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Research summary

Performance test

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TNO's quality system has been certified in accordance with ISO 9001.

Bosch angle grinder GWS 17-125 CIE in combination with Bosch dust guard GDE 115/125 FC-T and Bosch dust extractor GAS 35 M AFC

Client:
Robert Bosch GmbH
Max-Lang Straße 40-46
70771 Leinfelden-Echterdingen
Germany

Introduction

In recent years TNO has focused closely on innovations in tools, processes and workplace designs in industrial work environments. The primary objective has been to realise production processes and means of production that create minimal dust levels. In addition to the building industry, the metal industry, the aircraft industry and the wood industry are all focal points for product/process development. This work involves collaboration with employers' organisations, trade unions, government, employers, employees and manufacturers/producers. As an instrument for assessing a process or tool's functionality during professional use, TNO has developed the TNO Performance Test. This describes innovative production processes and means of production. When these processes/tools are being used, the relevant public/private Occupational Exposure Limits for harmful substances (such as quartz dust, wood dust (hardwood), hexavalent chromium) in the employees' breathing zone, in normal daily use, are not exceeded.

The Inspectorate SZW has included the TNO Performance Test explicitly in one of its internal instructions. Translated quote: "If you decide to carry out the work while applying the measures as they are stated in a TNO Performance Test as stated on TNO's website (stofvrijwerken.tno.nl) then I regard the exposure as being adequately controlled."

For employers, this means that they can communicate unequivocally with the inspectors of The Inspectorate SZW and no additional exposure measurements need be submitted. Both employers and employees gain an objective assessment instrument that can assist them in reaching the right conclusion when next they make an investment decision. For innovative producers/suppliers of production processes and means of production (tools), this provides an opportunity to distinguish themselves from their competitors on the basis of quality.

Test criteria

The exposure to harmful substances in the employee's breathing zone in the workplace is tested.
The following standards are applied:
- exposure to the relevant substance: public/private Occupational Exposure Limit (OEL) (see the SER website: http://www.ser.nl/en/grenswaarden/kwarts.aspx)
This standard is applied in The Netherlands and the limit value according to this standard for respirable quartz is 0.075 mg/m³.

In Germany the following standard is applied:
Technische Regeln für Gefahrstoffe 900 (TRGS 900)– Grenzwerte in der Luft am Arbeitsplatz „Luftgrenzwerte"

The limit value for respirable dust according to this standard is 3.00 mg/m³. From January 2019 the limit value for respirable dust according to this standard will be 1.25 mg/m³. The results of the measurements will also be compared to the future limit value.

Project description TNO Performance Test

TNO has carried out research into the emission of respirable quartz and respirable dust during grinding in calcium silicate using a Bosch angle grinder GWS 17-125 CIE, equipped with a Bosch dust guard GDE 115/125 FC-T, connected to a Bosch dust extractor GAS 35 M AFC.

TNO has carried out two tests. The first test is according to the method which is normally applied by TNO. A vertical test setup consisting of calcium silicate block is constructed. During the test, the disc of the angle grinder is plunged into the calcium silicate blocks. The grinder is moved over the test setup for 1.25 meter where the grinding disc is taken out of the material. The first testing method is illustrated in Figure 1. During the test at total number of 48 slots are grinded, resulting in a total of 60 meters.

During the second test setup the calcium silicate blocks are placed in a horizontal setup. The grinder enters the test material from the edge of the setup (meaning there is no dive-in operation). The grinder is moved over

the setup to the edge where the grinding disc exits the material. This second test is used to imitate the testing method which is used by BG Bau in Germany. However, since there are many differences between the tests of TNO and BG Bau (for example volume of the test room, ventilation flow, material, test procedure) the results are not comparable. The second testing method is illustrated in Figure 2. During this test a total number of 46 slots with a length of 1.31 meter are grinded, resulting in a total of 60 meters.

