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REPORT

AERO 94/140

AIR VALVE
INDUCED PRESSURE TESTS
&
AIR VALVE DISCHARGE TESTS
by

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Abstract & Keywords

The discharge rate and differential pressure characteristics curves were obtained for a range of air valves and using computer aided testing techniques.

The pressures induced by a range of kinetic air valves were obtained using sophisticated computer aided testing techniques..

Discharge rate; differential pressure; dynamic closure; air valve; induced pressure transients

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Design engineers recognise the importance of air valves on pipelines, as a cost effective method of maximising pipeline efficiency by eliminating air pockets during initial filling and, by allowing air into draining pipelines to prevent potentially destructive vacuum from forming. Few designers however are aware of the possible damage of double acting air valves to pipelines due to incorrect sizing or features inherent in specific air valve designs and/ or configurations.

Double acting air valves are generally assumed to be simple mechanical devices but are in reality, due to the unpredictable nature of air, complex in operation. Inherent in all conventional air valves, is the creation of either surge or water hammer on closure of the large orifice.

Air in pipelines is one of the most misunderstood phenomena in water supply today. This is largely due to the reluctance from air valve manufacturers to invest in research in this extremely important area. It follows therefore that many assumptions with no foundation in fact, have developed to explain air valve design, operation and, its effects on total pipeline efficiency.

An intensive research and development programme, in which all performance data available from air valve manufacturers' world-wide was reviewed, revealed the majority of double acting air valve designs to be impractical or inadequate to perform the function/s intended.

Vent-O-Mat developed the "Anti-Shock" range of air valves to have the advantage of totally de-aerating a pipeline but without the draw backs of conventional kinetic air valves which actually induce surge and water hammer on closure.

These valves have proved themselves in the field as a cost effective and efficient solution to 70% of pipeline problems i.e., they act as an efficient double acting air valve as well as a surge alleviation mechanism, providing comprehensive pipeline protection.

The Council of Scientific and Industrial Research was commissioned in 1994 to conduct tests on the Vent-O-Mat "Anti-Shock" air valves as well as the range of various air valve designs. The purpose of the tests were threefold namely:

1. Air Valve discharge performance
2. The magnitude of pressure transient pressures created by conventional kinetic air valves.
3. The magnitude to which Vent-O-Mat limits the transient pressures on closure.

Tests conducted conclusively prove that conventional air valves create very high pressure transients on closure of the large orifice. Vent-O-Mat "Anti-Shock" air valves act as efficient air valves whilst substantially limiting transient pressures induced on closure. A comprehensive explanation of these tests as well as a complete copy of the Council of Scientific and Industrial Research's report form part of this document.

1. SYNOPSIS

A range of Vent-O-Mat air valves as well as various other air valves were tested at the CSIR, using computer aided techniques

Two different types of tests were performed on the valves. In one of them the discharge rate of air and the associated pressure difference across the valves were assessed. The other test was performed measuring the peak pressure induced when a flow of water closed the valve.

2. INTRODUCTION

A wide range of air valves were tested. The aim of the tests were the following:

- to obtain graphical representation of the differential pressure versus air discharge rate characteristics for each of the valves;
- to determine the exact point at which dynamic closure occurs, whenever it occurs;
- to determine the peak pressure induced when a flow of water reaches and closes the valve.

3. TEST EQUIPMENT AND INSTRUMENTATION

3.1 Air Discharge Test

The test rig for air discharge test was constructed in such a way that the valves could be interfaced with a high pressure air supply in order to obtain the necessary pressure difference across them. Figure 1 presents a schematic layout of this set-up.

The rig was fully instrumented to measure the discharge rate and pressure difference. The outputs of the various sensors were monitored by means of a data acquisition device.

The valves were fed by a compressed air supply capable of storing 360 cubic metres of air at a pressure of 14 bars. The air supply to the valves were regulated by two parallel De Zurick rotary valves controlled by a Barber Colman microprocessor controller.

