



New VDI-Guideline on Fire and Explosion Protection on Elevators

Richard Siwek

FireEx Consultant GmbH, CH-4303 Kaiseraugst, Switzerland
r.siwek@fireex.eu

In December 2008 the VDI-Guideline Part 8 : 2008 was published. In this guideline the basic information regarding fire and explosion risks, fire and explosion protection measures are given and aims both the manufacturer's and the user's tasks.

In March 2011 the new the VDI-Guideline Part 8.1 : 2011 was published. The main information contains examples of preventive fire and explosion protection and constructional measures for fire and explosion protection in elevators.

Thanks to the results of extensive explosion trials on a bucket elevator conducted in the last years, important gaps in our knowledge have been filled and new findings regarding explosion venting and explosion suppression gained. These findings are also incorporated in this new guideline Part 8.1. Equations involving numerical values have been developed which represent an optimized mathematical matching of the innumerable experimental investigations, and which, as experience has shown, embrace the conditions of operational practice even for the most unfavourable cases.

Both guidelines are the basic for a European standard in form of a Technical Report on explosion protection on elevators.

1. Introduction

The guideline is applied to measures adopted to prevent explosions in elevators in which combustible dust/air mixtures or hybrid mixtures are found or can develop when operated in the intended manner.

The guideline provides information for manufacturers as well as special information for operators in the form of examples for conducting risk assessments and implementing of fire and explosion preventive and protective measures. Elevators are vertical conveyors of various designs for transporting bulk materials between different levels. They include bucket elevators, continuous bucket elevators, pendulum bucket elevators and corrugated-edge-belt conveyors. Dusty and potentially explosive bulk materials are mostly handled by belt elevators. All further considerations therefore refer to this type of elevators.

2. Research results

The relevant regulations on dust explosion venting (VDI 3673 Part 1, 2002; EN 14491, 2006) cannot be applied to elevators. The reasons lie in the special geometric form and in the installation (bucket conveyor) within the elevator shafts. For that reason a research program was carried out at the test station of the Research Centre for Applied Systems and Industrial Medicine FSA at Kappelrodeck, Germany on a bucket elevator shown in Figure 1.



Figure 1: Double-leg bucket elevator used for the investigation

The above mentioned guideline is mainly based on the results gained from the mentioned research program. First results were reported by Roseret al. (2001). Due to the fact that the research work are only finished using explosion venting with bursting disks the guideline is reporting in details the gained results. Additional research work are still going on regarding the application of flameless venting devices and the use of vent ducts as well as the application of explosion suppression systems on the elevators.

3. Design and arrangement of dust explosion systems

3.1 Single-leg bucket elevator

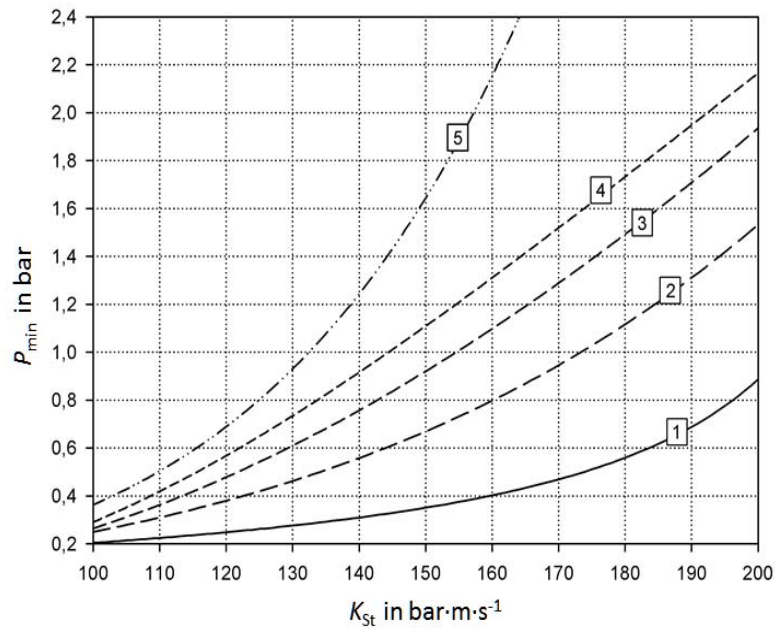
There is no comprehensive information on single-leg bucket elevators. In addition, they are seldom used. Recommendations can be found in the Final report EC/01/50.

3.2 Double-leg bucket elevator with rectangular shafts

The necessary minimum explosion resistance of the elevators depending upon the K_{St} value is presented in Figure 2 for various dust explosion venting systems configurations.

