TNO innovation for life

Rubi stone cutter DX-350 with water source

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Contents

1 Introduction

In recent years, TNO has focused intensively upon innovative improvements to tools, processes and workplace design in the industrial environment. The main purpose of these efforts is to create low-dust production processes and tools. As well as construction, our product and process development activities have targeted the construction, metal, aircraft and wood industries, working closely with industry organizations, trades unions, governments, employers, employees and manufacturers.

To describe innovative production processes and tools, and to assess their practical functionality, we have developed the TNO Performance Test. This checks that relevant statutory and in-house occupational exposure limits (OELs) for hazardous substances such as crystalline silica, hardwood dust and hexavalent chromium are not exceeded in areas where they may be inhaled by workers in the course of their everyday duties.

The Dutch labour inspectorate, explicitly endorses the TNO Performance Test in its "Basic Inspection Module for Crystalline Silica" (Basisinspectiemodule Kwartsstof). That document states, "If you decide to conduct your working activities using the measures contained in a TNO Performance Test, as described on the TNO website (stofvrijwerken.tno.nl or dustfreeworking.tno.nl), I [the inspector] will regard exposure as being adequately managed".

This means that an employer using the test is able to communicate unambiguously with the inspectors and that no additional exposure measurements need to be agreed. Moreover, it provides both the employer and its personnel with an objective measuring tool for the accurate assessment of proposed investments. Innovative manufacturers and suppliers of production processes and tools can also highlight their quality by complying with the test criteria.

The dust-free working label has existed since 2014. Over the years, more than 650 tools have been tested. As of 2021, the label has been moved internally within TNO to the Healthy Living and Work department. The TNO dust-free test room has been moved to RPS in Zwolle. In this new setup TNO is responsible for quality assurance and the reporting of the test results. Since the new structure, the format of the performance test has also been slightly adjusted.

2 Assessment criteria

The TNO Performance Test assesses exposure to hazardous substances in the “employee inhalation zone” in the workplace. The applicable norms for each substance, both statutory and in-house, are those contained in the database of Occupational Exposure Limits or OEL (Grenswaarde Stoffen op de Werkplek, GSW) maintained by the Social and Economic Council of the Netherlands (see https://www.ser.nl/en/themes/OEL-Database).

3 Project description

For this project, TNO studied emissions of respirable quartz dust when sawing ceramic tiles using a Rubi stone cutter DX-350 with water source. Water is applied to the system to capture dust during sawing. Brushes at the back of the sawing blade guide the water to the storage basin. The tests are performed in the worst-case room located at RPS Zwolle, which is a room of 15 m^3 and a ventilation flow of 150 m^3/h. The test results as determined in the worst-case room for the DX-350 are also applicable to the DX-350-N 1300, DU200 EVO, DV-200, DC-250, DS-250-N, DX-250 plus and DR-350 which were already assessed as equivalent to the DX-350 in previous versions of this report.

In this updated report table 1 is extended with information about the following tools: DCX-250 XPERT 1250, DCX-250 XPERT 1550, DC-250 PHYTON and the DC-250 SMART. The tools are added based on equivalence tests.

4 System specifications

The tested system consists of a Rubi stone cutter DX-350 (or equivalent*) with water source. Figure 1 shows the complete system.

Figure 1. The complete system.

Figure 2. The brush system mounted at the back of the sawing blade.

Table 1 Technical specifications of Rubi tool system and equivalent

Specification	DX-350-N 1300	DU-200 EVO	DV-200
Power supply [V]	120 to 380	110 to 240	110 to 230
Maximum rotational speed [min]	2,800	3490	2790
Sawing blade diameter (mm)	300-350	200	200
Cutting length [mm]	1485	650	1060
Cutting thickness (1 stroke) [mm]	115	35	35
Cutting thickness (2 strokes) [mm]	230	NA	NA
Weight [kg]	114	23,5	57,5

Specification	DC-250	DS-250 N	DX-250 Plus
Power supply [V]	110 to 230	230 (AC 50 hz)	230 (AC 50 hz)
Maximum rotational speed [min]	2,790	2800	2800
Sawing blade diameter (mm)	250	250	250
Cutting length [mm]	980 to 1205	1020 to 1520	1120 to 1530
Cutting thickness (1 stroke) [mm]	61	51	70 to 145
Cutting thickness (2 strokes) [mm]	90	NA	NA
Weight [kg]	70-75	110 to 125	79 – 89.5

Specification	DR-350	DC-250 Python	DC-250 Smart
Power supply [V]	230 (AC 50 hz)	110-230	110-230
Maximum rotational speed [min]	2,800	2790	2790
Sawing blade diameter (mm)	300-350	250	250
Cutting length [mm]	840	855 – 1210	980 -1210
Cutting thickness (1 stroke) [mm]	95	58	61
Cutting thickness (2 strokes) [mm]	150	88	90
Weight [kg]	63	69,5-75	59,55

Specification	DCX-250 XPERT 1250	DCX-250 XPERT 1550
Power supply [V]	110-230	110-230
Maximum rotational speed [min]	3350	3350
Sawing blade diameter (mm)	250	250
Cutting length [mm]	1250-1330	1550 – 1630
Cutting thickness (1 stroke) [mm]	60	60
Cutting thickness (2 strokes) [mm]	90	90
Weight [kg]	78	86

5 TNO Performance Test

Table 2 lists the key specific test conditions.

