

Australian Standard™

Environmental testing

Part 2.68: Tests—Test L: Dust and sand



This Australian Standard was prepared by Committee EL-026, Protective Enclosures and Environmental Testing for Electrical/Electronic Equipment. It was approved on behalf of the Council of Standards Australia on 23 October 2003 and published on 28 November 2003.

The following are represented on Committee EL-026:

Australian Chamber of Commerce and Industry
Australian Electrical and Electronic Manufacturer's Association
Electrical Compliance Testing Association
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This Standard was issued in draft form for comment as DR 03409.

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Part 2.68: Tests—Test L: Dust and sand

First published as AS 60068.2.68—2003.

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Published by Standards Australia International Ltd
GPO Box 5420, Sydney, NSW 2001, Australia

ISBN 0 7337 5609 3

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PREFACE

This Standard was prepared by the Standards Australia Committee EL-026, Protective Enclosures and Environmental Testing for Electrical/Electronic Equipment.

The objective of this Standard is to provide the electrotechnology industry with a complete set of environmental test procedures published as a series under AS 60068 *Environmental testing*. This Standard is Part 2.68 of that series.

This Standard is identical with, and has been reproduced from, IEC 60068-2-68:1994, *Environmental testing – Part 2-68: Tests—Test L: Dust and sand*.

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- *test specifications: in italic type;*
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CONTENTS

	<i>Page</i>
Introduction	iv
1 General	1
1.1 Scope	1
1.2 Description of test L	1
2 Normative references	2
3 Definitions	2
4 Test La: non-abrasive fine dust	3
4.1 Method La1: cyclic air pressure	3
4.2 Method La2: constant air pressure	6
4.3 Guidance for test La	9
5 Test Lb: free settling dust	17
5.1 Object	17
5.2 Method Lb	18
5.3 Guidance for test Lb	20
6 Test Lc: blown dust and sand	26
6.1 Method Lc1: recirculating chamber	26
6.2 Method Lc2: free blowing dust	31
6.3 Guidance for test Lc	34
Annex A (informative) General guidance	45
Annex B (informative) Bibliography	53

INTRODUCTION

The tests described in this part of IEC 60068-2 give information on effects for which the relevant specification may specify assessment criteria. Some of such effects are:

- a) ingress of dust into enclosures;
- b) change of electrical characteristics (for example, faulty contact, change of contact resistance, change of track resistance);
- c) seizure, or disturbance in motion of bearings, axles, shafts and other moving parts;
- d) surface abrasion (erosion);
- e) contamination of optical surfaces; contamination of lubricants;
- f) clogging of ventilating openings, bushings, pipes, filters, apertures necessary for operation etc.

Different tests have been specified to consider diversified aspects which may be used to verify constructional integrity of electrotechnical products or to simulate the conditions of operation in service.

The tests differ by the character of the air flow carrying the particulate matter, and by the type of such matter, resulting in a special methodology for each test.

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Australian Standard
Environmental testing**Part 2.68: Tests—Test L: Dust and sand**

1 General

This survey indicates the general structure of the dust/sand tests included in this publication. The structuring and a summary of the characteristics of the different tests are given in figure 1 and table 1. It should be noted that the dust test of IEC 60529 has its equivalent in the proposed method La2. See also annex A.

1.1 Scope

This part of IEC 60068-2 specifies test methods to determine the effects of dust and sand suspended in air, on electrotechnical products.

The test methods of this standard are not intended for the testing of air filters. Only method Lc2 is suitable for the simulation of the erosion effects of high velocity (more than 100 m/s) particles.

