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REPORT

Testing of the Graco EcoQuip Vapor Abrasive blast equipment in explosive atmospheres.

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Title

Testing of the Graco EcoQuip Vapor Abrasive blast equipment in explosive atmospheres.

Extract

The Graco EcoQuip Vapor Abrasive blast equipment was tested in explosive atmospheres of n-hexane and air to determine whether the blasting process would yield an ignition. Testing was performed on both rusted steel and aluminum with 5 different types of abrasives. The testing was conducted to support Graco's ATEX ignition hazard analysis for category 2 equipment, zone 1 explosive atmospheres.

Project Info

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1 Introduction

Reference is made to communication between Jeffrey N. Velgersdyk, Graco Inc., and Matthijs van Wingerden, Gexcon AS, regarding testing of the EcoQuip Vapor Abrasive blast equipment produced by Graco Inc.. The EcoQuip Vapor Abrasive blast equipment is a surface preparation tool using different abrasives mixed with water. Gexcon AS was asked to perform tests to determine whether sparks generated by this system will be potential ignition sources.

The equipment is intended to be used in atmospheres of flammable materials in the EPL Subgroup IIA [1] i.e. gases like for example methane and propane. Tests were performed with n-hexane and air mixtures in order to cover this entire subgroup with regards to minimum ignition energy and auto-ignition temperature.

The experiments were performed at Gexcon's test site at Børnesskogen, Norway in May 2019. This report describes the tests performed and results obtained from these tests.

2 Experimental setup

This section describes how the experiments were performed.

2.1 Experimental setup for the generation of explosive atmospheres

2.1.1 Explosive atmospheres in the Subgroup IIA

Table 2-1 shows the minimum ignition energy (MIE) and auto ignition temperature (AIT) of common gases in the IIA subgroup. To cover most of the subgroup, a gas has to be chosen with a low auto-ignition temperature (AIT) and minimum ignition energy (MIE). From the table n-heptane and diesel would be the best candidates. However, in order to get a high enough gas concentration with these gases, an ambient temperature of at least 30°C is required. Therefore, in this work n-hexane was used to cover the IIA group. N-hexane has a MIE of 0.24 mJ and an AIT of 220°C. N-hexane is explosive when the concentration is between 1.1% (LEL) to 7.4% (UEL) of gas/vapor in the mixture.

Table 2-1 Auto ignition temperature and minimum ignition energy (MIE) for common gases in the IIA gas group.

Components	Auto Ignition Temperature [°C]	Temperature Class	Explosion Group	MIE [mJ]
n-Heptane	204	T3	IIA	0.24
Diesel fuels	220	T3	IIA	
n-Hexane	230	T3	IIA	0.24
Petrol fuels	220-300	T3	IIA	
Cyclohexane	430	T2	IIA	0.22
Methanol	440	T2	IIA	0.14
Propane	470	T1	IIA	0.25
Ethane	515	T1	IIA	0.24
Acetone	535	T1	IIA	1.15
Toluene	535	T1	IIA	0.24
Benzene	555	T1	IIA	0.2
Methane	595	T1	IIA	0.28
Ammonium	630	T1	IIA	680

Various combustible gases have different regimes for their MIE with regards to the stoichiometric percentage of the combustible gas in air. For n-hexane the absolute minimum ignition energy is located at a fraction of around 1.7 of the stoichiometric percentage, leading to a concentration 3.67% hexane - air (stoichiometric ratio of one is equal to 2.16% n-hexane-air). At this concentration, hexane is most sensitive to electrical sparks.

