of maximum volume flow rate	maximum volume flow rate (100%)		minimum volume flow rate	average volume flow rate	maximum volume flow rate		maximum volume flow rate
p_{2max}	3	2	1		3	2	1		1
p_{2avg}	6	5	4		6	5	4		4
p_{2min}	9	8	7		9	8	7		7

3) Calculation of isentropic efficiency in test conditions

The isentropic efficiency of a compressor package at a given test condition is calculated using the equation below.

Equation 1

$$\eta_{isen,t} = \frac{V_t * p_1 * \frac{\kappa}{(\kappa - 1)} * \left[\left({}^{p_2}/_{p_1} \right)^{\frac{\kappa - 1}{\kappa}} - 1 \right]}{(P_{real} * 10)}$$

Where:

$\eta_{isen,t}$ = isentropic efficiency of the compressor package, multiplied by 100 (expressed in %) for a given test condition 't';

t = test condition 1 to 9 for products in the wide or limited volume flow control categories or test condition 1, 4 and 7 for products in the zero volume flow control category;

V_t = is the inlet volume flow rate (l/s), for the applicable test condition t, in l/s;

p_1 = inlet pressure (bar[a]), established for each discharge pressure;

p_2 = discharge pressure (bar[a]), which can be the maximum discharge pressure ($p_{2,max}$), minimum discharge pressure ($p_{2,min}$) or the average discharge pressure ($p_{2,avg}$);

[6] If a volume flow rate of 40% cannot be achieved, the lowest volume flow rate for that discharge pressure shall be used.
[7] If a volume flow rate of 50% cannot be achieved, the lowest volume flow rate for that discharge pressure shall be used.

P_{real} = electric input power (kW) of the basic package for the applicable test condition;

κ = the isentropic exponent of air: 1.4;

10 = a correction required when using inputs expressed in l/s, bar(a) and kW.

The configuration of a basic package is given in point 5.

4) Calculation of package efficiency

The package efficiency is calculated using the equation below.

Equation 2

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

Where:

η_{pack} = package efficiency, expressed in percentages (%);

$\eta_{isen,i}$ = isentropic efficiency of the compressor package (-), at the test conditions indicated in point 3, expressed in percentages (%);

f_i = weighing factor, according to Table 4 for low pressure compressor packages and to Table 5 for oil-free compressor packages.

Table 4: Weighting factors of isentropic efficiencies per test condition for low pressure compressor packages

	Wide flow control range				Limited flow control range				Zero flow control range
	40% of maximum volume flow rate	70% of maximum volume flow rate	100% of maximum volume flow rate		minimum volume flow rate	average volume flow rate	maximum volume flow rate		maximum volume flow rate
p_{2max}	1/16	1/8	1/16		1/16	1/8	1/16		1/4
p_{2avg}	1/8	1/4	1/8		1/8	1/4	1/8		1/2
p_{2min}	1/16	1/8	1/16		1/16	1/8	1/16		1/4

Table 5: Weighting factors of isentropic efficiencies per test condition for oil-free compressor packages

	Wide flow control range				Limited flow control range				Zero flow control range
	50% of maximum volume flow rate	75% of maximum volume flow rate	maximum volume flow rate (100%)		minimum volume flow rate	average volume flow rate	maximum volume flow rate		maximum volume flow rate

p_{2max}	1/16	1/8	1/16		1/16	1/8	1/16		1/4
p_{2avg}	1/8	1/4	1/8		1/8	1/4	1/8		1/2
p_{2min}	1/16	1/8	1/16		1/16	1/8	1/16		1/4

5) Basic package configuration and measurement

The relevant parameters shall be measured for the basic package of the compressor package or using a feature package in which case the following measurement procedure shall be applied so that the final results match as closely as possible the results that can be expected for a basic package of that product:

1) All features not belonging to the *basic package* configuration (see Table 6) which have an additional electrical power consumption shall be switched off during measurement.
2) All features not belonging to the *basic package* configuration (see Table 6) which have an additional compressed air consumption shall be closed off during measurement.
3) All features not belonging to the *basic package* configuration (see Table 6) which produce an additional pressure drop shall be handled as follows:
   a) In case of pressure drop at the inlet/suction side or any intermediate level, the feature(s) not belonging to the *basic package* is/are allowed to be dismounted during the measurement, by replacing it with suitable piping if necessary.
   b) In case of a pressure drop at the discharge side due to feature(s) not belonging to the *basic package*, the *discharge pressure* p_2 is allowed to be measured upstream to feature if feasible.
   c) In case the procedure under b) is not feasible and the pressure drop caused by the feature(s) not belonging to the basic package is/are known, the *discharge pressure* p_2 of the package may be corrected for the given pressure drop by adding the known pressure drop of the feature(s) not belonging to the *basic package* to the *discharge pressure* p_2.

Table 6 gives a minimum configuration of the *basic package* of low pressure compressor packages and oil-free compressor packages. If the absence of a component not listed in Table 6 hampers safe, reliable and continuous operation when the product is placed on the market and/or put into service, the component is considered part of the basic package.

