EFFECT OF PIPE DIAMETER IN PIPING SYSTEM BY USING ACOUSTIC EMISSION TECHNIQUE

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JUDUL: **EFFECT OF PIPE DIAMETER IN PIPING SYSTEM USING ACOUSTIC EMISSION TECHNIQUE**

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Dedicated to my beloved family & friends

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Universiti Malaysia Pahang, 2010

ABSTRACT

This project was carried out as a study of effect of pipe diameter different and different pressure in piping system by using Acoustic Emission technique. The objective of this research is to investigate the flow rate in the piping system due to the pipe diameter difference and pressure different and evaluates type of signal produce from the acoustic emission technique for each type of pipe diameter in piping systems. A test rigs consist of a galvanized steel pipe that have two different diameters to run the experiments. The liquid that has been used is water and it controlled by the ball valve to setting the three different pressures. The source of the AE signal was from the ball valve that controlled the pressure but the effect of different diameter also play it roll because it can give a different flow rate that will show either the flow of water is low or high turbulent flow. The signal was captured using AE sensor with help of Acoustic Emission Detector 2.1.3 software. For all pipe diameter and pressure, the values of hits, counts and RMS (average, minimum and maximum) were recorded and analyzed. All the value recorded was compared to the different of pipe diameter and different pressure. The result shows that there almost no AE activities on the pipe that has big diameter compare to the smaller one. The conclusion has shown that the big pipe diameter will secure the safety because of the flow of the water that enter the pipe is low in flow rate and produced low turbulent flow compare to the small pipe diameter.

ABSTRAK

Projek ini dilakukan sebagai kajian tentang pengaruh paip diameter yang berbeza dan tekanan cecair berbeza dalam sistem perpaipan dengan menggunakan teknik Emisi Akustik. Tujuan projek ini dijalankan adalah untuk mengetahui laju aliran cecair dalam sistem perpaipan kerana perbezaan diameter paip dan tekanan berbeza dan menilai isyarat dari teknik pembebasan akustik untuk setiap jenis diameter paip dalam sistem perpaipan. Sebuah rig ujian terdiri daripada paip baja Galvanis yang memiliki dua diameter yang berbeza untuk menjalankan eksperimen. Cecair yang telah digunakan adalah air dan dikawal oleh injap bola untuk mendapat tiga tekanan yang berbeza. Sumber dari isyarat AE itu dari injap bola yang mengawal tekanan tetapi kesan diameter berbeza juga member impak kerana ia boleh memberikan kadar kelajuan cecair terapung yang berbeza yang akan menunjukkan aliran air adalah aliran turbulen rendah atau tinggi. Isyarat ini ditangkap dengan sensor AE dengan bantuan software Detektor Akustik Emisi 2.1.3. Untuk semua diameter paip dan tekanan, nilai-nilai hits, jumlah dan RMS (rata-rata, minimum dan maksimum) direkodkan dan dianalisis. Semua nilai tercatat dibandingkan dengan perbezaan diameter paip dan tekanan yang berbeza. Keputusan kajian menunjukkan bahawa hampir tidak ada kegiatan AE pada paip yang memiliki diameter besar berbanding dengan yang lebih kecil. Kesimpulannya telah menunjukkan bahawa diameter paip besar akan menjamin keselamatan kerana aliran air yang masuk ke paip adalah rendah dan menghasilkan aliran turbulen rendah berbanding dengan diameter paip kecil.

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LIST OF ABBREVIATIONS

AE	Acoustic Emission
AD	Analog to digital
D/A	Digital to analog
NDE	Non destructive evaluation
NDT	Non destructive testing
PC	Personal computer
RMS	Root mean square
TFE	Teflon

LIST OF SYMBOL

A	Area
C_V	Flow coefficient
D	Diameter
D	Pipe diameter
l_e	Entry length
ρ	Density
Q	Flow rate
R_e	Reynolds Number
μ	Fluid viscosity
V	Flow velocity

CHAPTER 1

INTRODUCTION

1.1 THE OBJECTIVE OF PROJECT

The objective of this research is to investigate the flow rate in the piping system due to the pipe diameter difference and evaluates type of signal produce from the acoustic emission technique for each type of pipe diameter in piping systems. The effect will be seen in the type of the flow rate that was produced by changing the diameter of the pipe in the piping system and the pressure that was divided between low and high pressure (psi). Then, classify the signal and effect on the pipe diameter and choose the suitable diameter for the difference pressure that was choice.

1.2 SCOPE OF PROJECT

This focus is based on the following aspect:

i) Perform the entire experimental indicator such, a set of piping system and other.

ii) Capture the signal produced due to the flow rate that is produce by using different pipe diameter and difference pressure.

iii) The material of the piping system may be made of galvanized iron (Gi).

iv) Galvanized iron (Gi).In this project we prefer to use Galvanized iron (Gi). Because easy to get and widely used in plumbing work.

v) The element that was carried was liquid (water).

1.3 PROBLEM STATEMENT

Existing piping system may cause a several defect cause by the flow rate, type of fluid carried and the pressure. This defect may decrease the efficiency of the piping system. Some theory was related to the cause of the defect such as the diameter of the pipe, valve that controls the pressure and type of pipe material. Hence, this project is focus on the pipe diameter and the different of pressure by catch the signal produce by the piping system during the flow process. The equipment that uses to catch the signal is Acoustic Emission devices. This signal was interpret to find the conclusion about the effect of pipe diameter to the piping system.

1.4 PROJECT BACKGROUND

Pipe system was one of reliable, effective and safer system to transfer matter or energy. Varieties of materials were use to made a pipe system depend on the type of element that wants to transfer but major of it made of metal. Pipe systems are one of the most reliable and safest means of transfer of matter and energy. Now, because of high demand in the pipe system so many inventors have replaced metal with new material such as plastic products and composites that enhanced the domain of application of material systems in pipelines. Plastic pipes have salient features such as low weight, ease of connection and corrosion resistance. It was cheaper too compare to other material, but it can’t hold high pressure and temperature so it only suitable to used for simple liquid transfer that have moderate pressure and temperature. Galvanized iron (Gi) was widely used in the plumbing work to carried liquid such as water and oil. It’s cheaper than other metal pipe that used. Galvanized iron (Gi) Pipe is black steel pipe which has been hot dip galvanized. GI pipes are available in three grades depending on the thickness of the sheet used in the pipe. In certain sector such as water supply, power generates and etc, the length of piping system can be hundreds meters or kilometers so along the piping system there can be various of failure modes including crazing, cracking, large deformation, buckling, fracture, local damage, corrosion and clogging of piping system. Piping system also has lot of diameters that need to be concern and researches depend on the element that was carried and the effectiveness to achieve the destination. The effect of pipe diameter of piping system should taking serious to make sure transfer of element and energy smoothly and also avoid failure occur at the pipeline. Hopefully this research can expand inventive concept to understand the effective diameter in piping system affected.

CHAPTER 2

LITERATURE REVIEW

2.1 ACOUSTIC EMISSION (AE)

2.1.1 BRIEFING HISTORY OF AE

Although acoustic emissions can be created in a controlled environment, they can also occur naturally. Therefore, as a means of quality control, the origin of AE is hard to pinpoint. As early as 6,500 BC, potters (Figure 2.1) were known to listen for audible sounds during the cooling of their ceramics, signifying structural failure. In metal working, the term "tin cry" (audible emissions produced by the mechanical twinning of pure tin during plastic deformation) was coined around 3,700 BC by tin smelters in Asia Minor. The first documented observations of AE appear to have been made in the 8th century by Arabian alchemist Jabir ibn Hayyan. In a book, Hayyan wrote that Jupiter (tin) gives off a ‘harsh sound’ when worked, while Mars (iron) ‘sounds much’ during forging.

Figure 2.1: Potters.

Source: Ndt Resource center, 2001

Many texts in the late 19th century referred to the audible emissions made by materials such as tin, iron, cadmium and zinc. One noteworthy correlation between different metals and their acoustic emissions came from Czochralski, who witnessed the relationship between tin and zinc cry and twinning. Later, Albert Portevin and Francois Le Chatelier observed AE emissions from a stressed Al-Cu-Mn (Aluminum-Copper-Manganese) alloy.

The next 20 years brought further verification with the work of Robert Anderson (tensile testing of an aluminum alloy beyond its yield point), Erich Scheil (linked the formation of martensite in steel to audible noise), and Friedrich Forster, who with Scheil related an audible noise to the formation of martensite in high-nickel steel. Experimentation continued throughout the mid-1900’s, culminating in the PhD thesis written by Joseph Kaiser entitled "Results and Conclusions from Measurements of Sound in Metallic Materials under Tensile Stress.” Soon after becoming aware of Kaiser’s efforts, Bradford Schofield initiated the first research program in the United States to look at the materials engineering applications of AE. Fittingly, Kaiser’s research is generally recognized as the beginning of modern day acoustic emission testing. (Ndt Resource center, 2001)

2.1.2 BRIEFING INTRODUCTION OF AE

The acoustic-emission technology has been applied widely in industries, educational centre, medical field and certain organization to used as non-destructive inspection(NDI) or non-destructive testing(NDT) and technical diagnostic of industrial objects such as pipelines and pressure vessels, tanks, heat exchangers, bridges, cranes and other metallically structures. The latest acoustic –emission system has a multichannel and multifunction system that was build on the basis of personal computers. Acoustic technique is widespread among the methods of engineering diagnosis used nowadays to assess the state of machines and mechanism comprising rotating parts and movable joints. Potters observed the sound emanating from the pots while tapping to ascertain the soundness of the vessel as the cracking sound emitted by tin during deformation (also called as ‘tin cry’) is probably the first true acoustic emission techniques heard from metal.There are a lot of advantages using this technique compare to other:

i. Compactness and small weight of instrumentation,
ii. Small consumed power and capability of battery backup,
iii. Presence of the built-in uninterruptible power supply,
iv. The expanded temperature range of operation of instrumentation,
v. Hardening of instrumentation from effect of shocks, moisture and dust.
vi. Reliability, ease and convenience in usage.
vii. Ensure quality levels.
viii. Ensure customer satisfaction.
ix. Predicts impending failures, thus preventing costly shutdowns and aids in plant life extension.
x. Aids in optimum product design.

*NDT or NDI is the technology of assessing the soundness and acceptability of a material, component or structure without impairing its functional properties or ‘worth’ the term “NDT” includes many method that can detect:

- Detect surface or subsurface imperfections.
- Determines structure, composition or material properties.
- Measure geometric characteristics.

Examples include detecting and locating faults in pressure vessels, damage assessment in fibre-reinforced polymer-matrix composites, monitoring welding applications and corrosion processes, various process monitoring applications, global or local long-term monitoring of civil-engineering structures (e.g., bridges, pipelines, offshore platforms, etc.) and fault detection in rotating elements and reciprocating machines, to name but a few.

The scientific application of AE first emerged in the 1950's, but the decline of heavy industry, nuclear power and defense spending in the 1980s, together with some poor publicity, resulted in a quiet period for AE research. Nevertheless the technique has developed significantly and emerged as a very powerful method for numerous measurement problems, far beyond conventional non-destructive testing.

Today there is a transition to waveform-based analysis, which has opened up a new approach to AE analysis. Recent successes have been largely due to advances in high-speed digital waveform based AE instrumentation, improvements in high fidelity, high sensitivity broadband sensors and advanced PC-based signal analysis. This has given researchers an enhanced understanding of AE signal propagation, enabling a departure from traditional reliance on statistical analysis, significantly improving the monitoring capabilities of AE.

New developments have raised new problems, not least of which is sensor technology. Resonant transducers are useful in many applications but increasingly are replaced by sensors with broader frequency characteristics. Issues of flat response, sensitivity and calibration need to be addressed. Modern data transfer methods such as network techniques and wireless communication ensure that AE technology will be a field of interesting future developments and applications. (Ndt Resource center, 2001)

2.2 THEORY AE SOURCES

As mentioned in the Introduction, acoustic emissions can result from the initiation and growth of cracks, slip and dislocation movements, twinning, or phase transformations in metals. In any case, AE's originate with stress. When a stress is exerted on a material, a strain in induced in the material as well. Depending on the magnitude of the stress and the properties of the material, an object may return to its original dimensions or be permanently deformed after the stress is removed. These two conditions are known as elastic and plastic deformation, respectively.

The most detectible acoustic emissions take place when a loaded material undergoes plastic deformation or when a material is loaded at or near its yield stress. On the microscopic level, as plastic deformation occurs, atomic planes slip past each other through the movement of dislocations. These atomic-scale deformations release energy in the form of elastic waves which “can be thought of as naturally generated ultrasound” traveling through the object. When cracks exist in a metal, the stress levels present in front of the crack tip can be several times higher than the surrounding area. Therefore, AE activity will also be observed when the material ahead of the crack tip undergoes plastic deformation (micro-yielding).

Two sources of fatigue cracks also cause AE’s. The first source is emissive particles (e.g. nonmetallic inclusions) at the origin of the crack tip. Since these particles are less ductile than the surrounding material, they tend to break more easily when the metal is strained, resulting in an AE signal. The second source is the propagation of the crack tip that occurs through the movement of dislocations and small-scale cleavage produced by triaxial stresses.

The amount of energy released by an acoustic emission and the amplitude of the waveform are related to the magnitude and velocity of the source event. The amplitude of the emission is proportional to the velocity of crack propagation and the amount of surface area created. Large, discrete crack jumps will produce larger AE signals than cracks that propagate slowly over the same distance.

Detection and conversion of these elastic waves to electrical signals is the basis of AE testing. Analysis of these signals yield valuable information regarding the origin and importance of a discontinuity in a material. As discussed in the following section, specialized equipment is necessary to detect the wave energy and decipher which signals aremeaningful (Ndt Resource center, 2001)

2.2.1 ACTIVITY OF AE SOURCES IN STRUCTURAL LOADING

AE signals generated under different loading patterns can provide valuable information concerning the structural integrity of a material. Load levels that have been previously exerted on a material do not produce AE activity. In other words, discontinuities created in a material do not expand or move until that former stress is exceeded. This phenomenon, known as the Kaiser Effect, can be seen in the load versus AE plot to the right. As the object is loaded, acoustic emission events accumulate (segment AB). When the load is removed and reapplied (segment BCB), AE events do not occur again until the load at point B is exceeded. As the load exerted on the material is increased again (BD), AE's are generated and stop when the load is removed. However, at point F, the applied load is high enough to cause significant emissions even though the previous maximum load (D) was not reached. This phenomenon is known as the Felicity Effect. This effect can be quantified using the Felicity Ratio, which is the load where considerable AE resumes, divided by the maximum applied load (F/D).

Knowledge of the Kaiser Effect and Felicity Effect can be used to determine if major structural defects are present. This can be achieved by applying constant loads (relative to the design loads exerted on the material) and "listening" to see if emissions continue to occur while the load is held. As shown in the figure, if AE signals continue to be detected during the holding of these loads (GH), it is likely that substantial structural defects are present. In addition, a material may contain critical defects if an identical load is reapplied and AE signals continue to be detected. Another guideline governing AE's is the Dunegan corollary, which states that if acoustic emissions are observed prior to a previous maximum load, some type of new damage must have occurred. (Note: Time dependent processes like corrosion and hydrogen embrittlement tend to render the Kaiser Effect useless)(Ndt Resource center, 2001)

2.2.2 NOISE

The sensitivity of an acoustic emission system is often limited by the amount of background noise nearby. Noise in AE testing refers to any undesirable signals detected by the sensors. Examples of these signals include frictional sources (e.g. loose bolts or movable connectors that shift when exposed to wind loads) and impact sources (e.g. rain, flying objects or wind-driven dust) in bridges. Sources of noise may also be present in applications where the area being tested may be disturbed by mechanical vibrations (e.g. pumps).

To compensate for the effects of background noise, various procedures can be implemented. Some possible approaches involve fabricating special sensors with electronic gates for noise blocking, taking precautions to place sensors as far away as possible from noise sources, and electronic filtering (either using signal arrival times or differences in the spectral content of true AE signals and background noise)(Ndt Resource center, 2001)

2.2.3 PSEUDO SOURCE

In addition to the AE source mechanisms described above, pseudo source mechanisms produce AE signals that are detected by AE equipment. Examples include liquefaction and solidification, friction in rotating bearings, solid-solid phase transformations, leaks, cavitations, and the realignment or growth of magnetic domains. (Ndt Resource center, 2001)

2.3 THEORY ACOUSTIC WAVES

2.3.1 WAVE PROPAGATION

A primitive wave released at the AE source is illustrated in the figure right. The displacement waveform is a step-like function corresponding to the permanent change associated with the source process. The analogous velocity and stress waveforms are essentially pulse-like. The width and height of the primitive pulse depend on the dynamics of the source process. Source processes such as microscopic crack jumps and precipitate fractures are usually completed in a fraction of a microsecond or a few microseconds, which explains why the pulse is short in duration. The amplitude and energy of the primitive pulse vary over an enormous range from submicroscopic dislocation movements to gross crack jumps.

Waves radiates from the source in all directions, often having a strong directionality depending on the nature of the source process, as shown in the second figure. Rapid movement is necessary if a sizeable amount of the elastic energy liberated during deformation is to appear as an acoustic emission.

As these primitive waves travel through a material, their form is changed considerably. Elastic wave source and elastic wave motion theories are being investigated to determine the complicated relationship between the AE source pulse and the corresponding movement at the detection site. The ultimate goal of studies of the interaction between elastic waves and material structure is to accurately develop a description of the source event from the output signal of a distant sensor.

However, most materials-oriented researchers and NDT inspectors are not concerned with the intricate knowledge of each source event. Instead, they are primarily interested in the broader, statistical aspects of AE. Because of this, they prefer to use narrow band (resonant) sensors which detect only a small portion of the broadband of frequencies emitted by an AE. These sensors are capable of measuring hundreds of signals each second, in contrast to the more expensive high-fidelity sensors used in source function analysis. More information on sensors will be discussed later in the Equipment section.

The signal that is detected by a sensor is a combination of many parts of the waveform initially emitted. Acoustic emission source motion is completed in a few millionths of a second. As the AE leaves the source, the waveform travels in a spherically spreading pattern and is reflected off the boundaries of the object. Signals that are in phase with each other as they reach the sensor produce constructive interference which usually results in the highest peak of the waveform being detected. The typical time interval from when an AE wave reflects around the test piece (repeatedly exciting the sensor) until it decays, ranges from the order of 100 microseconds in a highly damped, nonmetallic material to tens of milliseconds in a lightly damped metallic material. Figure 2.2 and Figure 2.3 show the primitive AE and angulardependence. (Ndt Resource center, 2001)

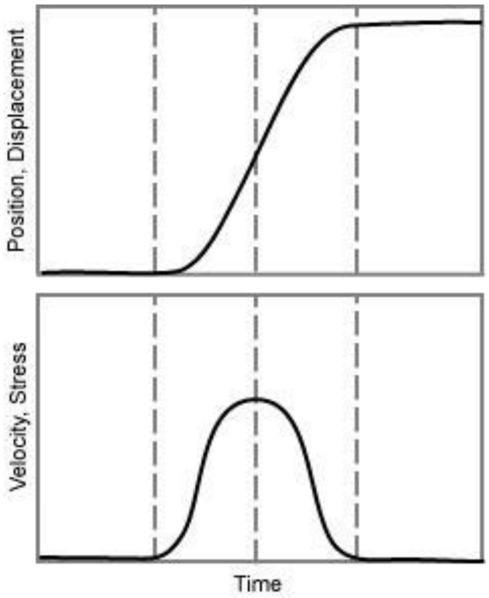


Figure 2.2: Primitive AE wave released at a source. The primitive wave is essentially a stress pulse corresponding to a permanent displacement of the material. The ordinate quantities refer to a point in the material.

