AN INITIAL ASSESSMENT OF THE CHANGES THAT WILL APPEAR IN A FORTHCOMING (2012) REVISION OF EN 12101-3

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SUMMARY

The standard EN12101-3:2002 defines the design criteria and testing methodologies necessary to verify that powered ventilators (fans) are capable of extracting smoke and hot gasses in the event of fire. This paper presents an initial assessment of the changes that will appear in the forthcoming (2012) revision of the standard EN 12101-3. The practical implications of the changes are considered for notified laboratories, fan and motor manufacturers. In so doing the paper clarifies the impact of the forthcoming revision.

INTRODUCTION

The standard EN12101-3:2002 was developed in response to a mandate from the European Commission, and enables emergency smoke control fans be tested and certified in accordance with the Construction Products Directive's conformance requirements for Fire Safety equipment. Not long after the official publication of EN12101-3, a working group was convened in May 2004 to review the standard. It had been noted that French and German translations were not always faithful to the original English text. Additionally, as the standard was being applied, technical problems, omissions and ambiguities became apparent. There was insufficient information for manufacturers and assessors regarding factory production control requirements and insufficient guidance given to test laboratories on test setups for various fan types and applications. The standard provided no practical information on the assessment of "minor changes" to approved products, making it difficult for test laboratories to decide if changes were "minor", with no re-test required or "major", with additional testing needed, to approve the change.

The working group was not convened to tighten certification requirements. The revision is intended to provide clarification and additional information that will ensure the uniform application of the standard by test laboratories throughout Europe and fully satisfy the requirements of the European Commission's mandate. The revision will significantly expand the guidance on the correct approach

to factory production control for assessors, fan manufacturers and motor manufactures. Many technical issues and assessment procedures are addressed, including new items such as the setting up and testing of fans with Variable Speed Drives and Soft Starters.

The European Standard EN 12101-3 is part of the package of thirteen EN 12101 Standards covering smoke and heat control systems. It has been prepared under a mandate given to the European Committee for Standardisation (CEN) by the European Commission and the European Free Trade Association and supports the requirements of EU Directives. As such, this European Standard is bound to be implemented by Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom. Furthermore, the main text of EN 12101-3 has been adopted by agreement into International Standard ISO 21927-3.

The revised standard will bear the full title "Smoke and heat control systems – Part 3: Specification for powered smoke and heat control ventilators (Fans)". This, in itself, is a change from the title of the published document. The term "control" has replaced "exhaust" to better reflect the revised scope of the standard and the word "fans" is added in parenthesis for clarification and to aid correct translation into other languages.

This Standard specifies the performance requirements of powered smoke and heat control (PSHC) ventilators (fans) put on the market and for which the main intended use is to be installed as part of a powered smoke and heat control ventilation system. It provides a procedure for approving a range of fans and their motors, from a minimum number of tests.

It specifies the levels of the performance related to the temperature/time characteristics, measured according to the corresponding test methods included in the standard. It provides for the evaluation of conformity of the product to the requirements of the standard.

EN 12101-3 applies to the following:

- series produced fans for smoke and heat control ventilation;
- impulse/jet fans for smoke and heat control ventilation;
- non-series produced fans for smoke and heat control ventilation.

Section 3 of the standard, "Definitions" has been re-drafted to provide for greater clarity and alignment with terms and definitions used in other industry European and International Standards.

The remainder of the standard has been significantly re-drafted in places to provide test laboratories, assessment bodies and manufacturers with more detail and clearer guidance, and re-ordered to comply with CEN requirements for harmonised standards.

REQUIREMENTS OF THE STANDARD (SECTION 4)

Section 4 begins by identifying the activation conditions for an emergency smoke and heat control fan. A fan may be required for "emergency only" use when it must move from a stationary condition to rated rotational speed, whereas a "dual purpose" fan shall move from any operating speed to rated speed. If a roof or wall mounted fan is fitted with shutters, flaps or louvers, they shall open in less than 60 seconds against an applied wind or snow load.

