



Westech In-Line Flame and Detonation Flame Arresters



MEASURE EXCELLENCE. PERFORM BETTER.

An Explosive Situation

Explosions due to flame arrester failures are destructive, expensive and potentially deadly. Prior to 1989, no arrester provided protection against all types of flame propagation. In fact, no practical technology existed for testing detonation flame arresters used in piping systems. Existing flame arrester standards were clearly inadequate for in-line applications. Improper arrester selection and application lead to storage tank and processing unit explosions. Without an arrester designed and tested to meet the levels of protection required, the potential for a major disaster is high.

With the existing and future guidelines for emissions control comes a new challenge for safe facility operations. Installation of marine vapour recovery and destruction systems creates a high potential for disaster. In fact, an earlier explosion at a marine vapour control system in the U.S., pointed out the need for enhanced standards and in particular, the need for an adequate test standard for in-line arresters.

The advent of USCG, CSA and CEN standards is a major step forward in safe facility operation. Investigations and research continue on Detonation Flame Arresters.

Definitions

End-of-Line Flame Arrester

This type of flame arrester is used where the potential ignition source is located outside the vessel or flow system that is being protected (unconfined); the flame travel length is no greater than that used for flame arrester testing (typically 5 feet/1.25 m), and there are no restrictions in the protected side piping.

In-Line (Detonation) Flame Arrester

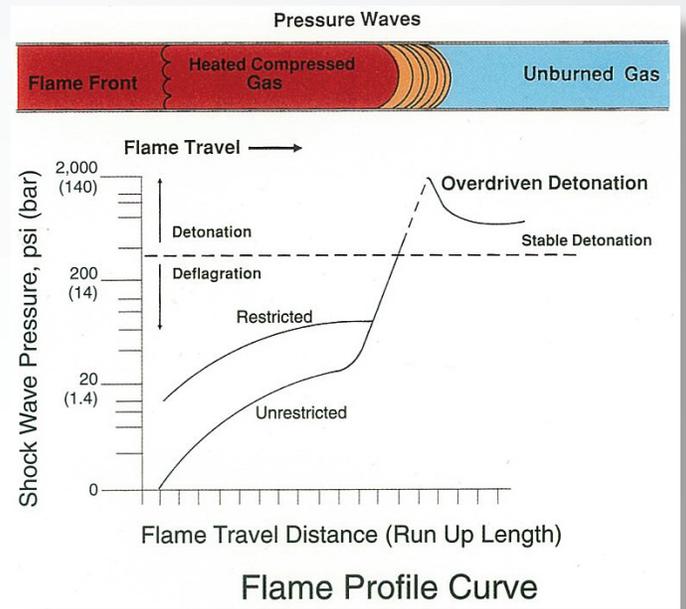
An arrester which has been designed and tested to arrest flame fronts of varying pressures and speeds with both restricted and unrestricted protected side piping as well as long run stable and overdriven detonations.

Deflagration

A flame front that propagates by the transfer of heat and mass to the unburned gas ahead of the flame front. Flame speeds can range from less than 1 m/s to greater than 350 m/s (supersonic) for very high pressure, turbulent flames. Overpressures can range from a very small fraction to as much as twenty times the initial pressure.

Detonations (Gaseous)

A flame front that propagates by shock wave compression ignition in a flammable gas mixture. Flame speeds are supersonic with Mach numbers ranging from 5 to 15. The pressure of stable detonation usually ranges from about 20 to 30 times the initial pressure but an overdriven detonation can achieve compression ratios in excess of 300 at the moment of transition from deflagration to detonation.



Overdriven Detonation

Also referred to as unstable detonation. The condition that exists during the transition of a combustion process from a deflagration into a stable detonation. This transition usually has the characteristic of producing extremely high explosion pressures in a relatively short time frame.

Stable Detonation

A detonation which has speed and pressure characteristics which do not vary significantly as the detonation progresses through a confined system, hence the term "stable".

Maximum Experimental Safe Gap (MESG)

The maximum gap between equatorial flanges in a spherical volume that will just prevent flame transmission from the vessel to the flammable gas mixture surrounding it.

Momentum Impulse

A phenomenon associated with increasing lengths of stable detonation travel. As the detonation travels down the line, the duration of temperature and pressure effects associated with the detonation increases up to a run-up distance of 300 pipe diameters

The Westtech Breakthrough

Westtech is an international company which has been servicing the needs of oil, gas, chemical and municipal I sewage industries for more than 30 years. Its detonation flame arrester program began by investigating the cause of flame arrester failures in vapour control systems.