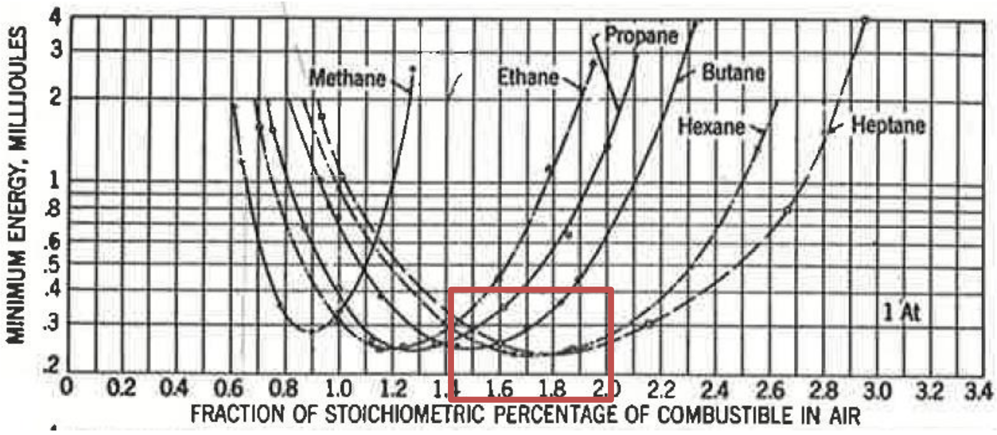

Figure 2-1 - Minimum Ignition Energy of combustible gases in air at different concentration regimes [2]

For alkanes the magnitude of the auto ignition temperature (AIT) decreases when the length of the molecule increases. This was found in the work of Kong (Kong et.al., 1995) [2] where the conclusion was that the AIT decreased by increasing the concentration of combustible gas in air for larger alkane molecules. The lowest values were found at the upper explosion limit (UEL). Hence, regimes around and up to UEL are of importance when considering hot surfaces.

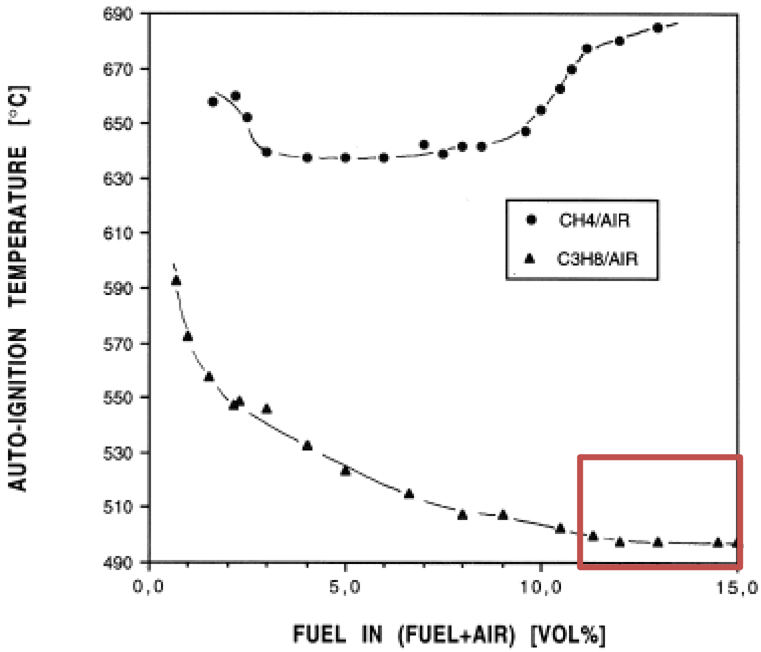

Figure 2-2 - AIT for propane-air mixtures and methane-air mixtures at over a regime of concentrations. [2]

Ignition by mechanical sparks is found to be dependent on both AIT and MIT [4]. It is also easiest to ignite a rich explosive atmosphere with sparks.

Since the sandblasting itself includes air and dilutes the area around the blasting, the tests were performed in explosive atmospheres with a rich concentration of n-hexane. The tests were typically started at around 7% of n-hexane and diluted by the blasting to around 4% of n-hexane, letting the equipment to be tested through a wide explosive range.

