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REPORT

Testing of the MBX Bristle Blaster 3500X Tool on Specific Surface Material Combinations in Explosive Atmospheres

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Extract

As part as an ignition safety assessment in accordance with the ATEX 94/9/EC Directive, experiments have been performed in order to investigate the potential ignition sources that are produced under normal use and expected malfunctions during the use of the Bristle Blaster tool on specific surface material combinations. The initial experiments were performed in air in order to study the temperature development during normal operations and expected malfunctions. Based on the results from the initial experiments, the Bristle Blaster was tested in an explosive atmosphere to find out whether the potential ignition sources were able to ignite the atmosphere.

Project Info

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1 Introduction

Reference is made to communication between Gary Hill, Talisman Energy (UK) Ltd, and Dave Price and Geir H. Pedersen, GexCon, regarding the possibility of using the Bristle Blaster for the removal of aluminium paints in potentially explosive atmospheres (zone 1, gas group IIA). The current work includes an ignition safety assessment, performed in cooperation between GexCon and Talisman Energy, for the evaluation of the MBX Bristle Blaster surface treatment tool. As part of this process, experimental tests have been performed in order to verify whether or not the tool can cause ignition when used in explosive gas/vapour atmospheres. The present report describes the experimental work performed, the results obtained and an ignition hazard assessment.

The experimental testing programme comprised two phases. During the surface temperature measurement phase, an infrared camera was used in order to identify the worst case operating conditions during normal operation of the tool. During these tests the tool was used on various types of surface materials such as rusted steel and rusted steel plates painted with aluminium paint. Both temperature measurements and visual observations of spark generation were used to identify the worst case scenario.

The second phase of the experimental test programme consisted of testing the worst case scenario found in phase 1 in an explosive atmosphere. The gas reactivity target for ATEX evaluation was “Gas Group IIA’’. An explosive atmosphere of hexane vapour (Temperature class T3) is considered to be one of the most sensitive explosive atmospheres with respect to ignition within this class and was therefore used during this work.

Tests were performed at GexCon’s test laboratory in Bergen during November 2012.

2 Experimental set-up

2.1 The MBX Bristle Blaster 3500X

The MBX bristle blaster 3500X is a pneumatic tool for metal surface maintenance, see Figure 2-1. The tool consists of wire bristle tips mounted on a rotating hub of a hand-held tool which operates at approximately 2300 rpm at the designed maximum air pressure of 6.2 bar with the 23 mm Bristle Belt installed. The tips of the individual bristle hit the surface and immediately retract which results in corrosion removal and generates a texture on the surface. This process can result in both locally hot surfaces and mechanical spark generation. The tool is equipped with an accelerator bar, allowing the individual tips to build up some tension before the tip springs off from the accelerator bar. This result in a higher local velocity of the bristle as the tips hits the surface of the target sample. To ensure that the grinding is optimal, it is recommended that the distance from the accelerator bar to the target surface does not exceed 8 mm. The experiments performed aimed at showing whether this can result in an ignition of a group IIA explosive atmosphere.