For the purpose of operational reliability, a fan must be classified into one or more application classes. The list has been expanded and clarified as follows:

- thermally insulated or uninsulated.
- installation in the smoke reservoir.

- installation outside smoke reservoir.
- horizontal or vertical direction of motor shaft.
- rear, side, top or bottom inlet application, i.e. motor exposure depending on the air stream.
- with frequency converter in the test conditions (converter type, cable, filter, inverter parameters) or voltage converters (in the test conditions).
- dual purpose or emergency only use.
- ducted cooling air required.

The requirements for electric motor rating and specification are clarified but remain essentially unchanged. Motor rating shall be limited by the temperature rise for one class lower than the insulation class of the motor. However, a new requirement for Motor Evaluation is added. The compliance of a motor for installation within a smoke control fan shall be demonstrated by a Factory Production Control by the manufacturer, evaluated by an independent Notified Body according to the provisions of the standard. The proposed method is as follows:

For Initial Type Testing (I.T.T.) of a motor to be installed within PSHC fans, tests shall be carried out in accordance with annexes A, B, C of EN 12101-3. For each test, a test report shall be prepared in accordance with annex C or D.

The ongoing compliance of a motor for installation within a smoke control fan with the requirements of this standard shall be demonstrated by a factory production control by the manufacturer, evaluated by a body notified according to this standard according to the following rules.

1. The motor manufacturer selects a body notified for inspection and, if necessary, a body notified for tests.
2. Only the selected inspection body performs the assessment of the FPC by the motor manufacturer and writes a “harmonized” inspection report at least in English language.
3. The motor manufacturer can then transmit the inspection report to all customers which are fan manufacturers, or directly to the notified test authority of the customer for confidentiality reasons.
4. If the motor manufacturer shall change or wants to change some element of design or construction, he must inform the selected test laboratory which will perform, if required by the rules indicated in the standard, additional test(s). Then the test report (also written in English) is provided by the motor manufacturer to the inspection body so that he can note these change in the inspection report.

Section 4 goes on to identify the requirements for effective smoke / hot gas control by a fan that must be demonstrated by the testing and assessment methods which are to be found in section 5. These include:

- Maintenance of volume flow or static pressure differential.
- The ability of the fan to start under fire conditions.
- Limitation of outer surface temperature or cooling air discharge temperature of thermally insulated fans.
- Smoke leakage and mechanical stability parameters.
- Ability of shutters, dampers, etc. to open under environmental conditions such as wind and snow.

- Response delay time of shutters, dampers, etc.

TESTING, ASSESSMENT AND SAMPLING METHODS (SECTION 5)

Clause 5.1 begins by stating that tests shall be carried out and reports prepared in accordance with the appropriate annexes A, B, C, D and E.

Various ancillary items may "approved" for use with a PSHC fan. This often means that the ancillary item needs to be tested together with a fan. A fan can be tested completely assembled with ancillaries for instance:

- flexible connection elements;
- anchors;
- airflow operated dampers or external powered dampers;
- shock absorber;
- sound absorber;
- support construction e.g. for powered roof or wall ventilators partition fans;
- thermal protection (e.g. PTC thermistor, Thermocouple, Pt100…);
- ON-OFF switch directly mounted on the fan and other electrical ancillaries (for example electrical safety box….);
- guide vanes;
- flow deflectors.
- A jet fan shall be tested completely assembled and suspended from a supporting construction in accordance with the manufacturer's installation instruction.

Clause 5.2 defines Performance Requirements, beginning with the Temperature/Time classification assessment. For EC certification of conformity, a PSHC fan shall be tested for one of the classes identified in Table 2 of the standard, reproduced as Table 1, below.