1.2 Description of test L

The dust and sand test is structured into three groups:

- La: *non-abrasive fine dust*. A test which is primarily oriented towards investigation of the seals of the test specimen. The test specimen is exposed to a very fine dust in the form of talc or an equivalent. The effects of temperature cycling resulting in a pressure difference between the inside and outside of the specimen may be reproduced.
- Lb: *free settling dust*. A test which is oriented towards investigation of the effects when simulating conditions at sheltered locations. The test specimen is exposed to a low-density dust atmosphere created by the intermittent injection of a small quantity of dust which is allowed to fall by gravity onto the specimen.
- Lc: *blown dust and sand*. A test which is oriented towards investigation of the seals and the effect of erosion when simulating outdoor and vehicle conditions. The test specimen is exposed to either a turbulent or a laminar air flow to which is added a quantity of dust, sand or a dust/sand mixture.

Table 1 – Summary of test characteristics

Procedure	Dust/sand type	Particle size	Dust/sand concentration	Notes
Test La				
Method La1	Talc or FE powder	<75 µm	600 g/m ² /h (grams per square metre per hour) deposit on reference surface	Test includes a cycling of the air pressure in the chamber
Method La2	Talc or FE powder	<75 µm	2 kg/m ³ (chamber volume)	Air pressure in the specimen may be reduced
Test Lb	Olivine or quartz or feldspar	<75 µm	6 g/m ² /d (grams per square metre per day) deposit on reference surface	Free settling dust
Test Lc				
Method Lc1	Olivine or quartz or feldspar	<75 µm or <150 µm or <850 µm	1 g/m ³ or 3 g/m ³ or 10 g/m ³	Blown dust and sand Recirculating chamber
Method Lc2	Olivine or quartz or feldspar	<75 µm or <150 µm or <850 µm	1 g/m ³ or 3 g/m ³ or 10 g/m ³	Free blowing dust

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60068-2. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 60068-2 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60529: 1989, *Degrees of protection provided by enclosures (IP code)*

IEC 60721-2-5: 1991, *Classification of environmental conditions – Part 2: Environmental conditions appearing in nature – Section 5: Dust, sand, salt mist*

3 Definitions

For the purpose of this part of IEC 60068-2 the following definitions apply.

3.1 dust: Particulate matter of unspecified origin or composition whose size ranges from 1 µm to 150 µm (see note to 3.7).

3.2 dust concentration: Total mass of dust particles per unit volume of air.

3.3 humidity: Relative humidity is defined as the ratio of the actual vapour pressure in the air at any temperature to the maximum of saturation vapour pressure at the same temperature.

3.4 hygroscopic: Having a tendency to absorb moisture.

3.5 particle size: General dimension of the dust and sand particles based on the premise that the particles are spheres; commonly measured by sieving, by calculating settling velocities, or by determining areas of microscopic images.

3.6 sand: Grains vary from spherical to angular whose size lies between 100 µm and 2 000 µm, but for environmental testing, the range is usually restricted from 150 µm to 850 µm (see note to 3.7).

3.7 sieve (square-meshed): Intended for the particle size analysis of the material to be sieved, which conforms to a test sieve standard specification.

NOTE – In test Lc of this standard the word “dust” has been used to include “sand”.

4 Test La: non-abrasive fine dust

4.1 Method La1: cyclic air pressure

4.1.1 Object

The object of this test is to determine the degree of protection against ingress of fine dust into electrotechnical products.

4.1.2 General description

Method La1 is a dust test in which the specimen is exposed to a dust-laden air flow containing non-abrasive powder of particle size <75 µm (see 4.3). The test does not simulate natural or induced environments.

A vertical air flow downwards is specified for the test.

For enclosures of a specific category the pressure in the dust chamber is varied cyclically in order to encourage the ingress of powder.

4.1.3 Description of test apparatus

The test chamber shall expose the test specimen to a mainly vertical, non-laminar air flow containing a specified quantity of test dust. For this purpose, the test dust shall be agitated and blown into a sealed chamber. It shall be possible to cycle the chamber pressure as required by 4.1.4.6.

Dust settled in the base of the test chamber shall be brought back into circulation.

The volume of the specimen shall be no more than 25 % of the test chamber volume and its base shall be no more than 50 % of the horizontal working space surface of the test chamber.