For bulk material with fine dust fractions that exhibit a K_{St} value $\leq 100 \text{ bar}\cdot\text{m}\cdot\text{s}^{-1}$, pressure relief may not be required provided that it can withstand explosion pressures of $P \geq 1 \text{ bar}$ overpressure. This applies under the following conditions:

- Ignition source location inside the elevator
- Free explosion venting without vent duct
- Every venting area \geq shaft cross-section area
- Free space in relation to the shaft cross-section $< 60 \%$
- Venting at the elevator head \geq shaft cross-section area
- Bucket distance $\leq 280 \text{ mm}$ with $K_{St} \leq 150 \text{ bar}\cdot\text{m}\cdot\text{s}^{-1}$
- Bucket distance $\leq 140 \text{ mm}$ with $K_{St} \leq 200 \text{ bar}\cdot\text{m}\cdot\text{s}^{-1}$
- Rectangular shaft cross section
- P_{stat} of venting system $\leq 0.1 \text{ bar}$
- Organic dusts
- Bucket material: metal
- P_{max} of dusts $\leq 10 \text{ bar}$
- K_{St} of dusts $\leq 200 \text{ bar}\cdot\text{m}\cdot\text{s}^{-1}$
- Vent efficiency of vent devices $E_F = 1$



5 venting: head + shafts (12 m distance) or only head to a maximum shaft length 12 m; 4 venting: head + shafts (6 m distance); 3 venting: head + shafts (6 m distance); 2 venting: head + boot + shafts (6 m distance); 1 venting: head + boot + shafts (3 m distance)

Figure 2: Required minimum explosion resistance P_{min} of the elevator depending upon the K_{St} value.

The curves depicted in Figure 2 can be described by the following numerical equation (1)

$$P_{min} = \exp(a \times K_{St}^c + b) , \text{ in bar} \quad (1)$$

The parameters a, b and c can be taken from the VDI-Guideline 2263 Part 8.1. Figure 3 shows 2 examples for calculation using the equation (1).

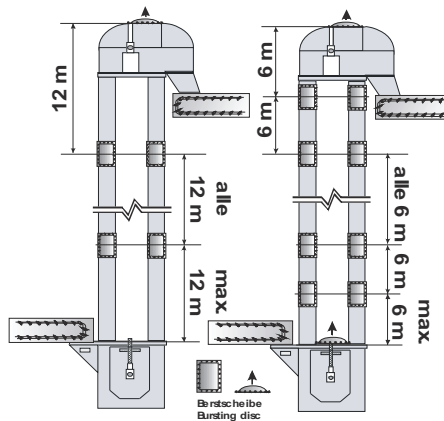


Figure 3: Examples of the necessary explosion resistance of double-leg bucket elevators for two explosion venting system configurations - $K_{St} \leq 150 \text{ bar} \cdot \text{m} \cdot \text{s}^{-1}$

The example on the left hand side of the Figure 3 results in a $P_{\min} = 1.7$ bar for metal buckets using in Figure 2 the curve 5 and the example on the right hand side of the Figure 3 results in a $P_{\min} = 0.7$ bar for metal buckets using in Figure 2 the curve 2.

As already mentioned the above equation (1) is only valid for metal buckets. Due to reduction in heat dissipation in the case of plastic buckets, the explosion resistance values of the elevators are to be increased according to Table 1.

Table 1: Percent increase of pressure resistance using plastic buckets

K_{St} , bar·ms ⁻¹	Percent increase
< 100	20 %
100 to 150	35 %
> 150 to 200	50 %

Figure 4 shows an example of a vented dust explosion.



Figure 4: Examples of the vented dust explosion in the bucket elevators - $K_{St} \leq 150$ bar·m·s⁻¹

3.3 Double-leg bucket elevator with circular shafts

If the buckets elevator has a circular shaft, the free cross-section area inside is considerably larger than in rectangular shafts. Considerably higher flame velocity and, thus, higher explosion pressures can occur. In this case, the explosion resistance of the entire casing including the elevator boot and head should be at least doubled. Therefore equation (1) transforms into equation (2)

$$P_{\min} = 2 \times [\exp (a \times K_{St}^E \times b)], \text{ in bar} \quad (2)$$

3.4 Use of flameless venting equipment or vent ducts

Studies are currently being conducted in order to provide information on the influences that affect venting. Until then the following can be recommended:

Flameless venting. The venting efficiency is determined within the context of an EC-type examination and must be given due consideration.