Table 1 — Test temperature and functioning time according to classification

Class	**Temperature** °C	**Minimum functioning period** min
F_{200}	200	120
F_{300}	300	60
F_{400} (120)	400	120
F_{400} (90)	400	90
F_{600}	600	60
F_{842}	842	30

For other types of assessment a fan can be tested for another temperature and/or time following Table 2 (e.g. 500°C/ 120 min), but this cannot lead to EC certification of conformity for this different combination (in the above example, EC certification of conformity class is F400 (120) as its level is Ff 500 (120)).

Table 2 — Test temperature and functioning time

Example of free classes	Temperature °C	Minimum functioning period min
Ff_{250} (120)	250	120
Ff_{300} (120)	300	120
Ff_{θ} (A)	θ	A

At the appropriate temperature given in the above tables, a fan shall function for not less than the appropriate minimum time, and shall re-start

- after 30 min of working at high temperature and the 2 min break for F842 class;
- and after 15 min of working at high temperature and the 2 min break for other classes,

when tested in accordance with annex C.

During the test, the volume flow shall not decrease by more than 10 % and not increase by more than 25%, or the static pressure difference (corrected for the effects of density due to temperature change) shall not decrease by more than 20 % and not increase by more than 50% of that measured at ambient temperature at the start of the test.

Outer surface temperature of, or cooling air discharge from, an insulated fan shall not increase by more than 180 K from the original room value. Information is provided on the correct location and number of thermocouples required for the test.

Further information is provided on the assessment and specification of equipment that may be subject to wind or snow loads and, finally in this section, requirements for the evaluation of a fan designed to be fitted with a duct for cooling air are identified.

EVALUATION OF CONFORMITY (SECTION 6)

This section of the standard revision represents a significant change from the equivalent parts of the published version and contains considerably more detail than before. The text is largely based on a format approved by CEN for use in the majority of product standards in the EN 12101 series. It is, by nature, prescriptive and mainly states what must be done rather than how to do it.

The compliance of a PSHC (fan) with the requirements of the standard and with the declared values (including classes) shall be demonstrated by:

- Initial Type Testing,
- factory production control by the fan manufacturer, including product assessment of the complete assembled PSHC fan,
- factory production control by the motor manufacturer.

The fan manufacturer shall always retain the overall control and shall have the necessary means to take responsibility for the product.

Initial Type Testing (ITT)

In general, all essential characteristics, for which the manufacturer declares performances, are subject to Initial Type Testing. Tests previously performed in accordance with the provisions of the standard, may be taken into account provided that they were made to the same or a more rigorous test method by an independent third party, under the responsibility of a product certification body. In addition, Type Tests or Initial Type Testing shall be performed for all characteristics included in the standard for which the manufacturer declares performances:

- at the beginning of the production of a new or modified PSHC fan; or
- at the beginning of a new or modified method of production (where this may affect the stated properties).

They shall be repeated for the appropriate characteristic(s), whenever a change occurs in the PSHC fan design, in the raw material or in the supplier of the components, or in the production process which would affect significantly one or more of the characteristics. Where components are used whose characteristics have already been determined, by the component manufacturer, on the basis of compliance with other product standards, these characteristics need not be re-assessed. The specifications of these components shall be documented.

Products marked in accordance with appropriate harmonized European specifications may be presumed to have the performances stated with that marking, although this does not replace the responsibility on the PSHC fan designer to ensure that the fan as a whole is correctly designed and its component products have the necessary performance values to meet the design.

All Type Tests and their results shall be documented in test reports to be retained by the manufacturer for at least 10 years after the last date of production of the fan to which they relate.

Factory Production Control (FPC)

This part is effectively an instruction manual on FPC for both the manufacturer and the FPC assessor. Although manufacturers having an FPC system which complies with the appropriate ISO 9000 series standard and which clearly addresses the requirements of EN 12101-3 are recognised as satisfying the requirements of the Council Directive 89/106/EEC, this section goes into considerable detail. It begins by clearly defining tasks and responsibilities, and stresses the importance of properly maintained documentation and the competencies of personnel.

Areas covered include equipment used for measuring and testing, equipment employed in the manufacturing process, control and inspection of raw materials and components, the design process, traceability and marking, controls during the manufacturing process and procedures for product testing and evaluation.