If the size of the specimen does not comply with this standard, the relevant specification shall prescribe which of the following procedures shall be applied:

- a) testing of individually enclosed sections of the product;
- b) testing of representative parts of the product comprising components such as doors, ventilating openings, seats, shaft seals etc., with the delicate parts of the product such as terminals, collector rings etc., in position at the time of testing;
- c) testing of smaller products having the same design details as full-scale products.

An example of a suitable test apparatus is given in figure 3.

4.1.4 Test conditions

4.1.4.1 Test dust

The test dust consists of dry fine-granular non-abrasive powder which shall be able to pass through a square-meshed sieve with a nominal wire diameter of 50 µm and a nominal width between wires of 75 µm.

Talc can be used for this test as analysis shows that it meets these requirements (see 4.3.4.2).

The test dust shall not be used for more than 20 tests. Care should be taken to keep the powder dry to maintain its fine granularity. It shall be dried by heating for 2 h at +80 °C before use.

4.1.4.2 Dust concentration

The quantity of test dust used for the test shall be sufficient to obtain a uniform deposition on the reference surface in the chamber of (600 ± 200) g/m²/h.

4.1.4.3 Air flow

The air flow in the test chamber shall be mainly vertical from top to bottom and it should not be laminar.

4.1.4.4 Air velocity

The air velocity shall give the possibility to generate a homogeneous distribution of the dust in the test chamber.

4.1.4.5 Humidity

The relative humidity in the test chamber shall be less than 25 %. This may be achieved by raising the test chamber air temperature (see clause A.3).

4.1.4.6 Air pressure in the specimen

Depending on the operating conditions there are two different categories of specimen enclosures.

Category 1: enclosures where an air pressure different from the environmental atmospheric air pressure may occur, for example caused by thermal cycling effects during operation.

Category 2: enclosures where the air pressure is that of the ambient air pressure.

The relevant specification shall state the category of the enclosure and the pressure reduction.

4.1.4.6.1 A specimen with a category 1 enclosure shall be introduced into the test chamber and mounted in its normal operating position. It shall be submitted to periods of reduced pressure specified in figure 2. The pressure reduction below ambient shall be 2 kPa (20 mbar) or 5 kPa (50 mbar), as prescribed in the relevant specification.

The dust shall be injected during each single cycle as shown in figure 2.

4.1.4.6.2 A specimen with a category 2 enclosure shall be introduced into the test chamber and mounted in its normal operating position. The vacuum pump shall not be operating in such a case.

4.1.4.7 Severities

The test severity defined by air pressure in the chamber and duration of test, depending on the category of enclosure (see 4.1.4.6) shall be prescribed by the relevant specification.

Category 1: pressure reduction of 2 kPa (20 mbar) or 5 kPa (50 mbar), as required by the relevant specification, for a duration of 2 h.

Category 2: atmospheric pressure for a duration of 4 h.

4.1.5 Preconditioning

The relevant specification may call for a preconditioning.

4.1.6 Initial measurements

The specimen shall be submitted to visual, dimensional and functional checks prescribed by the relevant specification.

4.1.7 Testing

The test chamber air shall be at a temperature high enough to ensure a relative humidity of 25 % or less. The specimen, while being at the ambient temperature of the laboratory, shall be introduced into the test chamber in the unpacked, switched-off, “ready for use” state, in its normal operating position or as otherwise specified in the relevant specification. In the case of multiple specimens, care shall be taken that the specimens neither touch each other nor shield each other against the influence of dust.

The relevant specification may call for the specimen to be switched on and/or operated during the test.

Dust shall be introduced into the chamber so that the specified concentration is maintained during the time specified for injection (category 1) or throughout the test duration (category 2).

At the end of the conditioning, the specimen shall remain in the closed test chamber until the dust has settled.

4.1.8 Intermediate measurements

The relevant specification may call for measurements during or at the end of conditioning while the specimen is still in the test chamber. If such measurements are required, the relevant specification shall define the measurements and the period or periods after which they shall be carried out.