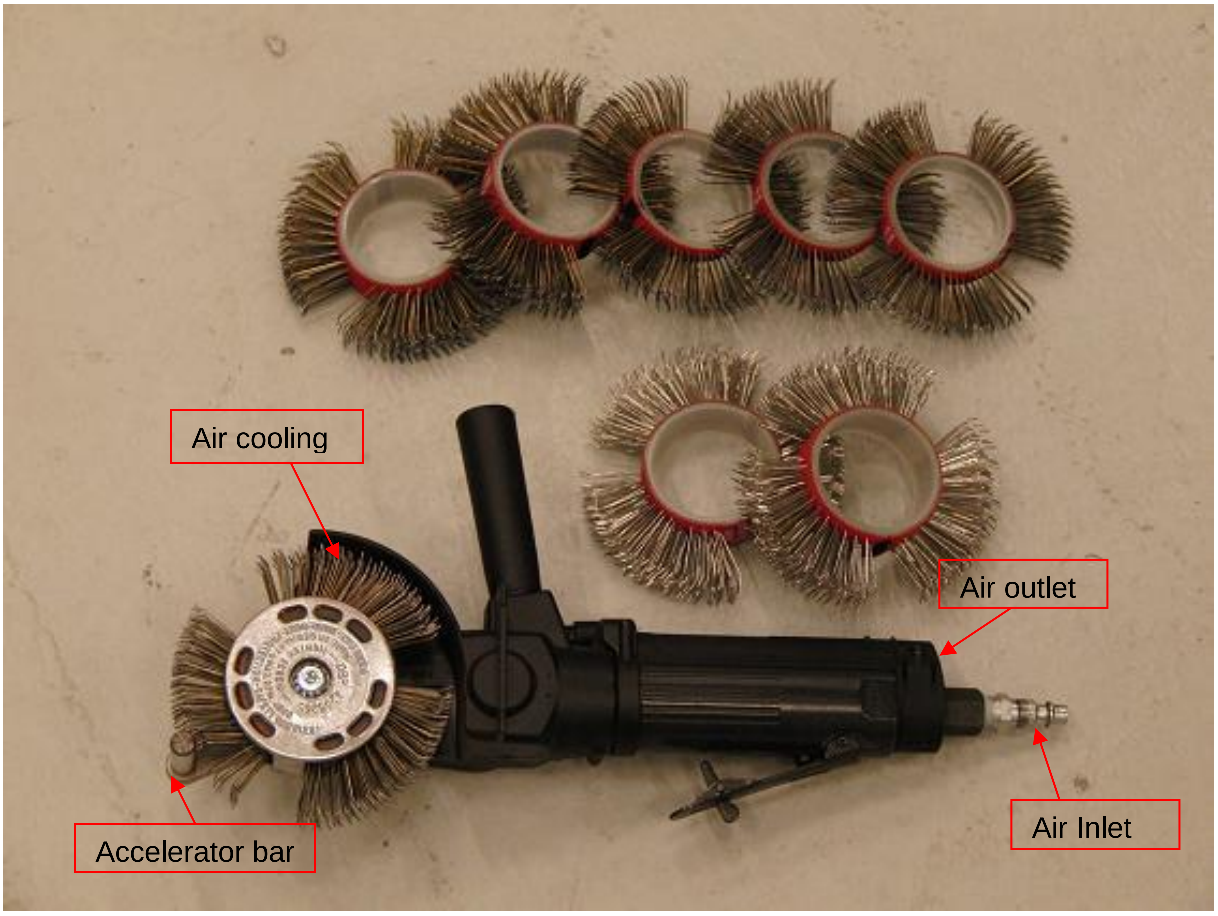

Figure 2-1 MBX Bristle Blaster tool

The tool was provided with two different types of brushes (MBX Bristle Blaster belts):

- MBX Bristle Blaster belt 23 mm (golden coloured)
- MBX Stainless Steel Bristle Blaster belt 23 mm (white steel coloured)

A few modifications were made to the tool in order to allow it to be remotely operated in an explosive atmosphere, see Figure 2-2. The air cooling system was blocked and air from the air outlet was redirected through a tube to the outside of the test volume to avoid fresh air from diluting the gas mixture. Loss of air cooling is identified as an expected malfunction during normal operation. The handle was also fixed in the "ON" position with tape, hence the tool could be operated remotely by controlling the supply of pressurized air. In addition an orifice flow restrictor, which normally comes with the bristle blaster, was removed in order to allow additional air into the tool. Removal of this flow restrictor is considered as an expected misuse.

Figure 2-2 ***Modifications made to the MBX Bristle Blaster in order to test the tool in an explosive atmosphere.***

1) The air cooling of the Bristle belt is removed and the exhaust air is directed away through a 3" hose.

2) The flow regulator is removed and replaced with a direct coupling to the pressurized air.

2.2 Surface Treatment

The paint used in surface treatment of the various materials is Intertherm 751CSA heat resistant, cold spray aluminum paint produced by International Paint. This is a two-component paint with metallic aluminum flakes used for insulation and mitigation of corrosion purposes. The paint was mixed in accordance to the mixing guidelines and applied to the various surfaces with a brush.