Three tables list the characteristics and means of control of materials, production and product conformity. The FPC of motor manufacturers is dealt with separately.

The fan Manufacturer shall also have documented procedures which specify how to deal with non-complying products, corrective actions and the handling, storage and packaging of products (with suitable storage areas preventing damage or deterioration.

The text then emphasises that the FPC system must address the product specific requirements of EN 12101-3, in effect introducing a specific FPC to be included with the manufacturer’s FPC system.

Two clauses provide instruction to assessors. The first states how they must conduct and document an initial inspection of a factory and FPC, and the second deals with the subject of continuous (once a year) surveillance.

Section 6 continues with some brief statements on how to deal with modifications to the product, the production process, or to the FPC system itself. It then concludes with specific instructions on the application of assessment and an FPC system to one-off products, pre-production products (e.g. prototypes) and products produced in very low quantity.

CLASSIFICATION AND DESIGNATION (SECTION 7)

This is a short clause which simply re-lists the temperature/time (F) classifications for EC conformity.

MARKING (SECTION 8)

This is simply a list of the information that must appear on the PSHC fan to provide evidence of conformity, traceability and essential details for correct application and installation of the product.

PRODUCT, INSTALLATION AND MAINTENANCE INFORMATION (SECTION 9)

The section is subdivided into 3 brief clauses that define sets of documentation which must be provided by the manufacturer.

- Product specification.
- Installation information.
- Maintenance information.

The instructions are basic, leaving the manufacturer to provide “appropriate” detail.

NORMATIVE ANNEXES.

Annex A. Type approval schedule for a range of ventilators

For the purpose of type approval it is not usually considered necessary to test every size of fan in a product range. The number of Initial Type Tests for PSHC fans can be significantly reduced provided that the following are tested:

- the ventilator with the most highly stressed impeller, and the ventilators with impellers in which the individual stress in any component, weld or fastening is the highest, as appropriate, if not the same;
- for ventilators with motors mounted in an enclosure which restricts the cooling, the worst case shall be tested; this is the fan with the smallest free area of the motor enclosure or the smallest section of exit or entry airway for cooling air;
- at least two sizes are tested at their highest rotational speed;
- the ventilator with the smallest motor frame size to be used, except for fans where the impeller is not mounted on the motor shaft and the motors are out of the airstream in ambient air and the cooling of the motor is not affected by heat transfer from the ventilator or the ventilator construction;

- if the highest impeller stress levels are determined by geometric similarity conditions, sufficient sizes of ventilators to ensure that the impeller diameters of the range are from 0,8 to 1,27 of those tested;
- if the highest impeller stress levels are determined by the calculation methods in this annex, sufficient sizes of ventilators to ensure that the impeller diameters of the range are from 0,63 to 1,27 of those tested;

NOTE: the coefficients are an approximation from Renard Series R20 in accordance with ISO 3. The aim of the coefficients 0,8 or 0,63 and 1,27 is to validate fans down to 2 or 4 sizes smaller and up to 2 sizes larger than those tested. Informative annex F contains more information.

- For a direct drive axial fan where the blade profile is not symmetrical and the fan may be supplied with motor upstream or motor downstream, the fan shall be tested with motor downstream. Experience, confirmed by measurements, has shown this to be the worst case.
- But if the fan range is intended to operate only with motor upstream, the tests can be performed in this configuration;
- If a fan or range of fans is intended for installation in either vertical or horizontal or intermediate positions, a minimum of one fan shall be tested in each of vertical (shaft down and motor downstream, or shaft up and motor upstream if the fan range is intended to work only with the motor upstream) and horizontal orientation;
- If a range of axial fans is also intended to be used for jet fan application, a minimum of one size of fan shall be tested in the jet fan configuration;
- A fan for use as a jet fan shall be tested completely assembled, with its ancillaries as listed in clause 4.1 if supplied with the jet fan. A test of the fan with only the inlet side silencer is allowed to qualify a jet fan, unless the jet fan is suspended by the silencers;
- For a reversible fan or jet fan, equipped with a symmetrical impeller (symmetrical blade profile or impeller with alternately orientated non-symmetrical blades) the test shall be performed with motor downstream.
- Any electrical device used in combination with the motor which could impact negatively the motor (change electrical signal, overheating…) shall be tested with the fan.
- Fan started by soft starter. Since the soft starter is bypassed just after the motor starting, it is not obligatory to test it, especially if the fan manufacturer wants to get both applications (with and without soft starter).
- Contra-rotating axial flow fan installation. Such installation does not require any additional test provided the individual fans are from a range tested with motor downstream.