Table 6 Configuration of the basic package

	Part or component	**Inclusion in basic package**
Air path	Inlet air filter	yes
	Inlet silencer	yes, if applicable
	Inlet throttle or guide vanes	yes, if applicable (depends on technology)

	Inlet unload valve	yes, if applicable
	Compression stage including moving members (commonly known as "air end" or "bare shaft compressor")	yes
	Variable diffusor vanes	yes, if applicable (depends on technology)
	Blow-off valve	yes, if applicable
	Check valve	yes, if applicable
	Discharge silencer	optional
Electric power & main drive	EMC filter	yes, if applicable
	Input choke	optional
	Electric/electronic motor control [2]	yes
	Sinus filter	yes, if applicable
	Main drive (electric) motor(s), driving the working members	yes
	Transmission, transmitting power from electric motor to "bare shaft compressor"	yes, if applicable
Ancillaries	Logical control system	yes, if applicable
	Magnetic bearing control and cooling	yes, if applicable
	UPS (uninterruptible power supply – to maintain power to magnetic bearings)	yes, if applicable
Water cooled	Cooling pump, to circulate the cooling medium	yes, if applicable
Other cooling	Cooling pump (and ancillaries) of liquid cooled parts (can be oil), not in contact with compressed air	yes, if applicable
	Main drive cooling fan(s) (to cool main drive motor and other parts)	yes, if applicable
	Heat exchanger fans (to cool compressed air)	yes, if applicable
	Cooling air baffling (noise cancellation)	optional
	Cooling air filter	yes, if applicable

'yes' means the part or component is included in the configuration of a basic package

'yes, if applicable' means that the design of the air compressor requires the use of this component to function safe, continuous and reliable. Where packages are based on technologies that do not require the use of this part to function safe, continuously and reliably, the part is not included in the configuration of the basic package.

'optional' means the part or component is not a mandatory part of the basic package, but it does not necessarily needs to be removed (or corrected for) when performing tests to determine the package efficiency. The manufacturer needs to state in its technical documentation whether the part is included or excluded when performing the tests.

[2] Electrical switchgear and frequency converter only concern the main electric drive motor. Note that other motors (of fans, pumps) present in the package may also be driven be driven by a variable speed drive and/or electrical switchgear.

Annex IV - Product compliance verification by market surveillance authorities

The verification tolerances defined in this Annex relate only to the verification of the measured parameters by Member State authorities and shall not be used by the manufacturer, importer or authorised representative as an allowed tolerance to establish the values in the technical documentation or in interpreting these values with a view to achieving compliance or to communicate better performance by any means.

Where a model has been designed to be able to detect it is being tested (e.g. by recognizing the test conditions or test cycle), and to react specifically by automatically altering its performance during the test with the objective of reaching a more favourable level for any of the parameters specified in this Regulation or included in the technical documentation or included in any of the documentation provided, the model and all equivalent models shall be considered not compliant.

When verifying the compliance of a product model with the requirements laid down in this Regulation pursuant to Article 3(2) of Directive 2009/125/EC, for the requirements referred to in this Annex, the authorities of the Member States shall apply the following procedure:

1) The Member State authorities shall verify one single unit of the model.
2) The model shall be considered to comply with the applicable requirements if:
    a) the values given in the technical documentation pursuant to point 2 of Annex IV to Directive 2009/125/EC (declared values), and, where applicable, the values used to calculate these values, are not more favourable for the manufacturer, importer or authorised representative than the results of the corresponding measurements carried out pursuant to point (g) thereof; and
    b) the declared values meet any requirements laid down in this Regulation, and any required product information published by the manufacturer, importer or authorised representative does not contain values that are more favourable for the manufacturer importer or authorised representative than the declared values; and
    c) when the Member State authorities test the unit of the model, the determined values (the values of the relevant parameters as measured in testing and the values calculated from these measurements) comply with the respective verification tolerances as set out in Table 7.
3) If the results referred to in point (2)(a) or (2)(b) are not achieved, the model and all equivalent models shall be considered not to comply with this Regulation.
4) If the result referred to in point (2)(c) is not achieved;
    a) for models that are produced in quantities of less than five per year including equivalent models, the model and all equivalent models shall be considered not to comply with this Regulation;
    b) for models that are produced in quantities of five or more per year including equivalent models, the Member State authorities shall select three additional units of the same model for testing. As an alternative, the three additional units selected may be one or more of equivalent models.
5) The model shall be considered to comply with the applicable requirements if, for these three units, the arithmetical mean of the determined values complies with the respective verification tolerances given in Table 7.
6) If the result referred to in point (5) is not achieved, the model and all equivalent models shall be considered not to comply with this Regulation.
7) The Member State authorities shall provide all relevant information to the authorities of the other Member States and to the Commission without delay after a decision being taken on the non-compliance of the model according to points (3) or (6).

The Member State authorities shall use the measurement and calculation methods set out in Annex III.

The Member State authorities shall only apply the verification tolerances that are set out in Table 7 and shall only use the procedure described in points 1 to 8 for the requirements referred to in this Annex. No other tolerances, such as those set out in harmonised standards or in any other measurement method, shall be applied.

Given the weight and size limitations in the transportation and testing of certain models of low pressure compressor packages and oil-free compressor packages, Member States authorities may decide to undertake the verification procedure at the premises of manufacturers, authorised representatives or importers before the products are put into service. The Member State authority can do this verification using its own testing equipment.

If factory acceptance tests are planned for such low pressure compressor packages or oil-free compressor packages, which will test parameters laid down in Annex II to this Regulation, the Member State authorities may decide to use witnessed testing during these factory acceptance tests to gather test results, which can be used to verify compliance of the product under investigation. The authorities may request a manufacturer, authorised representative or importer to disclose information on any planned factory acceptance tests relevant for witnessed testing.

In the cases mentioned in the two paragraphs above, the Member States authorities only need to verify one single unit of the model. If the result referred to in point (2)(c) is not achieved, the model and all equivalent models shall be considered not to comply with this Regulation.