4.1.9 Recovery

Unless otherwise required by the relevant specification, the specimen shall remain under standard atmospheric conditions for recovery for 2 h.

4.1.10 Cleaning

The relevant specification may prescribe removal of external surface dust to be carried out prior to final measurements.

4.1.11 Final measurements

After recovery the specimen shall be submitted to visual, dimensional and functional checks prescribed by the relevant specification.

4.1.12 Information to be given in the relevant specification

When this test is included in the relevant specification, the following details shall be given, in so far as they are applicable.

The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

	Subclause
a) Procedure to apply if the size of the specimen does not comply with this standard	4.1.3
b) Category of enclosure and pressure reduction*	4.1.4.6
c) Severities*	4.1.4.7
– air pressure in the chamber*	
– duration of test*	
d) Preconditioning	4.1.5
e) Initial measurements*	4.1.6
f) State of specimen, electric loading or operating during testing*	4.1.7
g) Position of the specimen if different from the normal operating position	4.1.7
h) Intermediate measurements	4.1.8
i) Recovery	4.1.9
j) Cleaning of the specimen	4.1.10
k) Final measurement*	4.1.11

4.2 Method La2: constant air pressure

4.2.1 Object

The object of this test is to determine the degree of protection against ingress of fine dust into electrotechnical products.

4.2.2 General description

Method La2 is a dust tightness test in which the specimen is exposed to a heavily dust-laden air flow containing non-abrasive powder of particle size $<75\ \mu\text{m}$. The test does not simulate natural or induced environments.

A vertical downwards air flow is specified for the test.

Enclosures of a specified category are tested with the internal air pressure lower than the surrounding atmospheric air pressure in order to encourage the ingress of powder.

The specified quantity of powder ensures that the dust concentration is extremely high and uniform. No means for monitoring the dust density is specified.

4.2.3 Description of test apparatus

The test chamber shall expose the test specimen to a mainly vertical, downwards non-laminar air flow containing a specified quantity of test dust. For this purpose the powder will be agitated and blown into a sealed test chamber. Air will, if prescribed by the relevant specification, be extracted from the specimen by a vacuum pump to enable the dust-laden test chamber air to penetrate through gaps, bushings or the like into the specimen. The pressure reduction shall be adjustable and shall be monitored. The extraction rate shall be measured.

Dust settled in the test chamber shall be brought back into circulation.

The volume of the specimen shall be no more than 25 % of the test chamber volume, and its base shall be no more than 50 % of the horizontal working space surface of the test chamber.

If the size of the specimen does not comply with this standard, one of the following procedures shall be applied as prescribed by the relevant specification:

- a) testing of individually enclosed sections of the product;
- b) testing of representative parts of the products comprising components such as doors, ventilating openings, seats, shaft seals etc., with the delicate parts of the product such as terminals, collector rings etc. in position at the time of testing;
- c) testing of smaller products having the same design details as full-scale products.

An example of a suitable test apparatus is given in figure 4.

4.2.4 Test conditions

4.2.4.1 Test dust

The test dust is identical to that prescribed in 4.1.4.1 for method La1.

4.2.4.2 Dust concentration

The quantity of test dust used for the test shall be at least 2 kg per cubic metre test chamber volume.

4.2.4.3 Air flow

The air flow in the test chamber shall be mainly vertical from top to bottom and it should not be laminar.

4.2.4.4 Air velocity

The air velocity shall give the possibility to generate a homogeneous distribution of the dust in the test chamber.

4.2.4.5 Humidity

The relative humidity in the test chamber shall be less than 25 %. This may be achieved by raising the test chamber air temperature (see clause A.3).

4.2.4.6 Air pressure in the specimen

Depending on the operating conditions there are two different categories of specimen enclosures.

Category 1: enclosures where an air pressure different from the environmental atmospheric air pressure may occur, for example caused by thermal cycling effects during operation.