Typically and by careful selection, it may be possible to qualify a comprehensive range of fans (e.g. axial flow fans from 315mm diameter to 1600mm diameter) from 3 ITTs.

This part of annex A also introduces the concept of approving PSHC fans for installation with electronic speed controllers such as Variable Frequency Drives (frequency converters) and provides some much needed rules which are further developed in following annexes.

The potential impacts of a frequency converter on a three-phase motor's winding insulation and bearings are briefly discussed. To approve a fan for operation via a PWM frequency converter at both ambient and at high temperature, it is possible to test a fan with a frequency converter (Pulse Width Modulation type) and some parameters to be measured and recorded are defined. A fan may be assumed to be able to withstand the same maximum peak to peak voltage values and rate of

voltage rise at the motor terminals in an installation as it did during the test, independent of the type or brand of PWM frequency converter being used.

If it is only intended that a fan be driven by a PWM frequency converter at ambient temperature, a fan tested direct-on-line can be installed with a frequency converter provided that the converter is by-passed during emergency smoke and heat exhausting operation.

Some small PSHC fans may be installed for operation with a voltage speed controller (voltage converter) at ambient temperature. Even though a voltage converter, or its voltage control circuitry, may be bypassed during smoke exhausting a motor which is supplied from a voltage converter may have experienced an increased temperature rise when run at a reduced voltage. Because of this effect inside the motor, a warm-up period of the test shall be performed with the output of the voltage converter set to run the motor at 70 % of nominal speed. The temperature rise of the motor during this warm up period shall not be greater than one class lower than the insulation class of motor.

Motor approval (A.2)

The next part of Annex A deals with the approval of motors. A fan range shall only be approved if the smallest and largest frame size motors used in the range are also tested within the fans, at their highest ratings (voltage, frequency, power, rotational speed…), except when the impeller is not mounted on the motor shaft, the motors are out of the air stream in ambient air and the cooling of the motor is not affected by heat transfer from the ventilator or the ventilator construction. When the motor is out of the air stream and the impeller is mounted on the motor shaft, motors from a different supplier to the one used in the fan test may be used, provided that the tested and alternative motors are of the same construction, i.e. same class of insulation and bearing type and class of fit and same synchronous speed and rating.

Section A.2 further develops the rules for approving and interchangeability of motors for various PSHC fan types and configurations. Illustrations are provided together with details of temperature measurements that may be taken to validate motor substitution, in some cases without the need for re-testing. For fans with the motor in the airstream without cooling (e.g. direct drive axial flow fans), motor interchangeability is only possible with motors already tested under specific conditions. Usually this will have been a re-testing of the fans with the alternative motors. Section A.3 develops this concept, providing rules to apply if a large motor range consists of two or more smaller homogeneous ranges.

Determination of highest stresses in impellers (A.4).

Here we are presented with rules and calculation methods for identifying the impellers in a fan range that must be tested because they are the most highly stressed or contain the most highly stressed component, weld or fixing. This section has been much improved and expanded, beginning with a comprehensive set of rules for assessing geometric similarity, followed by methods for calculating stresses in impellers that are not geometrically similar. Axial and centrifugal impellers are dealt with separately in both cases. The given calculation methods are for comparative (not design) purposes and only take into account centrifugally induced stresses as aerodynamically induced stresses are of less importance.