Table 7 Verification tolerances

Parameters	**Verification tolerance** by maximum volume flow rate (l/s)			
	$0 < V_1 \leq 8.3$	$8.3 < V_1 \leq 25$	$25 < V_1 \leq 250$	$V_1 > 250$
Inlet volume flow rate	± 7%	± 6%	± 5%	± 4%
Isentropic efficiency	-8%	-7%	-6%	-5%
Idle power	± 10%	± 10%	± 10%	± 10%
Discharge pressure	± 2%	± 2%	± 2%	± 2%

Annex V - Benchmarks

At the time of adoption of this Regulation, the best available technology on the market for low pressure compressor packages and oil-free compressor packages is as indicated in Table 8 and Table 9. These benchmarks are based on laboratory tests in controlled environments and may not always be achievable in all applications.

Table 8 Benchmarks of low pressure compressor packages, expressed as package efficiencies.

Low pressure compressor package of zero flow control range									
	Volume flow rate at point 4 (l/s)								
Discharge pressure at point 4 (bar(a))	1.8	4.4	11.2	28.3	71.4	180.3	455.0	1150	2900
1.2				34%	44%	49%	53%		
1.4		19%	30%	40%	52%	60%	60%	63%	
1.7			30%	37%	48%	63%	71%	78%	
2.0						51%			
2.4							61%		
3.3							68%		

Low pressure compressor package of zero flow control range with pressure peak capability									
	Volume flow rate at point 4 (l/s)								
Discharge pressure at point 4 (bar(a))	1.8	4.4	11.2	28.3	71.4	180.3	455.0	1150	2900
1.2				33%	45%	54%	55%	53%	56%
1.4				39%	45%	55%	59%	61%	63%
1.7					44%	55%	67%		
2.0								79%	

Low pressure compressor package of limited flow control range

	Volume flow rate at point 4 (l/s)								
Discharge pressure at point 4 (bar(a))	1.8	4.4	11.2	28.3	71.4	180.3	455.0	1150	2900
1.4					37%				
1.7								71.1%	

Low pressure compressor package of wide flow control range									
	Volume flow rate at point 4 (l/s)								
Discharge pressure at point 4 (bar(a))	1.8	4.4	11.2	28.3	71.4	180.3	455.0	1150	2900
1.2					40%	44%	54%	61%	
1.4						55%	63%	66%	78%
1.7						59%	67%	70%	73%

Table 9 Indicative benchmarks of oil-free compressor packages, expressed as package efficiencies.

oil-free compressor packages of zero flow control range and air-cooled				
	Volume flow rate at point 4 (l/s)			
Discharge pressure at point 4 (bar(a))	151.8	400.7	992	2460
6.7	66%	69%	68%	
7.8	65%	71%		

oil-free compressor packages of zero flow control range and water-cooled				
	Volume flow rate at point 4 (l/s)			
Discharge pressure at point 4 (bar(a))	151.8	400.7	992	2460
6.7	71%	75%	77%	

7.8	75%	76%	80%	

oil-free compressor packages of limited flow control range				
	Volume flow rate at point 4 (l/s)			
Discharge pressure at point 4 (bar(a))	151.8	400.7	992	2460
7.8			78%	

oil-free compressor packages of wide flow control range and air-cooled				
	Volume flow rate at point 4 (l/s)			
Discharge pressure at point 4 (bar(a))	151.8	400.7	992	2460
7.8	61%	66%		

oil-free compressor packages of wide flow control range and water-cooled				
	Volume flow rate at point 4 (l/s)			
Discharge pressure at point 4 (bar(a))	151.8	400.7	992	2460
6.7		68%		
7.8		68%		
8.9	71%	72%		

Explanatory Memorandum to the

Working Document on a draft COMMISSION REGULATION (EU) No …/…

implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for low pressure compressor packages and oil-free compressor packages

CONTEXT OF THE PROPOSAL

Grounds for and objectives of the proposal

The Ecodesign Framework Directive 2009/125/EC establishes a framework for the setting of ecodesign requirements for energy-related products. It is a key instrument of EU policy for improving the energy and other environmental performances of products in the Internal Market. The Directive lists products identified by the Council and the European Parliament as priorities for the Commission for implementation, including electric motor driven systems (Article 16). Electric motor driven compressors are considered to belong to electric motor systems just as electric motors, pumps and fans.[8] Therefore, compressors are priority product groups considered for implementing measures under the Ecodesign Directive. Compressors were also included in the Ecodesign Working Plan 2016-2019 among the products for which work is under way.

Consequently, a technical, environmental and economic analysis of compressors was performed ('preparatory studies'). A first study ran from March 2012 to June 2014 and focused specifically on 'standard air compressor packages'. A second preparatory study[9] ran from April 2015 to June 2017 and covered "Low pressure and Oil-free compressor packages" ("LP/OF compressors").

Both studies showed that (i) such compressors are placed in significant quantities on the internal market; (ii) the main environmental impacts in the life cycle of such compressors are considered significant and are related to their energy (electricity) consumption during use; and (iii) technically cost-effective solutions exist that could lead to significant reductions of environmental impact. The Commission considered that the conditions set out in Article 15 of Directive 2009/125/EC are satisfied for these types of compressors and these compressors are to be covered by (an) ecodesign implementing measure(s).

The outcome of the first study and a proposal for an ecodesign measure for standard air compressor packages were presented to the Consultation Forum on 23 October 2014. It is currently in Impact Assessment phase.

The outcome of the second study on LP/OF compressors will be presented to the Consultation Forum on [date].

General context

The scope of the first preparatory study initially covered all compressors driven by electric motors, but, in agreement with all stakeholders involved, and the Commission Services, it was

[8] COM (2008) 660 WP for 2009-2011 under Ecodesign Directive
[9] ENER Lot 31 preparatory study on "Low pressure and oil-free compressor packages", available on http://www.eco-compressors.eu

decided at an early stage to exclude from the Lot 31 study scope vacuum pumps and refrigeration compressors.