2.3 Test Materials

In order to determine the worst case scenario for using the MBX Bristle Blaster on various material combinations, a total of 7 different combinations of materials and aluminium paint were used. The different material combinations are shown in Figure 2-3.

a) Mildly corroded steel (R#)

b) Mildly corroded steel, Aluminium paint (R#(Alu))

c) Heavily corroded steel (Gex #)

d) Heavily corroded steel, Aluminium paint (Gex #(Alu))

e) Stainless steel (SS#)

f) Stainless steel, Aluminium paint (SS#(Alu))

g) Non corroded steel, aluminium paint (CS#(Alu))

Figure 2-3 Photographs showing the different types of materials used during the experiments.

2.4 Infra red camera

During the first phase of testing, a thermal imaging camera of the type Fluke Ti20 was used to measure the temperature generated by the bristle blasting process. According to the instrument calibration, the camera has an accuracy of 2°C, depending on the accuracy of the emissivity settings. The emissivity of the materials was calibrated against different known temperatures and the average emissivity was used.

2.5 Experimental set-up for tests performed in explosive atmospheres

The test volume used in the ignition experiments performed in explosive mixtures was a 1.5m^3 steel cabinet, open on 3 sides (covered with plastic for explosion venting purposes). The gas mixture was prepared using a re-circulation system consisting of a centrifugal fan and two sets of pneumatically controlled valves enabling the gas mixing system to be isolated from the test vessel. The re-circulation system sucks gas from the front top left corner of the cabinet and blows it back at the far right bottom corner of the cabinet. The recirculation system was used to "mix" the explosive atmosphere and ensure the generation of a homogeneous atmosphere inside of the cabinet.

Hexane (Gas Group IIA, Temperature class T3) was used during this work and was chosen as test vapours due to the ignition sensitivity to hot surfaces (minimum ignition temperature 225°C). This was done in order to cover gas class IIA adequately and beyond that possible by using propane as a test gas alone (minimum ignition temperature 450°C). The minimum ignition energy of these three gases/vapours is however similar (0.25-0.26 mJ).

The liquid hexane was added using a fine spray inside the re-circulation system. The pipes of the re-circulation system were heated to around 110°C in order to vaporize the liquid hexane. The concentration of the flammable gas in the test vessel was determined either by use of an oxygen analyser (type Servomex Xendos 2223) or an IR gas detector (type Simrad GD10). The concentration was monitored by sucking the vapour-air mixture from two positions inside the cabinet through a vacuum pump before reaching the sensors. The oxygen analyser and IR gas detector was calibrated prior to testing.

Tests were performed over a wide range of fuel concentrations. To confirm that the gas mixtures were explosive during the tests when the MBX tool was operated, they were ignited with a high voltage spark in the far right bottom corner after some of the tests.

The MBX bristle blaster tool was modified as described in section 2.1 and mounted on a pneumatic robot arm in order to remotely control and press the tool onto the test surface, see Figure 2-4. The Bristle Belt was replaced with a new one prior to all tests conducted. A test lasted for approximately 6 minutes. The speed of the rotating hub with the 23 mm Bristle Belt was recorded at 1800 rpm, in reference to the 2300 given in the operating manual of the tool.

Since the MBX Bristle Blaster tool is a manually operated tool, the pressure each operator uses during operation can be varied greatly. In order to simulate the operational conditions of different operators using the tool, the load applied to the tool was varied by changing the pressure applied to the pneumatic cylinder, actuating the robotic arm. Due to the nature of the bristle tips, a higher load on the tool will result in reduction of the rotational speed or stop the tool rotating completely. Various grinding forces were applied during each test, where the pressure applied typically varied from 0 barg up to 4 barg where the rotation of the bristle belt tended to slow down significantly or stop completely.
The relation between the pressure applied and the load subjected to the surface of the test material can be seen in Figure 2-5. The load was "calibrated" by letting the tool push onto an electrical scale while varying the pressure applied.

The test surface was mounted on top of a table which could be moved during the test to ensure that the target surface varied during the tests. The table was controlled by an electric motor, situated on the outside of the cabinet. In a typical test, the target surface was varied from side to side, both grinding on fresh material and already treated surface. Since the aluminium paint was removed relatively fast it was important to provide fresh material during the tests.

In an effort to simulate grinding in congested environments, a screen covered in aluminium tape was attached to the robotic arm. This was done so that the sparks generated by the grinding would slow down and increase the contact-time between the spark and flammable gas mixture, further increasing the chance of ignition.