The test rig was equipped with a factory calibrated PSE series 100 bar flow sensor situated in a position conforming to British Standards 1042. Pressure difference across the sensor was measured by means of a Sensotec differential pressure transducer, and the static pressure in the pipeline by a Sensotec absolute pressure transducer. The accuracy of these transducers is 0,1% of full scale capacity.

In all instances the transducers were selected to operate as close as possible to their full scale capacity, in order to minimise errors. The air temperature was measured by a resistance temperature detector (RRTD) upstream of the PSE flow meter.

The pressure difference across the air valves was measured by using a Kyowa absolute pressure transducer sensing the static pressure upstream of the valve.

The atmospheric pressure, continuously sampled by a separate transducer, was subtracted to obtain the pressure difference across the valve. Accuracy of the transducer is 0,1% of full scale capacity.

All the sensors above were connected to a PC equipped with an A/D converter.

3.2 Pressure Induced Test

Aim of the test was to determine the peak pressure induced in the valve and the connecting pipe when a rapid flow of water reaches and closes the valve.

Figure 2 shows a schematic layout of the rig used for the test. An air valve is connected, through a pipe, to a pressure vessel. A manually operated valve is inserted in the connecting pipe. The pressure vessel is partially filled with water. Water also fills the connecting pipe in the section between the vessel and the manual valve. The air present in the top part of the valve of the vessel is pressurised. This will cause when the manual valve is opened, a rapid flow of water towards the air valve. In the section of the pipe ahead of the manual valve is present a factory calibrated PSE series 100 Par 70 flow sensor is installed. The pressure across the sensor is measure by means of an HBM differential pressure transducer, whose accuracy is 0,1% of full scale capacity. This differential pressure is used to determine the velocity of the water when it approaches the air valve causing its sudden closure. The peak of the pressure induced, both in the air valve and in the pipe, is measured by means of a Kyowa absolute pressure transducer inserted in the pipe immediately in front of the valve. The accuracy of the transducer is 0,1% of full scale capacity.

All the sensors above were connected to a PC equipped with an A/D converter.

4. EXPERIMENTAL PROCEDURE

4.1 Air Discharge Test

As the air supply to the valve was gradually increased, the computer automatically sampled data points of differential pressure against discharge to be stored on a disc for plotting.

The important parameters were continuously displayed on the PC's monitor for control

In the event of a valve that closed dynamically the recording of data was terminated manually and the exact point of closure was known since a sudden increase of pressure peak was correspondingly monitored.

4.2 Pressure Induced Test

The air in the vessel was pressurised. Opening the manual valve, caused a rapid flow of water inside the pipe towards the air valve. When the water reached the valve, it caused sudden closure and correspondingly, the pressure both in the valve and the pipe increased suddenly.

The procedure was repeated for different air pressures in the vessel to obtain different water velocities.

The computer automatically sampled data points of water, velocity and pressure in the pipe, to be stored on disc.

5. RESULTS

5.1 Air discharge Test

A full range of Vent-O-Mat valves were tested. In addition to the Vent-O-Mat valves, a range of other air valve designs were tested.

The valve characteristics are presented as a plot of pressure difference across the valve, measured in bar against air discharge rate in litres per second at 1.01325 bar and 20 deg. C.