Vacuum pumps were, although they share certain technological characteristics with air compressors, excluded because they do not operate with inlet air at atmospheric conditions (inlet pressure close to 1 bar(a)). Furthermore, the range in technologies applied in vacuum pumps is extremely wide, offering several magnitudes in range of performance (e.g. a pressure difference of 10^{-12} mbar to over 1 000 bar) and includes non-motor driven systems.

Refrigeration compressors (also used heating applications such as heat pumps) were excluded as these neither have an atmospheric air intake nor a blow-off valve venting to the atmosphere. Furthermore, compressors in refrigeration and heating applications are covered by multiple implementing measures as (being) developed under:

1. Lot 1: Heat pumps for hydronic central heating;
2. Lot 2: Heat pumps for sanitary hot water;
3. Lot 10: Room air conditioners (< 12 kW);
4. Lot 12: Commercial refrigeration - display cabinets etc.;
5. Lot 13: Domestic refrigeration (household refrigerators and freezers);
6. Lot 21: Central heating (products other than CHP);
7. ENTR Lot 1: commercial refrigeration systems (chillers, etc.);
8. ENTR Lot 6: commercial (large) air conditioning systems.

The savings identified for the above product groups include improvements in the efficiency of the compressor part. Therefore it is expected that any remaining saving potential to be identified in the Lot 31 study for these products is greatly reduced.

The preparatory study then progressed to identify, in close collaboration with the European industry association *Pneurop*, preliminary data on sales and energy consumption of five compressor application ranges (standard air, low pressure, oil-free, process gas/inert and process gas/hazardous) with an estimated overall electricity consumption of 188 TWh/a[10].

However, these five areas still represented a too wide variety in technologies and applications to be covered in a single study and it was decided to exclude process gas compressors (for inert gases like air, noble gases and nitrogen, and hazardous gases like methane, ammonia, etc.) as these products are primarily designed and built upon client's specifications for complete integration into very specific industrial processes. The design process of process gas compressors generally involves balancing energy efficiency (because of the high operating costs) with safety issues (especially if hazardous gases are involved) for very specific applications and products are usually bespoke. The energy saving potential was considered to be very small and difficult to unlock by generic eco-design measures.

The study then focused on compressors for standard air applications as these are considered the "work horses" of the industry, with the highest number of sales, the highest electricity consumption and the largest energy saving potential. The group is also fairly homogeneous as the main technologies applied (rotary screw and vane compressors, with either fixed or variable speed drives, and piston compressors) have the same basic working principle (positive

[10] Ecodesign Preparatory Study on Electric motor systems / Compressors ENER Lot 31 FINAL Report of Task 1, 2, 3, 4, & 5 section 3.4 (p. 164) , VHK, 3 June 2014

displacement). A Working Document laying down a proposal for an ecodesign measure for standard air compressor packages was presented to the Consultation Forum on 23 October 2014.

Due to the unavailability of sales, price and performance data of low pressure and oil free compressors it was not possible to analyse these at the same level of detail in this first study.

A second study was performed from April 2015 to June 2017 to investigate the technical, economic and environmental aspects of compressors for the low-pressure and oil-free application ranges. The fact that both groups comprise compressors that operate on the basis of very different technical principles (positive displacement versus turbo-machinery) and no agreed method to compare performances for these two principles existed, created additional difficulty.

The present Working Document presents the Commission Services' proposal for a measure for low pressure and oil-free compressor packages.

The measure does not propose minimum energy efficiency requirements as the establishment of target efficiencies is cumbersome (as no parametric approach could be established), may introduce unknown effects on products characterised for a market segment of which no data was available, and ultimately leads to modest savings.

The proposed measure does aim to correct the market failure of incomparable information on energy efficiency of products by laying down standard rating conditions and a harmonised methodology for establishing the energy efficiency of the package, taking into account relevant differences in functionality of products, and in doing so contributes to a faster improvement in average energy efficiency than under a business-as-usual scenario.

Scope

The scope of the proposed measure covers low pressure air compressor packages, with a maximum volume flow rate of minimum 1 and maximum 4150 l/s and oil-free air compressors with a maximum volume flow rate of minimum 1 and maximum 3500 l/s, at average pressure.

A low pressure air compressor package is a compressor package designed to supply air, drawn in from the ambient, at discharge pressure levels of minimum 1.1 and maximum 5 bar(a)[11]

An oil-free compressor package is a compressor package designed to supply air, drawn in from the ambient, at discharge pressure levels of minimum 5 and maximum 15 bar(a) and which has not been in contact with lubricants for cooling, lubrication and sealing of the compression chamber(s) and the moving components contained therein, apart from water.

The scope covers packaged products, including the motor(s), transmission and motor drives or switchgear and other components required for safe functioning as intended, in line with the 'extended product approach' [12].

Economic significance

Market and stock

[11] Bar(a) is the absolute pressure, with zero pressure (space) as reference. The indicated outlet pressure range assumes as reference 100 kPa or 1 bar(a). The pressure increase over inlet conditions is thus minimum 0.1 bar and 4 bar.

