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Research Regarding End-of-line Flame Arresters for Interior Protection

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Abstract

On the basis of the end-of-line arresters function analysis, a description of the constructive solution is made out, as well as of the theoretical considerations which represent the basis of the design and execution of the discharge flame arrester for interior protection. The theoretical value of the functional parameters of the flame arrester is compared to the values of the tests.

Key words: *flame arrester, end-of- line, pressure drop, discharge arresters, diagram drop pressure, speed of the gaze.*

Introduction

End-of-line flame arresters are also known as vent-to-atmosphere flame arresters or discharge flame arresters. The classical use of this type of arresters is that of preventing the fire in the air from breaking into the enclosure (container). Around 1920, flame arresters started to be mounted on the aeration port of storage containers in the oil fields. These flame arresters prevented containers from exploding when the gas coming from the container was struck by lightning.

End-of-line flame arresters – also known as discharge flame arresters, due to their bidirectional functioning – are also used to prevent fires when the flame might break out in the air, in places such as refineries where flame arresters are mounted on air shafts, thus stopping the flame propagation into the air.

In the last period at worldwide scale there have increased the requirements regarding safety of both equipments, population (the operating personnel) and the environment protection. Directive 94/9/CE – ATEX, which became mandatory starting 01.07.2003, stipulates the meaning of potentially explosive air and the conditions that must be observed by the equipment meant to be used in such a potentially explosive air.

Discharge Arresters

Starting from the provisions of these norms, as well as from the clients' increasing demand of discharge arresters, we have designed and executed, within the research made during the process of writing the doctoral papers and thesis, a model of discharge arrester – *end-of-line – Dn 80 SL – Int*, as shown in fig.1.

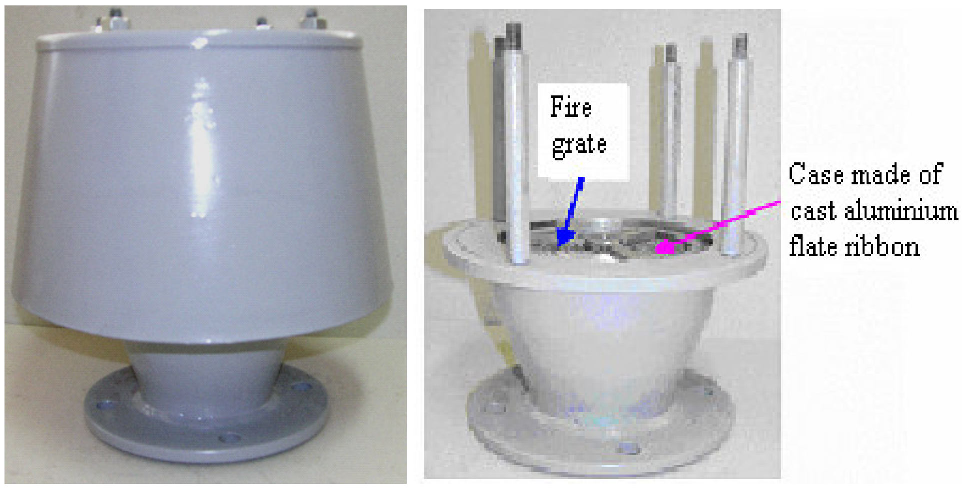

Fig. 1. Discharge flame arresters (end-of-line) Dn80-SL-Int

This type of arrester can be used in industrial platforms where there result various categories of gas which must be, under certain circumstances, exhausted in the air. It provides the protection of the equipment it is mounted on, that is on the inside. The new type of arrester, also called discharge arrester, must guarantee the following functional technical parameters:

- low hydraulic resistance (pressure drop) to allow the exhaust of high-flow gas and the correct functioning of the safety valves;
- the arrest of the flame when it reaches the arrester.

This type of arrester is characterized by the following:

- in order to guarantee as low a hydraulic resistance of the arrester as possible, the transit from the fastening area of the grid to the connecting element of the container has been made by means of a trapper sleeve. This solution guarantees an expansion area of vapours before passing through the grid, it provides the conditions for non-turbulent flow at the minimum hydraulic resistance;
- the arresting grid is assembled in one piece in an aluminum case (fig.2.);
- in order to protect the arresting grid against clogging, there has been introduced a case provided with a sieve, which has a certain opening of the mesh;
- weather protection is provided for by means of a plate sheet roof.

The arrester was tested in order to establish the diagram of grid pressure drops. The outcome of the tests is shown in diagram from fig.3.

If the container is not used for a certain period of time, there may occur the danger that the grid should be clogged with various bodies (bird nests, dead birds, etc.). In order to prevent such a phenomenon, the gas passes through a sieve that has a mesh of a certain size before being exhausted in the air, thus preventing the clogging of the grid (fig. 4.).

This type of arrester must guarantee the circulation in the arresting grid of a maximum flow of gas of $Q_{\max} = 1000 \frac{Nm^3}{h}$ [18].

