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İÇİN
YAPILAN AKADEMİK ÇALIŞMALAR**

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ÖNSÖZ :

İlerleyen yıllarda izleyeceğimiz Akademik çalışma bir kuramsal sonuç değil, yapılan bir Akademik irdelenimin verilerini içeren bir rapordur. Herşeyden önce bu çalışmada katkıda bulunan Sn. Prof. Dr. O. Cahit ERALP ve çalışma ekibindeki Sn. Erman ATALAY, Sn. Şakir ÇAVUŞ ve Sn. Cengiz HEYCAN' a özverili çalışmaları için teşekkür ederiz.

Bu ve ileride yapılacak bilimsel çalışmaların amacı, Ülkemizin yıllardır karşı karşıya bulunduğu ekonomik ve teknik sömürüyü sonlandırmaktır. Buna koşut olarak bilim ve teknikten uzak işbirlikçi yerli şarlatanların eylemlerine bir noktada dur demek ve bunları “meydanın o kadar da boş olmadığına” inandırmaktır.

Kurttekin Ltd. Şti. olarak, bilim ve teknolojinin evrensel olduğuna inanıyoruz. Bu bağlamda, gerekli teknik çalışmaların yapılması durumunda ülkemiz teknolojisinin hiçbir ülkenin teknolojisi gerisinde olmadığına eminiz.

Denetim kurumlarının biçimsel formasyonları (imalathane alanı, kapalı saha, açık depolama alanı, tuvalet yapısı, yemekhane, kalite kontrol laboratuvarı, stoklama sahası alanı) değil nihai ürünleri denetlemeleri gereken bir gelişim süreci içinde olduğumuza inanmak istiyoruz.

Bu arada birtakım denetleme organlarının belgelendirdiği ürünlerde, belgelenen ürünlerin Belgelendiği normlardan ne denli uzak olduğunu, geç , işlev ve performans olarak görmek bir TÜRK firması olarak bizleri son derecede huzursuz ediyor.

Bu arada uluslararası denetim kurumlarının, evrensel olması gereken teknik kriterlerde, kendi ülkelerindeki firmalara ne denli hoşgörülü, kendi ülkeleri dışındaki firmalara ne denli katı ve daha ötesi, prosedür gecikmeli olduğunu gözlemliyoruz.(Örneğin Bureau Veritas'ta , tüm koşulları yerine getiren firmamız dışında bir TÜRK firmasının belgelenmesinin 4 ay geri atılması).

Biz kendimizi, Ulusal bağımsızlık konusunda duyarlı tüm firmalar ile özdeş görüyoruz.

Teknolojik gelişimin gereği, kullanıcıların bilinçli ve sorgulayan davranışlarıdır. Sizlerin gereksinim duyduğunuz her konuda firmamız veritabanındaki tüm bilgileri sizlerle paylaşmak isteriz. Siz kullanıcılar ne kadar teknik bilgi sahibi olursanız, aradaki yerli asalaklar o denli azalacak, yurt dışındaki üreticilerle rekabet o denli gerçekçi olacaktır.

HAYDİ hep birlikte, TÜRKİYE için çalışalım.



MIDDLE EAST TECHNICAL UNIVERSITY



**MECHANICAL ENGINEERING DEPARTMENT
FLUID MECHANICS LABORATORY**

EMERGENCY AIR VENTS

Prof. Dr. O. Cahit ERALP

**Erman ATALAY
Şakir ÇAVUŞ
Cengiz HEYCAN**

ME483-02-13

**ANKARA
JANUARY 2002**

Name of the Project : Emergency Air Vents

Project Sponsored by : Kurttekin Ltd. Şti.