Category 2: enclosures where the air pressure is that of the ambient air pressure.

The relevant specification shall state the category of the enclosure and the pressure reduction.

4.2.4.6.1 A specimen with a category 1 enclosure shall be introduced into the test chamber and mounted in its normal operating position. It shall then be connected to a vacuum pump which maintains the air pressure inside the specimen below atmospheric air pressure. For this purpose, a suitable hole in the enclosure should be provided. If there is already a drain hole for condensed water in the walls of the enclosure, the vacuum pipe shall be connected to this hole. No special hole for the test shall be drilled in this case. If there is more than one drain hole in the walls of the enclosure, the vacuum pipe shall be connected to one of them and the others shall be sealed during the test.

4.2.4.6.2 A specimen with a category 2 enclosure shall be introduced into the test chamber and mounted in its normal operating position. All ordinary openings in the enclosure shall be left open.

4.2.4.7 Severities

The severity defined by the air pressure and by duration of test, depending on the category of enclosure (see 4.2.4.6) shall be prescribed by the relevant specification.

Category 1

Air pressure:

- 2 kPa (20 mbar), 5 kPa (50 mbar) or 10 kPa (100 mbar).

Duration of the test

- if, with the maximum reduced pressure stated in the relevant specification, the rate of air flow is less than 40 volumes per hour, the test shall be continued until 80 volumes have been drawn through, or a period of 8 h has elapsed.
- if a rate of air flow of 40 to 60 volumes per hour is attained, the duration is 2 h.

The object of the test is to extract from the specimen a volume of air corresponding to at least 80 times the free volume of air inside the enclosure of the specimen. However, the rate of extraction shall at no time exceed 60 volumes per hour.

Category 2

Air pressure:

- normal air pressure

Duration of the test:

- 8 h

4.2.5 Preconditioning

The relevant specification may call for preconditioning.

4.2.6 Initial measurements

The specimen shall be submitted to visual, dimensional and functional checks prescribed by the relevant specification.

4.2.7 Testing

The test chamber air shall be at a temperature high enough to ensure a relative humidity of 25 % or less. The specimen, while being at the ambient temperature of the laboratory, shall be introduced into the test chamber in the unpacked, switched-off, “ready for use” state, in its normal operating position or as otherwise specified by the relevant specification. In the case of multiple specimens care shall be taken that the specimens neither touch each other nor shield each other against the influence of dust.

The relevant specification may call for the specimen to be switched on and/or operated during the test.

When the specimen has been introduced into the test chamber, the vacuum pump shall be connected and switched on if this applies (category 1).

The testing begins by injecting the test dust.

At the end of the conditioning the vacuum pump shall be switched off (category 1) and the specimen shall remain in the closed test chamber until the dust has settled.

4.2.8 Intermediate measurements

The relevant specification may call for measurements during or at the end of the conditioning while the specimen is still in the test chamber. If such measurements are required, the relevant specification shall define the measurements and the period or periods after which they shall be carried out.

4.2.9 Recovery

Unless otherwise required by the relevant specification, the specimen shall remain under standard atmospheric conditions for recovery for 2 h.

4.2.10 Cleaning

The relevant specification may prescribe removal of external surface dust to be carried out prior to final measurements.

4.2.11 Final measurements

After recovery, the specimen shall be submitted to visual, dimensional and functional checks prescribed by the relevant specification.

4.2.12 Information to be given in the relevant specification

When this test is included in the relevant specification, the following details shall be given, in so far as they are applicable. The relevant specification shall supply information (see IEC 60068-5-1 clause 11) as required in the subclauses listed below, paying particular attention to the items marked with an asterisk(*) as this information is always required.