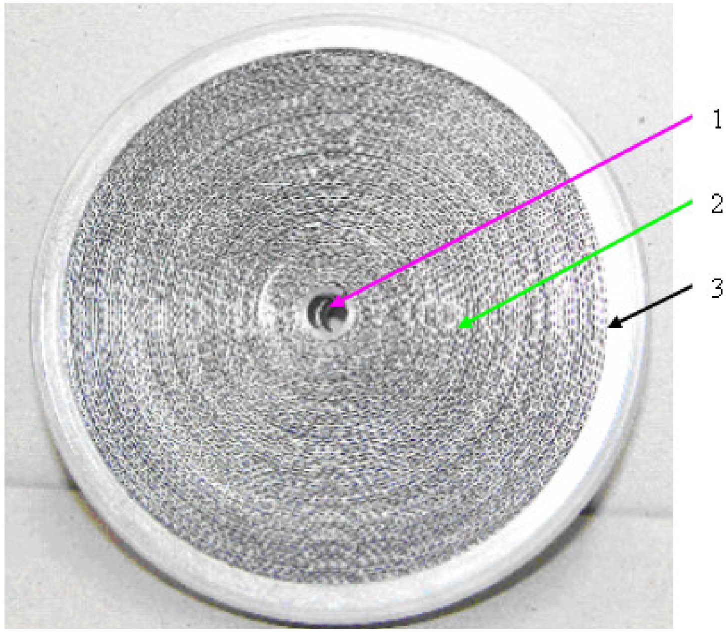

Fig.2. Case made of cast aluminum sheet plate,
1 - hub, 2 - crimped metal ribbon arresting elements,
3 - housing aluminium.