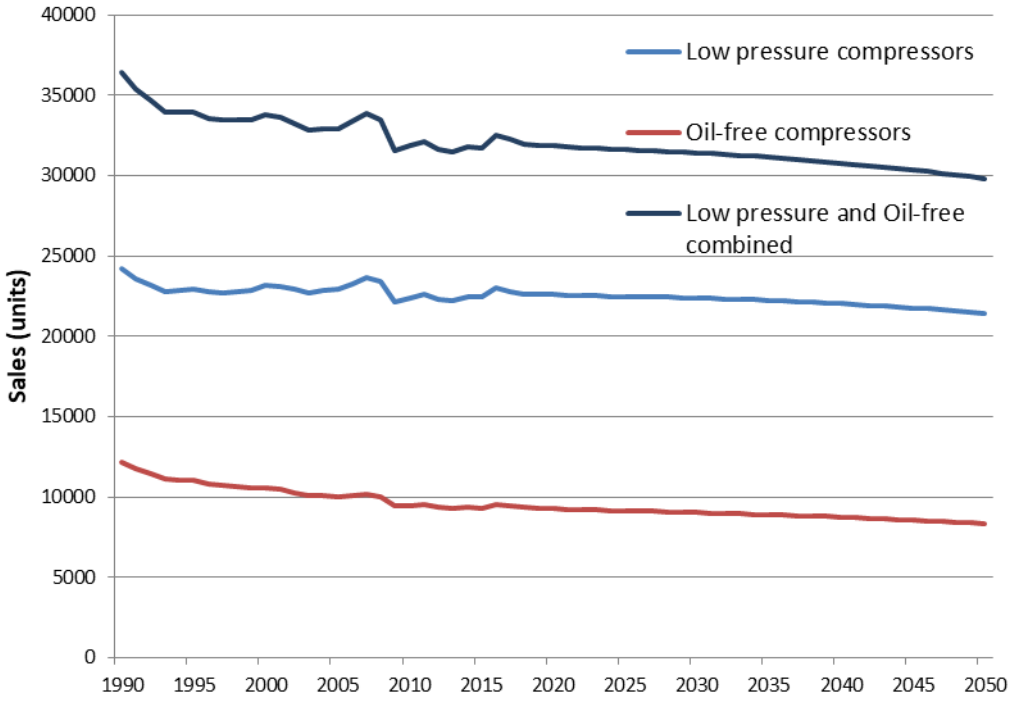
[12] The extended product approach considers that the ErP will be subject to various loads/user demands; the product scope extends to include controllability (flexibility and efficiency to react to different load situations, e.g. variable speed drive, 'inverter'), the quality of possible controls (sensors, actuators, central processing unit) and/or the quality of auxiliary devices that may or may not be part of the ErP as placed on the market (MEErP 2011 Methodology part 1l; Task 3.1)

The market significance (in sales and resulting stock, based on information in the preparatory study) of the products is shown below. Data are presented for the years 1990 to 2030.

Table 10 Sales of low pressure and oil-free compressor packages (in units per year)

Sales (#)	1990	2000	2010	2015	2020	2030
Low pressure compressor packages	24235	23198	22407	22497	22592	22387
Oil-free compressor packages	12202	10607	9486	9260	9270	9034
TOTALS	36437	33805	31893	31757	31862	31421

Figure 1 Sales of low pressure and oil-free compressor packages



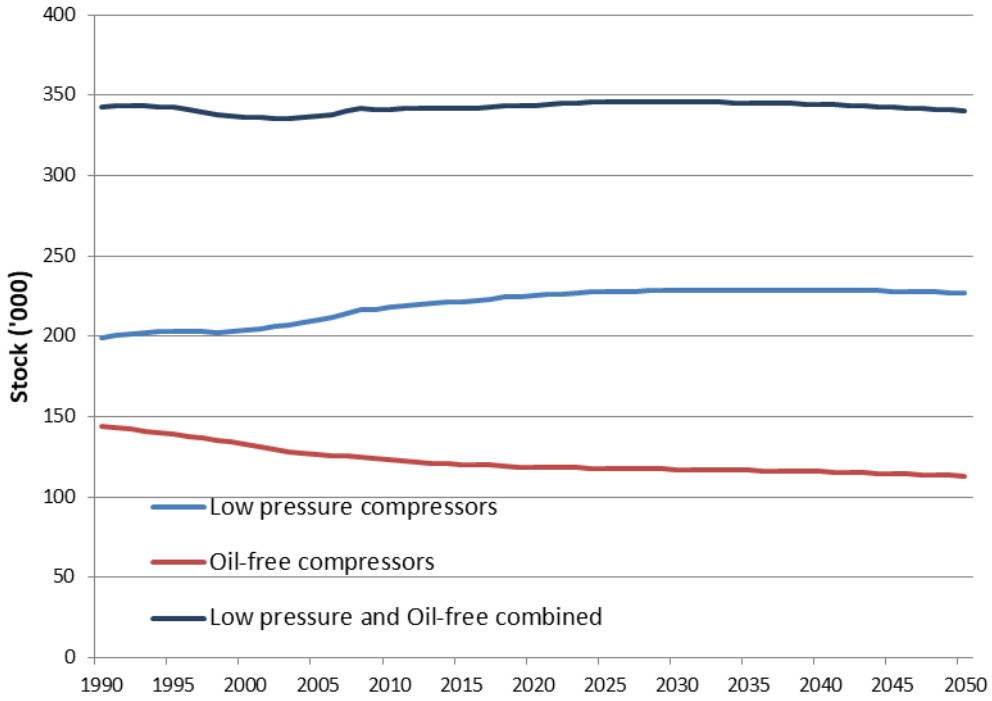
The data show overall sales of products in 2010 was some 31 893 units annually. Although this value does not meet the indicative sales threshold of 200 000 units/year indicated in Article 15.2.a of Directive 2009/125/EC, it is considered significant.