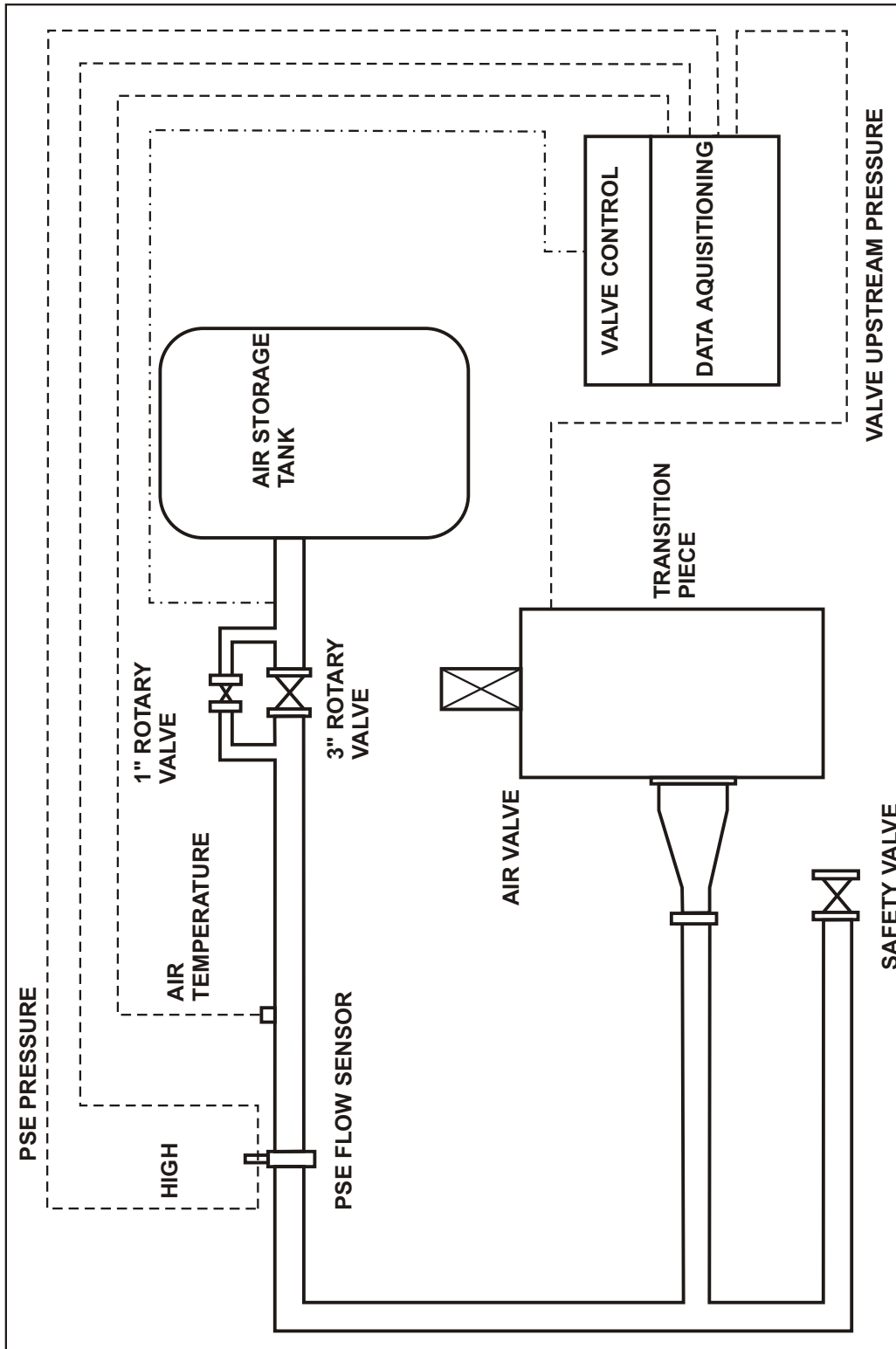
5.2 Pressure Induced Test

Various different air valve designs were tested. It was found that conventional kinetic air valves induced pressure transients in excess of 5 times the valves static rated pressure whereas the Vent-Mat, under equal conditions limited pressure rise to well below 1.5 times the valve's static working pressure.

