# Blast Protection in Demanding Industrial Environments

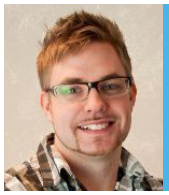
WHITE PAPER

## Protecting People, Surroundings and Assets in Demanding Industrial Environments

Enabling Wellbeing

Halton

## Author



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The author works in Halton Marine as a Sales Manager in Heavy Industry segment helping customers to find solutions for demanding industrial environments. He has several years of experience with industrial projects with needs for special protection. Feel free to contact him to discuss further about blast protection or if you need any assistance with HVAC and protection related matters in demanding industrial environments.

### About the paper

This text is the first article in Halton Marine's article series "Protecting people, surroundings and assets in demanding industrial environments". The series is focusing on helping stakeholders to understand the possible risks and protection solutions in demanding industrial environment. The first article focuses on blast protection, other articles about fire and gas protection will follow in the near future.

### About Halton Marine

Halton Marine is one of the world's leading suppliers of HVAC solutions specifically designed for demanding environments. Halton's track record includes deliveries to over 150 major cruise ships, 200 oil & gas projects both offshore and onshore and 150 naval vessels.

### Halton's scope of supply for heavy industry

- Blast dampers
- Fire dampers
- Pressure-relier dampers
- Air intake products

11 December 2019 - Lahti, Finland

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# Contents


4 Foreword

5 The basics

What is an explosion or a blast?

The blast force

7 Blast protection

Blast protection in general

Advantages of blast protection

9 How can Halton help you?

Benefits in project design and management

Technical benefits

Operation of BDH blast damper

10 Conclusion

11 References


# Foreword: “3 workers hurt and 50,000 people evacuated as fire rages after chemical plant explosion”

This is an example of a news headline after the latest major accident in petrochemical industry. In November 2019, a chemical plant located in Texas suffered from two massive explosions and raging fires after this. Fortunately, there were no fatalities although 3 workers were hurt and over 50,000 people had to leave their homes due to mandatory evacuation.

Only in the past two years, there has been over ten severe accidents around the world as shown in Table 1. And in addition to these, there are accidents or near miss cases that won’t make headlines. The severity varies from material damages to tens of people killed in accident, not to mention environmental and air pollution issues following these explosions.

| Date | Location | Accident |
|---|---|---|
| 03/2018 | Czech | Petrochemical Plant Explosion |
| 04/2018 | USA | Refinery Explosion |
| 09/2018 | Germany | Refinery Explosion |
| 10/2018 | Canada | Refinery Explosion |
| 11/2018 | China | Petrochemical Plant Explosion |
| 03/2019 | China | Petrochemical Plant Explosion |
| 06/2019 | USA | Refinery Explosion |
| 07/2019 | China | Gas Plant Explosion |
| 09/2019 | Saudi Arabia | Attack to Oil Processing Facility |
| 10/2019 | China | Petrochemical Plant Explosion |
| 11/2019 | USA | Petrochemical Plant Explosion |

Table 1. List of Explosions in Petrochemical Industry in 2018-2019

The petrochemical production is predicted to grow rapidly in the following decades. It is not only fuels and industrial chemicals that are made from petrochemicals, but also everyday consumer products such as plastics, clothes, detergents, fertilisers, medicines and countless other products. This puts on a pressure to develop the current petrochemical facilities and increase their capacity as well as to build entirely new plants and production facilities.

As the industry is growing, risk management, monitoring and preparing become essential in preventing above mentioned accidents from happening. As it is possible to reduce the risk of accident happening, it is impossible to completely remove the possibility of an explosion. Preparing for the worst is equally important and that is where blast protection makes a stand.

## What in an explosion or a blast?

Explosion is considered as an event, where energy is released in an extreme manner and followed by rapid increase in volume. There are different types of explosions, but usually two types are linked especially to industrial environment: Chemical and Mechanical Explosions