Table 11 Stock (installed base) of low pressure and oil-free compressor packages (in thousands of units)

Stock ('000)	1990	2000	2010	2015	2020	2030

Low pressure compressor packages	199	204	218	222	225	228
Oil-free compressor packages	144	133	123	120	118	117
TOTALS	343	336	341	342	344	346

Figure 2 Stock (installed base) of low pressure and oil-free compressor packages



Expenditure

The total annual expenditure for both groups of compressors is estimated to be some 7.5 billion euro in 2010, of which the energy costs make up over 90% of the total costs (i.e. approximately 7 billion euro).

Environmental significance

The preparatory study on low pressure and oil-free compressor packages concluded that the energy consumption during the use phase is the most significant environmental aspect, even if basic assumptions regarding electricity rates, purchase price and efficiency are changed. The conclusions are considered to be robust.

The analysis shows an annual electricity consumption of both low pressure and oil-free compressor packages in the EU of some 24 TWh/year in 2010. This electricity consumption is responsible for a combined greenhouse gas emission in 2010 of approximately 9.6 Mt CO_2-eq. If no specific measures are taken, the annual electricity consumption is predicted to be 27 TWh in 2020 and 29 TWh in 2030 corresponding with 10.3 Mt CO_2 in 2020 and 10 Mt CO_2 in 2030.

Note that the energy consumption of the installed stock is affected by both the number of units in stock and the average size (capacity) of the unit, which also has a relation to annual hours of operation and load factor. The annual greenhouse gas emissions are affected by both the annual energy consumption and the emission rates (kg of greenhouse gases emitted per kWh electricity consumed).

Improvement potential

In accordance with Annex II of Directive 2009/125/EC and Article 15.5(a-f) specific ecodesign requirements should be set at the level of least life cycle costs, but without entailing significant negative impacts on functionality, affordability, industry's competitiveness, proprietary technologies, etc.

The preparatory study identified improvement options for the energy performance of low pressure and oil-free compressor packages that would result in lower overall energy consumption and related emissions. This energy performance is expressed on the basis of the isentropic efficiency of the compressor package, weighted over multiple test conditions. The isentropic efficiency is the ratio of the theoretically required power to compress an ideal gas under constant entropy, from a given inlet pressure to a given discharge pressure, over the actual power absorbed by the unit for these conditions.

The study showed that there is disparity in the energy efficiency of compressors packages placed on the market, which means there is potential for improvement of average efficiency. Improving the energy efficiency has been proven to be cost-effective at product level, as the decrease in energy costs, makes up for the increase in purchase costs and results in lower life cycle costs.

But the data supplied to the study authors also showed that the products that make up the highest sales have very similar efficiencies. This means that in the case of minimum energy efficiency requirements, relatively small changes in requirements result in relatively large changes in number of products affected by this requirement.

Ecodesign requirements

The data available in the study allowed presenting the impacts of measures affecting approximately 10%, 25% and 40% of models on sale. The calculations show that a measure affecting 10% of sales resulted in energy savings of 0.08 TWh/a in 2030, and similarly a 20% share of effected sales saved 0.24 TWh/a in 2030 and a 40% share saved 0.35 TWh/a in 2030 when compared to a business-as-usual scenario. The energy savings in 2030, expressed as percentage of energy used in a business-as-usual scenario (without measures), range from 0.3% for the scenario "10% sales affected' to 0.8% and 1.2% respectively for "25%" and "40% sales affected".

The implementation of measures is however not straightforward. As no parametric equation to satisfactorily express the energy efficiencies of packages in scope could be established, the study presented average efficiencies in a table with discharge pressure and volume flow rate in rows and columns. Each individual cell in that table could then present a target efficiency for products characterised by that segment of the operating range. However, in case of insufficient data (such as a lack of market demand and market supply of compressors operating in a certain performance segments, or because of a limited number of manufacturers offering products in such segments) certain cells remained empty.

Furthermore, where such information was sufficiently available, calculating the actual target efficiency for a specific operating segment (combination of discharge pressure and volume flow rate) required elaborate bilinear inter- or extrapolations of target efficiencies, to be performed by the manufacturer/supplier.

On the basis of the above and the comments by stakeholders made during the study, the Commission Services decided not to propose minimum energy efficiency requirements for the following reasons: The energy savings are modest and larger savings by more stringent requirements will result in larger impacts on industries involved. Combined with the elaborate calculation required for showing compliance with target efficiencies, and the uncertainty in dealing with products operating in a performance range for which no average efficiency and target efficiencies could be established, makes setting minimum energy efficiency requirements a less attractive option.

In addition, the study also presented the effects and impacts of a measure aimed at increasing the use of packages that can supply a variable flow independent of discharge pressure ("VSD scenario") by 10% [13], and a measure aiming at increased recovery of (waste) heat recovery in the stock of 20% ("heat recovery scenario").

The possible measure related to increased use of variable flow control devices should primarily be based on increasing customer awareness regarding their actual demand for flow, at a certain pressure, over time. Savings can be achieved if indeed the correct compressor package is specified for a specific air demand profile. It is expected that certain fixed speed compressors are operating in a variable flow demand environment and would benefit from smarter flow control devices, rather than throttling the output or applying frequent blow-offs.

The possible measure related to increased use of heat recovery also aims at increasing awareness of customers, but also lays down minimal technical requirements for certain types of packages, to lower the real or perceived thresholds for customers to apply heat recovery.

The VSD scenario was calculated to save 0.5 TWh/a in 2030 or 1.6%. The heat recovery scenario results in 2.2 TWh/a savings in 2030 or 7.6%.

Energy audits (EMAS), awareness raising campaigns, and educational initiatives are considered more appropriate than ecodesign to achieve the savings related to use of variable flow devices and heat recovery.