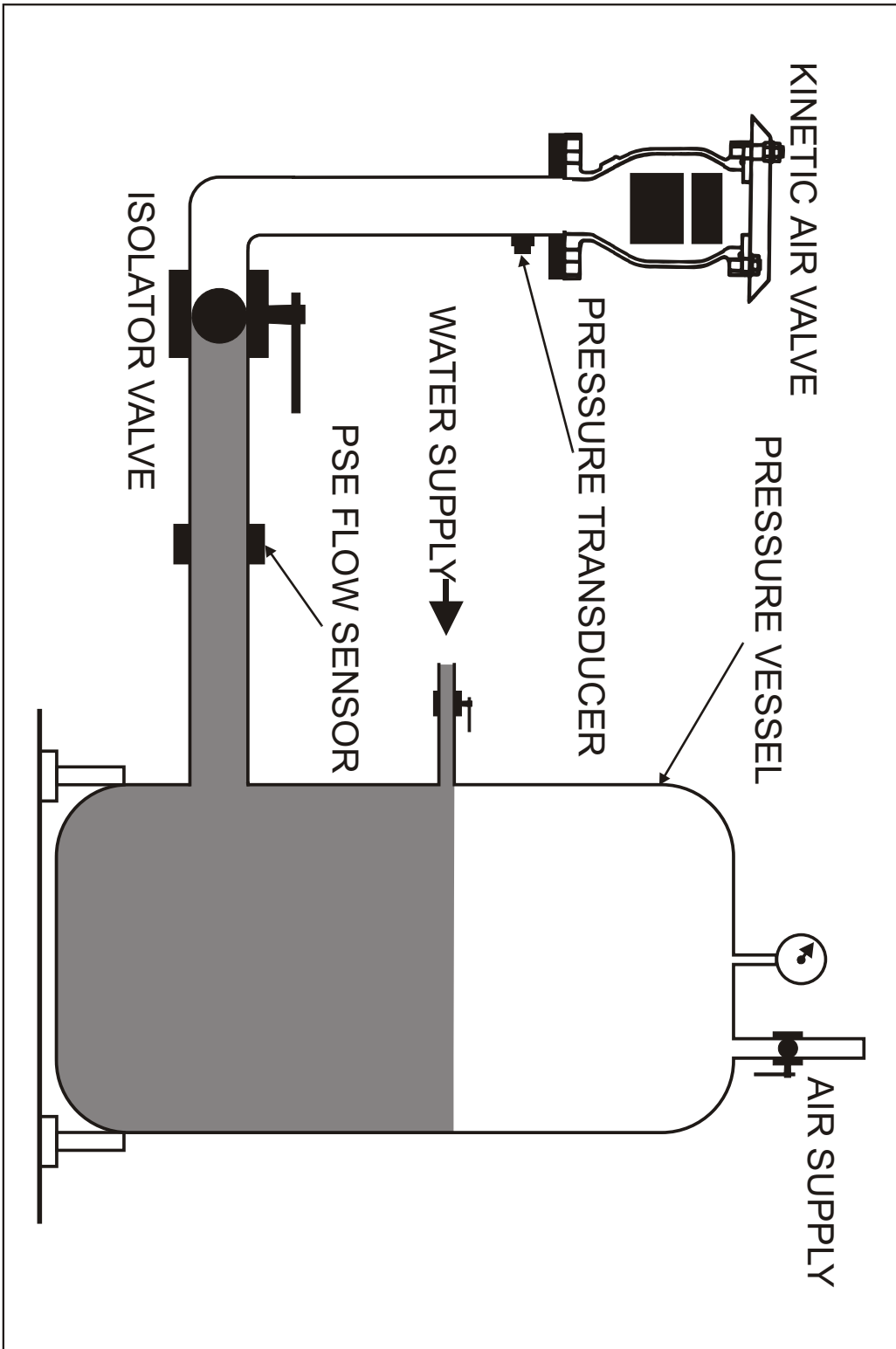
6 CONCLUSIONS

Conventional kinetic air valves have no way of limiting the velocity of approaching water while venting air. The operation of an air valve is such that it closes almost instantaneously on arrival of water and consequently a pressure rise is induced. The extent of this transient pressure rise can quite easily exceed the pipeline test pressure by a considerable margin, even at moderate filling rates and during normal operation.