Westtech discovered that existing flame arresters were not capable of preventing flame passage, regardless of piping configuration. It was also proven that existing standards governing flame arrester performance were inadequate for in-line use. Westtech concentrated on developing a comprehensive in-line detonation flame arrester standard which led to an advanced level of flame front arrestment technology. Actual tests were conducted rather than calculating results on paper, as had been the accepted practice in the past.

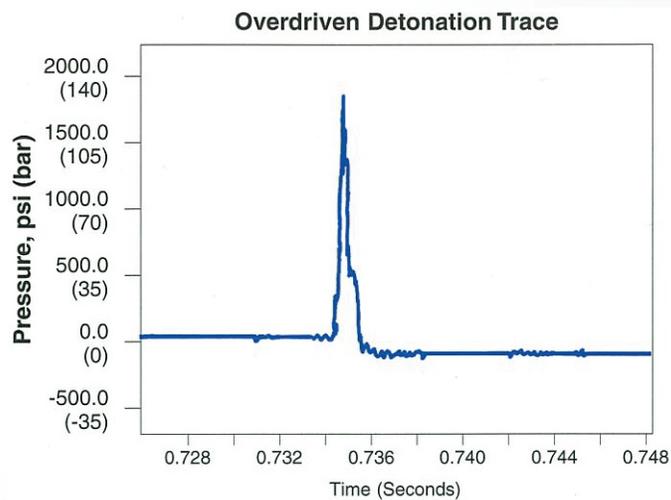
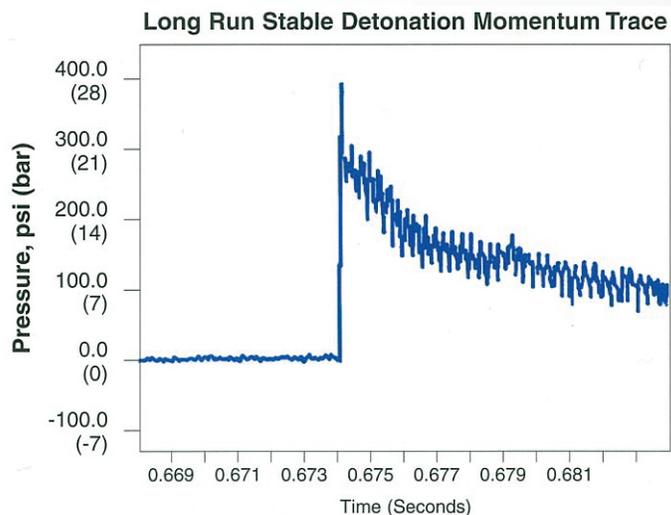
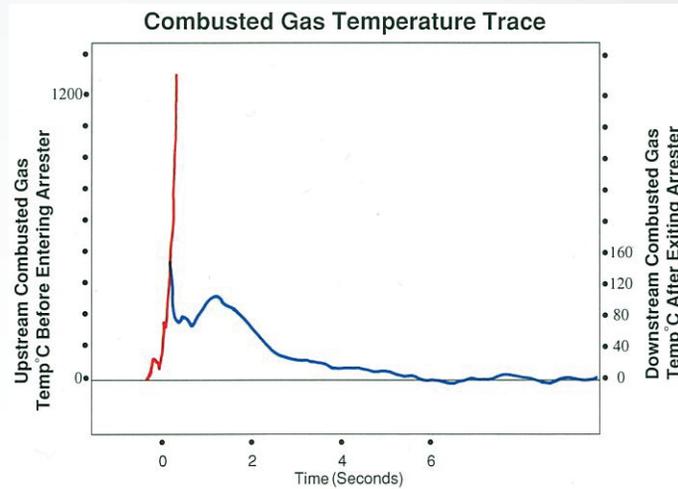


Westtech 18" diameter 1002' test tube for momentum testing of detonation flame arresters. This is the longest arrester test tube in the world.

Arrester Function

Quenching of the flame is accomplished by using a device which breaks the flame into very small "flamelets" that are passed through small flame channels in the arrester element. These same channels cool the flame front below the ignition temperature of the vapour mixture thereby quenching it. The function of an in-line (detonation) flame arrester falls into three categories:

- **Quench Flame Propagation**
- **Free Vapour Flow**
- **Independent Passive Operation**



Overdriven detonations and long run stable detonations are two types of flame propagation seen in pipeline explosions. Overdriven detonations have the characteristic of very high pressure for short durations, whereas long run stable detonations create high sustained pressures. Both types of flame propagation subject the arrester to different pressure and temperature characteristics, which have to be addressed by additional testing.