Project Supervisor : Prof. Dr O. Cahit ERALP

Project Team :
Erman Atalay
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Project Dates : Oct.2001-Jan. 2002

***Project Identification : Fall 2001 Term Project of ME-483
“Experimental Techniques in Fluid
Mechanics” Course, Mechanical
Engineering Department, Middle East
Technical University***

Project No : ME483-02-13

ABSTRACT

The aim of this course is to demonstrate and teach how experiments are done and how to handle the projects at the working life. The students separate into the groups and perform the projects which can be the industrial supported or for educational need. During this projects the students also learn the ways of working in group and becoming the member of the team. In the "Emergency Air Vent" project, flame arrester and pressure relief vent are to be examined. For the flame arrester the aim is to find the pressure drop for different flow rates and for different quenching diameter arrester elements. For the pressure relief vent, the relation between the inside pressure and the opening of the vent is considered. After performing the experiments for flame arrester, pressure drop vs flow rate graph was plotted for different quenching diameters and blockage. It is clear from the graph that the pressure drop is inversely proportional to quenching diameter and blockage. For the pressure relief vent, the opening pressure was found and different positions of the vent was recorded for different flow rates.

NOMENCLATURE

P	: pressure
Q	:flow rate
k	:orifice constant
ρ	:density
g	:gravitational acceleration
Δh	:manometer deflection
S_a	:distance between the left corner and the top corner of the triangle at arrester element cell
S_b	:distance between the right corner and the top corner of the triangle at arrester element cell
t	:thickness
H	:height

OBJECTIVE

The aim of the course is to become familiar with experimentation and get ideas of thinking experimental. In this project the flame arrester and pressure relief vent will be examined. In flame arrester the pressure difference according to the different flow rates will be examined by keeping the inlet pressure of the arrester 1.1 bar and the results will be plotted on a graph. In pressure relief vent, relation between the pressure and vent opening will be examined.

INTRODUCTION

In ME 483 Experimental Techniques in Fluid Mechanics course, students take projects as groups. Some of the projects are industrially supported and some of them are not, but all projects have practical usage. These projects make students get used to experimental studies, industrial applications and group work.

In "Emergency Air Vents" project, flame arrester and pressure relief vent is to be investigated. Flame arrester is a device that is used to prevent the flame propagation in pipes. Pressure relief vent is used to release the excess pressure in storage tanks.

For the flame arrester the aim is to find the pressure drop for different flow rates and for different quenching diameter arrester elements. For the pressure relief vent, the relation between the inside pressure and the opening of the vent is considered.

THEORY AND EXPERIMENTAL PROCEDURE

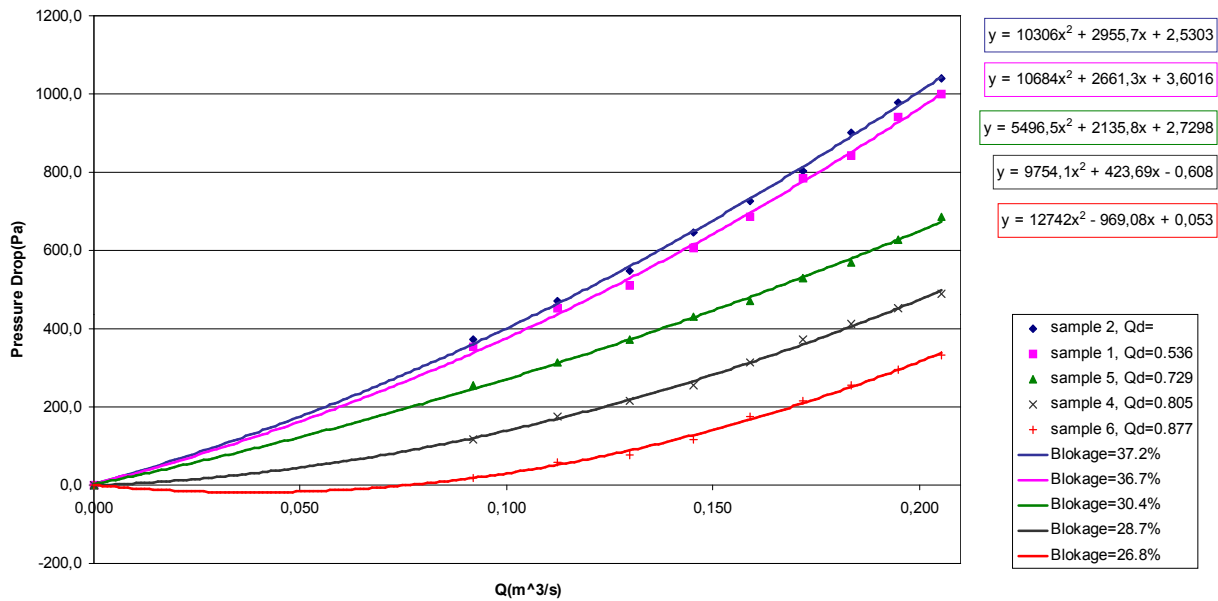
Flame arrester (4" and 2"): (at Appendix Pic.4) It is a device that is used to stop the flame that is propagating in pipes. The working principle is simple. While the flame passes over the arrester it loses heat and flame cannot pass to the other side of the arrester. There are also different types that are used to prevent detonations. These are stronger to resist detonations but working principle is the same with in-line flame arresters. Flame arresters are used mainly in pipes in which explosive materials like petroleum, natural gas or some chemicals are transported. They are also used with Pressure Vacuum Relief Valves (a device that arranges the pressure level of tanks by giving gas to the atmosphere when pressure is high and taking air to the inside of tank when the pressure is lower than the necessary level) in tanks containing flammable materials to prevent flame propagation while valve is operating.

