NFPA 654- 2017 Edition
Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids
TIA Log No.: 1259
Reference: 7.13.1.6.4
Comment Closing Date: April 13, 2017
Submitter: Gerd Mayer, REMBE, and Helen Sztarkman, REMBE

1. *Delete 7.13.1.6.4 in its entirety as follows:*

   **7.13.1.6.4** A flame-arresting and particulate-retention device that is designed for use on explosion vent discharge shall not be used as an explosion isolation device in a return air line.

**Substantiation.** The reason for our submittal is because this section eliminates the use of flameless vents for return air isolation, a methodology that has been used for years and is still used without incident. Please see the *attached report* for the full statement of the issue and substantiation.

**Emergency Nature.** The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action.

Anyone may submit a comment by the closing date indicated above. To submit a comment, please identify the number of the TIA and forward to the Secretary, Standards Council, 1 Batterymarch Park, Quincy, MA 02169-7471.
Q-Box-II LF- NFPA 654

Location: REMBE® Test Centre 59929 Brilon (Germany)

Date: 28th October 2016

Test procedure: Dipl.-Ing. Roland Bunse (administration),
B. Eng. Marcel Vogtland
# Contents

1. Introduction ........................................................................................................................ 3  
2. Methods .............................................................................................................................. 4  
3. Results ................................................................................................................................ 5  
4. Discussion ........................................................................................................................ 14  
5. Abbreviations .................................................................................................................... 17  
6. References ........................................................................................................................ 17
1. Introduction

NFPA recently released a 2017 revision for Standard 654, "Standard for the Prevention of Fire and Dust Explosions from Manufacturing, Processing, and Handling of Combustible Particulate Solids." The following section was added in this revision:

"7.13.1.6.4: A flame-arresting and particulate-retention device that is designed for use on explosion vent discharge shall not be used as an explosion isolation device in a return-air line."

REMBE® is the original designer and manufacturer of flame-arresting particulate-retention devices (flameless venting) and its product line is fully ATEX approved/certified (REMBE® Q-Box and Q-Rohr). REMBE® has used its technological knowhow, gained from developing the Q-Rohr and Q-Box, to develop solutions for return air isolation using these devices without the explosion panel/rupture disc. Hundreds of Q-Box LF and Q-Rohr LF units are now installed all over the country/world, because this method is a safe, simple and economical way to protect against the potential issues involved in returning air into a building.

The newly added section, 7.13.1.6.4, seeks to prohibit the use of these devices for return isolation. This restriction is also not mentioned in any other NFPA Standard.

Our research determined that there was no detailed, fact-based explanation for this inclusion and no discussion of this section. Nor are we aware of any reported loss event. The following committee statement was all that could be found and confirmed by phone call with an NFPA Senior Chemical Engineer:

Under the current provisions outlined in 7.13.1.6.3 it is not clear that the use of a device that would trap flame or particulate solids from re-entering the work space could become contaminated and present a secondary hazard in the form of blockage. Such an occurrence could result in excessive pressure beyond safe limits and could fuel additional flame spread into the work place.

First Revision No. 44-NFPA 654-2014 [New Section after 7.13.1.6.3].

For this reason, REMBE® Inc. has again undertaken simulation tests to determine whether the committee’s concern that the device would "become contaminated and present a secondary hazard in the form of blockage" was valid.
2. Methods

The test simulations were undertaken on an air material separator (AMS) with a volume of 1.2 m³. There is one explosion vent opening, sized 12” x 24” (305 x 610 mm). For all test simulations, REMBE®'s EGV explosion panel is installed on this vent opening with a static opening pressure \( (p_{\text{stat}}) \) of 0.18 bars. The vent area is determined to be 2 ft² (0.186 m²). On the other side of the AMS, there is a size DN 200 opening simulating a return air duct. To make this a worst case scenario, we removed the filter elements that might otherwise act as a barrier to the propagation of the explosion.

For all return air isolation purposes, a REMBE® Q-Box-II LF or REMBE® Q-Rohr®-3 LF flame and particulate retention device was utilized. The LF in the part name designates that no explosion panel is attached to the flameless vents such that the device is open on the bottom. The Q-Box-II LF was specifically fitted with a special plexiglass wall in order to allow observation of the inside of the Q-Box-II LF.

The Kst value of the corn starch used for these experiments is approximately 200 bar*m*s⁻¹. A dust load amount of 2.65 lbs (1200 g corn starch) is used for each simulation. The dust is injected into the AMS with 6 bar of pressure and the dust cloud formed is ignited using an electrochemical detonator with 2 x 5 kJ.