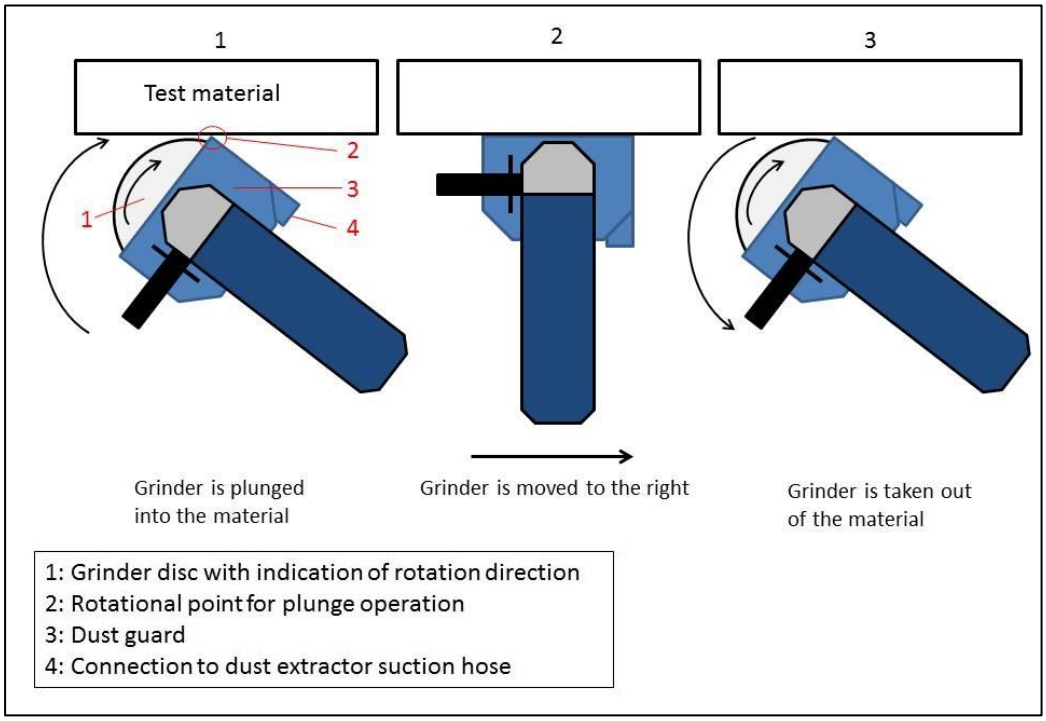


Figure 1: Schematic illustration of the first test method (top view)

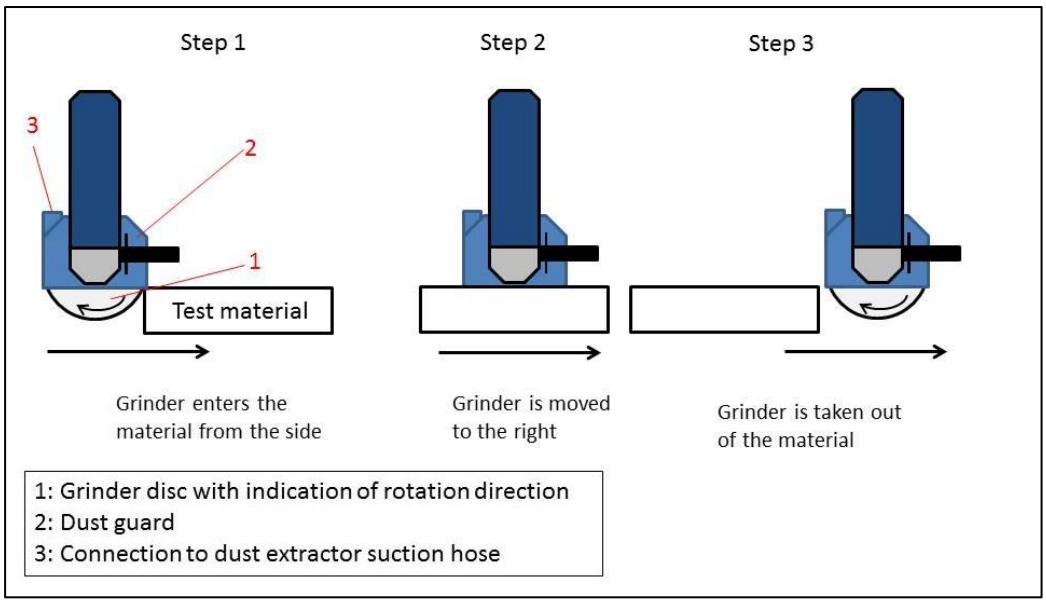


Figure 2: Schematic illustration of the second test method (front view)

Specifications of Bosch tool system

The tested system consists of a Bosch angle grinder GWS 17-125 CIE (or equivalent*) equipped with a Bosch dust guard GDE 115/125 FC-T, connected to a Bosch dust extractor GAS 35 M AFC (or equivalent**) without dust bag. The angle grinder is connected to the dust extractor by a flexible suction hose with a length of 5 meter and a diameter of 38 mm. The complete system is shown in Figure 3.