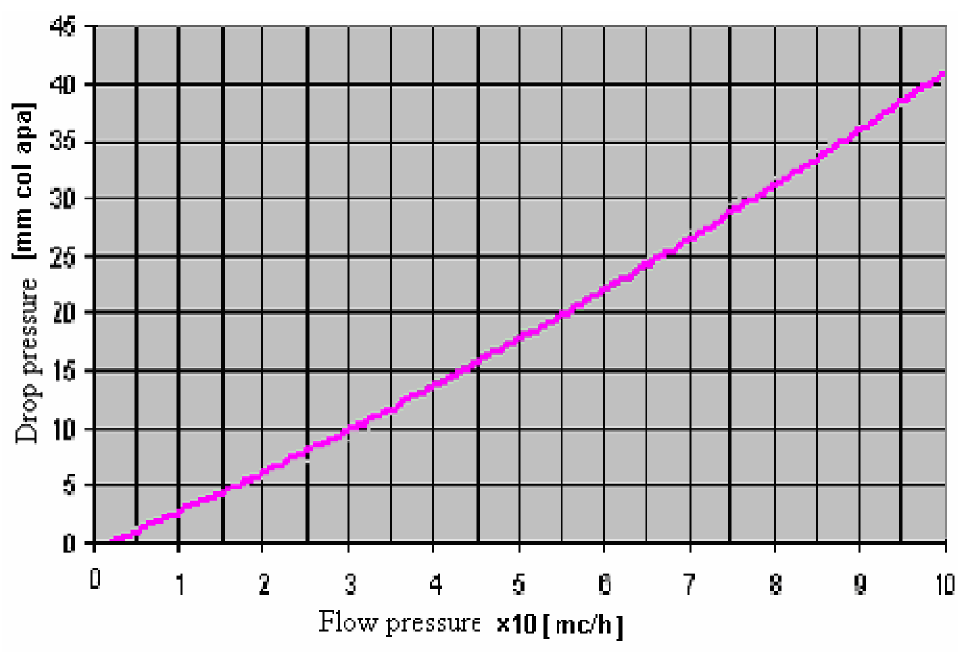

Fig.3.. The diagram of pressure drop on Dn80 SL arrester

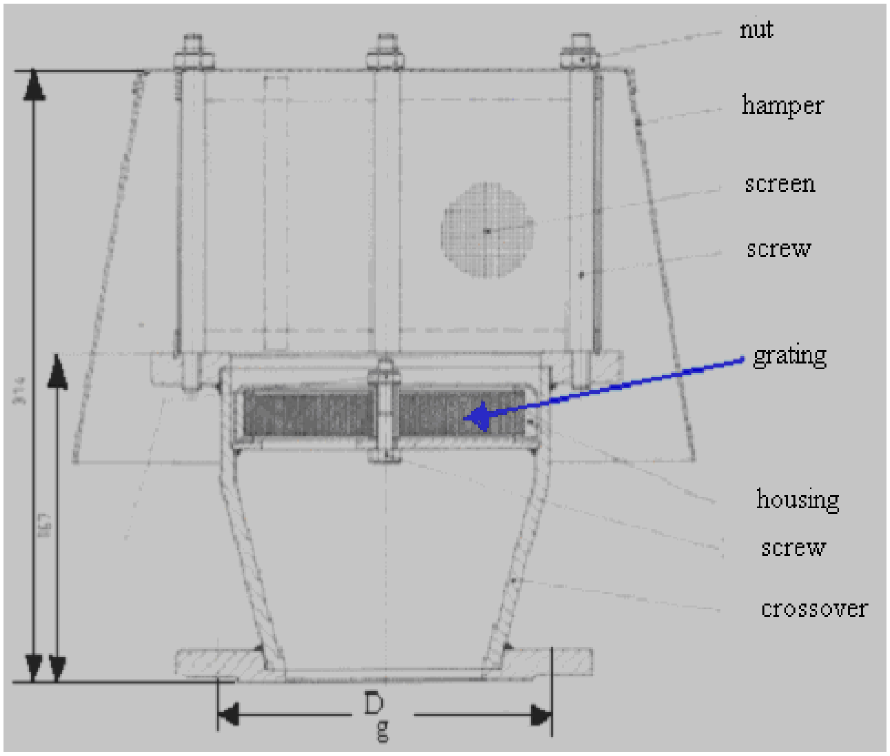

Fig. 4. End-of-line flame arrester – general sketch

Taking into consideration the recommendations in the literature and in order to guarantee the efficient functioning, the maximum speed value of the gas through the grid must observe the following specification [5, 18]:

$$w_{\max} = \frac{w_g}{2} = 17.5\frac{m}{s} \tag{1}$$

In such circumstances, the effective cross section of the arresting grid shall be calculated out of the equality condition of flows with the relation:

$$S_{ef} \cdot w_{\max} = Q_{\max} \Rightarrow S_{ef} = \frac{Q_{\max}}{w_{\max}} = \frac{1000 \cdot \frac{1}{3600}\frac{m^3}{s}}{17.5\frac{m}{s}} = 0.0158 m^2 \tag{2}$$

We have used the methodology in the publications for the calculation of the parameters of the arresting grid.

We have chosen the value of 0.76 mm for the diameter quenching of the flames produced by methane, methyl alcohol, butane, gasoline vapours and other similar substances [5].

For the hydraulic diameter equivalent d_{ech} of the channels with equilateral triangle profile (the shape of the ripples), the following relation shall be used [3, 5]:

$$d_{ech} = 0.67 \cdot h_0 \tag{3}$$

From equation (3), there results:

$$h_0 = \frac{d_{ech}}{0.67} = \frac{0.76}{0.67} = 1.13 \quad (4)$$

where: h_0 is the height of the reference tooth.

At this value of the effective cross section (2), there corresponds a very high pressure drop on the grid $\Delta p = 3914\frac{N}{m^2}$, and the arrester behaves like a valve which is almost closed.

Due to this reason, we shall increase the effective flow cross section of the gas through the grid, taking into account the obstructing factor of 35% corresponding to the h_0 parameter. In the specialty literature, it is stipulated the fact that the level of use of the cross area of the arrester is of about 20% [3, 5, 12].

The D=80*mm* grid diameter corresponds to the effective flow section $S_{ef} = 1758mm^2$ and the gas speed $w_{\max} = 1.6\frac{m}{s}$.

Calculating the *f* line pressure waste coefficient with Stokes formula, we obtain:

$$f = \frac{64}{R_e} = \frac{64}{6.9} = 9.2 \quad (5)$$

Using the relation :

$$\Delta p = f \cdot \frac{l}{d_{ech}} \cdot \frac{w_{\max}^2}{2} \cdot \rho \quad (6)$$

where : Δp - pressure drop on the arresting grid $\left[\frac{N}{m^2}\right]$;

l - channel length, *l=20 mm* ;

ρ - the density of the air used to establish the pressure drop ;

and introducing the data in (6) we obtain :

$$\Delta p = 9.2 \cdot \frac{20}{0.668} \cdot \frac{1.6^2}{2} \cdot 1.29 = 454\left[\frac{N}{m^2}\right] \quad (7)$$

Out of the diagram shown in figure 3, the maximum pressure drop on the curve is $420\frac{N}{m^2} = 42mm.col.H_2O$.

In order to reduce the pressure drop, the effective cross section shall increase. If we use a grid with the diameter of D=100mm then the speed is reduced to $w_{\max} = 1m/s$ and the pressure drop $\Delta p = 177\frac{N}{m^2} = 17.7mm.col.H_2O$

This pressure drop is accepted for the equipment where the flame arrester is used, due to the fact that the gas pressure in the column is $150mm.colH_2O$ and the gas is exhausted straight outside.

As this type of arrester is designed for the protection of the containers against the flames which break out in the air, we have chosen, as protective constructive solution, a taper sheet plate hat which guarantees, because of its shape and size, a gas layer inside and above the arresting grid, a layer which is made of a mixture of low-oxygen gas that ignites only after it has got out of this hat in its close proximity, when the gas mixes with air and forms an inflammable mixture.

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Cercetări privind fabricarea opritorilor de flăcări de sfârşit de linie pentru protecție interioară

Rezumat

Pe baza analizei funcționării opritorilor de sfârşit de linie, se face o descriere a soluției constructive şi argumentările teoretice ce au stat la baza proiectării şi realizării opritorului de flăcări de descărcare, pentru protecție interioară. Se prezintă compartiv valoriile teoretice ale parametrilor funcționali ai opritorului cu valorile testelor.