**Ambient conditions:**
Surrounding temperature: 9°C
Weather conditions: sunny

The “Q-Box-II LF- NFPA 654” test is divided into six scenarios:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Test number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot Test</td>
<td>16-10-001</td>
</tr>
<tr>
<td>1</td>
<td>16-10-002</td>
</tr>
<tr>
<td>2</td>
<td>16-10-003</td>
</tr>
<tr>
<td>3</td>
<td>16-10-004</td>
</tr>
<tr>
<td>4</td>
<td>16-10-005</td>
</tr>
<tr>
<td>5</td>
<td>16-10-006</td>
</tr>
<tr>
<td>6</td>
<td>16-10-007</td>
</tr>
</tbody>
</table>
3. Results

The first explosion is only a pilot test (test number 16-10-001) to confirm dust loading and ignition sources are functioning properly. Once all setups were determined to be functioning properly we continued on with the six different scenarios.

In the first scenario, as seen below in Figure 1, the DN 200 aperture is opened and a REMBE® EGV 12” x 24” (305 x 610 mm) explosion panel is used to properly vent the enclosure.

Figure 1: Scenario 1 (test number 16-10-002)

The still shot image below, Figure 2, details exactly what occurred during this event as the explosion was relieved through the aperture (left) and the explosion panel (right). The first scenario is used to simulate a typical explosion vented outdoors with a return air duct which is also vented to the outdoors.
In the second scenario, a REMBE® EGV 12” x 24” (305 x 610 mm) explosion panel is still used to properly vent the enclosure. The change in this scenario is found on the DN 200 aperture. Here we installed a REMBE® Q-Box-II LF 305 x 610 mm flame-arresting and particulate-retention device to mimic isolation of the return-air line in a standard dust collector application. Figure 3 below is a graphic representation of the setup and Figure 4 is a still shot of the event. This scenario takes the previous setup one step further by simulating the effects of return air isolation.
Figure 3: Scenario 2 (test number 16-10-003)

Figure 4: Scenario 2 still shot showing steam ejected from Q-Box II LF
After observing the venting systems effectively released and isolated the explosion, we moved on to Scenario 3. In this scenario we again used a REMBE® EGV 12" x 24" (305 x 610 mm) explosion panel to properly vent the enclosure. For this scenario we installed a 9.8 ft / 3 m long duct on the end of the aperture and then installed the REMBE® Q-Box-II LF 305 x 610 mm on the end of the duct. The setup can be seen below in Figure 5. This was to effectively simulate a lengthier return air duct in order to see how a possible occurring pressure pilling effect would impact the Q-Box-II LF.

Figure 5: Scenario 3 (test number 16-10-004)
Scenario 3 proved to effectively relieve the explosion (see Figure 6 above), so we moved on to Scenario 4. This scenario involved overloading the Q-Box-II LF with product. We used an identical setup to Scenario 3 however, for Scenario 4, the Q-Box-II LF was pre-filled with 7.28 lbs/3.3 kg of corn starch to simulate a potential blocking hazard. The setup of this can be seen in Figure 6 below and the level of corn starch added can be seen in Figure 7.
This scenario effectively simulated the NFPA 654 technical committee’s main concern of the Q-Box-II LF becoming contaminated and presenting a secondary hazard in the form of a blockage. The results of this scenario can be seen in Figure 9 below: the explosion is effectively vented and isolated.
After the Scenario 4 test proved successful, we attempted additional experiments with the Q-Rohr\textsuperscript{®}-3 LF. In Scenario 5 we copied the setup of Scenario 3 by using a REMBE\textsuperscript{®} EGV 12" x 24" (305 x 610 mm) explosion panel to properly vent the enclosure and a Q-Rohr\textsuperscript{®}-3 LF on the end of the 9.8 ft / 3 m long duct. The setup can be seen in Figure 10 below. This scenario was conducted to simulate a lengthier return air duct with the Q-Rohr\textsuperscript{®}-3 LF to see how a potentially occurring pressure piling effect would impact this device any differently. A still shot of the outcome can be seen below in Figure 11.
Finally we conducted one more experiment to determine if a complete flameless venting solution had any impacts on the overall effectiveness of the explosion protection equipment. We did this using a similar setup to Scenario 3 however we are now using a REMBE® Q-Box-II 305 x 610 mm flameless explosion vent to properly protect the enclosure. We are still using a Q-Rohr®-3 LF on the end of the 9.8
ft / 3 m long duct for return air isolation. The setup of this can be seen in Figure 12 and a still shot of the outcome can be seen in Figure 13.