Assessment of changes after testing (A.5).

Only the body responsible for testing the product range may make these assessments and determine if further testing is necessary. For the assessment of motors of different construction of from a different supplier we are referred back to annex A.2. If changes are made to the materials used in fan impellers, then some high temperature comparative mechanical tests may be applicable as an

alternative to retesting the fan with the most highly stressed impeller. The basic rules are provided and we are referred to informative Annex F for more explanation.

Annex B. Type approval schedule for a product range of motors.

For the purpose of type approval it is not usually considered necessary to test every size and speed of motor to be used in a range of PSHC fans. Provided tests are carried out on the largest and smallest motor frame size at the highest ratings (i.e. highest voltage, frequency, rotational speed and power), it may be assumed that all the motors in a range will comply with the standard. In some instances and under defined conditions it is possible that testing of dual frequency motors at 50Hz will cover their application at 60Hz. However, limitations are imposed by the maximum speed and maximum power that were tested to approve the range at 50Hz.

Assessment of changes after testing (B.2).

The new section B.2 is greatly expanded and goes into considerable detail. As in annex A.5, the assessment shall be made by the body responsible for testing the product range. There is a great deal of emphasis given to the assessment of detail changes that may be introduced by a motor manufacturer and section B.2.2 contains tables and drawings which identify critical components in a motor, their "security level" and rules to be applied for approving change. Sometimes testing will not be necessary, sometimes one test will be required, sometimes both small and large motors must be retested to approve a motor range. Separate tables are provided for mechanical construction data, electrical and insulation data, and application related "variant acceptability. This last table includes the addition of various optional accessories such as temperature monitoring devices and anti-condensation heaters but also provides information on how a motor may be used with a frequency converter and various filters and de-rates if all ITTs were performed direct-on-line and no specific re-testing with a frequency converter is planned.

Section B.2 concludes with a detailed "Normative" listing of motor data and components. Tables are provided that list the information required from the motor manufacturer by the test laboratory when selecting the motor sizes to be tested or re-tested.

Annex C. Test method for performance of powered ventilators for smoke and heat controlling use.

Much of this Annex is essentially the same as in the published standard, with minor editing to avoid ambiguity and improve understanding. Fans may be tested inside a furnace, directly connected to a furnace or connected to a furnace (heat source) by a recirculating duct system. The details of the test set up may be determined by the intended application and classification of the PSHC fan. To qualify the motor, the fan must be configured so that at ambient temperature, it takes between 80% and 100% of the rated power. A new section has been added that provides information on running clearances and how to measure them.

Section C.4 defines the test procedure and section C.5 specifies the information that must be included in the individual fan test reports and in the additional report that is required to provide details of a complete product range that may be approved by a number of tests. New clauses have been drafted to provide means of evaluating the tip or running clearances of fans for different installation categories and for a range of fans qualified from a limited number of test fans.

Annex D. Test method for resistance to temperature of electric motors for use in powered ventilators

This somewhat controversial annex has been retained and expanded to provide means for proving the resistance to temperature of an electric motor by testing independently of a PSHC fan. It can no longer be used to gain qualification for motors intended to replace the motors already tested in fans, unless those motors are also tested in accordance with this annex to provide suitable data for comparison. A potentially valuable use for this annex is the approval of changes to motor design or materials of construction, again by comparative testing. This could obviate the need for re-testing motors with multiple fan manufacturers who are all customers of the same motor manufacturer.

Annex E. Test method for operation under load

The "load" in the title of this short annex is the wind load or snow load that might affect the satisfactory operation of a roof or wall mounted ventilator. Test apparatus and procedures are described and the pass criterion is identified.

INFORMATIVE ANNEX F. GENERAL GUIDANCE.

This is a new annex that contains explanatory notes which are intended to serve as guidance for the planning, performance and reporting of a fire resistance test carried out in conformity with EN 12101-3. Here we will also find information that explains the logic behind various clauses that have been included in the standard.