	Subclause
a) Creation of a vacuum inside the specimen	4.2.3
b) Procedure to be applied if the size of the specimen does not comply with this standard	4.2.3
c) Category of enclosure and pressure reduction*	4.2.4.6
d) Severities*	4.2.4.7
– air pressure*	
– duration of the test*	
e) Preconditioning	4.2.5
f) Initial measurements*	4.2.6
g) State of specimen, electric loading or operation during testing	4.2.7
h) Position of the specimen, if other than the normal operating position	4.2.7
i) Intermediate measurements	4.2.8
j) Recovery	4.2.9
k) Cleaning	4.2.10
l) Final measurements*	4.2.11

4.3 Guidance for test La

4.3.1 Methods of verification of the degree of protection against ingress of dust into electrotechnical products

The two main parameters of the test methods are:

- a heavily non-abrasive dust laden air surrounding the specimen;
- simulated pressure changes, relative to ambient surroundings or within the specimen.

It shall be emphasised that the described methods are designed as tightness tests, and are neither intended, nor suitable for simulation of any natural dust environment.

Basic philosophy and methods of generating the test conditions are described and alternatives for test dust are discussed.

Furthermore, severity and factors affecting reproducibility are described, and some comments to interpretation of results and safety precautions are given.

The test apparatus for method La2, described in 4.3.3.3 is identical to the test apparatus for the dust tightness test specified in IEC 60529.

4.3.2 Basic philosophy behind test La, non-abrasive fine dust test

4.3.2.1 General

The purpose of tests carried out in accordance with test La is to determine the degree of protection offered by enclosures against ingress of fine dust into electrotechnical products.

Tests carried out in accordance with test La are primarily carried out in order to verify the dust tightness of the specimen, and secondarily to verify harmful effects of any dust penetrating into the specimen. Also safety and hazard effects of dust penetrating into the specimen can be verified by this dust test method.

Safety and hazard effects arising from dust in electrotechnical products may be electric shocks generated by conductive dust, or fire and explosions caused by combustible dust.

To analyze the requirements and limitations to the test method some reflections on dust sources, actions and effects are made in the following subclauses.

4.3.2.2 Sources of dust

The dust appearing in the surroundings of electrotechnical products is generated by several sources. The dust may be quartz, coal, de-icing salts, fertilizers for example penetrating into the products, for instance through ventilating holes or leaking enclosures.

The dust may also be small fibres from cotton or wool, real or artificial, generated from cloth or carpets by normal use in living rooms and offices.

Other sources are dust from seeds in barns, or flour being ground in mills.

The particle size varies from fractions of a 1 µm to the order of 100 µm.

4.3.2.3 Actions and effects of dust

4.3.2.3.1 Penetration

Penetration of dust into a specimen can occur as follows. It can be:

- carried in by forced air circulation, for example for cooling purposes;
- carried in by thermal motion of the air;
- pumped in by variations in the atmospheric pressure caused by temperature changes;
- blown in by wind.

4.3.2.3.2 Primary effects

The dust itself can have one or more of the following harmful effects:

- a) seizure of moving parts;
- b) abrasion of moving parts;
- c) adding mass to moving parts thereby causing unbalance;

- d) deterioration of electric insulation;
- e) deterioration of dielectric properties;
- f) clogging of air filters;
- g) reduction of thermal conductivity;
- h) interference with optical characteristics.

4.3.2.3.3 Secondary and combined effects

The presence of dust, in combination with other environmental parameters, can have harmful effects on the specimen, for example corrosion and mould growth. Especially, a damp heat environment in connection with chemically aggressive dust causes corrosion. Furthermore, clogged filters and other reductions of ventilation or cooling may cause overheating and fire hazard.

Investigation of the effects of non-conducting and corrosive dusts, for example de-icing salts can be carried out by a dust test using test dust mixed with the actual aggressive material, followed by a damp heat test.

However, in order to maintain reproducibility, dividing the investigation into a dust test using a neutral dust, followed by a standardized corrosion test should be considered.

In order to investigate effects caused by hygroscopic dust material, cotton linters may be mixed into the test dust, and follow the dust test by a corrosion test.