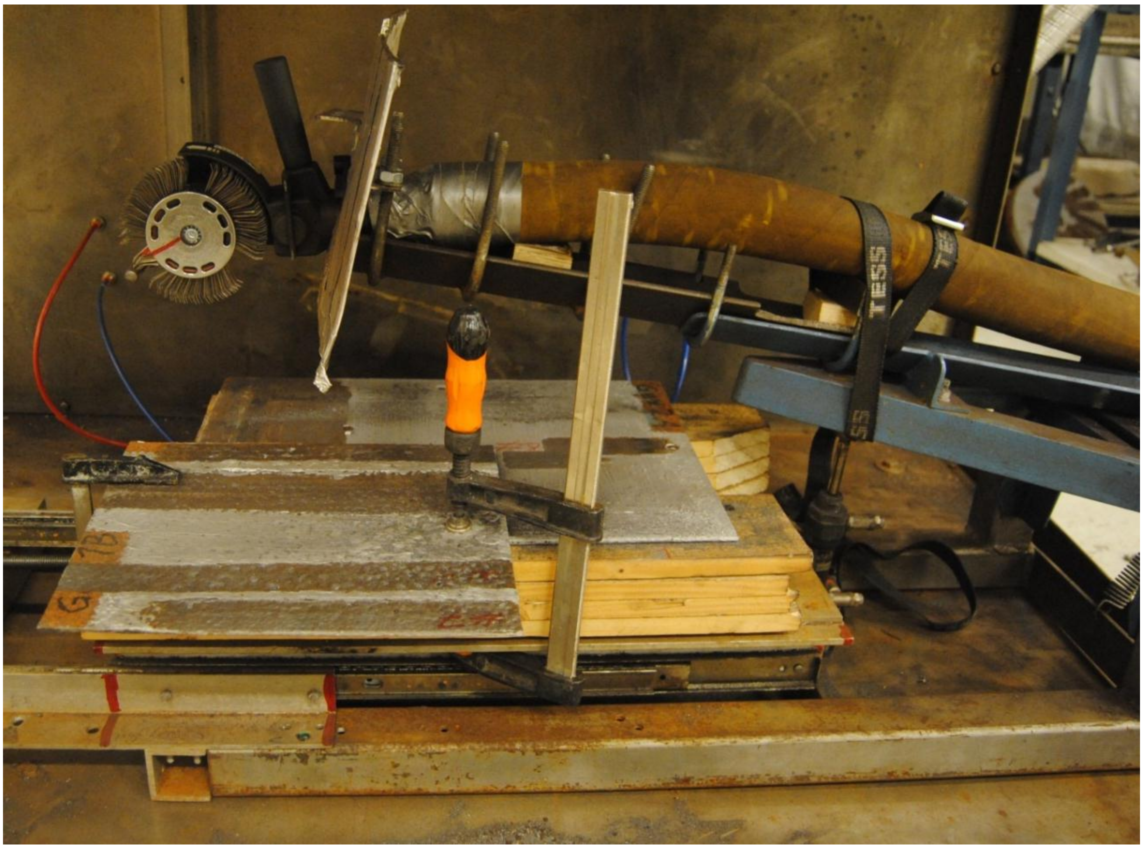

Figure 2-4 MBX Bristle Blaster mounted inside the test volume after test number 10.