Source: Ndt Resource center, 2001

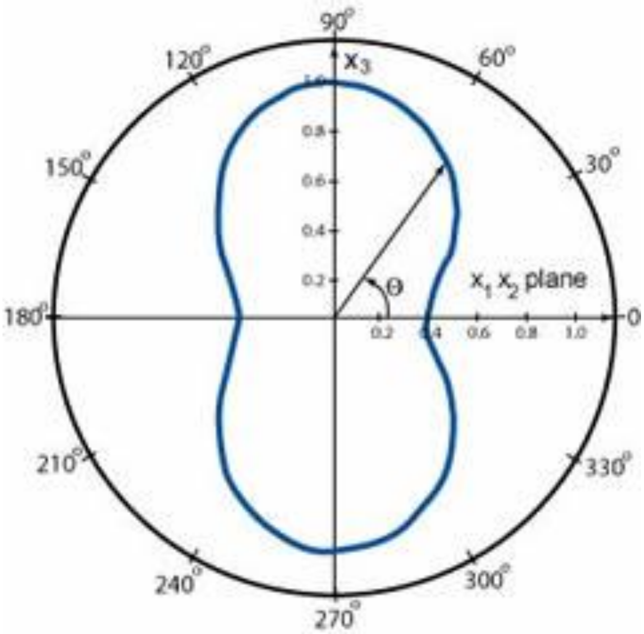


Figure 2.3: Angular dependence of acoustic emission radiated from a growing micro crack. Most of the energy is directed in the 90 and 270o directions, perpendicular to the crack surfaces.

Source: Ndt Resource center, 2001

2.3.2 ATTENUATION

The intensity of an AE signal detected by a sensor is considerably lower than the intensity that would have been observed in the close proximity of the source. This is due to attenuation. There are three main causes of attenuation, beginning with geometric spreading. As an AE spreads from its source in a plate-like material, its amplitude decays by 30% every time it doubles its distance from the source. In three-dimensional structures, the signal decays on the order of 50%. This can be traced back to the simple conservation of energy. Another cause of attenuation is material damping, as alluded to in the previous paragraph. While an AE wave passes through a material, its elastic and kinetic energies are absorbed and converted into heat. The third cause of attenuation is wave scattering. Geometric discontinuities (e.g. twin boundaries, nonmetallic inclusions, or grain boundaries) and structural boundaries both reflect some of the wave energy that was initially transmitted.

Measurements of the effects of attenuation on an AE signal can be performed with a simple apparatus known as a Hsu-Nielson Source. This consists of a mechanical pencil with either 0.3 or 0.5 mm 2H lead that is passed through a cone-shaped Teflon shoe designed to place the lead in contact with the surface of a material at a 30 degree angle. When the pencil lead is pressed and broken against the material, it creates a small, local deformation that is relieved in the form of a stress wave, similar to the type of AE signal produced by a crack. By using this method, simulated AE sources can be created at various sites on a structure to determine the optimal position for the placement of sensors and to ensure that all areas of interest are within the detection range of the sensor orsensors. (Sotirios J. Vahaviolos, 1999)

2.3.3 WAVE MODE AND VELOCITY

As mentioned earlier, using AE inspection in conjunction with other NDE techniques can be an effective method in gauging the location and nature of defects. Since source locations are determined by the time required for the wave to travel through the material to a sensor, it is important that the velocity of the propagating waves be accurately calculated. This is not an easy task since wave propagation depends on the material in question and the wave mode being detected. For many applications, Lamb waves are of primary concern because they are able to give the best indication of wave propagation from a source whose distance from the sensor is larger than the thickness.(Sotirios J. Vahaviolos, 1999)

2.4 PRINCIPLE OF AE TESTING AND AE PHENOMENON.

The generation of AE is a mechanical phenomenon, and can originate from a number of different mechanisms. Mechanical deformation and fracture are the primary source of AE, but phase transformation, corrosion, friction, and magnetic processes among others also give rise to AE. The energy thus released travels as a spherical wave front and can be picked up from the surface of a material using highly sensitive transducers, usually piezo electric type placed on the surface of the component. Sensors are coupled to the structure by means of a fluid couplant and are secured with tape, adhesive bonds or magnetic hold-downs. The output of each piezoelectric sensor (during structure loading) is amplified through a low-noise preamplifier, filtered to remove any extraneous noise and further processed by suitable electronic equipment and analyzed to reveal valuable information about the source causing the energy release. Various types of other sensors are stain gages, accelerometers, electromagnetic acoustic transducers and optic of fiber-optic interferometers. The frequency range of acoustic emission phenomenon extends from the infrasonic (<16Hz) into ultrasonic range. The largest and therefore the longest events such as earthquake are found at the lowest end of the scale while frequencies in the audible range occur predominantly in micro seismology i.e. during fracture phenomenon in rocks.

Acoustic emission in the proper sense covers the audible frequencies and the ultrasonic range. At higher frequencies, the acoustic emission is not intense enough in most cases and the material also absorbs large parts of the signal. The lower frequency limit is primarily set by the background noise.

2.4 .1 AE SIGNAL

The emissions from various sources outlined above are release as acoustic energy impulse. The energy thus released travels thought the structure as a spherical elastic wave to a detector, normally a piezo electric transducer which converts this acoustic impulse into electric signals. This electrical signal is then suitable processed and analyses to reveal information about the source causing the energy release. Two types of signals can be recognizing in general acoustic emission. There are:

a) **Burst emission**:

Burst emissions are discrete type of signals of very short duration (ranging from a few microsecond to a few millisecond) and hence of broad frequency domain spectrum. On the screen or monitor, they appear as individual signals or single needles well separated in time. Although these signals are rarely simple needle like, they usually rise rapidly to a maximum amplitude and decay in an exponential way to the level of background noise. Burst signal are characteristic of crack growth and propagation are also observed during twin formation as with the tin cry and micro-yielding.

b) **Continuous emission:**

If the acoustic impulses are emitted close to one another or if the burse very high then the signals occur very close and sometimes even overlap. In such case, the emissions are termed as continuous. In these types of emission, one cannot observe the individual signals separately.

2.5 FACTOR AFFECTING AE

Acoustic emission is the elastic energy that spontaneously released by materials undergoing deformation.AE is thus a wave phenomenon and AE testing uses the attribute or characteristics of these waves to characterize the material/process.AE waveform is the convolution result of three effects; generation at the source, propagation and measurement. Two of the most common waveform parameters are frequency and amplitude. As indicated earlier, AE is a wide band phenomenon and frequencies can range from audible range to about 50MHz .The observes frequency spectrum of the AE signals greatly depends on the geometry and acoustic properties of the specimen and characteristic of the sensor.

In general practical applications, the background noise governed by the lower frequency limit which is normally about 10kHz while the upper frequency limit is dictated by wave attenuation. Most of the practical applications of AE testing are carried out in the frequency range of about 100 kHz to 300 kHz.

The sensitivity of AE method is primarily governed by the background noise. For the AE signal to be discernible, its amplitude should be clearly above the noise level.AE from metal, wood, plastic and other source can generate signal ranging from fraction of micro-volts to more than hundred volts. The dynamic range of the signal amplitude from the test object may be 120dB (V).When the conditioning would be required to visualize and interpret the AE signal reliably. Apart from this, prior to any experimentation, the noise sources should be identified and then removed or inhibited or limited.

2.5.1 PLASTIC PIPES

Piping systems for gas and water distribution, sewer and drainage systems, capable protection, communication and industrials constitute the lifelines of various industries and communities. Many thousand kilometer long existing pipeline around the world made of metallic, concrete, polymeric, and composite materials perform their vital function with various degrees of efficiency, but generally with high degree of safety. A number of the existing piping networks are, however, locally or globally aged or are prone to potential damage and failure. Some piping systems may have even reached the limit of their service lifetime and may be at the stage of potential failure or may need retrofitting or even replacement. In the case of plastic pipes, it has proved quite reliable for gas, water and drainage systems as well as several other applications. The plastic materials, however, have their own salient features, which should be taken into consideration in all dealing with the safety, services life, failure event and the retrofitting strategies.

2.6 FAILURE PHENOMENON

Pipelines have good safety record (death, injuries, explosive) compare to other transportation, but it still not be a great transportation and getting failure called failure event. Failure event can be definition, a situation which can hinder its function, change its configuration jeopardize its integrity and potentially endanger the environment. Failure mode can be defined as an event or mechanism that causes the pipe to reach one or combine strength and serviceability limit state. There is a lot of potential consequence of pipeline failure such as injuries and loss of properties. That failure also affect on facilities such as expensive property and environmental damage. The failure of piping system usually may be fail cause of wrong design, material failure, production, inexpert technique installation, bad service condition, and environmental factor such as mechanical loads, thermal effects, chemical agent and ageing factor. Depending form the cause failure, usually piping will be rapture, fracture, loss of stiffness, large deformation, instability and buckling, deterioration of properties and loss the function of the piping system. (Sotirios J. Vahaviolos, 1999)

2.7 AE SYSTEM, SENSORS AND INSTRUMENTATION

Acoustic emission testing can be performed in the field with portable instruments or in a stationary laboratory setting. Typically, systems contain a sensor, preamplifier, filter, and amplifier, along with measurement, display, and storage equipment (e.g. oscilloscopes, voltmeters, and personal computers). Acoustic emission sensors respond to dynamic motion that is caused by an AE event. This is achieved through transducers which convert mechanical movement into an electrical voltage signal. The transducer element in an AE sensor is almost always a piezoelectric crystal, which is commonly made from a ceramic such as lead zirconate titanate (PZT). Transducers are selected based on operating frequency, sensitivity and environmental characteristics, and are grouped into two classes: resonant and broadband. The majority of AE equipment is responsive to movement in its typical operating frequency range of 30 kHz to 1 MHz. For materials with high attenuation (e.g. plastic composites), lower frequencies may be used to better distinguish AE signals. The opposite holds true as well.

Ideally, the AE signal that reaches the mainframe will be free of background noise and electromagnetic interference. Unfortunately, this is not realistic. However, sensors and preamplifiers are designed to help eliminate unwanted signals. First, the preamplifier boosts the voltage to provide gain and cable drive capability. To minimize interference, a preamplifier is placed close to the transducer; in fact, many transducers today are equipped with integrated preamplifiers. Next, the signal is relayed to a bandpass filter for elimination of low frequencies (common to background noise) and high frequencies. Following completion of this process, the signal travels to the acoustic system mainframe and eventually to a computer or similar device for analysis and storage. Depending on noise conditions, further filtering or amplification at the mainframe may still be necessary.

After passing the AE system mainframe, the signal comes to a detection/measurement circuit as shown in the figure directly above. Note that multiple-measurement circuits can be used in multiple sensor/channel systems for source location purposes (to be described later). At the measurement circuitry, the shape of the conditioned signal is compared with a threshold voltage value that has been programmed by the operator. Signals are either continuous (analogous to Gaussian, random noise with amplitudes varying according to the magnitude of the AE events) or burst-type. Each time the threshold voltage is exceeded, the measurement circuit releases a digital pulse. The first pulse is used to signify the beginning of a hit. (A hit is used to describe the AE event that is detected by a particular sensor. One AE event can cause a system with numerous channels to record multiple hits.) Pulses will continue to be generated while the signal exceeds the threshold voltage. Once this process has stopped for a predetermined amount of time, the hit is finished (as far as the circuitry is concerned). The data from the hit is then read into a microcomputer and the measurement circuit is reset. (Sotirios J. Vahaviolos, 1999)

2.7.1 AE TEST EQUIPMENT

The equipment for the processing AE signals is available in variety of form, ranging from single or dual channel systems to multi channel systems. The components common to all these systems include sensor, preamplifier, band pass or high pass filter, amplifier and signal conditioning circuit.Auxiliary instrumentation to assist in displaying the signal, analyzing and recording depend the application setting and user guide. See (Figure 2.4**)**.

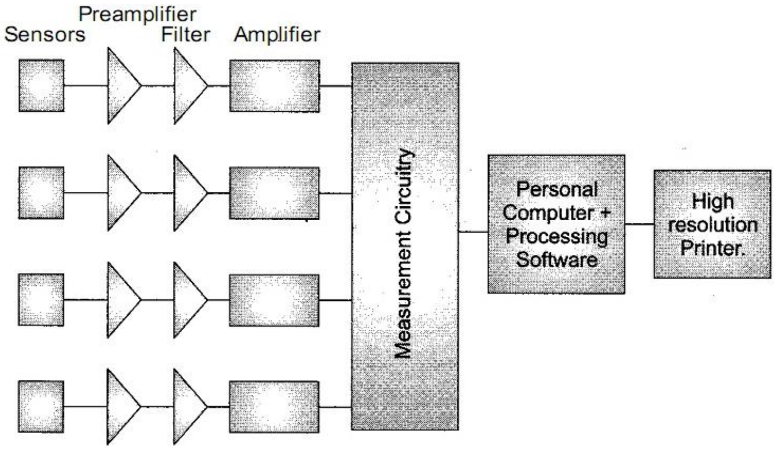


Figure 2.4: continuous emission

Source: Ndt Resource center, 2001

2.7.2 SENSOR

It is the main part in AE systems. The function of the sensor is to convert the acoustic wave energy emitted by the source into usable electrical signal typically voltage time signal. The signal can be generated by electromagnetic devices such as phonograph pickup by capacitive microphones by magneto restrictive devices or piezo electric devices. AE sensor need have high sensitivity, ruggedness, wide bandwidth (broad band sensor) and narrow bandwidth (resonant sensor) and fidelity. Piezoelectric is the active element with electrode on the top and bottom faces. The electrode will connect to the signal lead and the other one connect to electrical ground. A metal case are packaged the entire sensor as shield to minimize electromagnetic pick-ups.

2.7.3 COUPLANTS

To provide a good acoustic emission contact between the test object and the sensor, couplant are taking this purpose. The characteristic of the couplant should have are high wet ability, corrosion resistance, sufficient viscosity and easy removal. Usually couplant made from natural wax, silicone grease and epoxy propylene.

2.7.4 WAVEGUIDE

This devices as show in (Figure 2.5**)** are used when the sensor are not possible to place directly on the surface of the component for AE monitoring (high temperature applications). The waveguide isolate AE sensor from bad environmental conditions of high temperature / nuclear radiations and make sure acoustic communication between the object under investigate and the sensor are maintain.

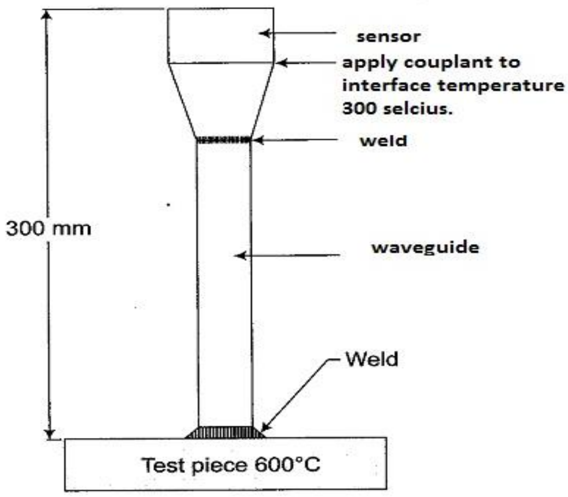


Figure 2.5: Specification of waveguide

Source: Ndt Resource center, 2001

2.8 AE INSTRUMENTAIΟΝ

2.8.1 PREAMPLIFIER

It is the first stage of the instrumentation system and the main application of this item is to enhance the signal level against noise. The pre-amplifier should locate near the sensor so that the sensor produces charge proportional to source intensity. The main used of preamplifier are to amplify the small sensor signals so that they can be transmitted over long signal cables. It's also used to match impedance of sensor to low impedance of signal cable where the low impedance cables pick up less airborne electrical interference. Other that, it also used to provide a means of common mode rejection to reduce electrical pick-up from the sensor and sensor cable. A perfect preamplifier should have are low noise, moderately high gain, low output impedance, good dynamic range, high stability, good common mode rejection and input impedance matching to the sensor. (Figure2.6)below show the preamplifier.

Figure 2.6: preamplifier

Source: Ndt Resource center, 2001

2.8.2 FILTER

Filter are allowing the amplifier signal from sensor and attenuating unwanted noise. An ideal filter allows the desired frequencies with unit gain and rejects unwanted frequencies. Filter with flat frequency response for desirable frequencies and sharp cut off for unwanted noise is required. Filters are design for different bandwidth and can be plugged to preamplifier to meet the specific requirements. A band pass filter allows only the band of frequencies and can be considered as a combination of low pass and high pass filters. Band pass filter with bandwidth ranging 100 kHz-300 kHz widely using in AE experimental. (Figure 2.7**)** show the filter.

Figure 2.7: Filter

Source: Ndt Resource center, 2001

2.9 AE SIGNAL FEATURE

With the equipment configured and setup complete, AE testing may begin. The sensor is coupled to the test surface and held in place with tape or adhesive. An operator then monitors the signals which are excited by the induced stresses in the object. When a useful transient, or burst signal is correctly obtained, parameters like amplitude, counts, measured area under the rectified signal envelope (MARSE), duration, and rise time can be gathered. Each of the AE signal feature shown in the image is described below. (Wolfgang Sachse et al, 1991)

2.10 WAVEFORM CHARACTERISTIC

AE signal is as received by the transducers contain information on the rate of emission, frequencies of the emitted waves, amplitude within the amplitude waves and energy information about the emitted signal.AE monitoring usually carried out in the presence of continuous background noise. Threshold detection is normally set above the background noise level. Reliable analysis of AE data requires that appropriate parameters be extracted from the AE signal. The characteristic of a typical acoustic emission wave are energy and signal level (RMS voltage) (Figure 2.8), event duration (Figure 2.9), rise time (figure 2.10), event, ring down count (RDC) (Figure 2.11), peak amplitude (Figure2.14). (Wolfgang Sachse et al, 1991)

2.10.1 ENERGY AND SIGNAL LEVEL (RMS VOLTAGE) WAVE

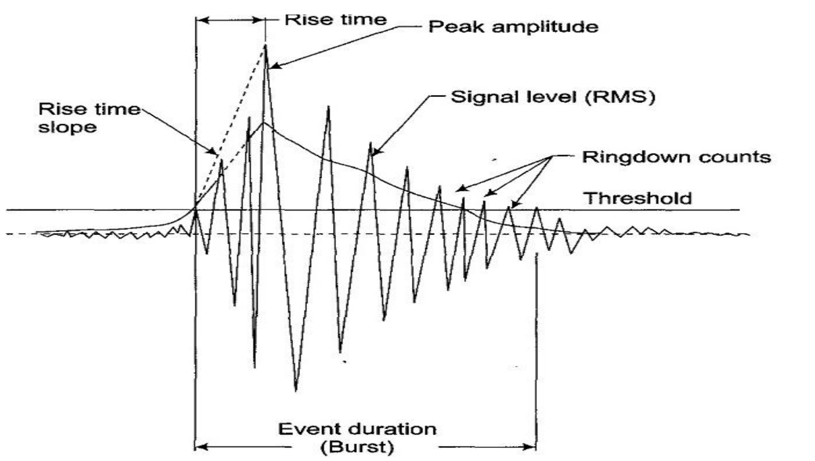


Figure 2.8: energy and signal level (RMS voltage) wave

Source: Ndt Resource center, 2001

2.10.2 EVENT DURATION WAVE

An AE event can know as a microstructure displacement or defect growth that produces elastic waves in the material under load or stress. The event duration can measure in the time between the first and the last threshold crossing. A chance in either average signal duration or the can indicate either a change in the signal path to the sensor or a change in the generating mechanism. The event count can defined as the number of acoustic emission events and it's obtained by counting each discerned. (James R. Matthews, 1983)