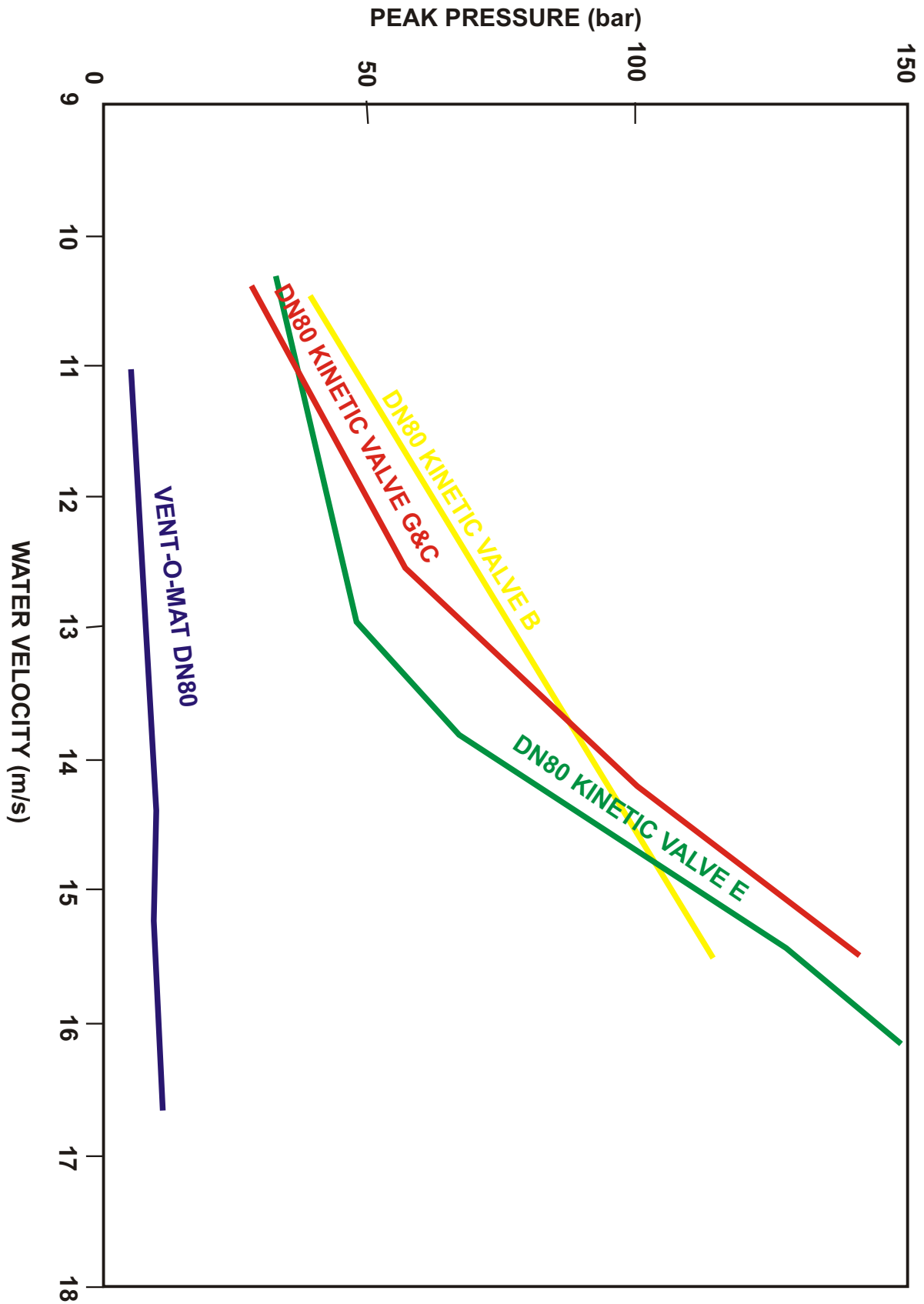
Computer monitored testing of pressure transients induced by various valves were conducted. The results consistently showed that the Vent-O-Mat Series RBX "Anti-Shock" valve reduces induced pressure rise to below 1.5 times valve rated working pressure, whereas, under equal conditions conventional air valves induced pressure rises to at least 5 times valve rated working pressure.