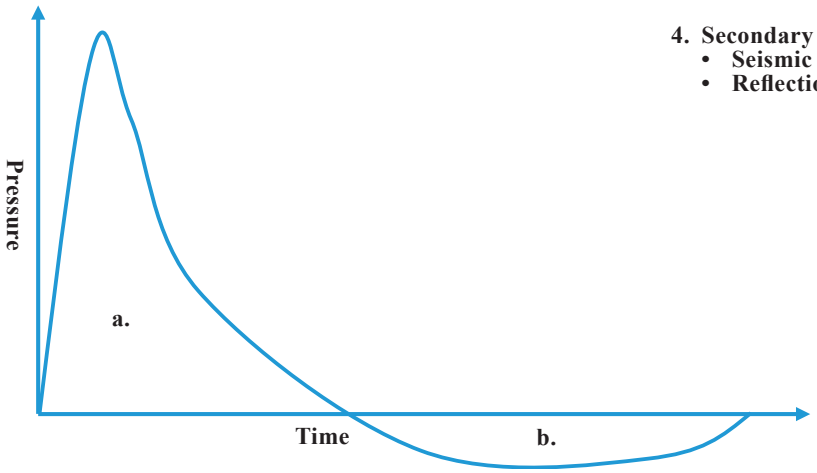
1. **Chemical explosion** is the most common one, happening especially in environments where flammable substances are present. Usually a source of heat (e.g. a spark or flame) will ignite the substance, which will lead to a chain reaction where oxidation happens rapidly and violently creating the explosion.
2. **Mechanical or physical explosion** is an event, where e.g. pressurized vessel or container ruptures and releases the content rapidly. As the pressurized content bursts out of the vessel, it expands and creates a shock wave.

In some cases, these explosions can follow each other: if pressurized vessel contains flammable substance, there is a high risk of igniting after being released from vessel. This will make the explosion effects dramatically more serious.

Blast or shock wave will follow right after the explosion. Basically, this is the increased pressure and flow resulting from the explosion. In industrial accidents the positive phase blast duration is quite long, and it can last up to 200ms. The negative phase of the blast, also called the suction phase, will follow over-pressure phase. In this phase the pressure returns towards the explosion point and creates a suction effect. It is important to remark both phases when protecting from blast as also under-pressure can harm people and equipment.

Normally explosion effects are divided as shown in the table 2 below. How these affect people and structures vary depending on several matters: explosive substance, distance from the explosion, force & duration of the explosion, damping factors and structural elements of the buildings.

1. **Blast Pressure Wave**
   a) **Over-pressure (positive phase of blast), pressure and wind effect**
   b) **Under-pressure (negative phase of blast), "suction"**




2. **Fragment and debris effect**
   - **High-velocity flying debris and fragment**
3. **Thermal effect**
   - **Fire and heat generated from the explosion**
4. **Secondary effects**
   - **Seismic effects**
   - **Reflections**

Table 2. Explosion Effects. Illustrative graphic.

## The Blast Force

When determining the intensity of the blast, normally pressure units and values (e.g. Bar, kPa, Psi) are used. Unfortunately, pressure units are not commonly understood by the public so it might be hard to figure out how much force a blast generated from an explosion contains.

For example, a car tyre may have over-pressure of 2,5 bars when fully inflated as at the same time the maximum pressure of 1 bar generated from an explosion might sound like a low value compared to a tyre. Table 3 below illustrates the pressure values compared with weight and area for better understanding of the blast pressure forces. But it must be noted that as blast is considered as dynamic pressure, the peak overpressure values last only for a really short period of time and cannot directly be compared with static pressure values shown in the table.

| Pressure | $kg/m^2$ | |
|---|---|---|
| 0,1 bar | 1019 $kg/m^2$ | 0,00001 bar = 1 Pa = 1 $N/m^2$ ~ 0,1 $kg/m^2$ |
| 0,16 bar | 1630 $kg/m^2$ | |
| 0,3 bar | 3058 $kg/m^2$ | |
| 0,5 bar | 5096 $kg/m^2$ | |
| 1,0 bar | 10193 $kg/m^2$ | |

Table 3. Pressure values

As shown earlier in the text, there are several different effects generated from an explosion. All these are dangerous to both people and material & equipment. Pressure alone is more harmful to humans than solid materials as the rapid changes in pressure affect particularly the air and liquid filled organs. The table 4 below shows the damage blast pressure can do to people and structures.

| Maximum Pressure Load | Effect |
|---|---|
| 0,1 bar | • Windows may break<br>• Temporary hearing loss possible |
| 0,16 bar | • People thrown off balance<br>• Flying debris |
| 0,3 bar | • Eardrum rupture highly likely |
| 0,5 bar | • Lung damage may occur<br>• Debris flying in high velocity |
| 1,0 bar | • Weak concrete structures will break<br>• Severe lung damage<br>• Bowel rupture / Other internal organs damaged<br>• Equipment will break<br>• Fatalities highly likely |

Table 4. Blast pressure effects

The injuries from blast are divided into 4 different categories:

1. **Primary Blast Injuries**

   These are the direct injuries generated by blast wave. As the blast wave causes dynamic pressure changes, these injuries occur most frequently in air or liquid filled organs (e.g. ears, lungs, bowel). Also head and neck injuries are common together with concussion.

