

## Policy on Stable Detonation Flame Arresters



### Summary:

Elmac Technologies® strongly recommends that an unstable detonation arrester be fitted in systems where a detonation may be possible, in order to deal with worst case conditions for the particular piping system.

### Policy on Stable Detonation Flame Arresters

It is the established policy of Elmac to supply two basic categories of in-line flame arrester; namely:

- Deflagration flame arresters – suitable for slow and fast deflagrations and subject to a maximum straight-pipe equivalent run-up distance from the source of ignition
- Unstable detonation flame arresters – suitable for deflagrations, stable and unstable detonations

Because unstable detonation arresters are designed and tested under the worst case conditions that any arrester is likely to experience for a given gas-group and initial pressure, the physical location of a device within a piping system relative to the ignition source is not subject to any restrictions (except in locations where endurance burning may occur).

This is not the case for a stable detonation arrester which must be positioned in such a location within a system that it can only ever experience a stable detonation or deflagration event.

In common with North American flame arrester manufacturers, Elmac does not supply the so-called stable detonation arresters (which are available from several European manufacturers) on the grounds that such devices may expose operators to unacceptable levels of risk.

In summary, such risk arises from the following factors in combination:

- Unstable detonations are much more destructive than stable detonations
- Stable detonations normally only occur where there have first been unstable detonations

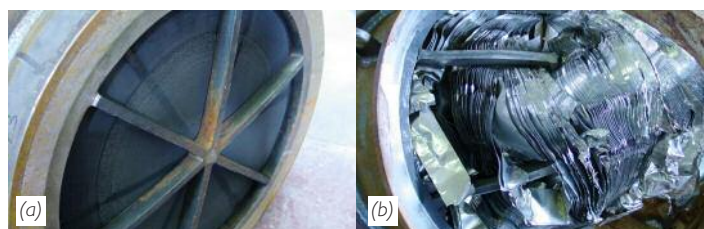


Figure 1 – Pictures of 'stable' detonation arresters subjected to (a) a stable detonation, and (b) an unstable detonation

- A stable detonation may suddenly be triggered back into an unstable form
  - Such events are not amenable to rigorous scientific predictions
- The risk is further increased by the possibility of changes in the design of the physical system which may render a stable detonation arrester unsuitable.

Because the determination of a stable detonation arrester position is not yet amenable to rigorous scientific and engineering design principles, there is no basis for confidence in the selection of a location for the arrester. It is possible that, despite best endeavours, a stable detonation arrester may encounter an unstable event with catastrophic consequences.

Accordingly, Elmac strongly recommends that an unstable detonation arrester be fitted in systems where a detonation may be possible, in order to deal with worst case conditions for the particular piping system.

### Elmac Expertise

Elmac have been manufacturing flame arresters since 1948, and bring enhanced levels of flame and explosion protection to a diverse range of applications. Elmac Technologies offers considerable technical leadership and using test facilities along with CFD capabilities, employs research teams renowned for developing solutions for the most challenging of industrial applications.

# Deflagrations, Detonations & DDT

## What is a flame arrester?

A flame arrester is a device fitted to the opening of an enclosure or to the connecting pipework of a system of enclosures and whose intended function is to allow flow but prevent the transmission of flame. Flame arresters protect pipelines and processing facilities involving flammable gases/vapours from fire and explosions. In-line flame arresters are generally faced with three types of duty as follows:

- **Normal operating duty** in which the gas mixture is transported along a pipeline at the temperature and pressure of the system without the presence of a flame
- **Deflagration duty** in which the gas mixture is ignited and a flame front travels along the pipeline at subsonic velocities (in the gas mixture)
- **Detonation duty** in which a detonation is defined as a combustion wave propagating at supersonic velocities and characterised by shock waves

## What is DDT?

A deflagration, when confined in a pipe, can accelerate as a result of the pre-compression of the fuel mixture ahead of the flame front and undergo a transition from deflagration to detonation (often called a DDT). When a detonation passes through a confined system without significant variation of velocity and pressure, it is called a **stable detonation**. However, during the transition from deflagration to stable detonation, the combustion wave passes through a limited spatial zone in which the flame velocity is not constant and in which the explosion pressure is significantly higher than the resultant stable detonation pressure. Immediately after DDT, the pressure and velocity of the detonation wave are significantly higher than the stable detonation values. This temporary condition is known as the overdriven detonation. The transition period consists of two phases; the DDT and the overdriven detonation. During this period of the transition, the detonation is referred to as an **unstable detonation**.