The Commission does propose to introduce mandatory information requirements so that the performance of products representing different technologies can more easily be compared as the test conditions and equations for calculating efficiencies are harmonised. This is considered a major step forward as until now, such a direct comparison was not possible. The information requirements are in essence fairly similar to voluntary certification schemes operating elsewhere in the world (CAGI in the USA). The product information requirements extend to resource efficiency aspects (by requiring information on presence of permanent magnetic material, containing critical raw materials) and by emphasising the benefits of heat recovery.

Energy labelling requirements are not proposed as the study did not conclude that this would lead to greater savings. Most if not all products are configured to the precise needs of customers and the harmonisation of information already helps in identifying more efficient products. Furthermore, the technical elaboration of a labelling scheme would be challenging considering that the efficiency depends on two dimensions (pressure and flow rate) and the labels would

[13] For packages based on positive displacement compressors this is mainly through speed control (Variable Speed Drive), for packages based on turbocompressors this is could be (a combination of) inlet guide vanes, throttling and/or speed control.

then need to be expressed using the table (matrix) of pressure / flow rate combinations, with different minimum and maximum efficiency values per table cell, and thus different label steps.

Time of implementation

The proposed dates of implementation of information requirements are 2022, allowing a 2 year period for changing product databases, brochures and websites.

The technical requirements related to use of heat recovery may be implemented by 2022 as well as these do not require profound changes to the products.

Consistency with other policies and objectives of the Union

The Ecodesign Framework Directive 2009/125/EC has been and still is an important instrument for achieving the objective Commission's Communication on Energy 2020 and Energy Efficiency Plan 2011 stating a goal of 20 % energy savings and greenhouse gas reductions compared with projections for 2020, and its implementation was one of the priorities in the.

As part of its long-term energy strategy, the EU has set targets for 2020 and 2030. These cover emissions reduction, improved energy efficiency, and an increased share of renewables in the EU's energy mix. It has also created an Energy Roadmap for 2050, in order to achieve its goal of reducing greenhouse gas emissions by 80-95%, when compared to 1990 levels, by 2050.

The proposed Regulation is a concrete contribution to this process and is in line with the goals set out in the Better Regulation Communication (COM(2016) 615) final to ensure the proposal respects the principles of subsidiarity (no EU intervention when an issue can be dealt with effectively by EU countries) and proportionality (EU action must not exceed what is necessary to achieve the objectives).

Existing legislation

The product groups low pressure compressor packages and oil-free compressor packages are currently not subject to product-specific EU environmental legislation. EU legislation in the field of product safety, both mechanical and electrical, applies.

Electric and mechanical safety (including operation in dangerous environments or handling of hazardous gases) of electric compressors is addressed by (not exhaustive):

- LVD - Low Voltage Directive 2006/95/EC;
- MD - Machinery Safety Directive No 2006/42/EC;
- PED - Pressure Equipment Directive 97/23/EC ;
- Simple Pressure Vessels Directive (87/404/EEC);
- ATEX Directive 94/9/EC
- EMC Directive 2004/108

The environmental performance of certain parts and components used in low pressure compressor packages and oil-free compressor packages may be covered by:

- Electric Motors Regulation 640/2009;

– Fan Regulation 327/2011;

Certain environmental impacts are addressed by

– WEEE 2012/19/EU as electric driven compressors meet the generic definition of 'electrical and electronic equipment' or 'EEE' referred to in the RoHS Directive 2011/65/EU as it means equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1000 volts for alternating current and 1500 volts for direct current.

The (recast of) the RoHS Directive 2011/65/EC excludes large scale fixed installations from its scope (article 2, 4, b) which are defined as:

large scale fixed installation' means a large scale combination of several types of apparatus and, where applicable, other devices, which are assembled and installed by professionals, intended to be used permanently in a pre-defined and dedicated location, and de-installed by professionals; (article 3.4)

This 'large-scale' definition likely covers most commercial and industrial applications of compressors, except the smallest ones, where - for instance- a pressure vessel is part of the package and the required connections are simple to perform. This latter description would fit maybe the smallest products in the scope of the proposed regulation.

The use of electric compressors may also be affected by measures that impact the application at site or plant-level, such as introduced under:

– The IED - Industrial Emissions Directive 2010/75/EC.

Legislation in third countries

China

The preparatory study showed that China has introduced mandatory and voluntary measures for air compressors. The requirements for air compressors relate to minimum efficiency and labelling requirements for various types of reciprocating, screw and vane compressors intended for various applications, some of which are identified as 'oil-free' and therefore at least partially overlap with the scope of the proposed regulation. However, the Chinese authorities have not yet introduced measures for turbo-machinery (that also belong to the group low pressure and oil-free compressors), nor are there indications they will do so in the near future.

USA

During the course of the preparatory study electric compressors have been investigated by the US Department of Energy (DOE). The first draft of DOE's study recommended regulating standard air and oil-free compressors, in a performance range that partially overlapped the 'low pressure' range as defined in the EU proposal. A second draft removed possible requirements for oil-free compressors and low pressure compressors and focused on standard-air compressors only.

However, a policy change introduced by the current president of the United States of America halted the policy process for regulating energy efficiency of compressors, and it is not known if or when it will be revived.

Mexico

In Mexico a voluntary endorsement label scheme exists for air compressors.

CONSULTATION OF INTERESTED PARTIES

Consultation methods, main sectors targeted and general profile of respondents

Stakeholders, such as (but not limited to) the relevant industries, non-governmental organisations, experts from Member States and Europe Standardisation Organisations, were consulted as part of the preparatory study as well as within the Ecodesign Consultation Forum. A publicly accessible website was set up to disseminate the interim and final study results and to provide a means for feedback from stakeholders to study authors.