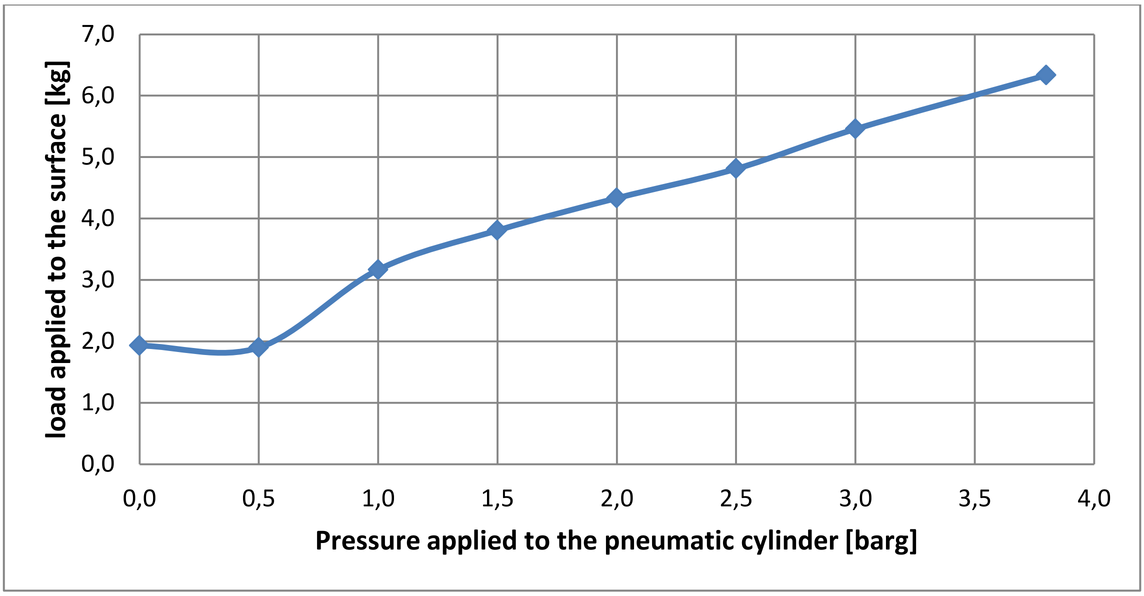

Figure 2-5 Load applied from the MBX Bristle Blaster to the target surface of the test sample

3 Results

3.1 Phase 1 – Infra red camera results

A number of tests were performed using the infra red camera to identify the worst case operational conditions and combinations of the different materials. These tests were performed both with manual operation of the tool and with the tool mounted on the robot arm, simulating the conditions to be used in phase two. Tests were performed both with the air cooling intact and blocked.

An example from an infra red photo is shown in Figure 3-1. From the picture it would seem that the bristle support belt becomes warm. This is however not correct. The red colour on the belt seemed, in addition to visible red light, to also reflect infra red radiation from the environment. The temperature of the parts was checked immediately after the completion of the tests, and it was confirmed that these parts were cold. This “emissivity error” was eliminated by measuring within areas which excluded the bristle belt itself.

The emissivity of the target surface was found by photographing specific material samples at known temperatures (14.6°C, 50.6°C, 73.9°C and 109.4°C). These photographs were then analysed and the emissivity for each material at the given temperatures was found. The emissivity is then used as an input to correct the temperature of the test photographs.

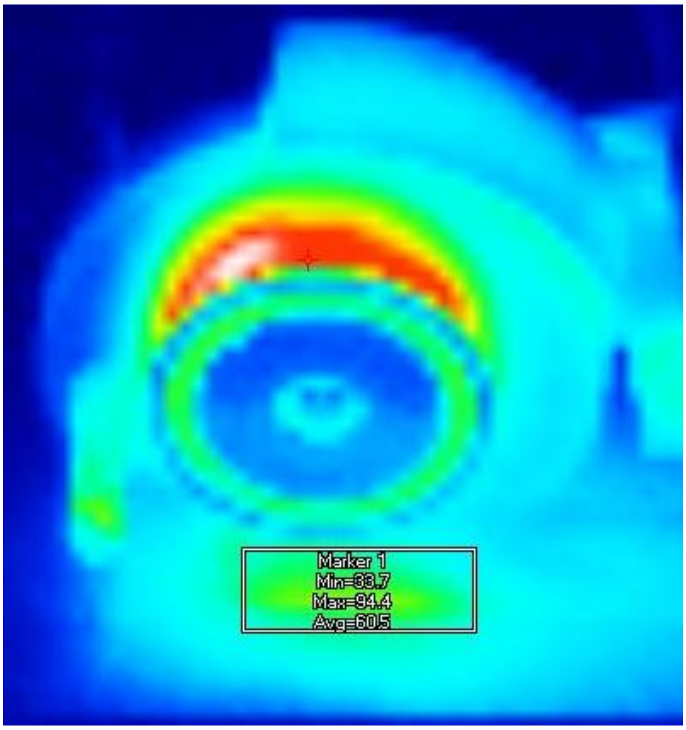

Figure 3-1 ***Typical example from an infra red photograph of a test with the MBX Bristle Blaster mounted on the robot arm. The minimum, maximum and average temperature of the target surface is measured within the rectangular area marked on the picture.***

The results from the tests are given in Table 3-1. The highest temperature recorded was 99.5°C. The same conditions were tested during phase 2, in explosive hexane atmosphere. These results indicate that the tool can be classified as Temperature Class T4. This means that the Bristle Blaster tool can in principle be used with gases and fluids with an auto ignition temperature higher than 135°C within the limits and safety margins according to the appropriate Ex-zone / equipment category (according the hazardous area classification etc).