Westech's World Class Test Facilities

Westech has the most sophisticated detonation flame arrester test facility in the world. Line sizes up to 18" in diameter and 1,000 feet (305 m) in length are used to test our arresters. Some of the most severe pipeline explosions in the world are generated at this facility.

The arresters are subjected to test explosions which are continuously monitored by eight computers, each with a sample rate of 100,000 samples per second. Specialized instrumentation is used to collect data from highly responsive customized gas analyzers, and pressure, temperature and optical flame sensors. A single test explosion generates 4 megabytes of data which is analyzed to evaluate arrester performance. On-line analysis has recorded flame speeds of up to Mach 7 and explosion pressures in excess of 3,000 psi (200 bar). Measurement of these kinds of speeds and pressures requires critical accuracy. All calibrations, gas analysis, pressure, temperature and optical measurements from the arrester tests are fully traceable and reproducible.

All tests are monitored by independent third party review organizations and accredited by standards organizations.

Unrivalled R & D

Westech's first step was to evaluate a number of sites where explosions had occurred. This led to the writing of "A Summary of Investigations from Ten In-Line Flame Arrester Failures" which addressed the inadequacy of current arrester designs and test standards. From this investigation it was obvious that a true in-line arrester capable of providing protection, regardless of piping configuration, was required.

The development of the USCG, UL, FM, CSA and CEN standards has advanced the area of arrester certification. However, research into flame propagation by Westech has established the need for further standards development. Rather than meeting the minimum standards, Westech voluntarily tests arresters for flame front phenomena such as momentum impulse shock, precompressed deflagration to detonation transition, thermal flux, reignition of downstream unburned gases, downstream reflected shock wave failure, lean mixture detonations and lower MESG vapours. In order to ensure maximum facility protection, Westech has also tested to established installation criteria related to upstream pipe size changes and the venting of combustion products.

Westech has made the commitment to work with standards associations worldwide to ensure that new developments from research are incorporated into future test standards. Because of this commitment to continued research and development, our customers can be assured of the highest level of protection now and in the future.



Raising Flame Arrester Standards

Research testing discovered the primary reason for flame arrester failures in the past and this led to the development of Westech's "A Comprehensive Test Method for In-Line Flame Arresters". This test method has been used as the cornerstone for all existing Detonation Arrester Standards.

For this work, Westech was awarded a Certificate of Merit in the invention category of the 1989 Canada Awards for Business Excellence and the 1990 Canadian Gas Processors' Association (CGPA) Award for Innovative Excellence.

From the ground breaking research into flame front phenomena came a new generation of true in-line detonation flame arresters. This extensive research and development lead to an arrester designed to provide protection when installed anywhere in the piping system.

Although the first priority was to design an arrester that would provide maximum protection, this was not enough. Westech also designed a product that would solve many of the operational problems common with current flame arrester designs.

Considerations for Arrester Application and Selection

Selection of the correct arrester requires a detailed look at the application and must be based on the following:

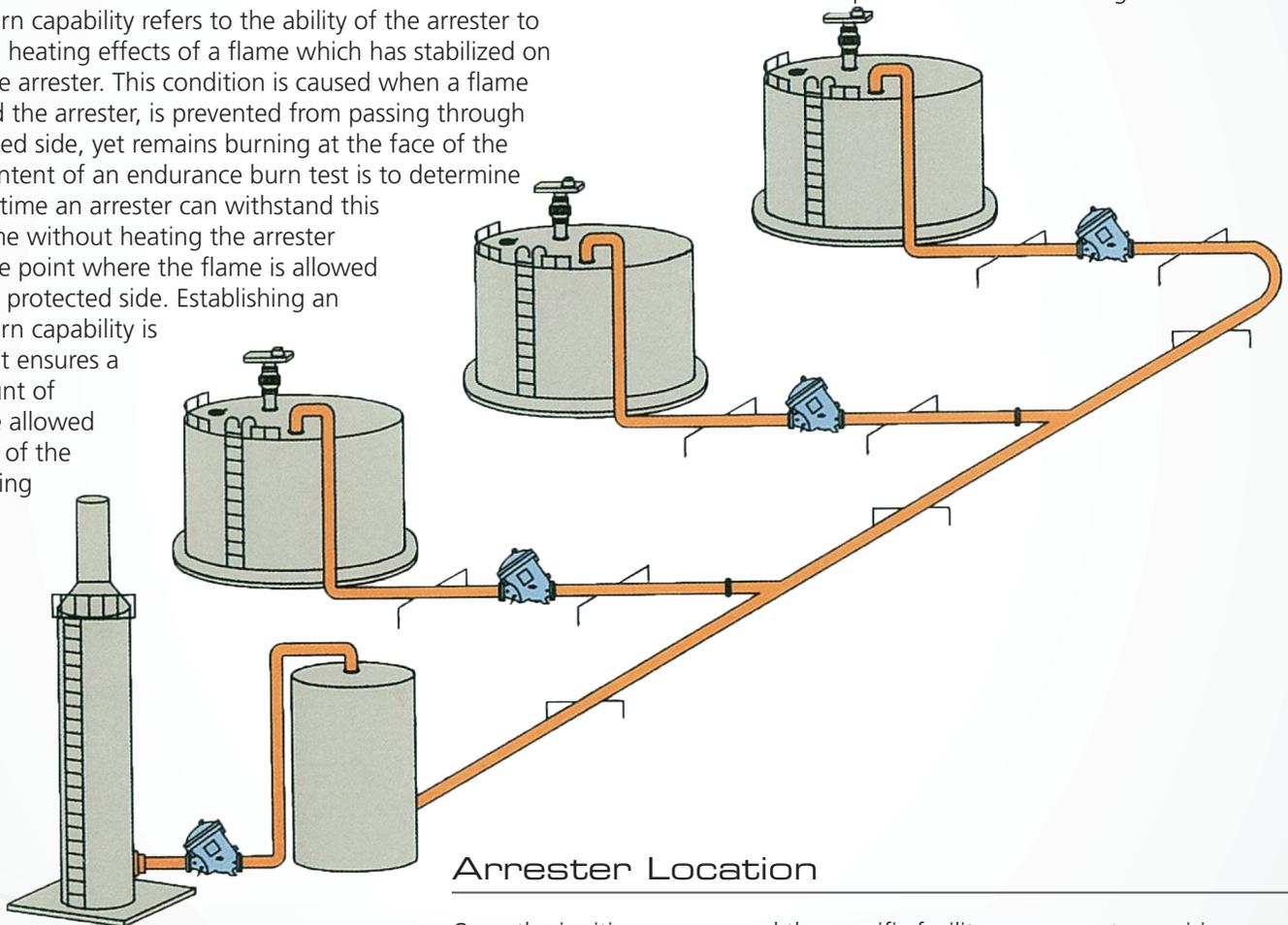
Testing and Certification

Acceptance testing which proves the capability of an arrester is the only guarantee of arrester performance. With the growing need for flame arresting devices, many companies are producing arresters. Unfortunately, only some of these devices are tested to minimum performance standards and some are not tested at all.

Explosion Capability

At the minimum, an arrester should be tested to meet a recognized standard which requires testing for overdriven detonations, stable detonations, long run stable detonations and deflagration testing with restricted and unrestricted (with and without elbows and/or valves) downstream piping.

Endurance burn capability refers to the ability of the arrester to withstand the heating effects of a flame which has stabilized on the face of the arrester. This condition is caused when a flame travels toward the arrester, is prevented from passing through to the protected side, yet remains burning at the face of the arrester. The intent of an endurance burn test is to determine the length of time an arrester can withstand this stabilized flame without heating the arrester element to the point where the flame is allowed to pass to the protected side. Establishing an endurance burn capability is important as it ensures a defined amount of response time allowed for disruption of the gas flow feeding the stabilized flame.



Arrester Location

Once the ignition sources and the specific facility components requiring protection are identified, the detonation flame arrester can be placed anywhere between the two, regardless of distance and pipe configuration.

In systems where tanks are manifolded together, there should be one arrester providing protection for each tank. When evaluating ignition sources in manifolded tank systems, each tank must be considered. In order to provide protection between tanks, in-line (detonation) flame arresters should be installed not only on the collection line, but on each tank.

Vapour Composition

For the purposes of arrester selection, a gas classification used by the USCG and others is Maximum Experimental Safe Gap (MESG). There is no guarantee of performance if the arrester is used in an application where the vapour has a lower MESG value than that for which the arrester has been tested. The operating pressure for the system in which the arrester is to be installed should not exceed the pressure at which the arrester has been tested.

Operating Pressure

Operating pressure is critical as the pressure associated with the flame in both detonation and deflagration modes is a direct function of initial line pressure at the time of ignition.



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