2.1.2 Test volume

The tests were performed in a 50 m³ testing vessel with dimensions of 2.5m x 2.5m x 8.0m. The vessel has one open end (right in Figure 2-3) which was covered with a plastic sheet to contain the combustible gas/air inside as well as to relief the explosion over pressure in case of an ignition.

Figure 2-3 50m³ testing vessel

The testing vessel size had to be relatively large due to the air coming into the system from the blasting equipment diluting the gas mixture and would allow for a larger duration of the tests

The vessel is equipped with a recirculation system with a n-hexane evaporation system. Pure n-hexane vapor was injected into the recirculation system to gradually increase the n-hexane concentration inside the vessel.

The mixture of n-hexane vapor and air inside the vessel was monitored using a binary gas analyzer from Stanford Research Systems Inc. model BGA244.

2.2 The Graco EcoQuip Vapor Abrasive blast equipment

During this work the Graco EcoQuip Vapor Abrasive blast equipment was used, see Figure 2-4. The main aim of this work was to test the potential ignition hazard of the blasting process when applying this equipment. The main equipment itself was positioned on the outside of the test vessel, while the nozzle was inside the test vessel. A Graco standard #7 blast nozzle (7/16", 11mm) was used during this work. The nozzle was connected via a 15m long hose to the equipment. The equipment was earthed to the test vessel using equipment’s green earthing cable. The nozzle was mounted in rubber mounting brackets to avoid it from being earthed to the steel in the vessel in order to best simulate a person holding the nozzle, see Figure 2-5.

The equipment was supplied from a 1000l water tank standing on the roof of the testing vessel, about 3m of the ground. Only gravity from this tank was used to supply the system with water.

Figure 2-4 Picture of the Graco Ecoquip Vapor Abrasive blast equipment in front of the test volume.

Figure 2-5 Nozzle mounted inside the testing vessel. The nozzle was electrical isolated from the steel using a rubber seal.

2.3 Test abrasives and surfaces

Five different abrasives were used with the Graco Ecoquip Vapor Abrasive blast equipment during this work. The abrasives were as followed:

- 30/60 mesh Garnet (GMA) (Figure 2-6)
- 80 mesh Garnet (GMA) (Figure 2-6)
- Fine Copper Slag 0.2-1.0mm grit size (Star Grit) (Figure 2-7)
- Coarse Copper Slag 0.4-1.9mm grit size (Star Grit) (Figure 2-7)
- Fine Crushed Glass 0.2-0.6mm (Figure 2-8)

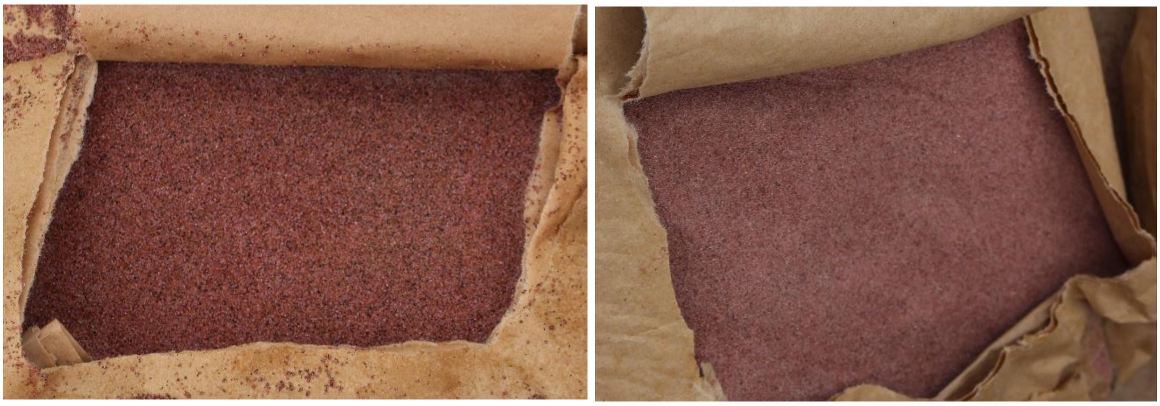

Figure 2-6 30/60 mesh and 80 mesh Garnet (GMA)

Figure 2-7 Coarse and fine copper slag (Star Grit)

Figure 2-8 Fine crushed glass

The blasting was performed on both rusty steel and aluminum, see Figure 2-9. The test pieces were approximately 1 x 1 m and could be lifted during a test, making it possible to blast on new material.