Table 3-1 Maximum temperatures measured with the infra-red camera using different material combinations.

Test no.	Material type	Brush type	Air Cooling	Operation	Maximum temperature [°C] at target surface
1	Mildly corroded steel	23 mm/ Golden	Normal	Manually	38.8
2	Mildly corroded steel	23 mm/ Golden	Blocked	Manually	41.1
3	Non corroded steel, aluminium paint	23 mm/ Golden	Normal	Manually	36.4
4	Non corroded steel, aluminium paint	23 mm/ Golden	Blocked	Manually	28.0
5	Stainless steel	23 mm/ Golden	Normal	Manually	37.3
6	Stainless steel	23 mm/ Golden	Blocked	Manually	43.8
7	Mildly corroded steel, aluminium paint	23 mm/ Golden	Blocked	Manually	24.3
8	Non corroded steel, aluminium paint	23 mm/ Golden	Blocked	Robot Arm	99.5
9	Mildly corroded steel, aluminium paint	23 mm/ Golden	Blocked	Robot Arm	94.4

In addition to the findings from the thermal imaging, visual observations of the spark generation was used to decide the material combinations to be further tested in phase 2.

3.2 Phase 2 – Ignition testing in gas mixtures

Based on the results of phase 1 with 99.5°C as the highest temperature obtained, hot surfaces are not likely to cause an ignition of a hexane-air mixture, having an auto ignition temperature of around 235°C. However, considerable amounts of visible sparks were observed when operating the tool on corroded steel, both treated and untreated with aluminum paint. These sparks are potential ignition sources. The combination of corroded steel and aluminum might cause thermite flashes. Therefore this combination is considered the most likely to produce sparks able to ignite an explosive atmosphere of hexane-air. An example of these sparks can be seen in Figure 3-2.

Figure 3-2 Visible sparks while grinding on heavily corroded steel painted with aluminium paint (Plate ''Gex 1B(Alu)'').

The tests were performed as described in section 2.5.

Although strong spark generation was observed, the explosive atmosphere did not ignite in any of the tests conducted. Test conditions and results are given in Table 3-2.

Table 3-2 Summary of the tests performed. Surface material in reference to Figure 2-3.

Test number	Surface material	Ignition	Comments
1	CS2(Alu) + CS3 (Alu)	No	Hexane concentration approximately 5.0% at the beginning of the test.
2	Gex 1B(Alu)	No	Hexane concentration approximately 4.7% at the beginning of the test. Ignited with a high voltage spark after the test to confirm the explosive atmosphere.
3	Gex 1B(Alu)	No	Hexane concentration approximately 5.3% at the beginning of the test.
4	Gex 1B(Alu)	No	Hexane concentration approximately 2.1% at the beginning of the test. The angle between the MBX Bristle Blaster and the

			target surface was adjusted to simulate non optimal working conditions. Ignited with a high voltage spark after the test to confirm the explosive atmosphere.
5	Gex 1A(Alu)	No	Hexane concentration approximately 3.0% at the beginning of the test. The air pressure regulator has been removed and the pressurized air is now going straight to the tool. The angle between the MBX Bristle Blaster and the painted plate was adjusted to simulate non optimal working conditions.
6	R2(Alu) + Gex 1B(Alu)	No	Hexane concentration approximately 3.0% at the beginning of the test. The MBX Bristle Blaster stopped working after this test. The reason for this is most likely due to the harsh operation of the blaster (higher working pressure than recommended in the manual) and the removal of the cooling air. The MBX Bristle Blaster has been used for more than 40 minutes before the breakdown of the equipment.
7	Gex 1B(Alu) + R4(Alu)	No	Hexane concentration approximately 3.8% at the beginning of the test. Simrad GD10 IR gas detector used to measure the fuel concentration. Confinement screen installed. Ignited with a high voltage spark after the test to confirm the explosive atmosphere.
8	Gex 1B(Alu) + Gex 2A(Alu)	No	Hexane concentration approximately 3.1% at the beginning of the test. Simrad GD10 IR gas detector used to measure the fuel concentration. Ignited with a high voltage spark after the test to confirm the explosive atmosphere.
9	Gex 1B(Alu) + Gex 2A(Alu)	No	Hexane concentration approximately 2.1% at the beginning of the test. Simrad GD10 IR gas detector used to measure the fuel concentration. The MBX Bristle Blaster stopped working (i.e. the rotation stopped) after only a couple of seconds of grinding. Ignited with a high voltage spark after the test to confirm the explosive atmosphere.
10	Gex 1B(Alu) + Gex 2A(Alu)	No	Hexane concentration approximately 2.2% at the beginning of the test. Simrad GD10 IR gas detector used to measure the fuel concentration. Second MBX Bristle Blaster broke down at the end of the test. Ignited with a high voltage spark after the test to confirm the explosive atmosphere.