2. **Secondary Blast Injuries**

   Secondary injuries are usually caused by objects and debris flying in high velocity. Especially small and sharp pieces of debris are extremely dangerous for humans.

3. **Tertiary Blast Injuries**

   Tertiary injuries are caused when person fall or are thrown to the ground or object.

4. **Quaternary Blast Injuries**

   Quaternary injuries are considered as other injuries caused by the explosion. These include e.g. burns, infections and crush injuries.

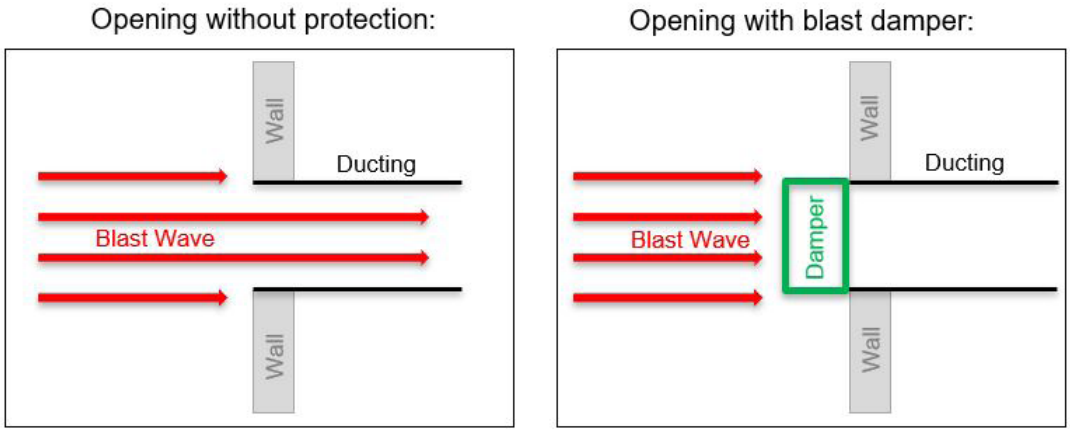
# Blast Protection

## Blast protection in general

When considering blast protection as a part of plant or facility design, it should be taken into account especially in two cases: in buildings' structural design and in HVAC design.

In structural design's point of view, all critical and essential buildings and structures should be designed to withstand the specified blast pressures generated from a possible explosion. Usually the pressure levels, potential explosion points and general layouts are specified in general guidelines and standards for petrochemical plants by process & plant owners. But although the structure is blast resistant, it does not necessary mean that the building would provide safety to people working inside it. These buildings have openings, air inlet and outlet points for ventilation and HVAC purposes. Without proper protection the blast wave will penetrate into the building through these openings and harm people and equipment inside.

Blast dampers and valves are used in these ventilation inlet and outlet points to prevent the blast wave and debris from entering the building as presented in picture 1. The mechanical structure may vary depending on the manufacturer, but the operating mechanism is the same: they close automatically when the blast wave hits them as in case of a sudden explosion there is no possibility for manually closing ventilation openings and preparing for the blast. Usually this equipment is installed to wall or roof but can also be used between ducts. Most of the blast protection equipment in the market provide protection from both the positive and negative phase of the blast.




Picture 1. Blast damper to prevent blast wave from entering the building

## Advantages of blast protection

The main purpose of blast protection equipment is naturally to provide safety in case of an accident and explosion, but it also helps to manage the repercussions after the possible incident. The main advantages are listed and explained below.

### 1. Ensuring safety of people, equipment and environment

The most important function of blast protection is to protect people working in the facility, the critical equipment & material and the environment around the plant. And there's also important point to be noted, which is not usually considered essential: If you can ensure safety of the people in case of an accident, there is a high possibility that those people are also able to limit the damages and prevent a possible butterfly effect from happening.

- Protection for the people working in the facility
- Protection for the equipment used in the facility
- Personnel and equipment remain operational in emergency situation and are able to control the process & situation the best they can right after the accident and prevent further incidents from happening.
- Protection for the environment if accident and its impacts can be limited

### 2. Flexibility in engineering and design's point of view

Although standards and general guidelines set the basis for engineering and design, blast protection might give the owner some flexibility in layout design. With blast protected structures and buildings, it is possible to achieve lower acceptable risk level.

- Flexibility in plant or facility layout design

### 3. Cost savings in case of an accident

Blast protection can help the owners to minimize the overall costs generated by the accident. Every minute that can be reduced from the duration of production standstill will save costs in recovering from the accident. Also personnel's injuries treatment and even fatalities will account for a remarkable share of the total costs.