Pressure Relief Vent : Pressure relief vent is connected to the top of the tanks to release the pressure occurred in the tank to prevent explosion. Like flame arrester it is used in chemical or petroleum storage tanks. When the inside pressure of the tank becomes greater than the atmospheric pressure plus the weight of the vent the vent is opened and the pressure is released.

The setup and experiments for 4" Flame Arrester:

- In the setup a compressor that is connected to an air tank that can supply 9 bar was used.
- A flow rate was controlled by a spherical valve that was mounted at the inlet of the setup.
- To measure the flow rate an orifice meter (35 mm hole diameter) was connected to valve by 2" diameter pipe. Manometer, containing mercury, was connected to the orifice meter at D-D/2 taps.
- 4" flame arrester was connected to 4" pipe that has pressure tap at a distance 50 cm away from arrester. Manometer, containing water, one end opened to the atmosphere was used to measure the pressure difference between inlet and outlet of the arrester. (The setup can be seen at Appendix Fig. 1)

Q vs P for 4" Flame Arrester at 1.1 bar inlet pressure



For different flow rates, pressure difference was measured and Pressure Drop vs Flow rate graph was plotted for arrester element 1.

To perform the same experiment for 2" flame arrester, 4" pipe was taken out and 2" pipe was inserted and pressure drop for different flow rates were measured and graph is plotted.

Afterwards, in order to perform the experiment with an inlet pressure of 1.1 bar for 4" flame arrester, the 4" pipe that had been taken out was again connected and another 4" pipe with a valve at the end to control the inlet pressure was connected to the outlet of the flame arrester. This 4" pipe has a pressure tap at a distance 50 cm away from arrester. A manometer was connected to the pressure taps at the inlet and outlet of the flame arrester to measure the pressure difference. (The setup can be seen at Appendix Pic.5)

This setup was used to find the pressure drop at flame arrester for six different arrester elements. On the same graph, pressure drop vs flow rate of six arrester elements were plotted.

The setup and experiments for Pressure Relief Vent:

The same pressure tank and orifice is used. After the orifice the 90° elbow was put and 4" pipe is constructed at the end of the elbow. At the pipe there is a tap hole to measure the pressure difference between the atmosphere and inside of the pipe. The vent is put at the top of the pipe.

In this experiment the flow rate and inlet pressure were taken. The relation between the inlet pressure and opening of the vent was considered.