4 Ignition Hazard Assessment

This chapter contains the results of the ignition hazard analysis based on the testing conducted by GexCon in November 2012.

The MBX Bristle Blaster 3500X has previously been tested and is currently ATEX approved in accordance with a declaration of conformity by Monti Werkzeuge GmbH [1]. This declaration of conformity states that the tool can be used within zone 1 in combination with specific materials (Category 2 Devices according to ATEX 94/9/EC [2]). These materials can be seen in Table 4-1.

Table 4-1 List of approved materials for surface treatment by the Bristle Blaster in Zone 1

High-carbon steel	Machining steel	Austenitic manganese steel
Nickel steel	Chromium nickel steel	Molybdenum steel
Chromium steel	Chrome vanadium steel	Silicon steel
Stainless steel	Tungsten	Copper
Aluminum	Austenitic chromium nickel steel (all non-corroding or stainless, regardless of the degree of rusting)	

It is however not allowed to use the Bristle Blaster in Zone 1 on the materials seen in Table 4-2.

Table 4-2 List of materials not approved for surface treatment by the Bristle Blaster in Zone 1

Magnesium	**Zinc**	**Lithium**
Boron	Titanium	Zircon
Thorium	Uranium	

The testing conducted within this report was completed so that the accepted materials as seen in Table 4-1 can be expanded with regards to materials covered with the Intertherm 751CSA Aluminum paint.

Table 4-3 contains the initial assessment of the relevance of the various potential ignition sources described in EN 1127-1[3]. The relevant ignition sources are described after the table.

Table 4-3 Overview of initial assessment of equipment related ignition sources that are relevant for the current Bristle Blaster unit

Ign ID No.	Guide words for ignition hazard tables – Potential ignition sources: Ref EN 1127-1[3], clauses 5.3 & 6.4	Relevance of ignition source**	Reason
1	Hot surfaces	Relevant	Moving parts and collisions/friction will occur when operating the tool.
2	Flames and hot gases (including hot particles)	Not relevant	Not present
3	Mechanically generated sparks	Relevant	Moving parts and collisions/friction will occur when operating the tool.
4	Electrical apparatus*	Not relevant	The tool is powered by compressed air without electrical components.
5	Stray electric currents and cathodic corrosion protection	Not relevant	Not present
6	Static electricity	Not relevant	Certain components and parts are made of insulating material. **The tool is already ATEX 94/9/EC approved.**
7	Lightning	Not relevant	Not present
8	Radio frequency (RF) electro-magnetic waves from 10^4 Hz to $3x10^{12}$ Hz	Not relevant	Not present
9	Electromagnetic waves from $3x10^{11}$ Hz to $3x10^{15}$ Hz	Not relevant	Not present
10	Ionising radiation	Not relevant	Not present
11	Ultrasonics	Not relevant	Not present
12	Adiabatic compression and shock waves	Not relevant	Not present
13	Exothermic reactions, including self-ignition of dusts	Not relevant	Not present

* Normally assumed to be adequately certified and thus safe for use as part of the mechanical equipment being assessed in which case it falls outside the scope of this ignition hazard assessment although a requisite degree of safety must be documented as part of the "technical file".
** Applicability to the Equipment Under Evaluation (EUE) usually denoted as either "Relevant" or "Not relevant". If necessary, the relevance of the ignition source on the inside and/or outside of EUE should be indicated.