Bosch angle grinder GWS 17-125 CIE

Bosch dust extractor GAS 35 M AFC

Figure 3. The complete tool system and dust extraction system

Table 1 shows the specifications of the Bosch angle grinder (or equivalent). Table 3 shows the specifications of the Bosch dust extractor.

* Angle grinders are considered equivalent when the dust production is similar or lower to those of the type tested. The power consumption, diameter of the grinding blade and the rotational speed are the relevant criteria.

** Dust extractors are considered equivalent when their specifications are similar or superior to those of the type tested. The flow capacity, underpressure, filter cleaning and recirculation are the relevant criteria.

Table 1. Technical specification of the Bosch angle grinder (or equivalent) which can be used in combination with the Bosch dust extractor GAS 35 M AFC

Specifications	GWS 17-125 CIE	GWS 17-125 CIEX	GWS 17-125 CI
Power comsumption [W]	1,700	1,700	1,700
Voltage [V]	230	230	230
Nominal no-load speed [min^{-1}]	2,800 – 11,500	2,800 – 11,500	11,500
Diameter grinding blade [mm]	125	125	125
Weight [kg]	2.4	2.5	2.4

Specifications	GWS 17-125 CIT	GWS 17-125 INOX	GWS 9-115
Power comsumption [W]	1,700	1,700	900
Voltage [V]	230	230	230
Nominal no-load speed [min^{-1}]	2,800 – 8.300	2,200 – 7,500	11,500
Diameter grinding blade [mm]	125	125	115
Weight [kg]	2.4	2.4	2.0

Specifications	GWS 9-125	GWS 9-125 P	GWS 11-125
Power comsumption [W]	900	900	1,100
Voltage [V]	230	230	230
Nominal no-load speed [min^{-1}]	11,500	11,500	11,500
Diameter grinding blade [mm]	125	125	125
Weight [kg]	2.0	2.1	2.2

Specifications	GWS 11-125 P	GWS 12-115 CIP	GWS 12-115 CIPX
Power comsumption [W]	1,100	1,200	1,200
Voltage [V]	230	230	230
Nominal no-load speed [min^{-1}]	11,500	11,500	11,500
Diameter grinding blade [mm]	125	115	115
Weight [kg]	2.3	2.2	2.3

Table 2. Technical specification of the Bosch angle grinder (or equivalent) which can be used in combination with the Bosch dust extractor GAS 35 M AFC

Specifications	GWS 9-125 CIEP	GWS 9-125 CIEPX	GWS 13-125 CI
Power comsumption [W]	1,200	1,200	1,300
Voltage [V]	230	230	230
Nominal no-load speed [min^{-1}]	2,800 - 11,500	2,800 - 11,500	11,500
Diameter grinding blade [mm]	125	125	125
Weight [kg]	2.2	2.3	2.3

Specifications	GWS 13-125 CIE(X)	GWS 15-125 CIP	GWS 15-125 CIEP(X)
Power comsumption [W]	1,300	1,500	1,500
Voltage [V]	230	230	230
Nominal no-load speed [min^{-1}]	2,800 - 11,500	11,500	2,800 – 1,500
Diameter grinding blade [mm]	125	125	125
Weight [kg]	2.3	2.5	2.5

Specifications	GWS 15-125 CIP	GWS 15-125 CIEP(X)	GWS 15-125 CIH
Power comsumption [W]	1,500	1,500	1,500
Voltage [V]	230	230	230
Nominal no-load speed [min^{-1}]	11,500	2,800 – 1,500	11,000
Diameter grinding blade [mm]	125	125	125
Weight [kg]	2.5	2.5	2.3

Specifications	GWS 15-125 CITH	GWS 15-125 CIH
Power comsumption [W]	1,500	1,500
Voltage [V]	230	230
Nominal no-load speed [min^{-1}]	2,800 – 9,300	11,500
Diameter grinding blade [mm]	125	125
Weight [kg]	2.3	2.3