DATA AND RESULTS

The pressure drop and flow rate readings from the manometers for 4" flame arrester at 1.1 bar inlet pressure are as follows:

(for flow rate mercury and for pressure water is used in manometers)

4" FLAME ARRESTER					
Q(mm)	P(mm)2	P(mm)1	P(mm)5	P(mm)4	P(mm)6
400	106	102	70	50	34
360	100	96	64	46	30
320	92	86	58	42	26
280	82	80	54	38	22
240	74	70	48	32	18
200	66	62	44	26	12
160	56	52	38	22	8
120	48	46	32	18	6
80	38	36	26	12	2
0	0	0	0	0	0

The calculated values are:

Q(m³/s)	P(Pa)2	P(Pa)1	P(Pa)5	P(Pa)4	P(Pa)6
0,205	1038,8	999,6	686,0	490,0	333,2
0,195	980,0	940,8	627,2	450,8	294,0
0,184	901,6	842,8	568,4	411,6	254,8
0,172	803,6	784,0	529,2	372,4	215,6
0,159	725,2	686,0	470,4	313,6	176,4
0,145	646,8	607,6	431,2	254,8	117,6
0,130	548,8	509,6	372,4	215,6	78,4
0,112	470,4	450,8	313,6	176,4	58,8
0,092	372,4	352,8	254,8	117,6	19,6
0,000	0,0	0,0	0,0	0,0	0,0

The pressure drop and flow rate readings from the manometers for 4" flame arrester are:

(for flow rate mercury and for pressure water is used in manometers)

4" FLAME ARRESTER (ELEMENT 1)	
h(mm) for Q	h(mm) for P
0,008	0,003
0,035	0,007
0,080	0,010
0,113	0,012
0,200	0,015
0,325	0,025
0,415	0,029
0,690	0,035
0,850	0,042
0,080	0,048
0,140	0,068
0,193	0,087
0,255	0,110

0,350	0,145
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The calculated values are:

4" FLAME ARRESTER (ELEMENT 1)	
Q(m³/s)	ΔP(Pa)
0	
0,008	29
0,016	69
0,025	98
0,030	118
0,039	147
0,050	245
0,057	284
0,073	343
0,081	412
0,092	471
0,121	667
0,143	853
0,164	1079
0,192	1422

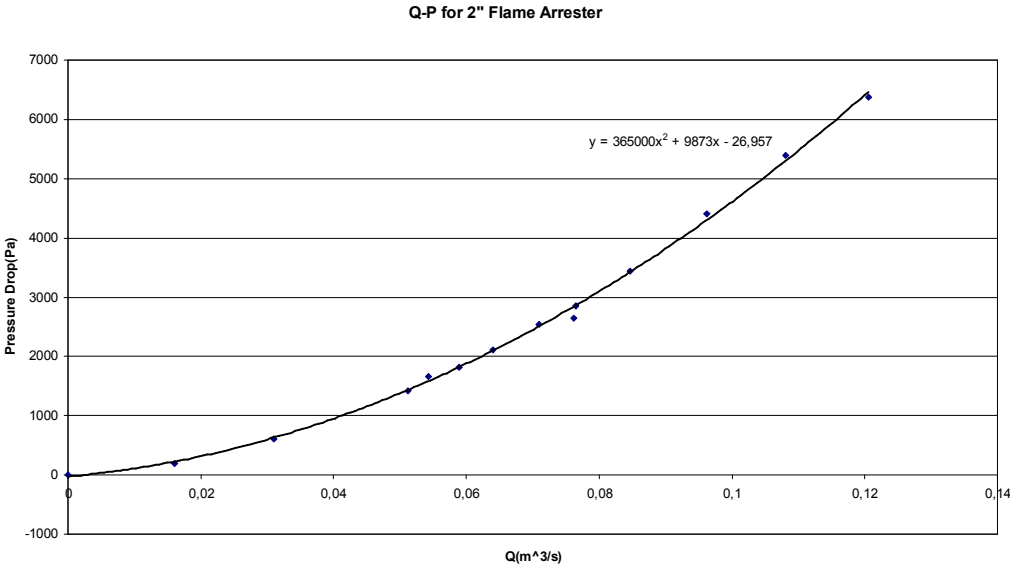
The pressure drop and flow rate readings from the manometers for 2" flame arrester are:

(for flow rate mercury and for pressure water is used in manometers)

2" FLAME ARRESTER	
h(mm) for Q	h(mm) for ΔP
0,033	0,020
0,124	0,062
0,339	0,145
0,448	0,185
0,528	0,215
0,650	0,260
0,756	0,290
0,028	0,170
0,055	0,270
0,068	0,350
0,088	0,450
0,111	0,550
0,138	0,650

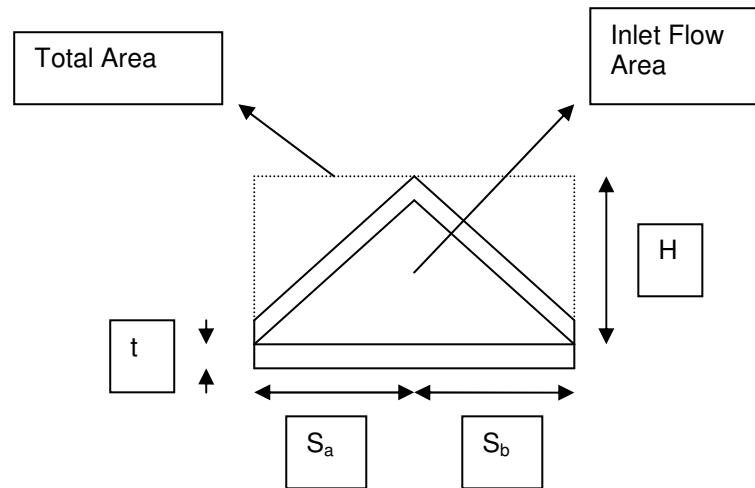
The calculated values are:

2" FLAME ARRESTER	
Q(m ³ /s)	P(Pa)
0	
0,016	196
0,031	608
0,051	1422
0,059	1815
0,064	2109
0,071	2551
0,077	2845
0,054	1668
0,076	2649
0,085	3434
0,096	4415
0,108	5396
0,121	6377



Quenching Diameter and Blockage:

When observed from a toolmakers microscope an element of a flame arrester simply looks like the figure below.



Quenching diameter is defined as,

$$D_q = 4 * (\text{Inlet flow area}) / (\text{Circumference of inlet triangle})$$

Also, blockage is calculated from,

$$\text{Blockage (in \%)} = (\text{Solid area}) / (\text{Total area})$$

The experiment is performed on six different four inch flame arresters. Their quenching diameters and blockage percentage are calculated by using geometry calculations. Dimensions are obtained from the microscope.

The thickness for each flame arrester element is taken as constant and its 0.2 mm. The table shows the height and spacing for six different samples.

	S _a (mm)	S _b (mm)	H (mm)
Sample 1	0.85	1.1	0.78
Sample 2	0.685	0.65	0.875
Sample 3	1.495	1.535	1.615
Sample 4	1.11	1.38	1.1
Sample 5	1.36	1.1	1
Sample 6	1.31	1.68	1.16

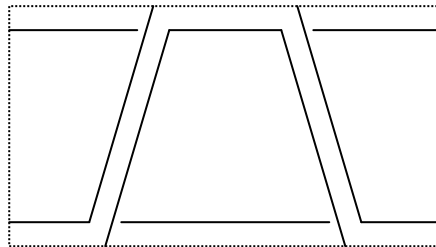
A sample calculation for sample 1 is shown below.

For Sample 1	
Inlet area (mm ²)	0.5655
Circumference (mm)	4.223
Quenching diameter (mm)	0.5356
Solid area (mm ²)	0.701
Total area (mm ²)	1.911
Blockage	0.3668

The results for the six samples are summarized in the table below. One can compare the given quenching diameters for six samples with the ones that are calculated.