1. Hot surfaces:
If an explosive atmosphere comes into contact with a heated surface ignition can occur. Not only can a hot surface itself act as an ignition source, but a dust layer or a combustible solid in contact with a hot surface and ignited by the hot surface can also act as an ignition source for an explosive atmosphere.

All moving parts can become sources of ignition if they are not sufficiently lubricated. Collisions and friction between the bristle wire tips and treated surfaces will generate hot surfaces. The results from the testing regarding generation of hot surfaces can be found in section 3.1. ***None on the tests performed resulted in ignition of the explosive atmosphere.***

2. Flames and hot gases (including hot particles):
Assumed not present, hence not relevant, since it is assumed that no hot materials are handled in or by the current equipment.

3. Mechanically generated sparks:
As a result of friction, impact or abrasion processes, particles can become separated from solid materials and become hot due to the energy used in the separation process. If these particles consist of oxidisable substances, for example iron or steel, they can undergo an oxidation process, thus reaching even higher temperatures. These particles (sparks) can ignite dust/air-mixtures. In deposited dust, smouldering can be caused by the sparks, and this can be a source of ignition for an explosive atmosphere. Mechanical sparks can occur due to the collision between the bristle wire tips and treated surfaces. The combination of rust-contaminated bristle tips and light metals can produce incendive thermite sparks.

The generation of thermite sparks and the ability of these sparks to ignite an explosive atmosphere of hexane-air in reference to the various surface materials and the Intertherm 751CSA aluminum paint can be found in section 3.2. ***None on the tests performed resulted in ignition of the explosive atmosphere.***

4. Electrical apparatus:
Not relevant, not present.

5. Stray electric currents and cathodic corrosion protection:
Not relevant, not present.

6. Static electricity:
Incendive discharges of static electricity can occur under certain conditions. The discharge of charged, insulated conductive parts can easily lead to incendive sparks. With charged parts made of non-conductive materials, and these include most plastics as well as some other materials, brush discharges and, in special cases, by combination of conductive and non-conductive materials, propagating brush discharges are also possible.

The possibility of static electricity from the MBX Bristle Blaster resulting in an ignition of an explosive atmosphere have previously been investigated and taken into account in the declaration of conformity by Monti Werkzeuge GmbH. The use of the Bristle Blaster on different surface materials does not change the properties of the tool, hence this potential ignition source is found not relevant.

7. Lightning:
Not relevant, not present.

8. Radio frequency (RF) electro-magnetic waves from 10^4 Hz to $3x10^{12}$ Hz:
Not relevant, not present.

9. Electromagnetic waves from $3x10^{11}$ Hz to $3x10^{15}$ Hz:
Not relevant, not present.

10. Ionising radiation:
Not relevant, not present.

11. Ultrasonics:
Not relevant, not present.

12. Adiabatic compression and shock waves:
Not relevant, not present.

13. Exothermic reactions, including self-ignition of dusts:
Not relevant, not present.

5 Conclusion

During the current work spark generation and occurrence of hot surfaces on materials coated with aluminium based paint was investigated. The tool was also tested in explosive atmospheres of hexane-air in combination with rusted steel and aluminium based paint in order to investigate the ignition properties of the material combinations.

A number of tests have been performed using an infra red camera to measure the highest temperature obtained during normal operation and expected malfunctions of the tool on various materials. The highest temperature obtained was when the tool was mounted on a robot arm and used on corroded steel painted with aluminum paint. The maximum temperature obtained was 100°C on the surface of the target material.

The tests performed in explosive hexane-air mixtures showed that the MBX Bristle Blaster 3500X does not produce strong enough ignition sources to ignite the explosive atmospheres of hexane-air when used on the material combinations tested. Hence, it is considered that the potential ignition sources produced by the MBX Bristle Blaster tool are very unlikely to ignite explosive atmospheres of Gas Group IIA/T3.

6 References

[1] Declaration of Conformity, MBX® Bristle Blaster® 3500X. Issued by Monti Werkzeuge GmbH at 30.06.2010.

[2] Directive 94/9/EC of the European Parliament and Council of 23 March 1994: On the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres.

[3] European Standard EN 1127-1, Explosive atmospheres – Explosion prevention and protection - Part 1: Basic concepts and methodology, October 2011.