Meetings with stakeholders were held on 26 April 2016 and 6 March 2017 within the context of the preparatory study. The Consultation Forum (CF) meeting is held on [date].

Building on the results of the preparatory study, Commission services presented a working document (WD) which included:

1. Information requirements
2. Requirements to foster the application of heat recovery
3. Requirements related to material efficiency

The WD was sent to the members of the Consultation Forum and was published on DG ENER's ecodesign website and placed on the Commission's CIRCA port alongside the stakeholder comments received in writing before the meeting.

Summary of responses and how they have been taken into account

[to complete after the Consultation Forum Meeting]

Collection and use of expertise

Scientific/expertise domains concerned

External expertise was gathered through the preparatory study providing a technical, environmental and economic analysis, carried out by an external consultant on behalf of DG ENER .

Methodology used

The methodology followed the provisions of the Directive, in particular its Article 15 and Annexes I and II. The technical, environmental and economic analysis followed the structure of the 'Methodology Study Ecodesign of Energy-using Products' developed for the Commission's Directorate General for Enterprise and Industry and endorsed by stakeholders.[14]

Main organisations/experts consulted

[14] The terms of references requested the use of the MEErP Methodology.

The preparatory study was conducted in an open process, taking into account input (where available) from relevant stakeholders including experts from manufacturers and their association, environmental NGOs, consumer organisations, EU/EEA Member State experts and experts from third countries.

LEGAL ELEMENTS OF THE PROPOSAL

Summary of the proposed action

1. Definition of the scope of the proposed Regulation

The scope of the proposed ecodesign Regulation covers low pressure compressor packages with an inlet volume flow rate between 1 to 4150 l/s and oil-free compressor packages with an inlet volume flow rate between 1 to 3500 l/s, when providing the maximum volume flow rate at average pressure.

2. Staged implementation of ecodesign requirements

The proposed measure would enter into force in a single tier 2022, to allow time for manufacturers to change their product databases, brochures and websites and perform product tests if needed.

3. Measurements and calculations

Measurements and calculations of the relevant product parameters should be performed taking into account the generally recognised state-of-the-art calculation and measurement methods.

In this context, manufacturers may apply reliable, accurate and reproducible measurement and calculation methods and harmonised standards set up in accordance with Article 10 of Directive 2009/125/EC, as soon as they are made available and published for that purpose in the Official Journal of the European Union.

Requirements for calculation and measurement methods are specified in Annex III.

The measurement standards applicable to compressors covered by the proposed measure are ISO 1217 and ISO 5809. There are currently no EN versions of these standards.

4. Conformity assessment procedures

As required in Article 8 of Directive 2009/125/EC the proposed Regulation specifies the applicable conformity assessment procedures.

5. 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 initially test a single model. If this model is produced in quantities of 5 or less units per year, this model must meet the requirements or else is considered to be non-compliant. If the model is produced in quantities of more than 5 units annually and fails the initial test, a further three units shall be tested and

the arithmetical mean of the results of these tests shall be used as basis for compliance assessment. The Member States authorities shall apply verification tolerances as defined in the proposed text.

6. Information requirements

In order to facilitate compliance checks, manufacturers are requested to provide information in the technical documentation referred to in the conformity assessment procedures.

7. Benchmarks

Based on the currently available technologies, benchmarks for energy efficiency are provided for best performing products. These benchmarks are based on the average isentropic efficiency, varying per product flow control category pressure level and flow rate (V_1) and the proportional loss factor (d) as established in the preparatory study to be used to calculate the benchmark efficiency.

8. Date for evaluation and possible revision

The main issues for a possible revision of the proposed Regulation are:

- the appropriateness of setting ecodesign requirements for energy efficiency;
- the appropriateness of widening or more exactly specifying the scope of products and/or its exclusions;
- the appropriateness of modifying the information requirements;

Taking into account the time needed by manufacturers to adapt to the new situation and the time needed to collect, analyse and complement the data in order to properly assess the technological progress on compressors, a review can be presented to the Consultation Forum five years after entry into force of the proposed Regulation.

9. Derogation

[-]

10. Repeal

[-]

Legal basis

The proposed Regulation is an implementing measure pursuant to Directive 2009/125/EC, in particular its Article 15(1). The Directive was based on Article 95 of the Treaty, now Article 114 (TFEU).

Subsidiarity principle

The adoption of ecodesign measures for compressors by individual Member States would lead to obstacles to the free movement of goods within the Community. Such measures must therefore have the same content throughout the Community. In line with the principle of subsidiarity, it is thus appropriate for the measure in question to be adopted at EU level.

Proportionality principle

In accordance with the principle of proportionality, this measure does not go beyond what is necessary in order to achieve the objective. It offers requirements which act as an incentive for technology leaders to invest in high-efficiency compressor technology. Higher savings can only be obtained with considerable impacts on manufacturers and customers.

Choice of instruments

Proposed instrument: Regulation.

Other means would not be adequate for the following reason(s): The proposed form of action is a Commission Regulation implementing Directive 2009/125/EC, because the objectives of the action can be achieved most efficiently by fully harmonized requirements throughout the EU (including the date for entry into force), thus ensuring the free movement of complying compressors. No costs arise for national administrations for transposition into national legislation.

BUDGETARY IMPLICATION

The proposal has no implications for the Community budget.

ADDITIONAL INFORMATION

Review/revision/sunset clause

The proposal includes a review clause.

European Economic Area

The proposed act concerns an EEA matter and should therefore extend to the European Economic Area.