Specifications	GWS 1000	GWS 1400
Power comsumption [W]	1,000	1,400
Voltage [V]	230	230
Nominal no-load speed [min^{-1}]	11,500	11,500
Diameter grinding blade [mm]	125	125
Weight [kg]	2.7	3.0

Table 3. Technical specifications of the Bosch dust extractor GAS 35 M AFC or equivalent

Specifications	GAS 35 M AFC	GAS 55 M AFC
Power consumption [W]	1,380	1,380
Voltage [V]	220	220
Maximum volume flow [m³/hr]	266 [1]	266 [1]
Maximum underpressure [mbar]	254 [2]	254 [2]
Filterarea [cm²]	6,150	6,150
Filter class [-]	M	M
Filter efficiency [%]	99,9	99,9
Reservoirvolume [l]	35	55
Dimensions (L x W x H) [mm]	515 x 450 x575	570 x 450 x865
Weight [kg]	12.4	16.2

[1] at the ventilator side

[2] at the end of the suction hose

TNO Performance test

The most important test conditions are shown in Table 4. The test conditions are equal for test 1 and test 2.

Table 4. Test conditions "Worst Case"

Type of material: calcium silicate blocks CVK L100/198
Percentage respirable quartz in calcium silicate: 25%

Source strength: 60 meter per 60 min.
(480 meter per 8-hour working day)
Production: 100 % duration of operation
Employee exposure time: 8-hour work day

Diameter grinding disc: 125 mm
Thickness of grinding disc: 2.5 mm
Depth of grinding slot: 25 mm
Nominal speed: 2,800 – 11,500 rpm

Direction of dust emission: in the direction of the suction hose
Maximum speed of machining: 75 m/s

Compartiment of suction system: semi-complete

Suction capacity of dust extractor with hose: 118 m^3/hr (start of measurement) to 116 m^3/hr (end of measurement)

Filter efficiency: 99.9% (M)
Cleaning system dust extractor: automatic (reverse pulse)

Dust capture in container without dust bag: “open”
Dust filters “open”.

Length of suction hose: 5 m
Diameter of suction hose: 38 mm

Measurement methodology

For each experiment, dust samples are collected at three locations in the employee's breathing zone:

- on the employee's left lapel;
- in the centre of the employee's lapel;
- on the employee's right lapel.

Dust samples are collected on 37 mm glass fiber filters. These filters are installed in FSP 10 cyclones, which are located on the employees lapels. Gilliam AirCon2 airpumps with a set capacity of 10 liters per minute provide the air flow through the cyclones. The weight of respirable dust captured on the filters is determined using gravimetric analysis. The measured weight is divided by the total volume of sampled air, resulting in the concentration of respirable dust in mass per volume (mg/m^3). The results of the three filters are averaged.

Test results

A summary of the test results is shown in Table 5 and Table 6 and shown in Figure 4 and Figure 5.

Situation	Concentration respirable quartz [mg/m^3]
Occupational Exposure Limit (OEL) TGG-8h	0.075
100% duration of operation	0.24
“Heavy use”	0.12
“Light use”	0.03
Outdoors	-
Professional use	-

Table 5. Summary of the measurement results for test 1

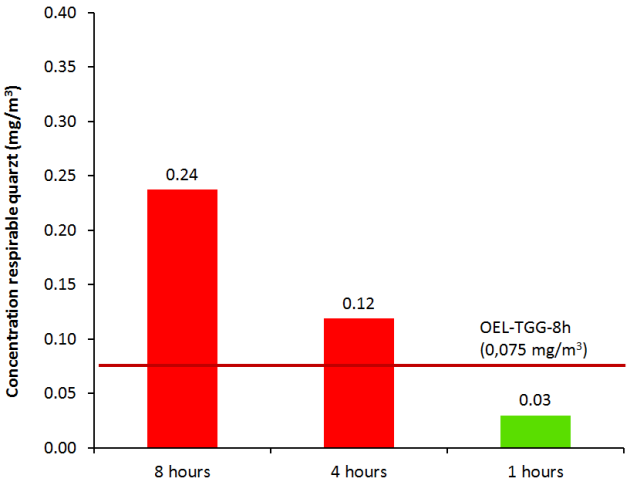


Figure 4. Test results for exposure of respirable quartz relative to the OEL

Situation	Concentration respirable dust [mg/m^3]
TRGS 900 limit	3.00
TRGS 900 limit from January 2019	1.25
100% duration of operation	1.01
“Heavy use”	0.50
“Light use”	0.13
Outdoors	-
Professional use	-