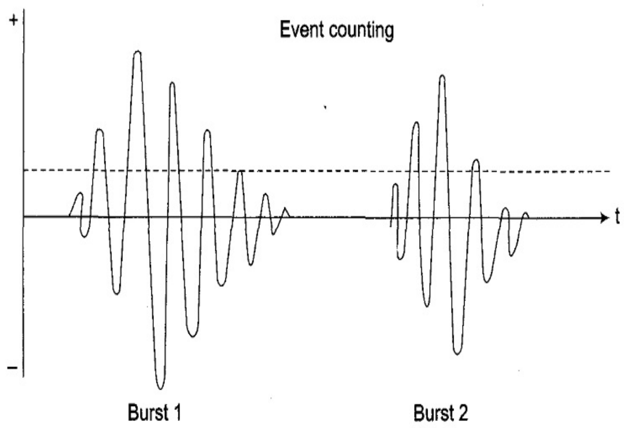


Figure 2.9: Event duration wave
Source: Ndt Resource center, 2001

2.10.3 RISE TIME WAVE

Rise time can be known as the time required for the signal to reach its peak amplitude and normally counted from the time between first threshold crossing and the peak amplitude while decay time refers to the time taken by the signal to decay from its peak value to just above threshold level. (Wolfgang Sachse et al, 1991)

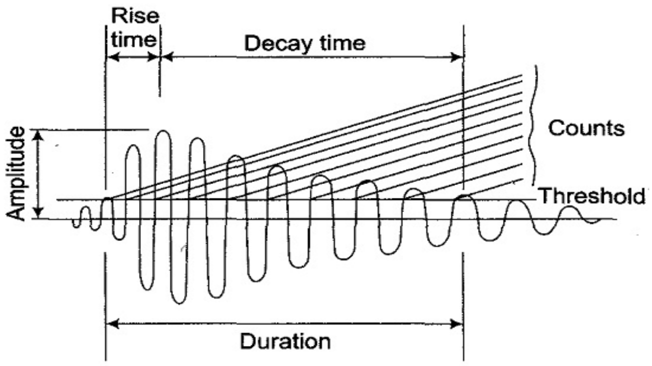


Figure 2.10: rise time wave
Source: Ndt Resource center, 2001

2.10.4 RING DOWN COUNT (RDC) WAVE

The ring down count or the other name known as acoustic emission count is the number of times the acoustic emission exceeds a preset threshold during any selected portion of a rest. A larger event requires more cycle to ring down to the trigger level and will produce more counts than a smaller event. Correlation also have been established between total counts, counts rate and various fracture mechanism parameters such as stress intensity factor or fatigue crack propagation rate. (Sotirios J. Vahaviolos, 1999)

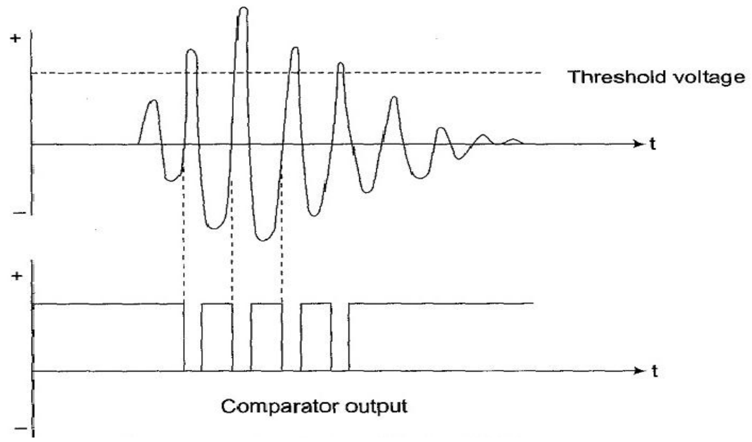


Figure 2.11: ring down count (RDC) wave

Source: Ndt Resource center, 2001

2.10.5 PEAK AMPLITUDE WAVE

The peak amplitude can be measure where the peak value of the largest excursion attained by the signal wave form from an emission event. It can be related to the intensity of the source in the generally performance using a log amplitude to provide accurate measurement of both large and small signals. Amplitude distributions have been correlated with deformation mechanism in specific material. (Sotirios J. Vahaviolos, 1999)

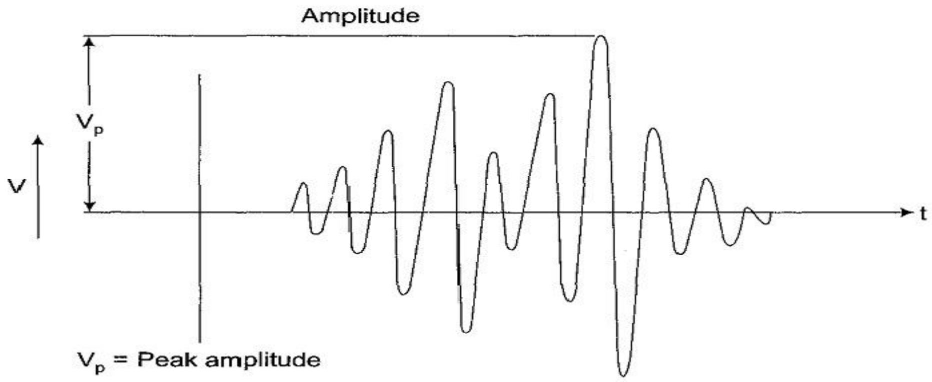


Figure 2.12: Peak amplitude wav

Source: Ndt Resource center, 2001

Acoustic emission test is attributed to the rapid release of energy in a material. If the energy content of the acoustic emission signal can be related to the energy release and the true energy has been observed to be directly proportional to the area under the curve encompassing the acoustic emission waveform. Energy measurement offer advantage over other parameter such as ring down counts in that energy measurement can be directly related to important events such as deformation mechanism and strain rate. (Ndt Resource center, 2001)

2.11 DATA DISPLAY

Software-based AE systems are able to generate graphical displays for analysis of the signals recorded during AE inspection. These displays provide valuable information about the detected events and can be classified into four categories: location, activity, intensity, and data quality as show in Figure 2.13

Location displays identify the origin of the detected AE events. These can be graphed by X coordinates, X-Y coordinates, or by channel for linear computed-source location, planar computed-source location, and zone location techniques. Examples of each graph are shown to the right.

Activity displays show AE activity as a function of time on an X-Y plot in Figure 2.14. Each bar on the graphs represents a specified amount of time. For example, a one-hour test could be divided into 100 time increments. All activity measured within a given 36 second interval would be displayed in a given histogram bar. Either axis may be displayed logarithmically in the event of high AE activity or long testing periods. In addition to showing measured activity over a single time period, cumulative activity displays in Figure 2.15 can be created to show the total amount of activity detected during a test. This display is valuable for measuring the total emission quantity and the average rate of emission.

Intensity displays are used to give statistical information concerning the magnitude of the detected signals. As can be seen in the amplitude distribution graph to the near right, the number of hits is plotted at each amplitude increment (expressed in dB’s) beyond the user-defined threshold. These graphs can be used to determine whether a few large signals or many small ones created the detected AE signal energy. In addition, if the Y-axis is plotted logarithmically, the shape of the amplitude distribution can be interpreted to determine the activity of a crack (e.g. a linear distribution indicates growth).

The fourth category of AE displays is used for evaluating the quality of the data collected. Counts versus amplitude, duration versus amplitude, and counts versus duration are frequently used crossplots. As shown in the final figure, each hit is marked as a single point, indicating the correlation between the two signal features. The recognized signals from AE events typically form a diagonal band since larger signals usually generate higher counts. Because noise signals caused by electromagnetic interference do not have as many threshold-crossing pulses as typical AE source events, the hits are located below the main band. Conversely, signals caused by friction or leaks have more threshold-crossing pulses than typical AE source events and are subsequently located above the main band. In the case of ambiguous data, expertise is necessary in separating desirable and unwanted hits.

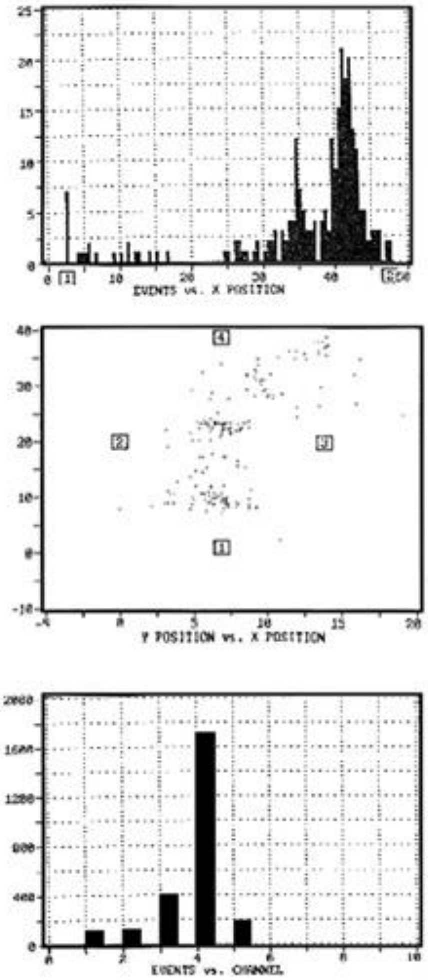


Figure 2.13: location, activity, intensity, and data quality

Source:Ndt Resource center,2001

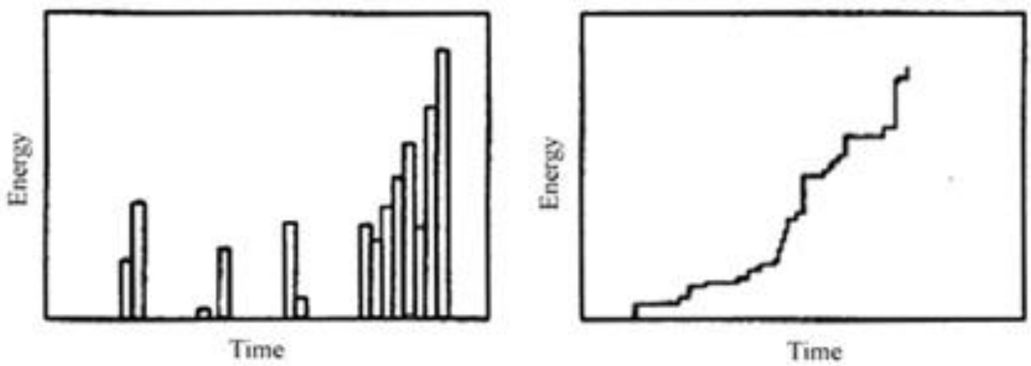


Figure 2.14: Activity displays show AE activity as a function of time on an X-Y plot

Source: Ndt Resource center, 2001

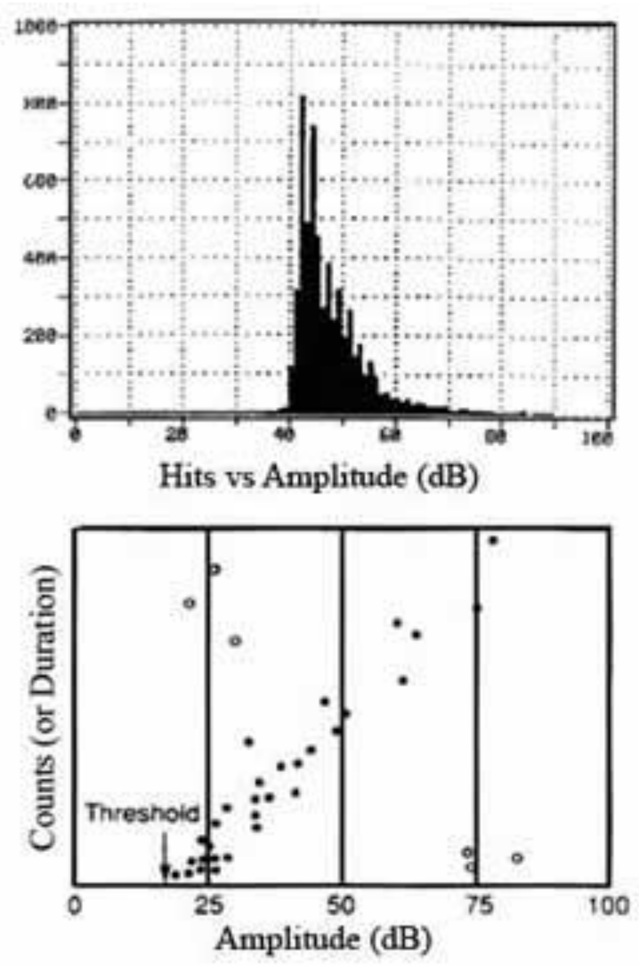


Figure 2.15: single time period, cumulative activity

Source: Ndt Resource center, 2001

2.12 EQUIPMENT IN TEST RIGS AND FLOW ANALYSIS IN CIRCULAR PIPE

2.12.1 Valve

There is much type of valves that can be used for variety of usage such as for industrial or domestic. The functions were different according the type of usage. Basically, valves are used manual or automatic control. Valves come with variety of size and also in wide range of price. It can used as simple as to control open and closed the flow of the system. It can also very complex and specific as can be seen in many power plants.

The valve that used in this study was ball valve. It function is to control open closed off the flow thus produce low, medium or high pressure. Ball valve actually was introduced since World War II. They consist of a body which houses a rotating ball which has an orifice or bore machined directly through it. The ball located in the body by two sealing rings.

Rotation of the ball through 90° opens and closes the valve and allows fluid to flow directly through the orifice in the closed position, the blank side of the ball block the inlet and the outlet preventing any flow. The handle that attached to the ball is in-line with the axis of the pipe when the valve is open; conversely, if was at right angles to the pipes axis, this indicates that the valve is closed.

For this project, the knowledge of the ball valve internal construction is important since the acoustic emission source is generated from the ball valve itself. The flow of the liquid in the pipe will be disturbed by the act of the opening gate at the ball valve. The continuous impact of the fluid to the ball will create AE signal and propagate through the fluid and the pipe wall.

2.12.2 FLOW ANALYSIS IN A CIRCULAR PIPE

The basic knowledge about flow in pipe was necessary for this project for this case; the principle of fluid mechanics is required since it is about the fluid flow motion. There are two kind of flow; open flow which is driven by gravity force and close flow, mainly driven by pressure different. Many complex engineering application; mostly in mechanical and chemical engineering always deal with the close flow such as ducting in a large air-conditioning system and also the flow of petrol from tank to vehicle engine. Meanwhile, the flow in circular pipe will deal with the close flow. The example of open flow is river and drain system.

Fluid flow analysis usually will do for two kinds of flow characteristic which are laminar flow and turbulent flow. Laminar flow can be described as flow that moves smoothly with Reynolds number below than 2000.meanwhile the turbulent flow is where the Reynolds number is greater than 4000 and this kind of flow contains wake and flows with irregular velocity fluctuations. Besides, it also characteristic by rapid and continuous mixing of the fluid in a chaotic manner. The different of these flows can be described as shown as the Figure 2.16

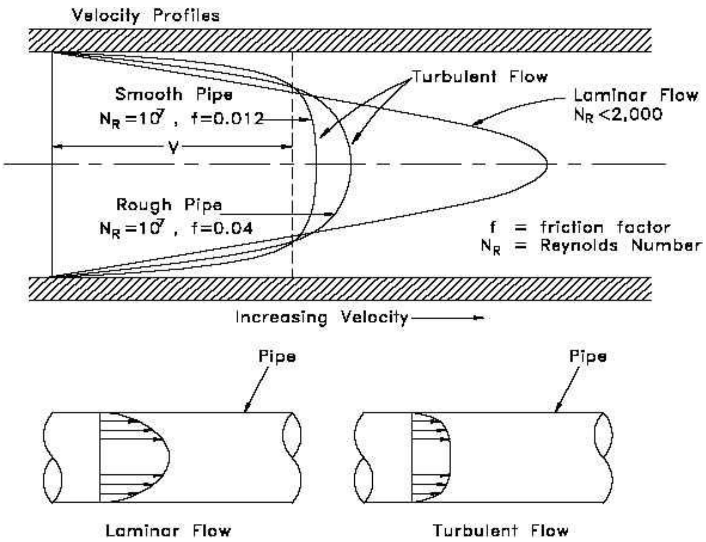


Figure 2.16: Comparison between laminar flow and turbulent flow

Source: Robert Alan Granger, 1995

There are few parameters that can be affecting a flow characteristic such as, flow velocity, diameter pipe, kinematic viscosity of fluid and the roughness parameter. To find out the flow is laminar or turbulent, Reynolds number of the flow need to be computed. This dimensionless number can be determined using equation 2.1

$$Re=\frac{\rho v D}{\mu} \quad \textbf{(2.1)}$$

Where, ρ is fluid density, v is the flow velocity, D is pipe diameter and μ is dynamic viscosity of fluid. The flow can be also be calculated by using equation 2.2

$$V=\frac{Q}{A} \quad \textbf{(2.2)}$$

Where Q is volume flow rate and A is piping cross section.

2.12.2.1TURBULENT FLOW

Turbulent flow always occurs inside the piping system. Therefore, turbulent flow is main focus for this project since laminar flow rarely happen in the normal application. The knowledge of turbulent flow is important when we study about the fluid motion. For every flow that entering the pipe, it will start with laminar region, then transition region and lastly followed by turbulent region. Refer to Figure 2.17

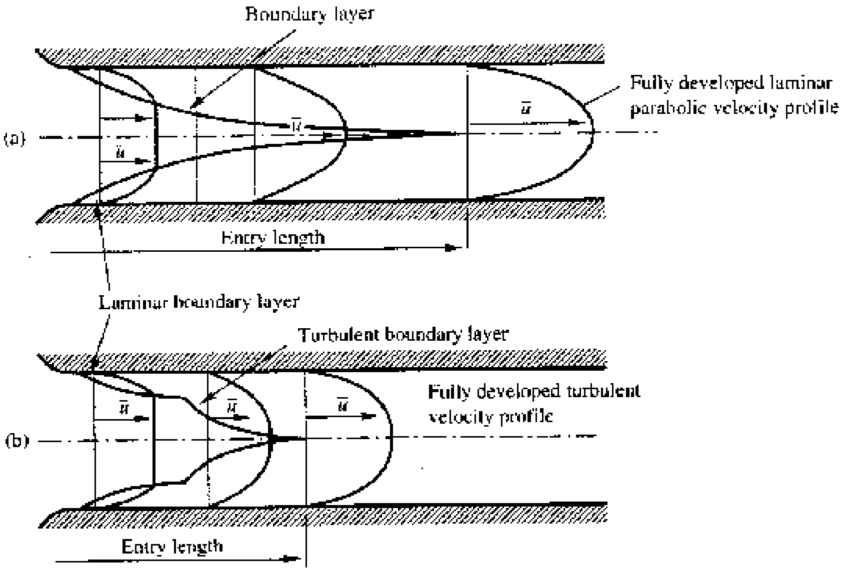


Figure 2.17: process laminar flow transform to turbulent flow

Source: Robert Alan Granger, 1995

There is a equation where to determined the distanced or entry length, $_{\varepsilon}$for the flow to fully developed which is

$$\frac{\varepsilon}{D} = 4.4(Re)^{1/\varepsilon} \qquad \textbf{(2.3)}$$

This equation will used to calculate the length of pipe for test rigs where it is necessary to do measurement of the acoustic emission signal within the fully develop turbulent flow region. Otherwise, the result will be affected by other variables such as the effect of transition region and etc.

2.13 APPLICATION OF AE

Acoustic emission is a very versatile, non-invasive way to gather information about a material or structure. Acoustic Emission testing (AET) is is applied to inspect and monitor pipelines, pressure vessels, storage tanks, bridges, aircraft, and bucket trucks, and a variety of composite and ceramic components. It is also used in process control applications such as monitoring welding processes. A few examples of AET applications follow.

i) Weld Monitoring:

During the welding process, temperature changes induce stresses between the weld and the base metal. These stresses are often relieved by heat treating the weld. However, in some cases tempering the weld is not possible and minor cracking occurs. Amazingly, cracking can continue for up to 10 days after the weld has been completed. Using stainless steel welds with known inclusions and accelerometers for detection purposes and background noise monitoring, it was found by W. D. Jolly (1969) that low level signals and more sizeable bursts were related to the growth of micro fissures and larger cracks respectively. ASTM E 749-96 is a standard practice of AE monitoring of continuous welding. Figure 2.18 show a Weld Monitoring.