	D _q (given, mm)	D _q (calculated, mm)	Blockage (%)
Sample 1	0.64	0.536	36.7
Sample 2	0.58	0.624	37.2
Sample 3	1.2	1.172	21.7
Sample 4	0.83	0.805	28.7
Sample 5	0.66	0.729	30.4
Sample 6	1	0.877	26.8

It can be seen that quenching diameter is inversely proportional with blockage. Sample 2 has a conflict in order, this is because of the elements geometry (shown below).



After this, one can correlate the pressure drop in the flame arrester with blockage values. It is seen that as the blockage increases, pressure drop rises for all samples. The table below shows the rank for five different samples and their relation with pressure drop. Pressure drop values are taken at the maximum flow rate.

	Blockage (%)	Pressure Drop (Pa)
	max.	max.
Sample 2	37.2	1038.8
Sample 1	36.7	999.6
Sample 5	30.4	686
Sample 4	28.7	493
Sample 6	26.8	333.2
	min.	min.

For the pressure relief vent:

Manometer height (mm mercury) for Q	Position of the vent
172	Opening
340	Pic. 1
600	Pic. 2
760	Pic. 3

Q(m ³ /s)	Position of the vent
0.135	Opening
0.189	Pic. 1
0.251	Pic. 2
0.283	Pic. 3

Opening pressure of the vent is: 765 Pa

Weight of the vent is = 2230 gr

Area = 0.02 m²

Theoretical opening Pressure = 1029 Pa

SAMPLE CALCULATIONS

Flow Rate:

$$Q = k\sqrt{(h \cdot 0.001)}$$

$$Q = 0.3245 \cdot \sqrt{(400 \cdot 0.001)}$$

$$Q = 0.205 \text{ m}^3/\text{s}$$

Pressure Difference:

$$P = \rho \cdot g \cdot \Delta h$$

$$P = 1000 \cdot 9.81 \cdot 0.001 \cdot 142$$

$$P = 1391.6 \text{ Pa}$$

Opening pressure for vent:

$$P = 2.1 \cdot 9.81 / 0.02 = 765 \text{ Pa},$$

(for the weight instead of 2.23 kg, as approximation 2.1 kg is used since some part of the vent does not contribute to weight but helps the vent to open).

DISCUSSION AND CONCLUSION

In this project, basic concepts of experimental techniques were used to obtain certain correlations for flame arresters and pressure relief vent. Experimental and theoretical results were compared at the end. The setups for the devices were constructed in the Fluid Mechanics Lab

For flame arresters, at different flow rates pressure drop was measured. For the pressure relief vent, the opening pressure and position of vent at different flow rates were determined.

The project was mainly on the 4" flame arrester. After constructing the setup (Appendix, Fig. 1), first experiment was performed at which the outlet of the flame arrester was opened to atmosphere.

Then for six different arrester element by keeping the inlet pressure at 1.1 bar pressure drops were measured for different flow rates. The compressor was not able to supply constant flow rate for more than about 200 litres per second and the flow rate was decreasing gradually. Therefore, the flow rate is set to high values by the inlet valve and adjustment for the inlet pressure at 1.1 bar is done. As the flow rate decreases, the pressure drop values are taken instantaneously at certain flow rates. This procedure requires the control and record of three manometer values for the group members. Two manometers showing the flow rate and pressure drop varies and the manometer showing back pressure is kept constant by adjusting the outlet valve.

The data obtained from the six samples is compared with the six different quenching diameters and blockage values. Samples are observed under a toolmakers microscope and dimensions are taken. The quenching diameter results show similarity with the ones given from the producer. In order to calculate quenching diameter and blockage, geometrical approach is used. Quenching diameter for the second sample flame arrester element is not used in the graphs and correlations since the procedure to calculate its quenching diameter does not apply to its unique shape. It is seen that quenching diameter and blockage is inversely proportional, as expected. Correlation between the blockage and pressure drop can be seen clearly from the graph 1 in data and results. The graph shows that theoretical results are strongly related with the experimental results.