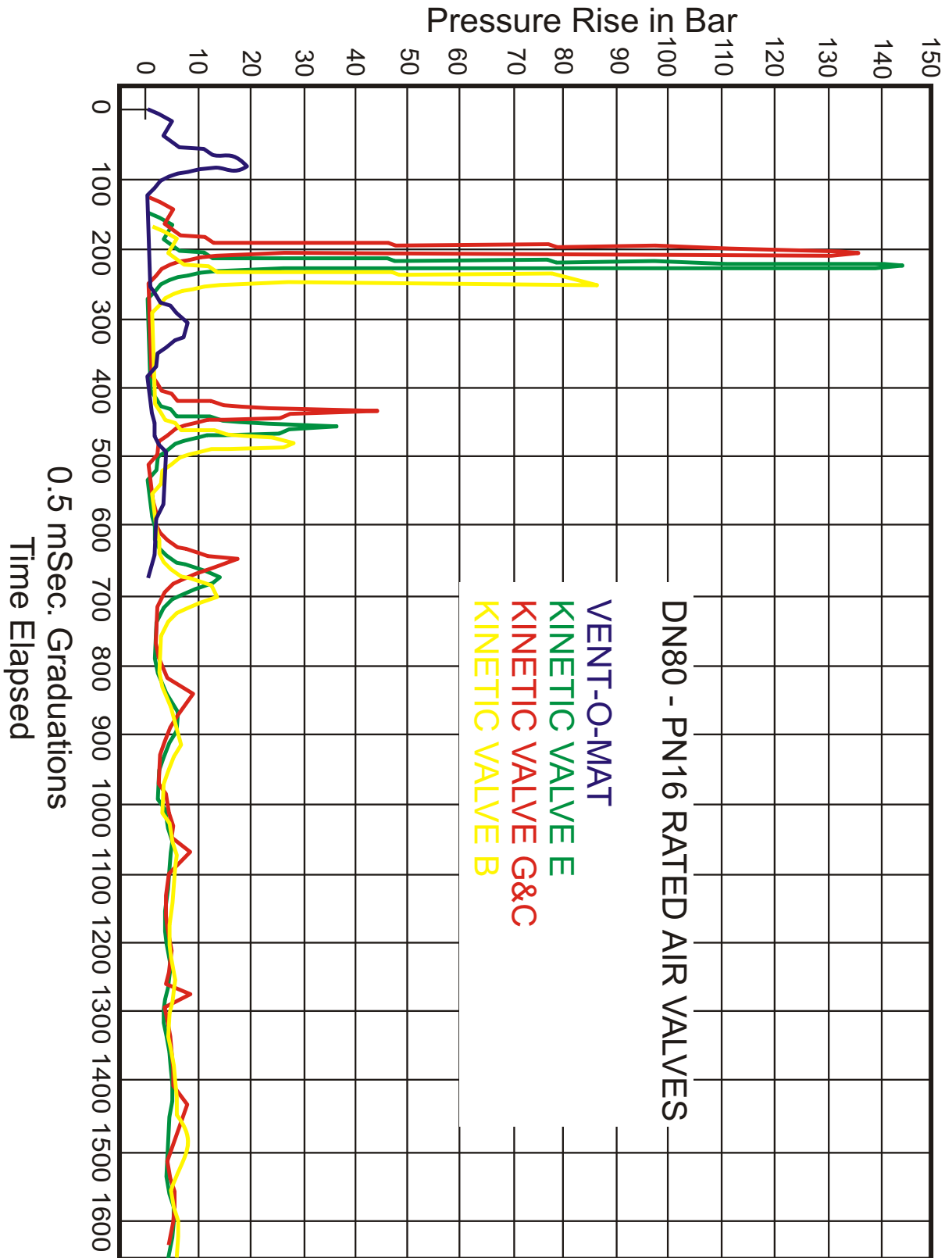
SCHEMATIC LAYOUT OF AIR DISCHARGE SET-UP



SCHEMATIC LAYOUT OF INDUCED PRESSURE TEST SET -UP



PEAK PRESSURE INDUCED VERSUS APPROACHING WATER VELOCITY IN AIR VALVE THROAT UNDER EQUAL CONDITIONS FOR VARIOUS AIR VALVE DESIGNS



MAGNITUDE OF PRESSURE RISE INDUCED UNDER EQUAL CONDITIONS FOR VARIOUS AIR VALVE DESIGNS ON CLOSURE OF THE LARGE ORIFICE AT A DISCHARGE DIFFERENTIAL OF 0.17 BAR.