Figure 2.18: Weld Monitoring

Source: Ndt Resource center, 2001

ii) Bucket Truck (Cherry Pickers) Integrity Evaluation

Accidents, overloads and fatigue can all occur when operating bucket trucks or other aerial equipment. If a mechanical or structural defect is ignored, serious injury or fatality can result. In 1976, the Georgia Power Company pioneered the aerial manlift device inspection. Testing by independent labs and electrical utilities followed. Although originally intended to examine only the boom sections, the method is now used for inspecting the pedestal, pins, and various other components. Normally, the AE tests are second in a chain of inspections which start with visual checks. If necessary, follow-up tests take the form of magnetic particle, dye penetrant, or ultrasonic inspections. Experienced personnel can perform five to ten tests per day, saving valuable time and money along the way. ASTM F914 governs the procedures for examining insulated aerial personnel devices. Figure 2.19 show a Bucket Truck (Cherry Pickers) Integrity Evaluation.

Figure 2.19: Bucket Truck (Cherry Pickers) Integrity Evaluation

Source: Ndt Resource center, 2001

iii) Gas Trailer Tubes:

Acoustic emission testing on pressurized jumbo tube trailers was authorized by the Department of Transportation in 1983. Instead of using hydrostatic retesting, where tubes must be removed from service and disassembled, AET allows for in situ testing. A 10% over-pressurization is performed at a normal filling station with AE sensors attached to the tubes at each end. A multichannel acoustic system is used to detection and mapped source locations. Suspect locations are further evaluated using ultrasonic inspection, and when defects are confirmed the tube is removed from use. AET can detect subcritical flaws whereas hydrostatic testing cannot detect cracks until they cause rupture of the tube. Because of the high stresses in the circumferential direction of the tubes, tests are geared toward finding longitudinal fatigue cracks. Figure 2.20 show a Gas Trailer Tubes.

Figure 2.20: Gas Trailer Tubes

Source: Ndt Resource center, 2001

iv) Bridges:

Bridges contain many welds, joints and connections, and a combination of load and environmental factors heavily influence damage mechanisms such as fatigue cracking and metal thinning due to corrosion. Bridges receive a visual inspection about every two years and when damage is detected, the bridge is either shut down, its weight capacity is lowered, or it is singled out for more frequent monitoring. Acoustic Emission is increasingly being used for bridge monitoring applications because it can continuously gather data and detect changes that may be due to damage without requiring lane closures or bridge shutdown. In fact, traffic flow is commonly used to load or stress the bridge for the AE testing. Figure 2.21 show a Bridges.

Figure 2.21: Bridges

Source: Ndt Resource center, 2001

v) Aerospace Structures:

Most aerospace structures consist of complex assemblies of components that have been design to carry significant loads while being as light as possible. This combination of requirements leads to many parts that can tolerate only a minor amount of damage before failing. This fact makes detection of damage extremely important but components are often packed tightly together making access for inspections difficult. AET has found applications in monitoring the health of aerospace structures because sensors can be attached in easily accessed areas that are remotely located from damage prone sites. AET has been used in laboratory structural tests, as well as in flight test applications. NASA's Wing Leading Edge Impact Detection System is partially based on AE technology. The image to the right shows a technician applying AE transducers on the inside of the Space Shuttle Discovery wing structure. The impact detection system was developed to alert NASA officials to events such as the sprayed-on-foam insulation impact that damaged the Space Shuttle Columbia's wing leading edge during launch and lead to its breakup on reentry to the Earth's atmosphere. Figure 2.22 show an Aerospace Structures.

Figure 2.22: Aerospace Structures

Source: Ndt Resource center, 2001

vi) Role of acoustic emission in the study of rock fracture:

The development of faults and shear fracture systems over a broad range of temperature and pressure and for a variety of rock types involves the growth and interaction of micro cracks. Acoustic emission (AE), which is produced by rapid micro crack growth, is a ubiquitous phenomenon associated with brittle fracture and has provided a wealth of information regarding the failure process in rock. This paper reviews the successes and limitations of AE studies as applied to the fracture process in rock with emphasis on our ability to predict rock failure. Application of laboratory AE studies to larger scale problems related to the understanding of earthquake processes is also discussed. In this context, laboratory studies can be divided into the following categories. 1) Simple counting of the number of AE events prior to sample failure shows a correlation between AE rate and inelastic strain rate. Additional sorting of events by amplitude has shown that AE events obey the power law frequency-magnitude relation observed for earthquakes. These cumulative event count techniques are being used in conjunction with damage mechanics models to determine how damage accumulates during loading and to predict failure. 2) A second area of research involves the location of hypocenters of AE source events.

This technique requires precise arrival time data of AE signals recorded over an array of sensors that are essentially a miniature seismic net. Analysis of the spatial and temporal variation of event hypocenters has improved our understanding of the progression of micro crack growth and clustering leading to rock failure. Recently, fracture nucleation and growth have been studied under conditions of quasi-static fault propagation by controlling stress to maintain constant AE rate. 3) A third area of study involves the analysis of full waveform data as recorded at receiver sites. One aspect of this research has been to determine fault plane solutions of AE source events from first motion data. These studies show that in addition to pure tensile and double couple events, a significant number of more complex event types occur in the period leading to fault nucleation. 4) P and S wave velocities (including spatial variations) and attenuation have been obtained by artificially generating acoustic pulses which are modified during passage through the sample. (www.sciencedirect.com)

Others

1. Fiber-reinforced polymer-matrix composites, in particular glass-fiber reinforced parts or structures (e.g. fan blades)
2. Material research (e.g. investigation of material properties, breakdown mechanisms, and damage behavior)
3. Inspection and quality assurance, (e.g. wood drying processes, scratch tests)
4. Real-time leakage test and location within various components (small valves, steam lines, tank bottoms)
5. Detection and location of high-voltage partial discharges in transformers
6. Railroad tank car and rocket motor testing

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION ABOUT THE FLOW CHART

Methodology is one of the most important to be made and take a deep consideration before in order to complete any research and development. The main reason to make a methodology is to assure that the project will be made just in time and following the planning that has made until it is finished. By doing the fine methodology, it will ensure that the project or research is following the objective that have been stated earlier which mean it will follow the guideline based on the objectives. Most important subject in the methodology is to state the step or the structure to conduct some method and experiment related to the research or the project. By using the objectives and scopes as the guideline, methodology can be described as the root of the research. Another key usage for methodology does not refer to research or to the specific analysis technique. This often refers to anything and everything that can be encapsulated for a series of process, activities and tasks. This use of the term is typified by the outline who, what, where, when and why. In the documentation of the processes that make up the discipline, which is being supported by "This" methodology, that is where we would find the "method" or processes of the research. With this methodology, it is easier to indicate the problem in our research because it has step by procedure. The research will move smoother and faster with this structure methodology

.Referring the Gantt chart this final year project (FYP) get started with some introduction or briefing by supervisor. For several first weeks some management schedule has been setup for this project that should covered the whole week in the future. Gantt chart was produce by using Microsoft excel.

After that, this project was continuing with some literature review about the title. In this literature review, it is about to find or to gather all the information related to this project. Find the type, related chart, table and the system that used on the effect of the different diameter pipe in the piping system by using acoustic emission system(AE).All the information gather from internet, journal, reference book and related person. The project was continued by making a planning on how to make an experiment that related with piping system and different of pipe diameter. This will consider about the design of the experiment and the cost to assembly it and the size of the pipe diameter that should be used in the experiment. Also should know about the principle and used of the application of the acoustic emission system (AE).All the subject that mention earlier come out using all data collection, earlier thesis related and metric link before this. Try to evaluate or analysis the mechanical and software part of piping system come out. From this entire source the real experiment will be performing. Once again make an analysis to the final result.

Lastly, the final report writing and prepare the final preparation. This process will be predicted to be finished in one week to arrange and accomplish. A report is guided by UMP thesis format and also guidance from supervisor. All task scheduled is taking around fourteen weeks to complete.

3.2 FLOW CHART

To achieve the objectives of this project, a methodology has been constructed like Figure 3.1. The methodology flow chart is purposed to give guidelines and directions to successfully accomplish the main goal of this project.

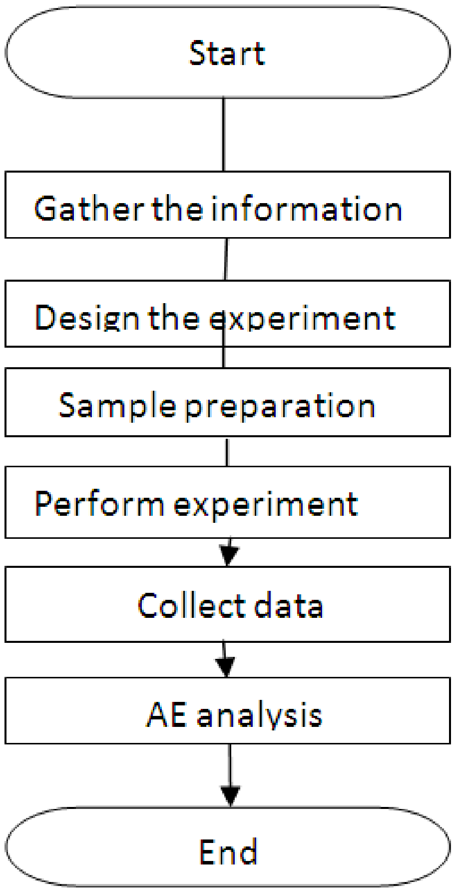


Figure 3.1: Project Flow Chart

3.3 GATHER THE INFORMATION

The information about this project was about the piping system, principle of Acoustic Emission (AE) and fatigue in piping system related to the diameter of the pipe. The information was collected from certain source such as internet (related journal), UMP thesis, and related person to this field.

3.3.1 INFORMATION FROM INTERNET

The information from the internet was most important to assure non-stop information about this topic.

3.3.2 INFORMATION FROM UMP THESIS & REFERENCE BOOK

One of main references to refer in order to get right and suitable method to perform this project especially in scope of methods to do list and example to type an introduction, methodology and more. Although sometime the thesis was not related to this project title but the method is almost same. So, it's sometime useful to this project. Reference book also is a main source to search a information related to the project. Those include a book from library. After several inspections there were many international books that were related to this project. Below is a related book that can be a reference to this project:

1. Allen H. Bingham, Calvin W. Ek, Jerry R. Tanner.1992.Acoustic emission testing of aerial devices and associated equipment.
2. R. E. Gray, ASTM Committee D-18 on Soil and Rock for Engineering Purposes.1981. Acoustic emissions in geotechnical engineering practice.
3. Wolfgang Sachse, Kusuo Yamaguchi, James Roget, AEWG (Association).1991. Acoustic emission: current practice and future directions.
4. Sotirios J. Vahaviolos.1999. Acoustic Emission.
5. George C. Moran, Paul Labine.1986. Corrosion monitoring in industrial plants using nondestructive testing.

3.3.3 INFORMATION FROM RELATED PERSON

The related person that was related to this project is the supervisor that guide on how to elaborate the concept of the acoustic emission, piping system, giving some advice and material and how to write the proper report. Also related person was the other student that doing project that was related to the acoustic emission although the major title is different. Those persons give an advice and proper method to perform the experiment. Some discussion has been held to get a best test rigs and result.

3.4 DESIGN THE EXPERIMENT

This project was a document that related, discuss and research result about the experiment that wants to found out about the effect of the different of pipe diameter in piping system using acoustic emission. The effect will show about the flow rate that produces when using the different pipe diameter. The result will be in set of data that will interpret buy using Microsoft excel to get the graph so can be analysis. In order to serve that must conduct the most suitable experiment to get the good result. The design of the experiment that include the piping system and suitable model of acoustic emission that can take a result properly and in efficiency way.

In this experiment. Two main equipments will be use that is hydraulic bench pump and Acoustic emission system. The hydraulic bench pump will have two pipes that are inner and outer pipe. Those pipes have same diameters that are ¾ inch. There will be a single piping system that attached to the hydraulic bench pump on the first entering point that is pipe 1(diameter ¾ inch).Pipe 1 will connected to the pipe that will be a manipulated factor that is the pipe that can be change and replaced with multiply different diameter. The diameter of the manipulated pipe that is use was 1 inch & 3/4 inch. At the end of the manipulated pipe will attached back to the pipe 2 as the flow pipe that flow back the liquid to the tank that will be used back in the inner pipe 1.Pipe 2 through will attach to the hydraulic bench pump. Pipe 2 also has a diameter of ¾ inch The liquid will flow back to the tank and ready to pumped back from the pump to the pipe 1.Then it will continued flow through the manipulated factor pipe to the pipe 2.Acoustic emission will play the role at the end of manipulated pipe, before the pressure gauge and the ball valve.The devices that have a sensor will be placed on the pipe surface. Between the sensor and the surface of the pipe will be a couplant that is grease. In this experiment also will have a pressure different as the manipulated factor. For each diameter of the manipulated pipe that has been tested will experience three different type of pressure that is low pressure(10Psi),medium pressure(20Psi) and high pressure(25Psi) Figure 3.2and

Figure 3.3 show the instrument that will be use in this experiment. The acoustic emission will be placed near the ball valve that attached to the pipes 2.That will be the first point for the acoustic emission devices. Then the next location will decide about 15centimeter from the first point. The acoustic emission will be located about 10 point on the pipes surface. At each point the program will be running for 30second to get the data.

Figure 3.2: Acoustic emission devices

Figure 3.3: Computer that will attach to AE instrument to collect the data.

3.5 SAMPLE PREPARATION.

In this project, the different of pipe diameter will be samples to test a flow rate in the piping system. The pipe diameters that will be use in this experiment are ¾ inch and 1 inch. Both pipes will have a 3 meter in length. Also there is three type of pressure that will be tested for each diameter of pipe that is low pressure(10Psi),medium pressure(20Psi) and high pressure(25Psi).This different pipe diameter and different pressure will produce the different of flow rate either turbulent or laminar flow. We will use acoustic emission to get the information about the type of flow rate in the piping system by detect the vibration produce by the pipe. This acoustic emission system will also detect certain damage in the piping system either fatigue, corrosion and leakage and produce certain data that will interpret using Microsoft Excel software to get a proper graph and will be analysis to find the suitable pipe diameter to use for either for the low, medium and high pressure. The material of the pipe that will be used is Galvanized Iron (GI). This type of pipe was chosen because it was suitable to use for water transfer, can be use for long period and widely use in variety sector. Figure 3.4 and Figure 3.5 showed the apparatus that was used in this experiment.

Figure 3.4: Pressure gauge

Figure 3.5: Test rigs

3.6 PERFORM THE EXPERIMENT

After the design the experiment and prepare the manipulated instrument then can proceed to other stage that is perform the experiment. First, the test rigs of the experiment will be ready. The manipulated pipes that will be used have a length of 3 meter. This pipe came as parts so it should be assemble first. After assemble the manipulated pipe, the acoustic emission system will be assembly as planning. Second, the piping system will be check again to measure there is not leaking to the pipe surface that will cause error to result of the experiment. This test will perform by allow the liquid flow through the pipe. At this test, the ball valve will be completely closed to block the water and allow the pressure gauge shown the maximum pressure that can be reached in the pipe. The maximum pressure that can be reached was 30Psi. Third, the flow liquid also will be check to measure there were not have a other material that can be stuck or cause a damage to the indicator devices if it clash with it. At this test, the liquid in the tank will be observed to detect the object that can be obstacle to the liquid flow during flow though the pipes. The ball valve also will be closed completely until the pressure in the pipes reached the maximum level then the ball valve will completely release to allow the dirt and struck material getting out from the pipes. Lastly, the acoustic emission sensor will be placed at the located placed that has plan. The first location was on the pipes surface near the ball valve that was attached to the pipes 2 that is the outer pipes that bring back the liquid to the tank that will be recycle to use back. The bit of grease was swept on the acoustic emission surface before it was placed on the pipe surface. For the first step, the ball valve will closed quarter to produce the low pressure (10Psi).Then the program will be running for 30 second to allow the acoustic emission to detect the vibration that was produce by the pipe surface due to the water flow in the pipes. Next step was to place the acoustic emission devices to the next location that was 15centimeter from the first location. The program will also be running for 30 second. These procedures will be continued repeated until the devices completed detect the vibration at 10 locations on the pipe surface. Lastly, the flow rate of the water at the low pressure was taken. After the experiment as completed for the low pressure, the experiment for the medium pressure will be held. All the procedure will be same except for the adjusting the ball valve. The ball valve should be adjusted half closed to make the pressure exceed the medium pressure (20Psi).The procedure for the high pressure(25Psi) was the same but the ball valve will be closed until the pressure exceed the 25Psi.After the experiment was completed for the first pipe diameter(1 inch),the next pipe diameter will be used. The diameter will be ¾ inch. After assemble the test rigs. The procedure will be same as before. Then the experiment will be performing. The result was produce in the set of data that must be interpreted by using Microsoft Excel software to get the graph so can be analysis.

3.7 COLLECT DATA

After make an experiment properly then we will collect the data get from the instrument. We will use an AED-2000V virtual instrument as Figure 3.6 and Figure 3.7 to collect the data from the devices that was attach to the end of manipulated pipe as mention before. AED-2000V virtual instrument can get a data from the devices and translate it into the certain mode or result that easy to read. The result will be in set of data. To convert it to graph must used Microsoft Excel software. After that the graph will be analysis. Certain calculation has been made using specific calculation. Especially if want to know Reynolds number and determine the type of flow whether it’s laminar or turbulent.

Figure 3.6: AED-2000V virtual instrument (front).

Figure 3.7: AED-2000V virtual instrument (back).

3.8 AE ANALYSIS

After get the data signal from the devices than the analysis will be done to determine whether there is several signals that can be interpret base on the flow rate that was produce due to the different of the pipe diameter and different pressure. From this data also can determine the suitable pipe diameter that can be used in this piping system to increase the efficiency either the low, medium or high pressure that was used.

3.9 CONCLUSION

The whole process is important for this project since we want to know the effect of different pipe diameter and liquid pressure toward the flow rate in the piping system. The experiment must follow all the step to make sure that it will proceed according the project flow chart. All the step will conduct us to the next step which is analysis based on the result that we will get in the experiment.

CHAPTER 4

RESULT AND DISCUSSION

4.0 INTRODUCTION

For Final year project 2 the galvanized iron pipe was used to assemble the test rigs and the experiment was conducted in fluid laboratory UMP.As mentioned in the previous chapter, there was two tests were conducted to achieve the objective of this project .Firstly, the experiment was conducted to test the acoustic emission device on the 1 inch pipe diameter with 3 different pressure. The value of those pressures was mentioned early in the previous chapter. Second experiment was conducted by using 3/4 inch pipe diameter on 3 type of pressure. Note that, some of the result from this experiment shows the same pattern for each one of them. This was happening due of certain errors that occur during the experiment and the factor will be discussed in this chapter. In this chapter was show the result that get from both of the experiments that was conducted and will also discuss about the result and the error that occur during the experiment. The example of acoustic emission signals that viewed using software Physical Acoustic AE-win 3.1 were as in the Appendix C

As mentioned in the earlier chapter, acoustic emission method is one of the NDT methods; where it can be done online, thus lower the cost of monitoring process. One of the important characteristic of this technique is it can be used to only sense the specific defect by recognizing the pattern signal that appear. Besides this method is noise tolerant, which mean, the data is free from unwanted signal. This has been proved by two simple tests where the sensor is placed to the pipe without any flow and without touching anything. No result shown by the recording software for both tests.

It is vital to make sure that the signal was in the stable conditions before ‘recording ‘can be started. There are two important precaution steps that need to apply. First, the water flow must be allowed to flow in the test rigs for several minute and make it circulate each time after adjusting the valve opening to ensure of stable turbulence. Second, record time must be started after a few seconds the sensor was placed at the specific location. The longer time is better since this step was applied to eliminate any unwanted signal and vibration that may occur when placing the sensor on the pipe.