Table 6. Summary of the measurement results for test 2

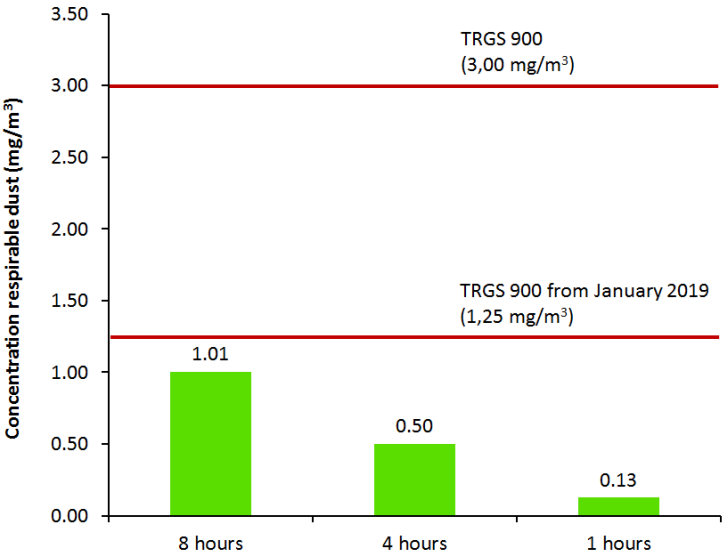


Figure 5. Test results for exposure of respirable dust relative to the TRGS 900

The measurement uncertainty of the applied measurement methodology is approximately 15% (5% analysis, 5% sampling and 5% reproducibility of the user). This means a possible uncertainty (including rounding of the results) in the final label of +/- 1 hour in the most extreme case.

The average measured quantity of respirable dust for testing method 1 is 0.95 mg/m³, while for testing method 2 the averaged quantity is 1.01 mg/m³. Taken into account also the measurement uncertainty, this means that both testing method produce approximately the same amount of respirable dust.

Conclusion

TNO has measured the following: the exposure of respirable dust in the breathing zone when using the Bosch angle grinder GWS 17-125 CIE, equipped with a Bosch dust guard GDE 115/125 FC-T, and connected to a Bosch dust extractor GAS 35 M AFC with 5 meter suction hose (diameter 38 mm) without dust bag.

For the first test and a duration of operation of 100% (8 hours per 8-hour working day) the exposure to respirable quartz in the employees breathing zone averages 0.24 mg/m³. This value is higher than the statutory threshold limit value of 0.075 mg/m³ (OEL TGG-8h) and, in view of this, when used in this situation, the tool system does not comply with the prevailing standard for exposure to respirable quartz.

In addition to “100% duration of operation”, TNO defines the following references with regard to professional use:

- heavy use: 4 hours grinding per 8-hour work day
- light use: 1 hour grinding per 8-hour work day

For heavy use, the tool system does not comply with the prevailing standard. For light use, the tool system does comply with the prevailing standard.

For the second test and a duration of operation of 100% (8 hours per 8-hour working day) the exposure to respirable dust in the employees breathing zone averages 1.01 mg/m³. This value is lower than the current statutory threshold limit value of 3.00 mg/m³ (TRGS 900) and, in view of this, when used in this situation, the tool system complies with the prevailing standard used in Germany for exposure to respirable dust.

In addition to “100% duration of operation”, TNO defines the following references with regard to professional use:

- heavy use: 4 hours grinding per 8-hour work day
- light use: 1 hour grinding per 8-hour work day

Similarly, in these situations the total system complies with the standard.

In January 2019, the value of the exposure limit according to the TRGS 900 will be lowered to 1.25 mg/m³. Also for the future limit value, the exposure to respirable dust is below the statutory threshold limit, for 100% duration of operation, for heavy use and for light use.

TNO applies a mass fraction of 25% for respirable quartz in calcium silicate. For concrete and brick 15% is applied. This means that the period during which the tested tool system may be used to grind in concrete and brick is longer than for calcium silicate. Similarly for grinding in concrete or brick, in all the above-mentioned situations the exposure remains under the statutory threshold limit value.