Figure 2-9 Pictures of the test setup with the nozzle blasting on a steel and aluminum plate.

The abrasives and blasting materials were chosen in order to cover the typical worst-case combinations when it comes to spark generation.

2.4 Compressor

The compressor used during this project was a Kaeser M122. The technical specifications are shown in Table 2-2. During the tests this compressor was used on full load. During the blasting this compressor would keep a pressure of typically 7.5 bar (110 psi).

Table 2-2 Technical specifications of the Kaeser M122 compressor

Flow rate		Gauge working pressure	
m^3/min	cfm	bar	PSI
11.1	390	7	100
10.1	355	8.6	125
9.5	335	10	145
8.2	390	12	175
7.3	360	14	200

3 Results

Table 3-1 shows the tests matrix and concentrations measured during the tests as well as the test duration of the tests.

Table 3-1 Test matrix and concentrations during the tests

Test	Abrasive	Test piece	Start concentration	End concentration	Test duration
1	80 mesh garnet	Steel	6.2	3.0	5:40
2	30/60 mesh garnet	Steel	6.2	3.3	3:22
3	30/60 mesh garnet	aluminum	7.0	4.1	3:22
4	crushed glass fine	Steel	6.8	4.0	3:42
5	crushed glass fine	aluminum	7.6	3.1	5:40
6	copper slag coarse	Steel	6.7	2.5	6:20
7	copper slag coarse	aluminum	7.6	4.2	3:50
8	80 mesh garnet	aluminum	7.6	3.4	3:48
9	copper slag fine	aluminum	7.4	2.4	7:48
10	copper slag fine	Steel	7.4	3.4	4:27

None of the tests yielded an ignition.

After the last test, the explosive atmosphere inside the vessel was ignited using an oscillating spark in order to confirm that an explosive atmosphere prevailed.

4 Conclusion

The Graco EcoQuip Vapor Abrasive blast equipment was tested in explosive atmospheres of n-hexane to determine whether the blasting process would yield an ignition. The testing was conducted to support Graco's ATEX ignition hazard analysis for category 2 equipment, zone 1 explosive atmospheres.

Testing was performed on both rusted steel and aluminum with 5 different types of abrasives:

- 30/60 mesh Garnet (GMA)
- 80 mesh Garnet (GMA)
- Fine Copper Slag 0.2-1.0mm grit size (Star Grit)
- Coarse Copper Slag 0.4-1.9mm grit size (Star Grit)
- Fine Crushed Glass 0.2-0.6mm

N-hexane concentrations around 7% were normally used as the starting concentration and diluted to around 4% for all tests. None of the tests yielded an ignition.

As such the equipment can be used in potentially hazardous areas involving explosive atmospheres caused by gases and vapors of the Subgroup IIA.

5 References

[1] ISO 80079-36:2016 – Explosive atmospheres – part 36: Non-electrical equipment for explosive atmospheres — Basic method and requirements

[2] B. Lewis and G. von Elbe; *"Combustion, Flames and Explosions of Gases"*, 2. Edition. Academic Press Inc. New York and London 1961

[3] D. Kong et.al.; "*Auto-ignition of CH_4/air, C_3H_8/air, CH_4/C_3H_8/air and CH_4/CO_2/air using a 1 l ignition bomb*", Journal of Hazardous Materials 40 (1995) 69-84.

[4] W. Bartknecht; *"Explosions-schutz – Grundlagen und Anwendung"*, Springer-Verlag Berlin Heidelberg, 1993