Figure 12: Scenario 6 (test number 16-10-007)

Figure 13: Scenario 6 still shot
4. Discussion

Below in Figure 14 is a summary of the test results performed for each different scenario. This provides a brief synopsis of each successful experiment.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Test number</th>
<th>Dustload</th>
<th>Ignition energy $E_i$</th>
<th>Ignition delay $t_i$</th>
<th>$P_{\text{red}}$ [bar]</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot Test</td>
<td>16-10-001</td>
<td>1200 g</td>
<td>2 x 5 kJ</td>
<td>400 ms</td>
<td>0.155</td>
<td>EGV 305 x 610 (primary vent); open DN200 duct</td>
</tr>
<tr>
<td>1</td>
<td>16-10-002</td>
<td>1200 g</td>
<td>2 x 5 kJ</td>
<td>400 ms</td>
<td>0.190</td>
<td>EGV 305 x 610 (primary vent); Q-Box-II LF</td>
</tr>
<tr>
<td>2</td>
<td>16-10-003</td>
<td>1200 g</td>
<td>2 x 5 kJ</td>
<td>400 ms</td>
<td>0.190</td>
<td>EGV 305 x 610 (primary vent); Box-II LF attached to duct</td>
</tr>
<tr>
<td>3</td>
<td>16-10-004</td>
<td>1200 g</td>
<td>2 x 5 kJ</td>
<td>400 ms</td>
<td>0.205</td>
<td>EGV 305 x 610 (primary vent) duct adapted with a Q-Box-II LF including dust load 3.3 kg</td>
</tr>
<tr>
<td>4</td>
<td>16-10-005</td>
<td>1200 g</td>
<td>2 x 5 kJ</td>
<td>400 ms</td>
<td>0.310</td>
<td>EGV 305 x 610 (primary vent) and a tube adapted with a Q-Box-II LF</td>
</tr>
<tr>
<td>5</td>
<td>16-10-006</td>
<td>1200 g</td>
<td>2 x 5 kJ</td>
<td>400 ms</td>
<td>0.225</td>
<td>EGV 305 x 610 (primary vent) and a tube adapted with a Q-Rohr® LF attached</td>
</tr>
<tr>
<td>6</td>
<td>16-10-007</td>
<td>1200 g</td>
<td>2 x 5 kJ</td>
<td>400 ms</td>
<td>0.255</td>
<td>Q-Box-II with explosion panel (primary vent) and duct with Q-Rohr® LF attached</td>
</tr>
</tbody>
</table>

Figure 14: Summary of test results
As can be seen throughout these results, the Q-Box-II LF and the Q-Rohr®-3 LF effectively isolated the simulated clean air side of the dust collector. This simulated result is far more intense than a real-world situation of an explosion propagating down the clean air side. In a real-world situation, the clean air plenum and filter elements would create a barrier, further reducing the propagation potential into the clean air side, since the majority of the explosion is primarily vented through the explosion vent or inlet duct (on the dirty side of the collector). The remaining flames and pressure wave that may break through to the clean air side would be greatly reduced in a real-world situation compared to what was observed in these experiments.

With that said, we tested the committees concern that a flame and particulate retention device (i.e. Q-Box-II LF and the Q-Rohr®-3 LF) could become contaminated, which would present a secondary hazard in the form of blockage. The following sequence of figures below demonstrates the amount of blockage we used in Scenario 4 which directly addresses these concerns.
As seen in these results, there were no excessive pressures developed which could rise beyond safe limits and fuel additional flame spread into the work place. Figure 18 specifically highlights that there is no secondary explosion that could occur in the work place because the Q-Box-II LF dissipates any flames which could ignite the exterior combustible dust. Let’s be clear: NFPA 654 section 7.13.1.6.3 would never allow this type of dust load, but even the exaggerated potential blockages emphasized in Figure 16 and 17 are not able to reduce the functional capability of the device. In all experiments the explosion was effectively vented, indicating that the Q-Box-II LF and the Q-Rohr®-3 LF are more than capable of being used as a return air isolation device. Summarized, the Q-Box-II LF and the Q-Rohr®-3 LF is a safe and effective device for use in return air isolation applications.

REMBE® GmbH Safety + Control

Brilon, 11th November 2016

i.V. Dipl.-Ing. Roland Bunse
Senior Consultant/ Technical Sales Explosion Safety
Product Manager Flameless Venting and Explosion Isolation
5. Abbreviations

- **Ei**: ignition energy
- **T_A**: surrounding temperature
- **t_i**: ignition delay
- **p_1**: pressure sensor
- **V_1**: volume of the vessel

6. References

- NFPA 654: *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*. Quincy