Venting with vent ducts. When vent ducts are used on the elevator boot and head, the necessary increase in the venting areas is calculated according to EN 14491 (2006). In doing so, the elevator boot and/or head is to be considered as a separate vessel with a volume of V_{boot} or V_{head} . The openings to

the flanged elevator shafts are not considered venting areas in this context. If additional vent ducts are required on the elevator shafts, these venting areas must be considerably larger than the cross-section area of the elevator shaft.

3.5 Recommendations for explosion resistant construction of double-leg bucket elevators

The installation of a venting device in the boot of an elevator often leads to considerable problems resulting from the hazard area that has to be taken into consideration and the possible necessity of vent ducts leading outwards, especially in the case of elevators installed within a building.

If the elevator boot cannot be vented (Figure 5), the elevator boot and shafts up to the point of the first vent area are to be reinforced up to an explosion resistance of $P = 1.7$ bar (Figure 2, curve 5), when the shafts are vented after maximum of 12 m.

After that it is possible to build with a lower level of explosion resistance, e.g., with an explosion resistance of $P = 0.7$ bar (Figure 2, curve 2), when the maximum distance of the venting in the shafts are limited to 6m.

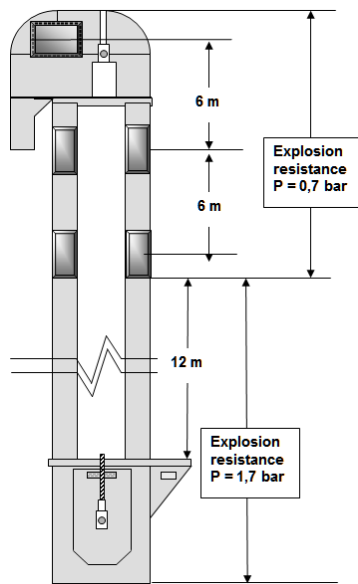


Figure 5: Examples of a combination of pressure resistance design when venting on the lower part of the elevator is not possible - $K_{St} \leq 150 \text{ bar} \cdot \text{m} \cdot \text{s}^{-1}$

4. Explosion suppression

When (VDI 2263 Part 8.1, 2011) was published the test research was not yet finished. Therefore from the publication from Vogl and Radandt (2010) it can be derived orientation data for the installation distance of the extinguishing barriers in the shafts and the pressure resistance of the bucket elevators (Table 2 and Figure 6).

Table 2: Installation distance of extinguishing barriers and minimum pressure resistance of bucket elevators as a function of pressure/flame detection

Detection Activation Pressure P_{act}	Installation distance l , m of extinguishing barriers	Minimum pressure resistance P_{a1} , bar	Minimum pressure resistance P_{a2} , bar
$80 < P_{act} \leq 110 \text{ mbar}$	8	1.5	1.2
$30 < P_{act} \leq 80 \text{ mbar}$	6	1.0	0.7
$P_{act} \leq 30 \text{ mbar}$	5	0.7	0.4
Flame detection	1.5	0.3	0.2

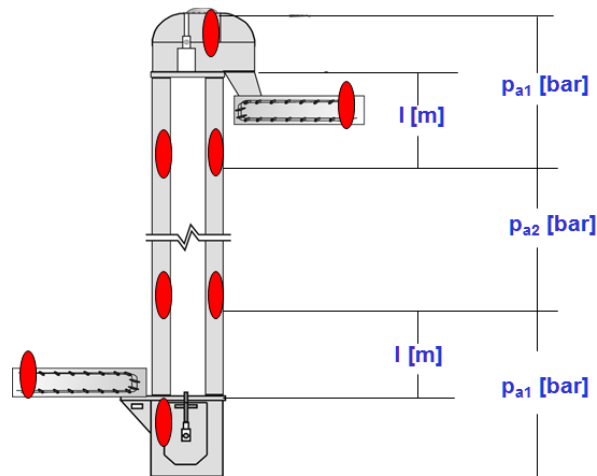


Figure 6: Installation distance of extinguishing barriers and minimum pressure resistance of elevators as a function of detection

5. Explosion isolation systems

The guideline provides an overview of the most frequently used explosion isolation measures currently employed in practice at the interfaces to attached equipment and areas.

6. Fire fighting

In case of fire inside of elevators, fire extinguishers or mobile fire brigade deployment are not suitable due to the danger of triggering a dust explosion. In such cases external cooling is the only sensible measure.

The VDI-Guideline provides form for the assessment of fire hazards.

References

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