4.3.2.4 Test for verification of tightness against dust

4.3.2.4.1 Movement of air into the specimen

Looking at the mechanisms which support penetration of dust into the specimen (see 4.3.2.1), it can be seen that an air movement into, or in and out of the specimen is needed for the test method.

The air movement can be accomplished by operating the specimen continuously or intermittently depending on its construction, (see 4.3.2.5), or by creating a stream of air with a fan. The air movement can also be created by a continuous or cyclic air pressure change in the specimen, relative to ambient, using an air pressure system.

The latter way has been selected for the present method, as the object is to verify dust tightness primarily, and to maintain a high degree of reproducibility. It is also a relatively simple way to create the air movement. It can, in some cases, complicate interpretation of the tests results (see 4.3.8).

4.3.2.4.2 The chamber dust concentration

The purpose of the test method is to verify the dust tightness of the specimen and not to simulate the dust conditions in which the specimen is intended to operate.

Consequently, the requirement of the chamber dust environment is only to establish a heavily dust laden volume of air surrounding the specimen. The dust concentration shall be very high compared with concentrations found under actual operational conditions either natural or man made, in order to get an ample amount of dust to facilitate investigation of dust ingress.

For information, the dust deposit rate of the present test method, (which shall not be monitored) is approximately 10^4 times the dust deposit rate of the free settling dust test method Lb.

4.3.2.4.3 Constant versus cyclic pressure

The present non-abrasive dust test La calls for a simulated pressure difference between the exterior and the interior of the specimen.

In the method La1 the pressure difference is cyclic and established by variation of the chamber pressure.

In the Method La2 the pressure difference is constant and established by connecting a vacuum pump to the specimen.

The advantages of method La1 are:

- the pressure difference is cyclic as normally found under operational conditions;
- the cyclic pressure does not tend to clog leakages with the test dust as observed when using constant pressure;
- as the cyclic pressure is established by variation of the chamber pressure, the integrity of the specimen is not affected, and further, no doubt arises in selecting an existing hole for the pump connection.

The advantage of method La2 is:

- the method La2 is recognized by many test laboratories and well-established in other IEC publications.

4.3.2.4.4 Selection of dust particle size

For evaluation of the dust tightness of a specimen, the test may be carried out with dust material of any kind. The major requirement is the particle size distribution which shall contain the smallest particle sizes found in actual operation locations. Only a soft material is needed to detect the tightness of a specimen. The reason to choose a soft material is to protect the specimen against abrasive effects.

4.3.2.5 Operational state of the specimen during conditioning

The operational state of the test specimen can affect dust penetration, depending on the type and characteristics of the specimen.

The pumping effect of a heat generating specimen of closed construction is simulated by the chamber air pressure system and therefore, the specimen can be in the switched-off condition during conditioning.

Sealing of moving parts, for example motor shafts and push-buttons may be affected by the movement, and the specimen shall consequently be tested in the operational state.

The present dust test method is not suitable for testing specimens of open construction, for example specimens with open forced air cooling and specimens with ventilation openings for convection cooling, as the chamber dust concentration is too high to give reasonable interpretation of the results.

4.3.3 Methods of generating the test conditions

4.3.3.1 General requirements

General requirements of the following parameters shall be fulfilled in order to generate reproducible test conditions:

- a) dust concentration;
- b) uniformity of dust distribution;

- c) temperature;
- d) relative humidity;
- e) electrostatic charge build-up;
- f) the simulated air pressure to the specimen;
- g) dust characteristics

The parameters a) to f) are controlled by the design of the test apparatus. Guidance on design of the test apparatus is found in 4.3.3.2 and 4.3.3.3. Guidance on selection of the test dust is found in 4.3.4.

4.3.3.2 Test apparatus for Method La1 (cyclic air pressure)

4.3.3.2.1 The test chamber

An example of a suitable test chamber is shown in figure 3. It is advised that the inner surface of the chamber is electrically conductive and grounded to avoid electrostatic charge build-up. If electrostatic effects on the dust penetration into the specimen is the object of a test, the specimen has to be charged relative to the chamber.