The threshold value needs to be set in the software setting before recording can be done. The proper selection of the threshold is necessary to allow better form of signal can be shown. If the value is too high, no signals or hits maybe recorded. Meanwhile if the threshold value is too low, the signals may appear as continuous signal instead or burst signal. Note that, burst signal form is better in term of recognizing the pattern of AE signals. For first experiment, the threshold value is 57dB.In the second experiment, 37dB was used. It is because very little signals were recorded for ¾ inch pipe diameter if the 57dB value was taken.

4.1 DETERMINING THE LOCATION OF AE SOURCE.

It is important to know the source of the AE signal before any test was conducted. The best location for sensor then can be determined in order to get better result. The intensity of AE signal will decrease as the distance from any AE source increase.

From early hypothesis, the source of AE signals was from the fluid flow itself. Turbulent flow will create a lot of small bubbles and breaks within very small period. This high frequency process theoretically will create the acoustic emission signal; as burst signal. Second hypothesis, the AE source was from the valve since fluid flow always gives impact to the valve especially when it is nearly closed.

The result from second experiment reveals that AE signals started to propagate from the valve. It shows that after 150cm distance from ball valve, the signals turn weak and approaching zero (Refer Figure 4.1 and Figure 4.2) any signal recording after this range will give no reading. The first two points were the best place for sensor since it gave the higher AE activity to be recorded.

4.2 PIPE DIAMETER CLASSIFYING

The main objective for this study was to measure the acoustic emission signal from the pipe flow and find a method to classify the pipe diameter using acoustic emission technique.

Only 90 signals were used for result over 500 to 600 signals per measurement. These data were taken in term of average RMS, average min RMS and average max RMS. The filtering of data was make to ensure that the data was relevant to been taken as a final result and can be analysis.

Table 4.2 show the Reynolds number for the flow for each pressure that was control by ball valve. We can see all the flow is turbulent because of the value of Reynolds number was over 4000.But the value was not consistent because of the test rigs construction. The leak that occurs from the test rigs and the water flow from the hydraulic pump that was not so efficiency become the main disturbed factor to the flow in the test rigs.

The valve used was ball valve with arm type.(Figure 4.1 and figure 4.2).The pressure that was used are 10Psi,20Psi and 25Psi.Those pressure was choose because of the power of hydraulic pump that only can be reach only to those pressure.

Diameter (Inch)	Pressure (Psi)	Time(second)	Area(m^2)	Flow rate(m^3/s)	Velocity (m/s)	Reynolds number
1	10	2.98	2.850x10^{-4}	1.3424x10^{-3}	4.710	75602.47
	20	3.91	2.850x10^{-4}	1.0230x10^{-3}	3.589	57618.51
	25	8.87	2.850x10^{-4}	4.5096x10^{-3}	15.823	253994.56
3/4	10	3.08	2.850x10^{-4}	1.299x10^{-3}	4.557	97559.43
	20	4.87	2.850x10^{-4}	0.8213x10^{-3}	2.8818	61682.50
	25	6.97	2.850x10^{-4}	0.5739x10^{-3}	2.0136	43101.89

Table 4.1: Flow rate, velocity and Reynolds value for each diameter and pressure

Figure 4.1: Ball valve

Figure 4.2: Ball valve

4.3 EXPERIMENT 1

Table 4.2, Figure 4.3 and Figure 4.4 show the result from the first experiment. Total hits and counts within 30 seconds (± 1 second) of signal recording time are presented. The timer started after a few seconds before the Physical Acoustic software collect the data. This gap of time was needed to ensure the acoustic emission device was in stable condition and to prevent the other unwanted signal be a disturbed factor in order to take an appropriate signal that was needed. The long period of this gap of time was better and can increase the percentage to get the right signal. This condition was applied for all the tests that will be conducted.

Table 4.2: Result from the measurement process

Points	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Hits	117	92	39	82	36	43	61	13	20	2
Counts	1725	846	90	189	75	222	173	21	31	3

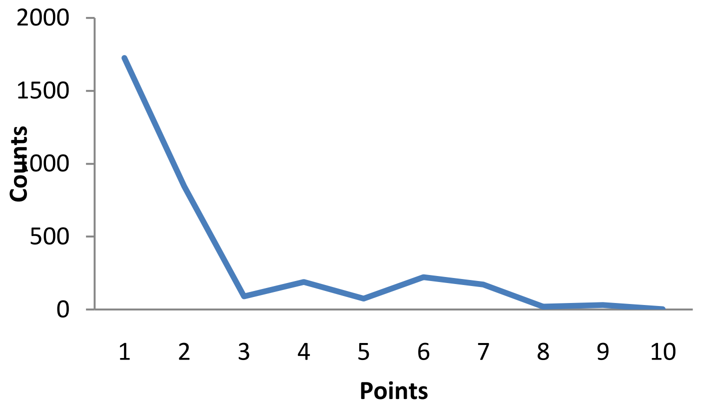


Figure 4.3: Result for *counts*

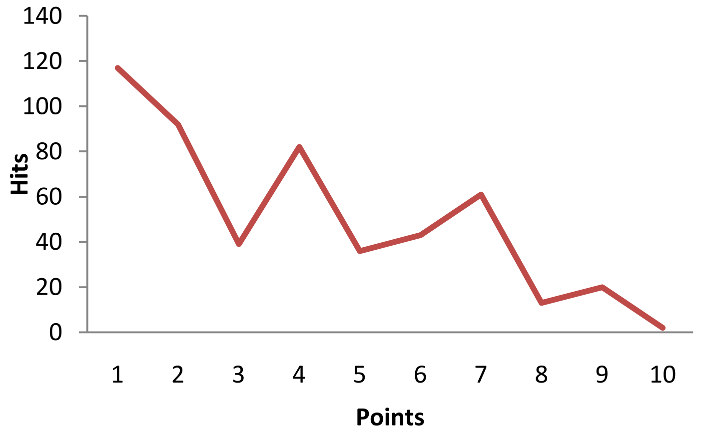


Figure 4.4: Result for *hits*

The result shows that the total hits and counts values are decreased when the distance from the value is increased. At point number 10(150 cm from the ball valve), the total hits and counts value were approaching zero. This condition shows that the original source of the acoustic emission signals was from the valve.

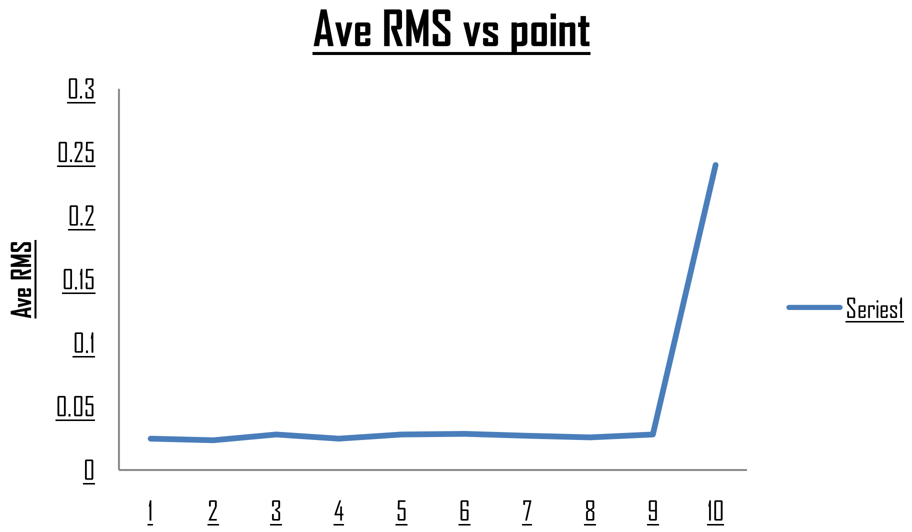


Figure 4.5: Average RMS at 10 point (Diameter: 1 inch, Pressure: 10Psi)

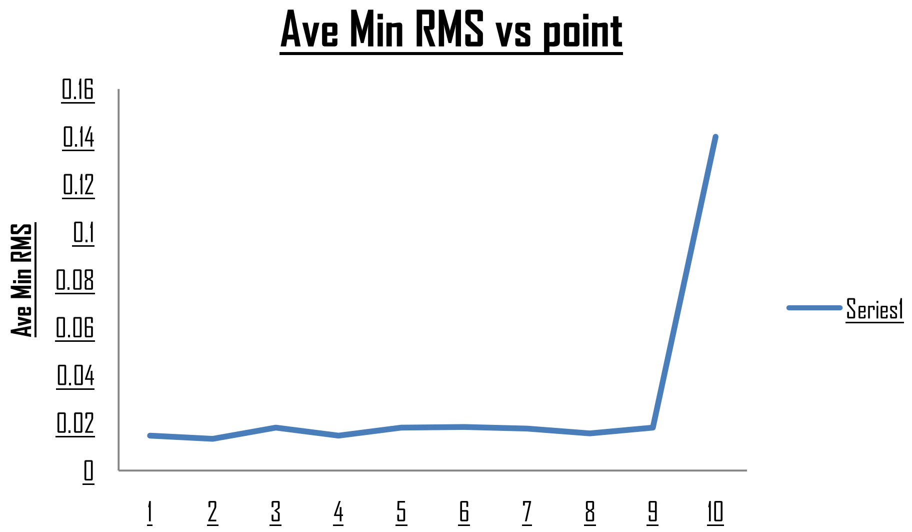


Figure 4.6: Average minimum RMS at 10 point (Diameter: 1 inch, Pressure: 10Psi)

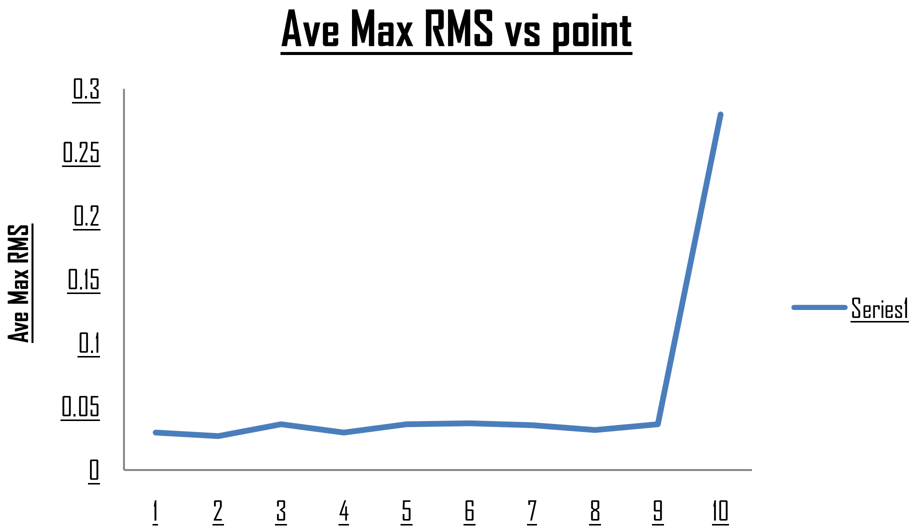


Figure 4.7: Average maximum RMS at 10 point (Diameter: 1 inch, Pressure: 10Psi)

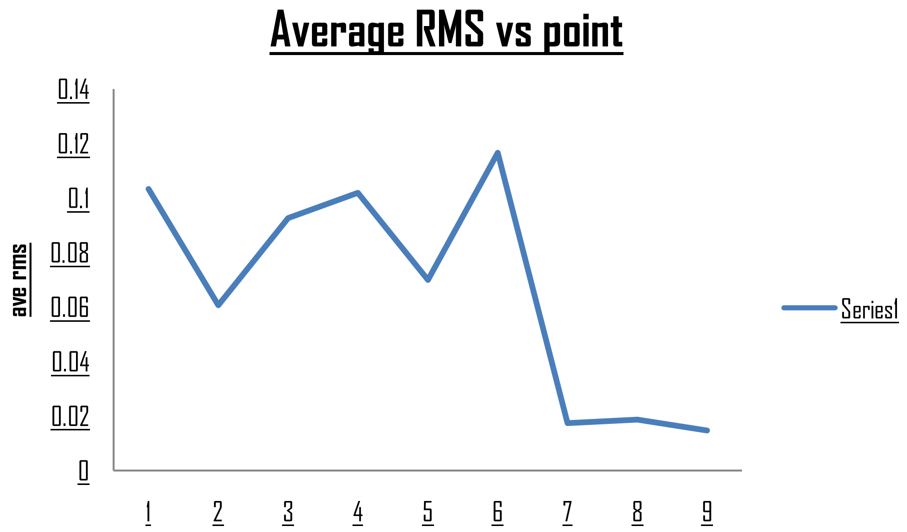


Figure 4.8: Average RMS at 10 point (Diameter: 1 inch, Pressure: 20Psi)

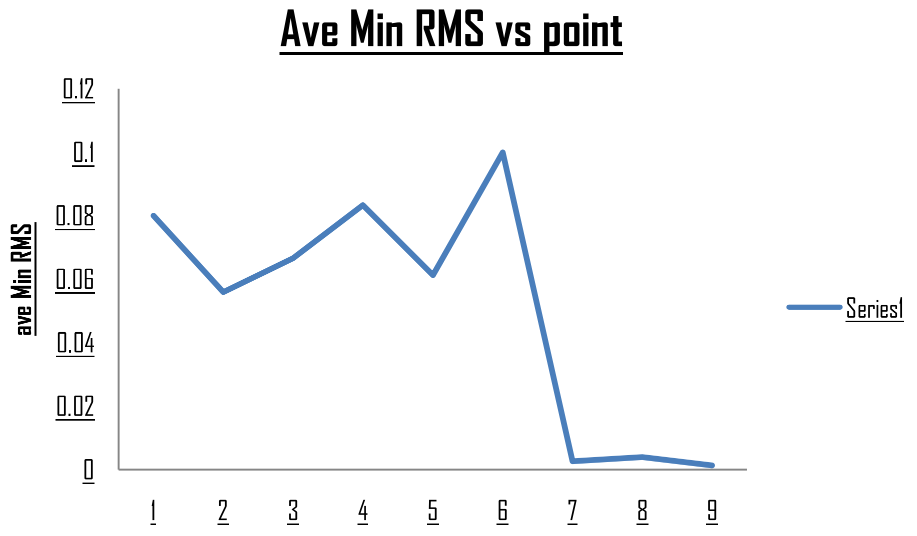


Figure 4.9: Average minimum RMS at 10 point (Diameter: 1 inch, Pressure: 20Psi)

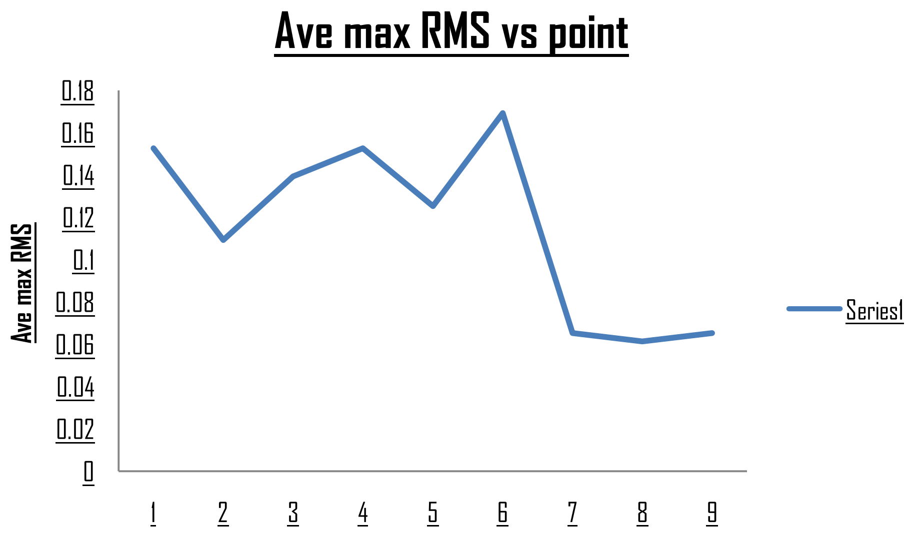


Figure 4.10: Average maximum RMS at 10 point (Diameter: 1 inch, Pressure: 20Psi)

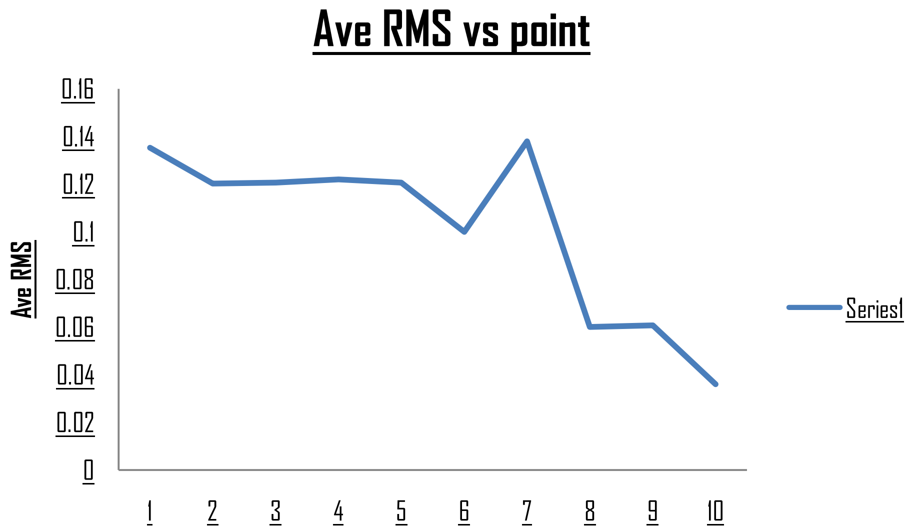


Figure 4.11: Average RMS at 10 point (Diameter: 1 inch, Pressure: 25Psi)

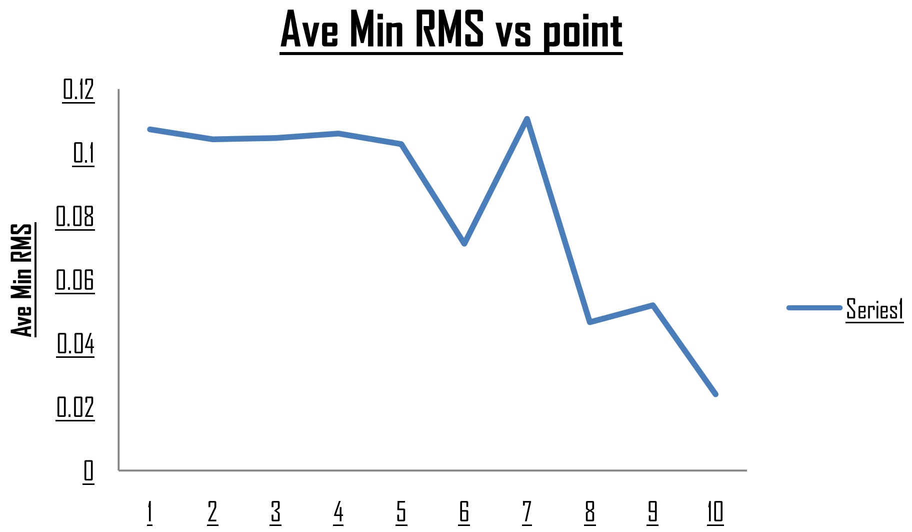


Figure 4.12: Average minimum RMS at 10 point (Diameter: 1 inch, Pressure: 25Psi)

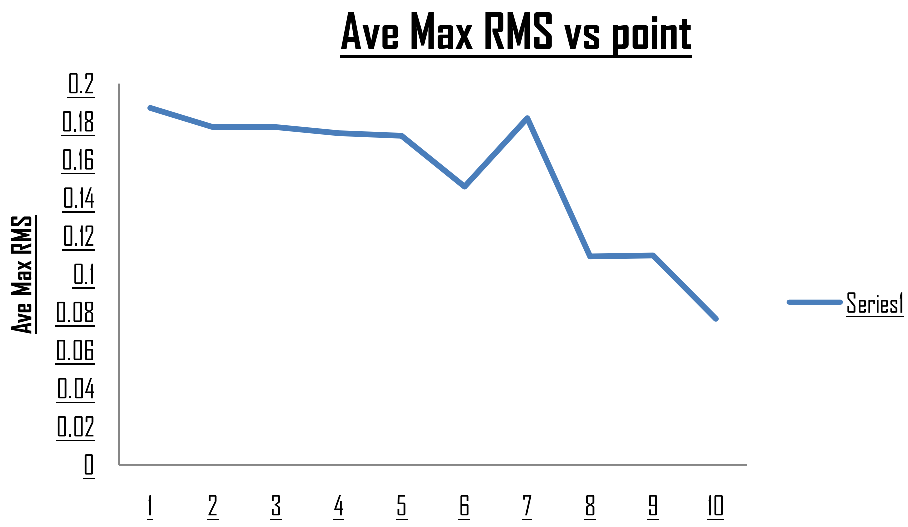


Figure 4.13: Average maximum RMS at 10 point (Diameter: 1 inch, Pressure: 25Psi)

From the graph above ,the maximum RMS value for pipe diameter 1 inch with 10 Psi was detect at point 10 that was 1.5 meter from the ball valve. While the minimum RMS was at point 2 that was 0.3 meter from the ball valve. As mentioned at the previous chapter. The first point was placed 0.15 meter from the ball valve that controlled the pressure of the water in the pipe. The velocity of water in this pipe at this moment was 4.710 m/s and the Reynolds number was 75602.47.The value of RMS at point 10 was higher that the value at the point 2 because the pressure was low. Note that the point 10 was much closed to the inner pipe where the water was entered the pipe. Although the pressure of the water at the inner pipe and the outer there was near the ball valve is slightly same but when the water was entered the pipe there come in turbulent form and flow smoothly when arrive at the ball valve thus the value of RMS at point 2 was lower. Another factor was the pressure that set was low, that mean the ball valve was closed only quarter of the wide opening so the water still can flow trough it without have a greater friction with the pipe inner surface and the gate of the ball valve.(Refer to Figure 4.5,Figure 4.6 and Figure 4.7)

Then, the pressure was changed to 20 Psi. The velocity of the water in the pipe was 3.589 m/s and the Reynolds number was 57618.51.Refer to Figure 4.8,Figure 4.9

and Figure 4.10, the maximum RMS was occur at point 6.The higher RMS was 0.169333 V. The minimum RMS was occur at point 9 that was 0.001333 V. This phenomenon was same as the previous cases that the pressure was 10 Psi, but the AE signal in this cases more lower than the previous cases because the effect of the pipe diameter. The vibration still maintains the rhythm. Maybe of some error occur or leakages make the pressure in the pipe decrease and lower the turbulent force and decrease the vibration that detect by the AE signal.