- Protection for production process and equipment
- Minimizing the personnel related costs
- Minimizing the downtime
- Minimizing the overall cost caused by the incident

The costs of adding blast protection to the plant design and procurement is only a fraction of the total costs when petrochemical or power plants are being constructed. But in unfortunate case of an accident, prominent cost savings will be gained.

# How can Halton help you?

## Benefits in project design and management

Halton has been working in demanding onshore and offshore projects in Oil & Gas, Nuclear industry and Naval industry for several years. Halton is experienced in blast protection and can help you in many ways.

- Provide help with blast protection design and selecting the suitable products
- Competitive and flexible lead times: standard products ready for transportation even in 4 weeks
- ATEX certified products, suitable for Zones 1 & 2
- EAC certified
- Products widely tested by 3rd party research centres as well as internal testing conducted
- Project management, documentation and support services provided

## Technical Benefits

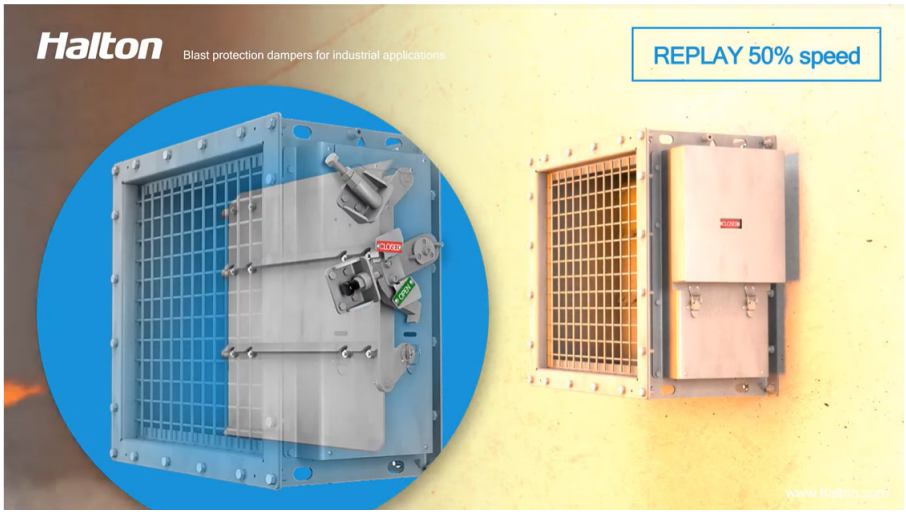
Halton released new BDH Blast Damper in September 2019. It's designed to be used in demanding offshore and onshore environments, e.g. in Oil & Gas and Petrochemical industry as well as in Power Plants.

- Adjustable minimum closing pressure from 0,1 bar; tested with max. pressure of 1 bar
- Low pressure drop values
- Protects from both positive (blast) and negative (suction) phase
- Can be installed vertically/horizontally on wall/ roof and between ducts
- Mechanism is designed to be reliable and easy to operate
- Modular construction available for larger openings
- Debris catcher available as an accessory
- Low maintenance; operation checks once a year

Picture 2. Halton BDH Blast damper

### Operation of BDH Blast Damper

BDH Blast Damper is a mechanical damper, that is designed to withstand high blast pressures, close the air passage way and prevent blast pressure from entering the building. It is manually armed and will remain closed after the blast until re-armed.




Picture 3. Halton BDH operation principle. Click picture to see animation.

## Conclusion

As mentioned several times, it is possible to reduce the risk of accident happening, but it is impossible to completely remove the possibility of an explosion. Ensuring people a safe place to work, even in case of an incident, is the most important matter. But as presented, blast protection provides several other advantages in addition to just protecting people. And as famous British author on the topic of chemical engineering safety, Dr. Trevor Kletz, once said:

"There's an old saying that if you think safety is expensive, try an accident. Accidents cost a lot of money. And, not only in damage to plant and in claims for injury, but also in the loss of the company's reputation."

We at Halton are happy to help you with any industrial protection related matter.

- Are you familiar with blast protection?
- How would you benefit from blast protection?
- What are your main challenges in blast protection?
- For what kind of project are you considering blast protection for?
- How can Halton help you?

Please visit Halton' site dedicated to blast protection: http://www.industrialblastdampers.com/

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1112/2019

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# About us

## Halton Group

Halton Group specializes in indoor environment solutions, ranging from public and commercial buildings to foodservice facilities. Founded in Finland in 1969, Halton operates today in over 35 countries around the world, with annual sales of €220 million and over 1600 employees. The company has production facilities in Brazil, Canada, China, France, Finland, Germany, Malaysia, United Kingdom, and the USA.