The humidity is most conveniently controlled by raising the test chamber temperature. One way to establish isothermal conditions inside the chamber is a design consisting of an inner chamber made of aluminium, surrounded by an outer chamber made of thermal insulating material. Controlled heated air is circulated in the space between the inner and outer chamber. Air guide plates are situated in this space in order to distribute the steam of air evenly. The principle is equal to that of a free field temperature chamber.

The cyclic air pressure action on the specimen is established by variation of the test chamber pressure. That requires an airtight construction of adequate strength to withstand the specified pressure (see 4.3.3.2.3).

4.3.3.2.2 The dust injection system

The dust injection system shall be able to maintain a uniform suspension of dust with adequate density in the test chamber. This function can be realized using a screw conveyor to transport the dust from the bottom of the chamber to the top. The dust density can be controlled by the speed of the screw conveyor. Depending on the shape of the chamber bottom and the floating properties of the dust, a mixing device may be needed to guide the dust to the inlet of the screw conveyor. The uniformity of the suspended dust can be controlled by a fan placed horizontally at the outlet of the screw conveyor.

4.3.3.2.3 The cyclic air pressure system

Cyclic air pressure shall be introduced to the specimen in order to simulate natural pressure variations and consequently increase the possibility of penetration of dust into the specimen.

The cyclic air pressure is established by cyclic variation of the test chamber pressure.

A test pressure cycle consists of a low pressure phase followed by an ambient pressure phase inside the chamber.

The test cycle introduces an exchange of air from the outside to the inside of the specimen during the pressurization phase (i.e. return to ambient pressure).

The advantage of performing the pressure variation by changing the chamber pressure instead of changing the internal pressure of the specimen is keeping the integrity of the specimen (see 4.3.2.4.3).

4.3.3.3 Test apparatus for method La2 (constant air pressure)

The constant air pressure test apparatus for method La2 is identical to the test apparatus described in IEC 60529.

The test consists in placing the specimen in a suitable closed chamber in which talc is kept in suspension by a high velocity air stream. The air pressure inside the specimen is kept at a constant pressure below the ambient pressure. The test duration depends partly on the size of the specimen, partly on total leakage of the specimen, which determine the volume of air being exchanged.

The requirements and main features of the test apparatus are described in the following subclauses.

4.3.3.3.1 The test chamber

An example of a suitable test chamber is shown in figure 4. Advice on the construction of the test chamber in order to maintain reproducibility of temperature, relative humidity and electrical charge build up, is given in 4.3.3.2.1.

4.3.3.3.2 The dust injection system

The dust injection system shall be able to maintain a uniform suspension of dust with adequate concentration in the test chamber. This function is realized using an air loop system including a fan to circulate the dust. Means to establish a uniform dust deposit is needed and may be a secondary fan at the top of the chamber. The function can also be realized, using a screw conveyor system and a fan as described in 4.3.3.2.2.

4.3.3.3.3 The constant air pressure system

The constant air pressure action to the specimen is established by connecting a vacuum pump to the specimen itself. This may in some cases interfere with the integrity of the specimen when drilling a hole in the enclosure is necessary (see 4.3.2.4.3).

4.3.4 Test dust

For evaluation of the dust tightness of a specimen, talc is specified as the standard dust but the test may be performed with dust material of any kind.

The major requirement is the particle size distribution which shall contain the smallest particle sizes found in actual operation locations. An average of 35 % by weight less than 1 μm is observed in various locations. Only a soft material is needed to detect the tightness of a specimen. The reason to choose a soft material is to protect the specimen against abrasive effects.

4.3.4.1 Composition of the dust

Five characteristics are of importance when selecting the grade of dust for the test:

- a) availability;
- b) hardness;
- c) hygroscopicity;
- d) chemical inactivity;
- e) health hazard.