Then, the pressure was changed to 25 Psi. The velocity of the water in the pipe was 15.823 m/s and the Reynolds number was 43101.89.Refer to Figure 4.11,Figure 4.12 and Figure 4.13, the maximum RMS was occur at point 1.The higher RMS was 0.187333 V. The minimum RMS was occur at point 10 that was 0.024 V. The velocity of water become slower than previous cases that used 10 Psi and 20 Psi because the ball valve was almost closed to make

The pressure becomes 25 Psi, the higher pressure that can achieve by the hydraulic pump. Still, the result proved the early hypothesis especially for the 1 inch and 25 Psi pressure. The higher AE signal was detect at the first point that was 15 cm from the ball valve. The readings also have a higher value compare to other maximum RMS value that was reading in the previous cases and experiment. The ball valve that almost closed give a maximum friction to the water that flow in the test rigs thus make a higher vibration that can be detect by the AE devices.

4.4 EXPERIMENT 2

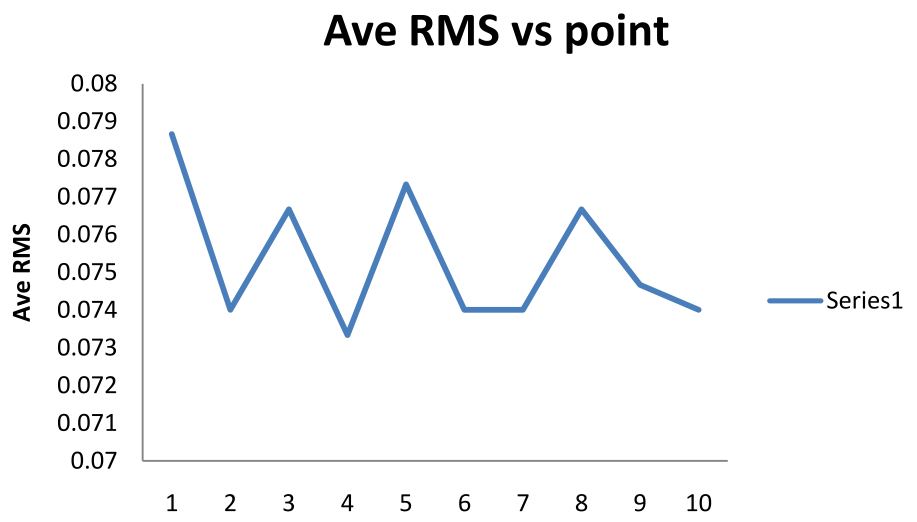


Figure 4.14: Average RMS at 10 point (Diameter: ¾ inch, Pressure: 10 Psi)

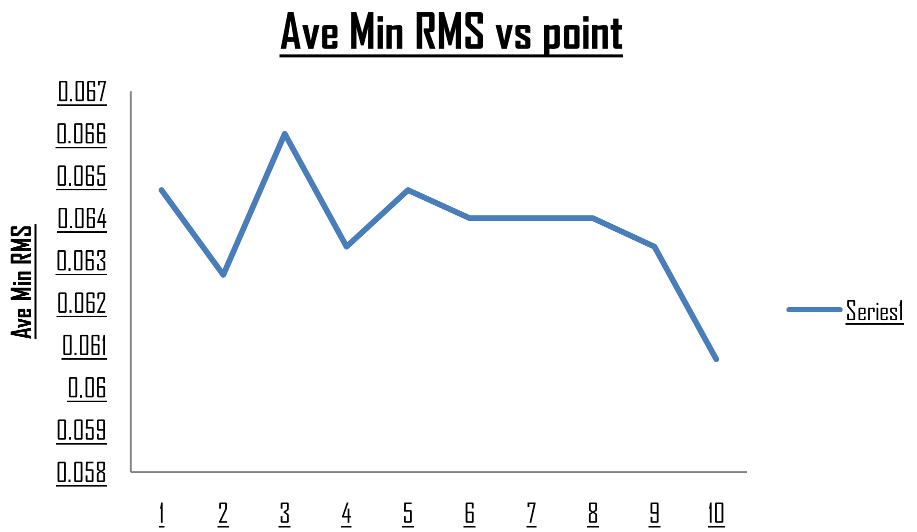


Figure 4.15: Average minimum RMS at 10 point (Diameter: ¾ inch, Pressure: 10 Psi)

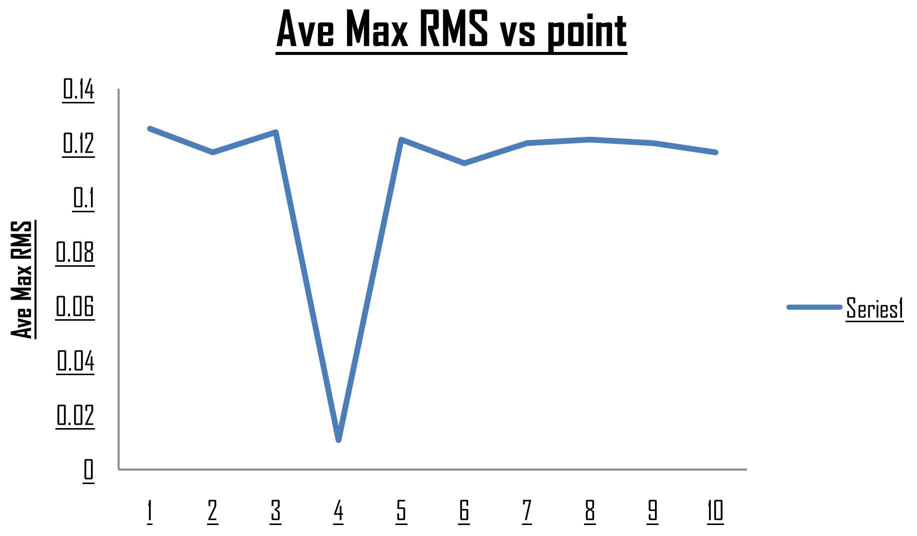


Figure 4.16: Average maximum RMS at 10 point (Diameter: ¾ inch, Pressure: 10 Psi)

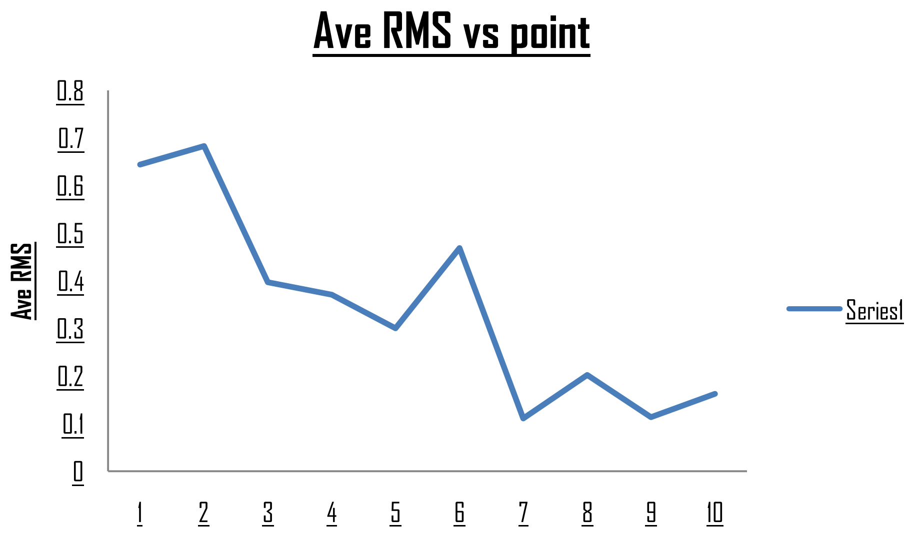


Figure 4.17: Average RMS at 10 point (Diameter: ¾ inch, Pressure: 20 Psi)

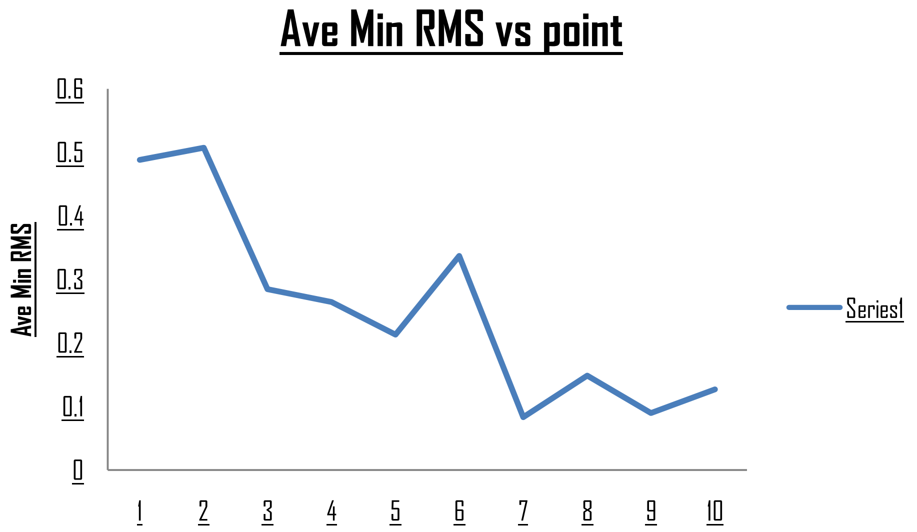


Figure 4.18: Average minimum RMS at 10 point (Diameter: ¾ inch, Pressure: 20 Psi)

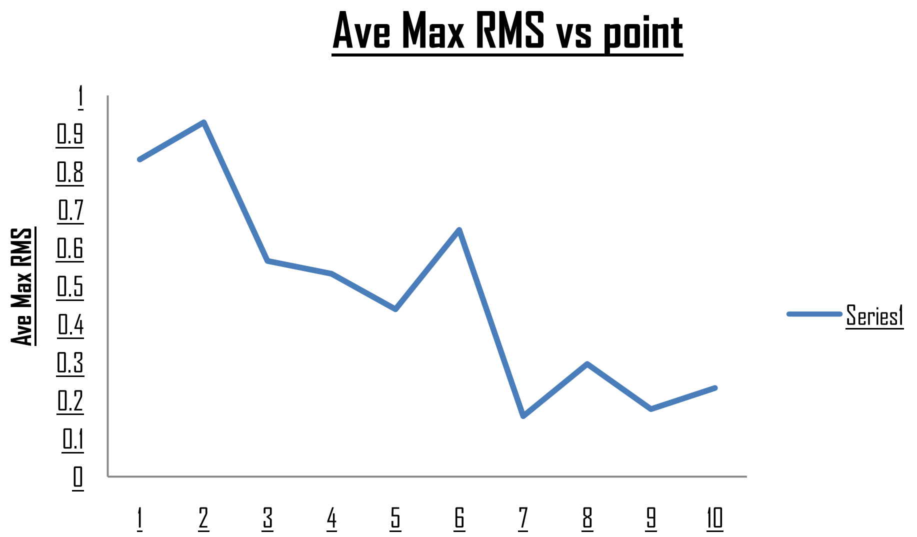


Figure 4.19: Average maximum RMS at 10 point (Diameter: ¾ inch, Pressure: 20 Psi)

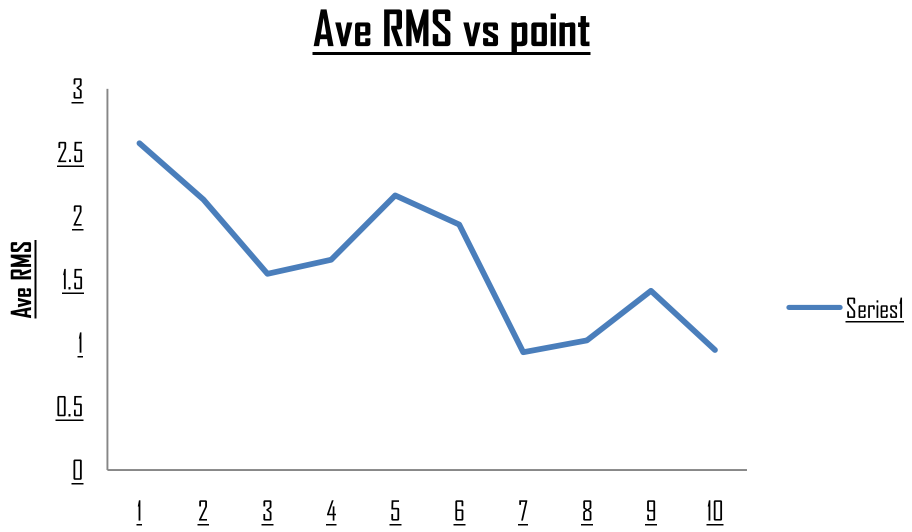


Figure 4.20: Average RMS at 10 point (Diameter: ¾ inch, Pressure: 25 Psi)

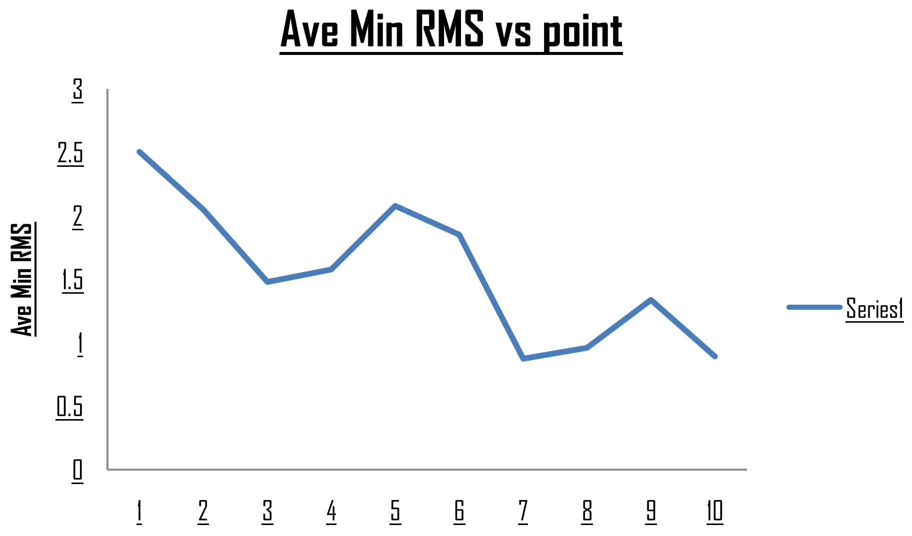


Figure 4.21: Average minimum RMS at 10 point (Diameter: ¾ inch, Pressure: 25 Psi)

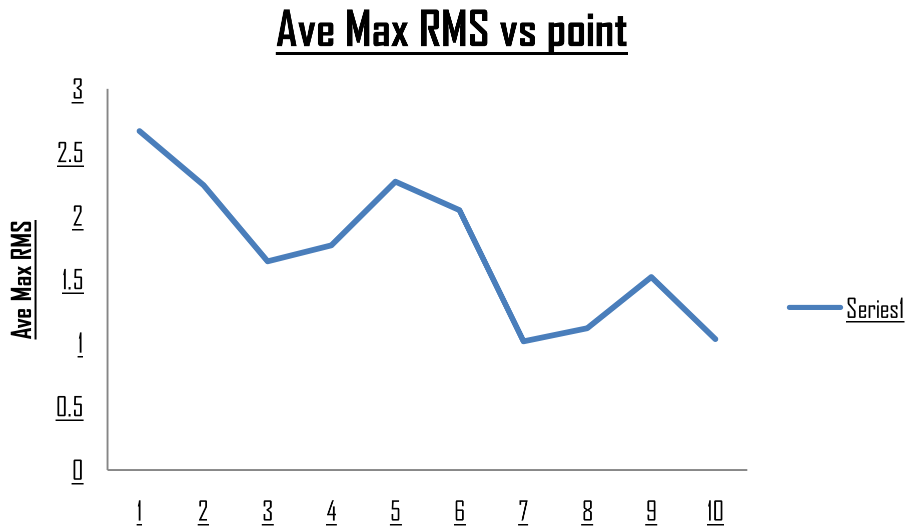


Figure 4.22: Average maximum RMS at 10 point (Diameter: ¾ inch, Pressure: 25 Psi)

In this experiment, the pipe diameter was ¾ inch and the pressure that was set was 10 Psi. The velocity of the water in the pipe was 4.557 m/s and the Reynolds number was 97559.43.Refer to Figure 4.14,Figure 4.15 and Figure 4.16, the maximum RMS was occur at point 1.The higher RMS was 0.125333 V. The minimum RMS was occur at point 4 that was 0.010867 V. note that the flow was in turbulent since the Reynolds number was over 4000.In this cases the diameter of pipe was almost half of the diameter pipe that was used in first experiment, so the flow rate become more rough and higher than the first experiment because of the same density of water that entering in the test rigs. Although the same pressure was used as in the first experiment but the result in this second experiment was more relevant. The previous chapter has been told the hypothesis of the source of AE signal that occur by the factor of the ball valve. So, in this second experiment can proved the hypothesis because the higher RMS occur at the first point that is 15cm from the ball valve so the AE signal was most detected at that point.