The tables below shows how the total system performed in various tests. The round label shows the responsible duration of operation in hours per 8-hour work day. The rectangular label specifies the various professional situations in more detail. Green indicates a use that does not exceed the relevant threshold limit value throughout an 8-hour work day.

Label for grinding calcium silicate according to the OEL TGG-8h

Reference: 180 meter / 8 hours

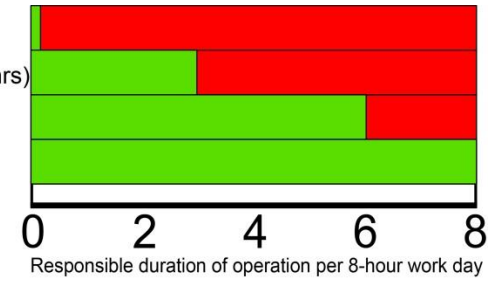
No measures

100% duration of operation (8 hrs grinding/8hrs)

Heavy use (4 hrs grinding/8hrs*)

Light use (1 hrs grinding/8hrs*)

* given proportional operation during an 8-hour work day



Label for grinding concrete according to the OEL TGG-8h

Reference: 240 meter / 8 hours

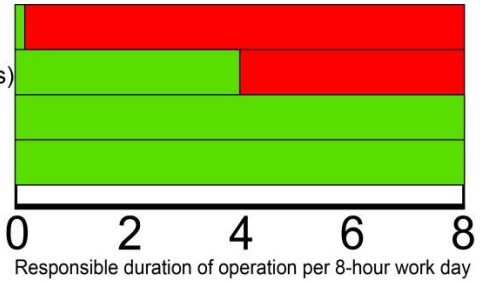
No measures

100% duration of operation (8 hrs grinding/8hrs)

Heavy use (4 hrs grinding/8hrs*)

Light use (1 hrs grinding/8hrs*)

* given proportional operation during an 8-hour work day

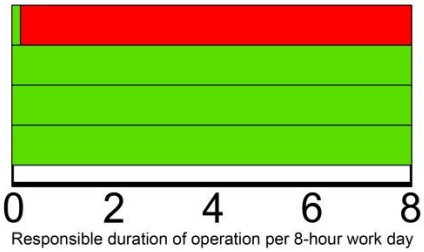


Label for grinding calcium silicate according to the TRGS 900 (current and future limit value)

Reference: 480 meter / 8 hours

No measures
100% duration of operation (8 hrs grinding/8 hrs)
Heavy use (4 hrs grinding/8 hrs*)
Light use (1 hrs grinding/8 hrs*)

* given proportional operation during an 8 hour work day

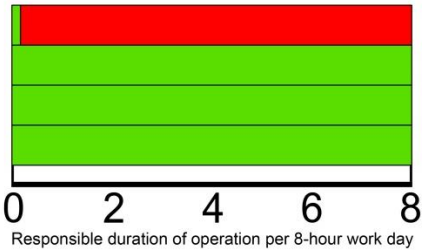


Label for grinding concrete according to the TRGS 900 (current and future limit value)

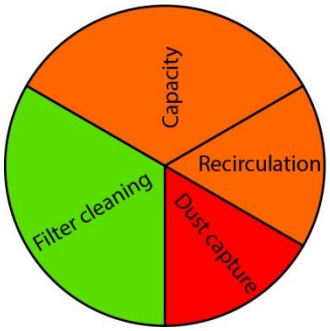
Reference: 480 meter / 8 hours

No measures
100% duration of operation (8 hrs grinding/8 hrs)
Heavy use (4 hrs grinding/8 hrs*)
Light use (1 hrs grinding/8 hrs*)

* given proportional operation during an 8 hour work day



Label dust extractor with 5 meter suction hose (diameter 38 mm) without dust bag



Capacity (operational)
- 150 - 200 m³/hour
- 100 - 150 m³/hour
- < 100 m³/hour

Recirculation dust extractor
- H-classification according to IEC-norm 60335-2-69
- M-classification according to IEC-norm 60335-2-69
- L-classification according to IEC-norm 60335-2-69

Filter cleaning
- Automatic cleaning (mechanic/air pulse) or filter replacement
- Manual
- None

Dust capture
- Closed system (dust bag)
- Open system (dust bag)

N.B. This test involves no decision regarding the prolonged use of dust extractors.