Subjects that are discussed in this annex include:

- Calculation of comparative blade stress in centrifugal impellers.
- Origin of the power coefficients used in Annex D to provide for a de-rate during a motor test.
- The parameters to be taken into consideration when a motor is driven from a frequency converter.
- The Renards series of preferred numbers.
- Guidance on evaluation of different bearing types.
- Changing the material of construction of a fan.

Informative Annex ZA

This is the final section of the standard which, in accordance with European Commission rules, identifies the clauses of EN 12101-3 which address the provisions of the European Construction Products Directive (89/106/EEC). The clauses of this standard shown in this annex meet the requirements of the mandate given under the EU Construction Products Directive. Compliance with these clauses confers a presumption of fitness of the powered smoke and heat control ventilator (fan) covered by this annex for its intended uses. The system of "attestation of conformity" is identified and the annex concludes with the instructions to the certification body for drawing up the EC certificate of conformity and the instructions to the fan manufacturer for CE Marking and labeling the PSHC fan.

CONCLUSIONS

The revision of EN 12101-3 is long overdue and answers many questions that have been raised by both manufacturers and test laboratories since the publication of the first edition of the standard. It has taken account of the wealth of experience gained in the testing of many fans and provides much information to laboratories on specific issues. Manufactures and assessors have firm guidance on the ongoing attestation of conformity of products through Factory Production Control. This revision should provide both suppliers and users with the confidence that compliant fans will operate satisfactorily in a fire emergency situation and make a valuable contribution towards the saving of lives.

NORMATIVE REFERENCES FROM EN 12101-3

[1] EN 1363: Fire resistance tests

[2] EN 1366: Fire resistance tests for service installations

[3] EN 60034-1: Rotating electrical machines, rating and performance

[4] EN 60034-17: Rotating electrical machines –Part 17: Cage induction motors when fed from converters - Application guide

[5] IEC/TC 60034-18-41: Rotating electrical machines –Part 18-41: Qualification and quality control tests for partial discharge free (Type I) electric insulation systems used in rotating electrical machines fed from voltage converters.

[6] EN 60085: Electric insulation – Thermal evaluation and designation.

[7] IEC/EN 60034-2: Methods for determining losses and efficiencies from test

[8] ISO 281: 1990: (Rolling bearings-Dynamic load ratings and rating life)

[9] ISO 281: Amendment 1 2000-02-15(Rolling bearings-Dynamic load ratings and rating life)

[10] ISO 281: Amendment 2 2000-02-15(Life modification factor α_{XYZ})

[11] ISO 834-1: Fire resistance tests. Elements of building construction — Part 1: General requirements for fire resistance testing

[12] EN ISO 5167: Measurement of fluid flow by means of pressure differential devices

[13] EN ISO 5801: Industrial fans, performance testing using standardized airways

[14] EN 12101-2: 2003-06: Smoke and heat control systems — Part 2: Specification for natural smoke and heat control ventilators

[15] EN 13501-4: Fire classification of construction products and building elements — Part 4: Classification using data from fire resistance tests on components of smoke control systems

[16] EN ISO 6892-1:Metallic materials. Tensile testing. Part 1: Method of test at room temperature

[17] EN ISO 6892-2:Metallic materials. Tensile testing. Part 2: Method of test at elevated temperature

[18] EN ISO 1009: Metallic materials. Fatigue testing. Axial force-controlled method

[19] EN ISO 204: Metallic materials. Uniaxial creep testing in tension. Method of test.

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[4] ISO 3: 1973, Preferred numbers — Series of preferred numbers

[5] EN ISO 9001, Quality management systems — Requirements (ISO 9001:2000)

[6] ASTM E1461: Standard test method for thermal diffusivity by the flash method

[7] ASTM E228: Standard test method for linear thermal expansion of solid materials with a Push-Rod Dilatometer

[8] UNE 400309:Pyknometers