Then, the pressure was changed to 20 Psi. The velocity of the water in the pipe was 2.8818 m/s and the Reynolds number was 61682.50.Refer to Figure 4.17,Figure 4.18 and Figure 4.19, the maximum RMS was occur at point 2.The higher RMS was

0.93 V. The minimum RMS was occur at point 7 that was 0.083333 V. This phenomenon was same as the previous cases that the pressure was 10 Psi. The AE signal in this cases more higher than the previous cases because the ball valve was half closed so it give greater friction to the water to flow through the gate in the ball valve thus make the vibration more greater, also the AE signal. The AE signal become weaker as the AE devices was located far from the ball valve. The point 7 was placed at 1.05 meter from the ball valve, but still the minimum RMS at point 7 was higher than the minimum RMS from the minimum RMS at the previous cases.

Then, the pressure was changed to 25 Psi. The velocity of the water in the pipe was 2.0136 m/s and the Reynolds number was 43101.89.Refer to Figure 4.20,Figure 4.21 and Figure 4.22, the maximum RMS was occur at point 1.The higher RMS was 2.669333 V. The minimum RMS was occur at point 10 that was 0.874 V. The velocity of water become slower than previous cases that used 10 Psi and 20 Psi because the ball valve was almost closed to make

The pressure becomes 25 Psi, the higher pressure that can achieve by the hydraulic pump. Still, the result proved the early hypothesis. The higher AE signal was detect at the first point that was 15 cm from the ball valve. The readings also have a higher value compare to other maximum RMS value that was reading in the previous cases and experiment. The ball valve that almost closed give a maximum friction to the water that flow in the test rigs thus make a higher vibration that can be detect by the AE devices.

CHAPTER 5

CONCLUSION AND SUGGESTION

5.1 INTRODUCTION

This chapter wills summary all the result that was collected on the previous chapter and will be evaluate. Suggestion will be make to improve the process on piping system.

5.2 CONCLUSION

This study had proved that the acoustic emission (AE) technique can be used for the pipe different diameter classifying and pressure that controlled by valve condition monitoring. The technique offers great opportunity to have a new approach of lower cost and time consuming for pipe and pressure monitoring.

From this project, AE signals were start to propagate from ball valve that controlled the pressure and the diameter of the pipe. It was proved by the first experiment. Besides, it also shows that the fluid can be propagation medium for AE signals. The important key for successfulness of this method for pipe diameter classifying is the wake interferences phenomena as presented in chapter 2.

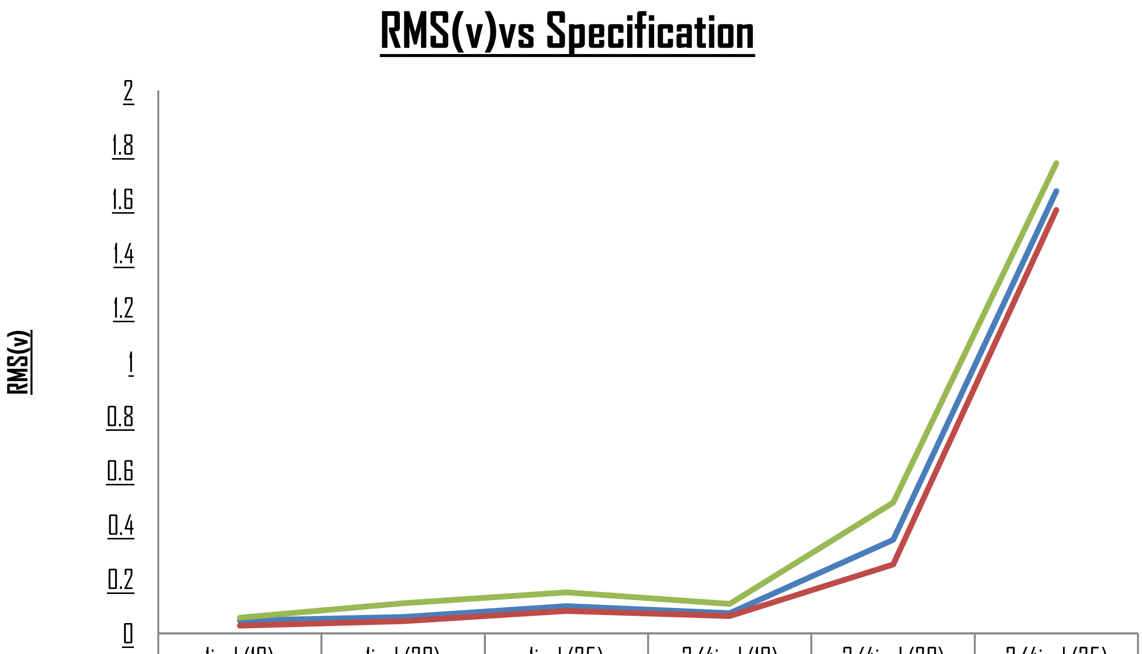
The pressure that was used was important because the ball valve will play the roll in controlled the pressure by control the arm. The high pressure that mean the friction of the water at the gate in the ball valve will increase rapidly and make a vibration also increase. Thus, the AE signals can be detect efficiencies by the AE devices. This fact was important in the industrial in order to control the security of the system to ensure that the system was safe to used and indicated the accident before it happen especially to the pipe that have low quality. This method also can lower the cost or repair of the pipe system if the crack and the source of failure can be detect first. The diameter of pipe also play the main roll where they can control the amount of density and the flow rate thus effect the Reynolds number either it is turbulent or laminar but usually the flow in the industrial sector was turbulent. When the diameter that used was big so the density of water will increase and the Reynolds number will decrease and lower the pressure. Make a flow smoother through the ball valve although the friction at the gate of ball valve was high thus decreasing the vibration of the pipe surface and decrease the percentage of pipe to damages and crack.

5.3 SUGGESTION

The result for pipe diameter classifying experiment was based on only ten points for each diameter pipe and the pressure in the pipe. However, the result may be dissimilar if more points were used, but with little different. Also, the pressure that was used was limited because the hydraulic pump capability. Further study needs to be done for more data and having more variety of pressure and different pipe diameter that should be tested.

More points for sensor can be done if the sensor itself has smaller area of surface. Besides, the current sensor used has a flat surface meanwhile the pipe is cylinder shape. The surface of the sensor doesn’t fully touch the pipe and may cause inaccurate signals capturing. So, an adapter is needed to ensure all the sensor surface area can capture the AE signals from the pipe.

The most important suggestion is to redesign the test rig to eliminate the constraints occur, thus getting more convincing result for the test. Figure 5.1 show the conclusion of all result.



	1inch(10)	1inch(20)	1inch(25)	3/4inch(10)	3/4inch(20)	3/4inch(25)
Ave RMS	0.047802	0.061022	0.101356	0.075333	0.345267	1.629667
Min RMS	0.028833	0.045666	0.082956	0.063733	0.254467	1.560253
Max RMS	0.057667	0.110589	0.151256	0.108887	0.481267	1.7326

Figure 5.1: Comparison between the RMS in different pipe diameter and pressure

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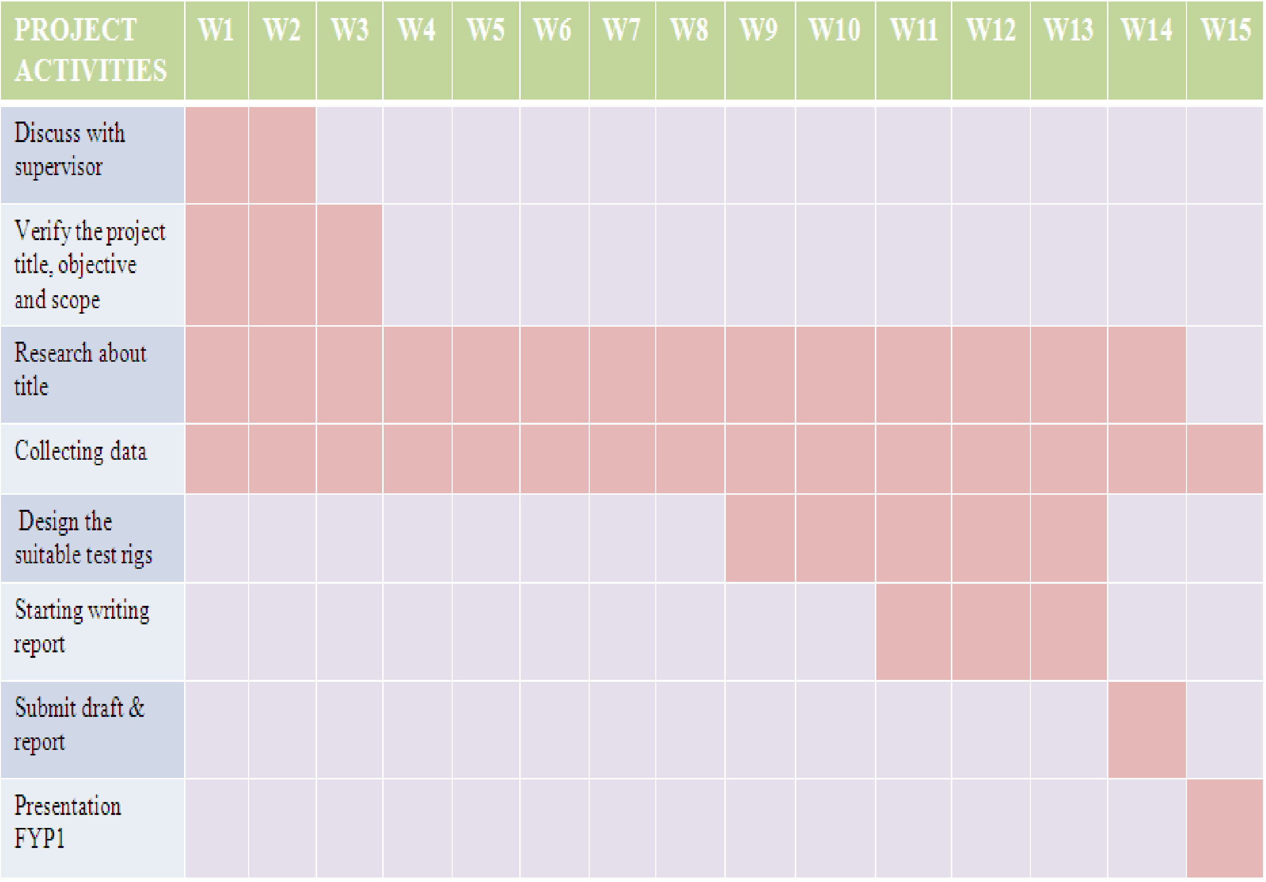
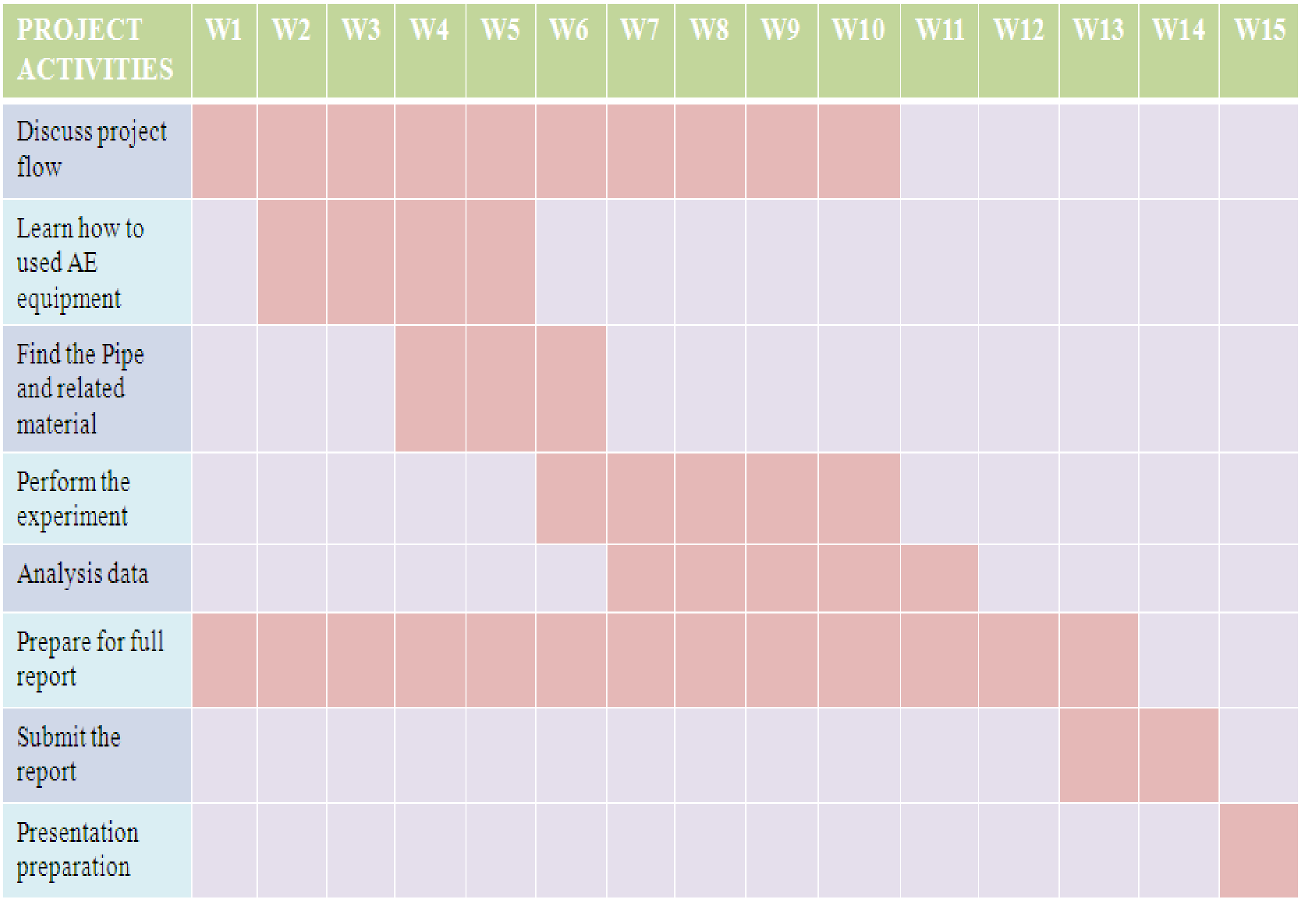
APPENDIX A