## Unstable detonations represent worst case conditions

The phases described above are illustrated in figure 2. This shows the change in pressure of the pressure/shock wave as the flame front progresses along a pipe. It can be seen from this figure that an unstable detonation represents a more severe condition than either a deflagration or a stable detonation, with a significantly higher pressure peak.

Arresters designed for a stable detonation or deflagration will not necessarily prevent flame transmission or withstand the shock wave pressures associated with unstable detonation events. Indeed, some commercially available stable detonation arresters have been independently tested under unstable detonation conditions and have failed to prevent flame transmission.

The DDT takes place very suddenly as can be seen from figure 2. The transition time may be only a few microseconds, which at typical flame speeds equates to a few pipe diameters of straight pipe length. It is not possible, with the current state of the science, to predict with any confidence the exact location of a potential DDT in a piping system, so determining the ideal position of a stable detonation arrester is impossible.

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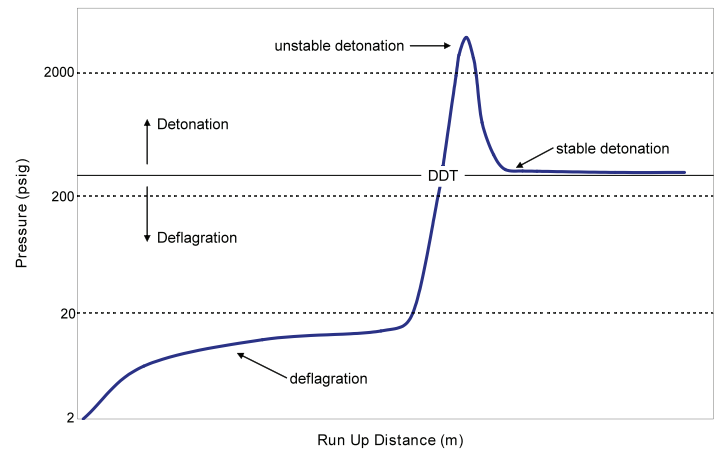


Figure 2 – Typical pressure profile with flame front run up distance

## Unstable detonations are unpredictable

Due to the high number of factors that affect the run-up length for DDT, it is impossible to determine the position in a system or the time when the DDT transition may take place. The concept of predicting a run-up distance for a stable or unstable detonation is fundamentally flawed. Also, in the event that the system pressure reduces, it is possible that the onset of the transition may be delayed such that an unstable detonation reaches the flame arresting device. Under such conditions, a stable detonation arrester might allow flames to pass through.

## Stable detonations may become unstable detonations

As can be seen from figure 2, a stable detonation event normally only takes place once an unstable event has occurred. However, a stable detonation may be suddenly triggered back into an unstable detonation. Experimental studies have revealed the existence of phenomena such as “galloping” detonations. Under certain conditions (for example at low initial pressures, or near to detonation propagation limits) a detonation wave may be subject to repeated transitions from stable to unstable to stable with catastrophic implications for a stable detonation arrester if that is the only safety device installed.

## Conclusions

In light of the fact that:

- Unstable detonations are much more destructive events than stable detonations
- The location of unstable detonations cannot be predicted with any certainty
- A stable detonation may undergo sudden transition to an unstable detonation

It follows that use of a stable detonation arrester in isolation is not sufficient to protect a system from transmission of a flame and exposes the user to significant risk.

**In any system where detonation events are a possibility, an appropriately designed and tested unstable detonation arrester device should be fitted.**