Worst-case room specifications: 15 m^3 volume and 150 m^3/h ventilation flow	Operator exposure period: eight-hour working day.
Material: Ceramic tiles, dimensions (450x300x10 mm)	Reference productivity: 50 meter sawing, thickness 10 mm per 8 hour working day
Percentage of quartz in respirable dust: Ceramic tiles: 25% Natural stone tile: 50% Bricks and concrete: 15% Sandstone and Limestone: 25%	Sawing blade diameter: 250 mm Sawing blade thickness: 2.0 mm Rotational speed 50 m/s System compartmentalization: “semi-complete”
Process: 60 minutes of sawing Productivity (60 minutes): 50 meter sawing, Material thickness 10 mm (permanent operations)	Water supply: 6 litre/min (water supply valve fully open)

6 Test results

A total of two test cycles were carried out in accordance with the measurement protocol (Meetprotocol 'Testkamer voor label Stofvrijwerken' - TNO2021 R11849).The test results are summarized in Table 3 and Figure 3.

Table 3. Summary of measured data.

Situation	Respirable quartz dust concentration (mg/m³)
OEL, eight-hour time-weighted average (TWA)	0.075
8-hour use	0.23
4 hour use	0.12
1 hour use	0.029
Outdoor use	-
Practical use	-
Quartz percentage in material	25%

Label for sawing in Ceramic tiles (25% quartz) & sand-lime blocks (25% quartz) in the worst-case room (15 m³)

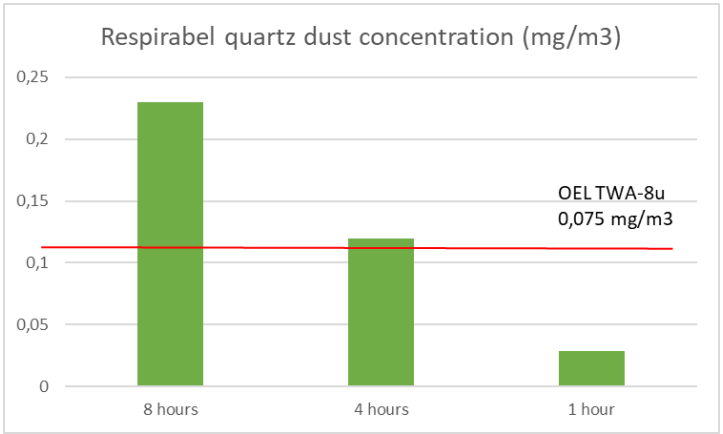

Figure 3. Exposure to respirable quartz dust at OEL for sawing in ceramic tiles (test conditions)

Label for sawing in natural stone tiles (50%) quarz in the worst case room (15 m³)

Label for sawing in bricks and concrete (15% quartz in the worst case room (15 m³)

7 Conclusion

TNO measured exposure to respirable quartz dust in the “employee inhalation zone” when sawing ceramic tiles (25% quartz) using the Rubi stone cutter DX-350 with water source in the TNO worst-case room.

In permanent operation (an entire eight-hour working day), average exposure was 0.23 mg/m³. This is above the statutory occupational exposure limit (OEL) of 0.075 mg/m³ (eight-hour time-weighted average or TWA), meaning that the system tested does not comply with the applicable standard for exposure to respirable quartz during full workday operations.

As well as “permanent operation” TNO has also defined two more reference situations.
- Heavy use: four hours of operation per eight-hour working day.
- Light use: one hour of operation per eight-hour working day.

For heavy use, the system does not comply with the standard. For light use, the system complies with the norm. The system is tested in the TNO worst-case room with a volume of 15 m³ . This machine is normally not used in such a small room due to the size of the machine. For a more realistic situation, the results are also calculated for a room size of 100 m³ with a ventilation rate of 4 (often applied in industrial applications), resulting in a ventilation flow 400 m³/h. This results in a concentration reduction of 400 m³/h divided by 150 m³/h, which is 2⅔ for larger room sizes. The results for the worst-case room and a larger room are presented in Table 4.

The machine can also be used to saw bricks, concrete and sand blocks and lime blocks. Results are also presented for these materials. It should be noted that the results are obtained for a given source. The source is the dust production which is based on the number, length, thickness and height of the kerfs. The presented labels for brick, sandstone, limestone and concrete are based on the same source. If the source is altered (materials with other dimensions) also the dust production will change. This is mainly applicable since the material thickness of brick, sandstone and concrete is larger (50 to 100 mm) than the thickness of the tested tiles (10 mm). The results for sand/lime blocks and bricks and concrete are also presented in Table 4.

Table 4. Responsible use for the different material sources in the worst-case room and large room.

Situation	Material	Responsible duration of operation (hours)
Worst case room (15 m³ & 150 m³/h)	Ceramic tiles (25% Quartz)	3
	Natural stone tiles (50% Quartz)	1
	Sand/lime blocks (25% Quartz)	3
	Bricks/concrete (15% Quartz)	4
	Ceramic tiles (25% Quartz)	7
Large room (100 m³ & 400 m³/h)	Natural stone tiles (50% Quartz)	3

The inaccuracy of the exposure measurements is about 15% (5% for the analysis, 5% sampling and 5% reproducibility of the test operator). Readers are referred to the TNO measurement protocol (see TNO website www.dustfreeworking.tno.nl).

The label present the system's performance in graphic form. The round label shows the total "responsible operating time" in hours per eight-hour working day.

8 Signature

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