There are several sources of error for the experiment. The pressure losses from the pipes and connections are reduced by connector devices and they are neglected. The plus shaped part used to hold and tighten the element in the flame arrester inside, can block the air flowing if its not properly aligned with its counterpart. This can cause large pressure drops. During the project, several experiments are repeated to obtain exact results after realizing this phenomenon.

For pressure relief vent, the opening pressure found from the experiment is smaller than the theoretical one that was calculated from weight and area. The reason for this is the vent is not closed fully at initial position. There is a leakage between the surfaces of the parts and the pressure does not increase more than the determined pressure. The vent should be used at that pressure value in applications. When the flow rate is increased the vent starts to vibrate. The opening point is defined as the instance where the pressure inside starts to decrease and balance with atmospheric pressure after a certain increase. At higher flow rates, the opened vent becomes stable and its angle is preserved at a certain flow rate. For different flow rates, the open position of the vent changes. Three photos were taken for three different positions and flow rates which are shown in the appendix (pic 1,2,3).

There is about 250 Pa of difference between the experimental opening pressure and the theoretical opening pressure. This is because of the leakage of air from the connections and rough surface of the opening.

For the flame arrester, the parts that hold the element inside cause blockage and increase in pressure drop. These parts could be made thinner to occupy less area so that blockage will be decreased. The opening of the pressure relief vent must be designed to prevent the air escape from the pipe. The losses at the vent, makes it hard to calculate the opening pressure.

As a result, this project was helpful for analysing flame arresters and pressure relief vents and their behaviour in a range of flow rates. Experimental and theoretical data is compared and correlations are found which helps to understand the phenomenon clearly.

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APPENDIX

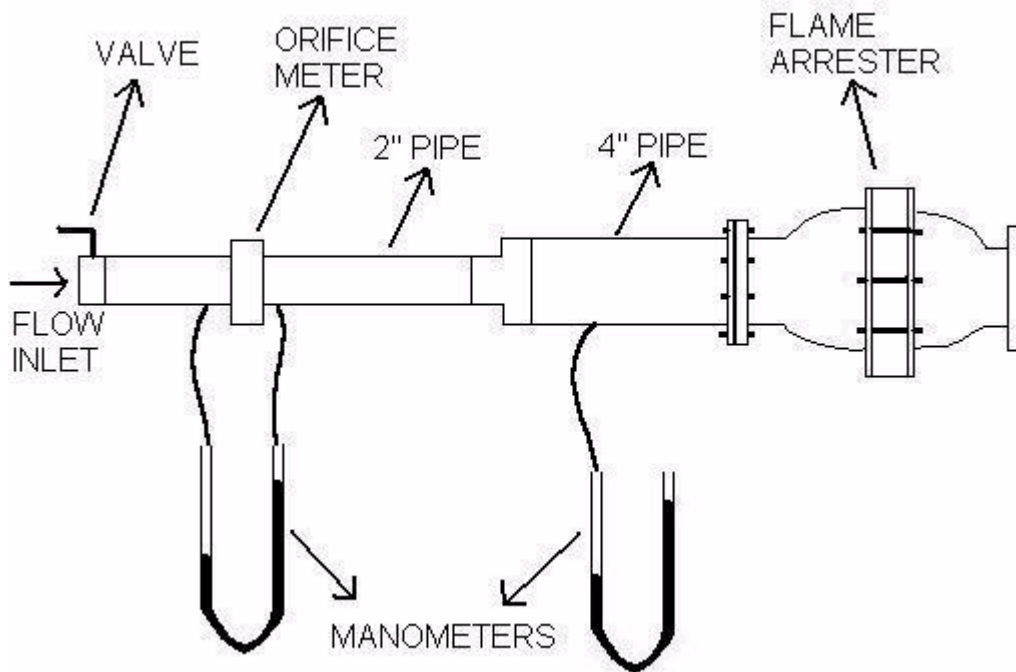


Figure 1