Gantt chart for Final Year Project 1

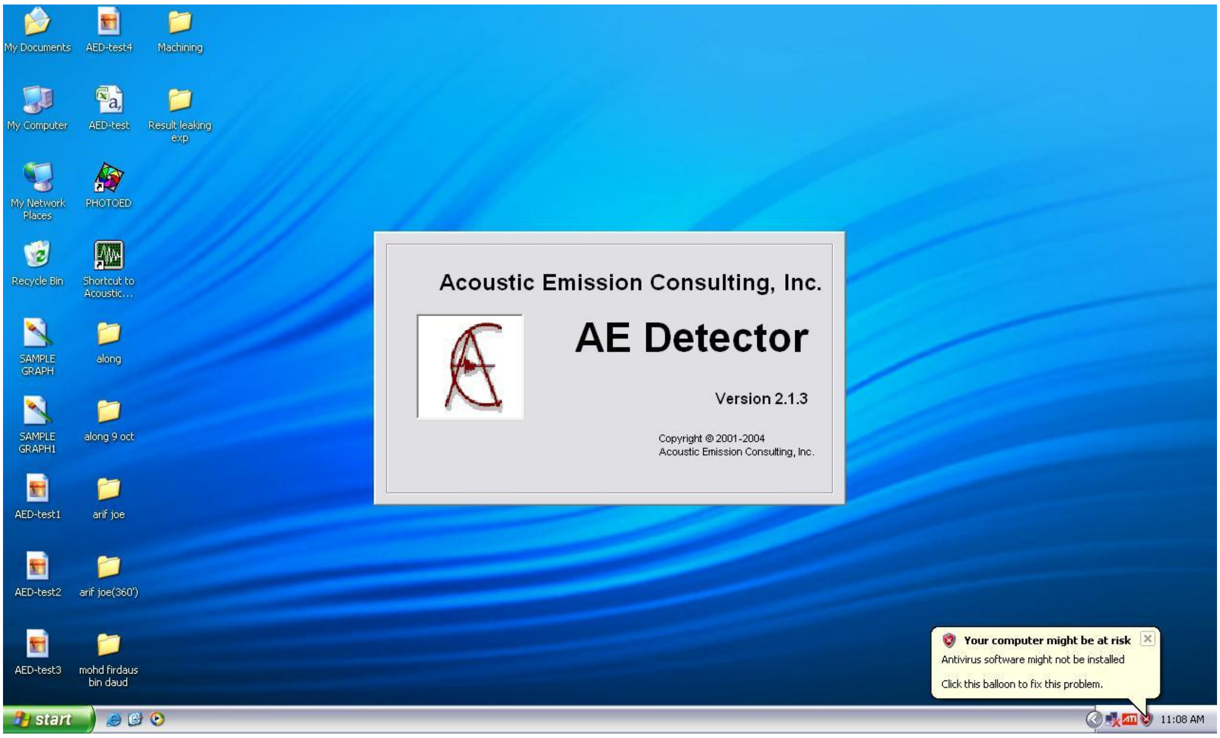


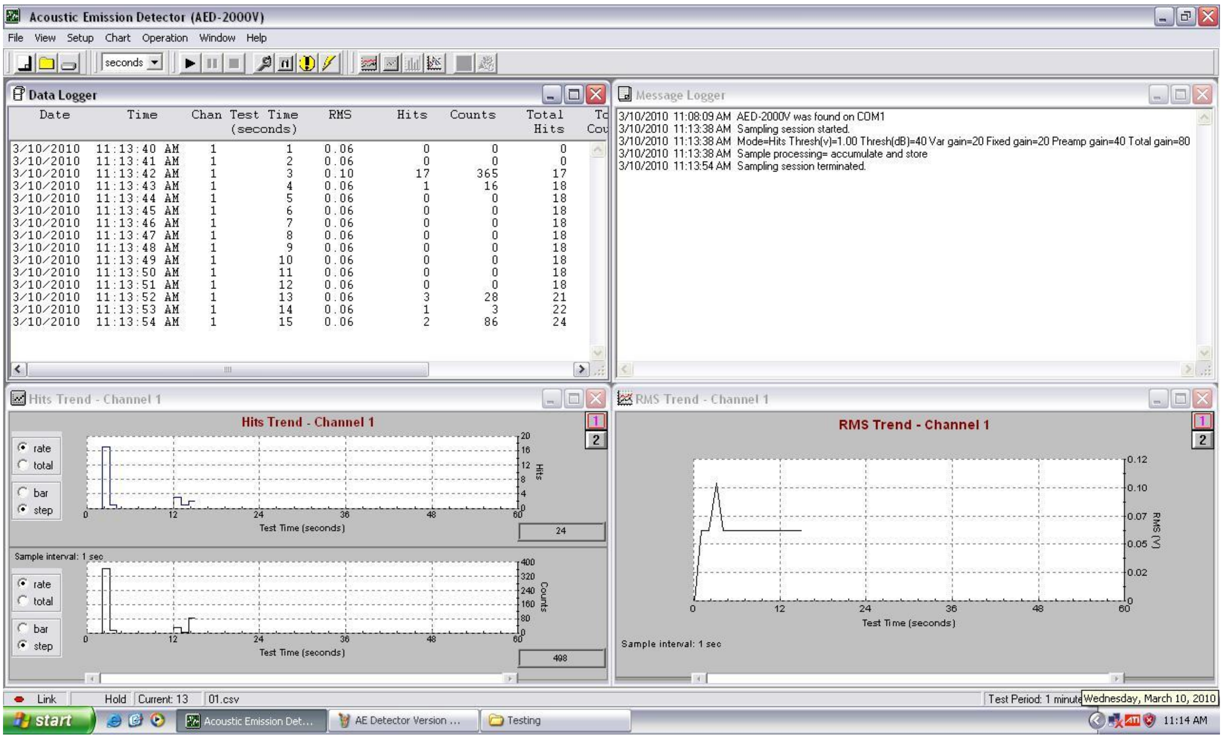
Gantt chart for Final Year Project 2

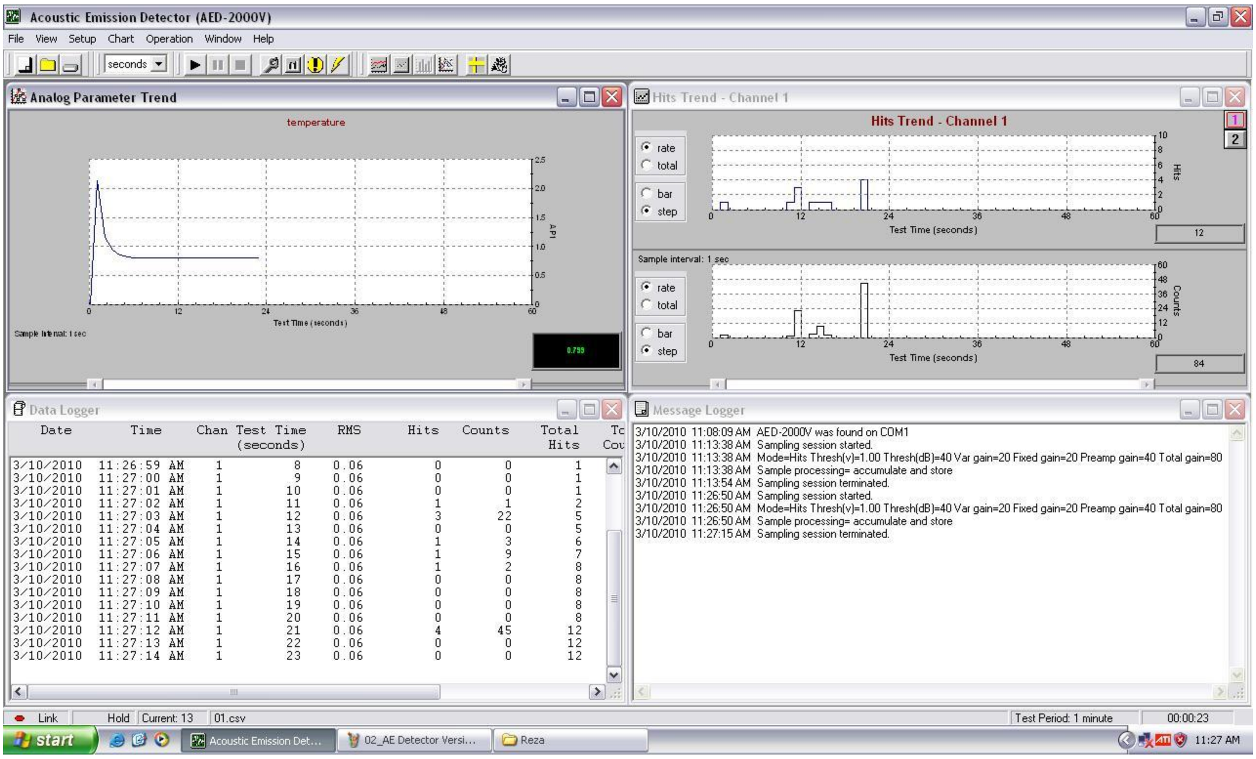


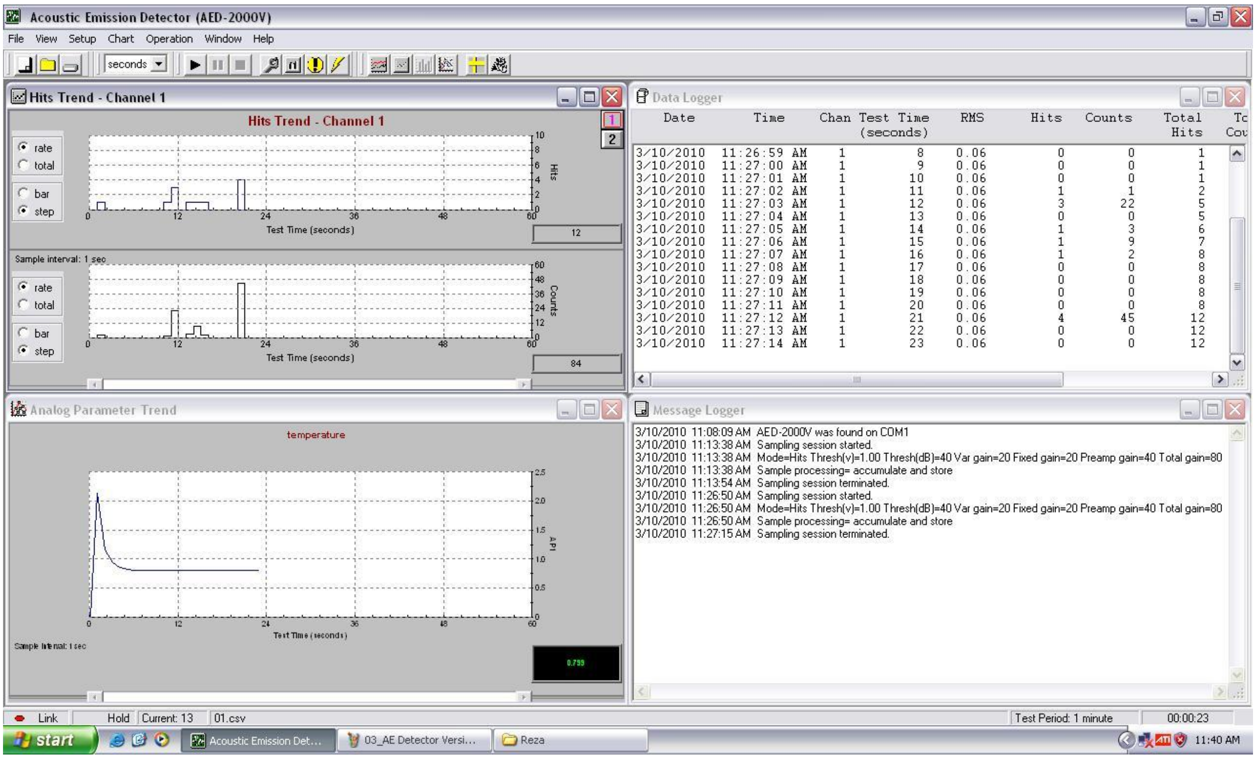
APPENDIX B

Mode setup applied for Acoustic Emission Detector 2.1.3 software



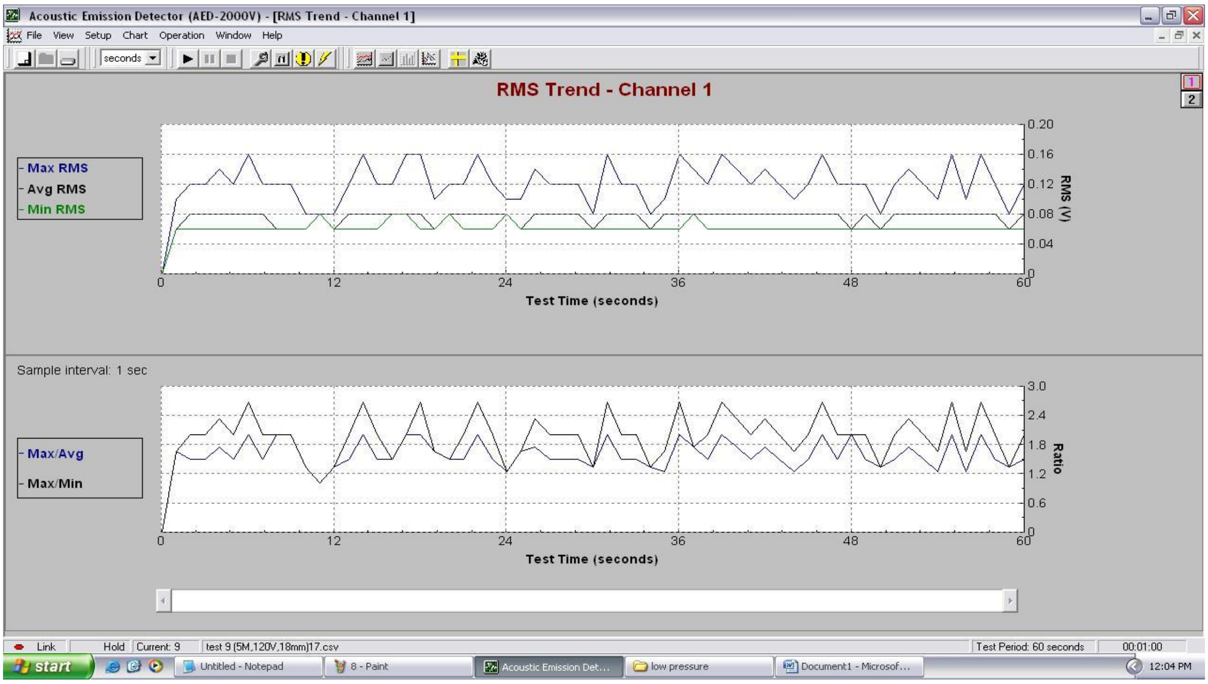


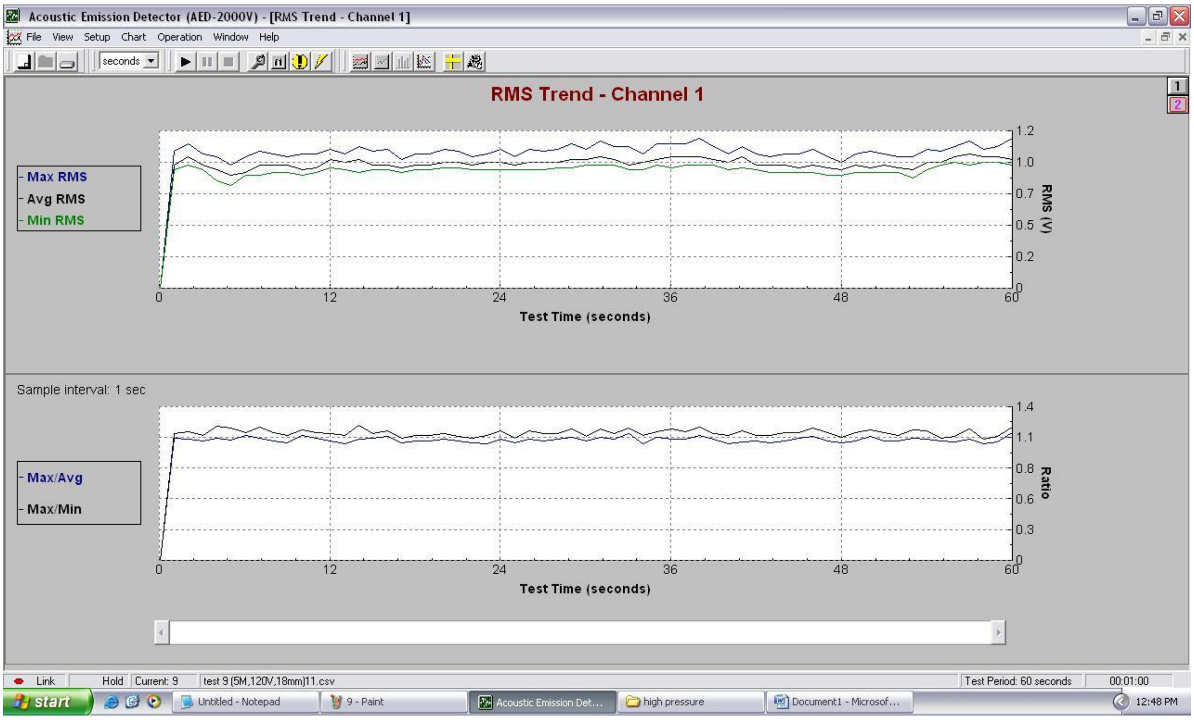

Acoustic Emission Detector (AED-2000V)
File View Setup Chart Operation Window Help
Analog Parameter Trend
temperature
Test Time (seconds)
Sample interval: 1 sec
Hits Trend - Channel 1
rate
total
bar
step
Test Time (seconds)
Sample interval: 1 sec
Data Logger
Date Time Chan Test Time (seconds) RMS Hits Counts Total Hits
3/10/2010 11:26:59 AM 1 8 0.06 0 0 1
3/10/2010 11:27:00 AM 1 9 0.06 0 0 1
3/10/2010 11:27:01 AM 1 10 0.06 0 0 1
3/10/2010 11:27:02 AM 1 11 0.06 1 1 2
3/10/2010 11:27:03 AM 1 12 0.06 3 22 5
3/10/2010 11:27:04 AM 1 13 0.06 0 0 5
3/10/2010 11:27:05 AM 1 14 0.06 1 3 6
3/10/2010 11:27:06 AM 1 15 0.06 1 9 7
3/10/2010 11:27:07 AM 1 16 0.06 1 2 8
3/10/2010 11:27:08 AM 1 17 0.06 0 0 8
3/10/2010 11:27:09 AM 1 18 0.06 0 0 8
3/10/2010 11:27:10 AM 1 19 0.06 0 0 8
3/10/2010 11:27:11 AM 1 20 0.06 0 0 8
3/10/2010 11:27:12 AM 1 21 0.06 4 45 12
3/10/2010 11:27:13 AM 1 22 0.06 0 0 12
3/10/2010 11:27:14 AM 1 23 0.06 0 0 12
Message Logger
3/10/2010 11:08:09 AM AED-2000V was found on COM1
3/10/2010 11:13:38 AM Sampling session started.
3/10/2010 11:13:38 AM Mode=Hits Thresh(v)=1.00 Thresh(dB)=40 Var gain=20 Fixed gain=20 Preamp gain=40 Total gain=80
3/10/2010 11:13:38 AM Sample processing= accumulate and store
3/10/2010 11:13:54 AM Sampling session terminated.
3/10/2010 11:26:50 AM Sampling session started.
3/10/2010 11:26:50 AM Mode=Hits Thresh(v)=1.00 Thresh(dB)=40 Var gain=20 Fixed gain=20 Preamp gain=40 Total gain=80
3/10/2010 11:26:50 AM Sample processing= accumulate and store
3/10/2010 11:27:15 AM Sampling session terminated.
Link Hold Current: 13 01.csv Test Period: 1 minute 00:00:23
start Acoustic Emission Det... 02_AE Detector Versi... Reza 11:27 AM

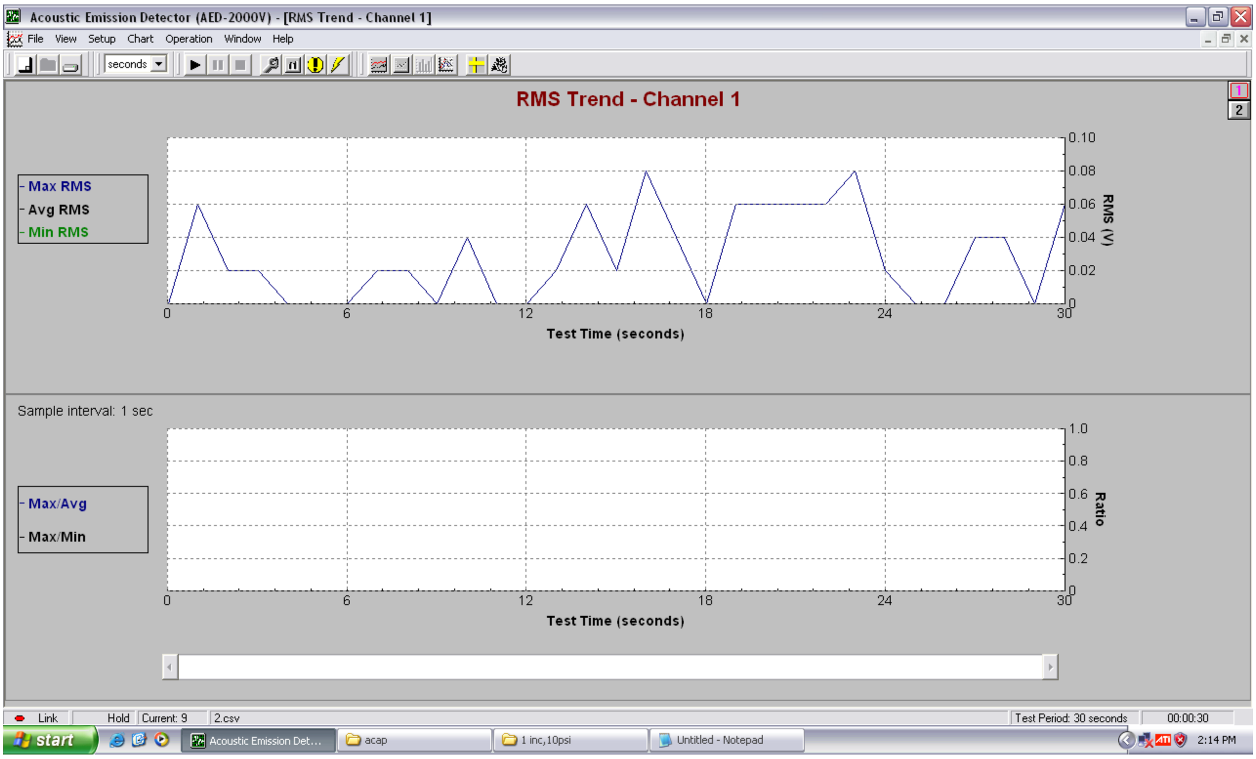

Acoustic Emission Detector (AED-2000V)
File View Setup Chart Operation Window Help
Hits Trend - Channel 1
rate
total
bar
step
Test Time (seconds)
Sample interval: 1 sec
Data Logger
Date Time Chan Test Time (seconds) RMS Hits Counts Total Hits
3/10/2010 11:26:59 AM 1 8 0.06 0 0 1
3/10/2010 11:27:00 AM 1 9 0.06 0 0 1
3/10/2010 11:27:01 AM 1 10 0.06 0 0 1
3/10/2010 11:27:02 AM 1 11 0.06 1 1 2
3/10/2010 11:27:03 AM 1 12 0.06 3 22 5
3/10/2010 11:27:04 AM 1 13 0.06 0 0 5
3/10/2010 11:27:05 AM 1 14 0.06 1 3 6
3/10/2010 11:27:06 AM 1 15 0.06 1 9 7
3/10/2010 11:27:07 AM 1 16 0.06 1 2 8
3/10/2010 11:27:08 AM 1 17 0.06 0 0 8
3/10/2010 11:27:09 AM 1 18 0.06 0 0 8
3/10/2010 11:27:10 AM 1 19 0.06 0 0 8
3/10/2010 11:27:11 AM 1 20 0.06 0 0 8
3/10/2010 11:27:12 AM 1 21 0.06 4 45 12
3/10/2010 11:27:13 AM 1 22 0.06 0 0 12
3/10/2010 11:27:14 AM 1 23 0.06 0 0 12
Analog Parameter Trend
temperature
Test Time (seconds)
Sample interval: 1 sec
Message Logger
3/10/2010 11:08:09 AM AED-2000V was found on COM1
3/10/2010 11:13:38 AM Sampling session started.
3/10/2010 11:13:38 AM Mode=Hits Thresh(v)=1.00 Thresh(dB)=40 Var gain=20 Fixed gain=20 Preamp gain=40 Total gain=80
3/10/2010 11:13:38 AM Sample processing= accumulate and store
3/10/2010 11:13:54 AM Sampling session terminated.
3/10/2010 11:26:50 AM Sampling session started.
3/10/2010 11:26:50 AM Mode=Hits Thresh(v)=1.00 Thresh(dB)=40 Var gain=20 Fixed gain=20 Preamp gain=40 Total gain=80
3/10/2010 11:26:50 AM Sample processing= accumulate and store
3/10/2010 11:27:15 AM Sampling session terminated.
Link Hold Current: 13 01.csv Test Period: 1 minute 00:00:23
start Acoustic Emission Det... 03_AE Detector Versi... Reza 11:40 AM

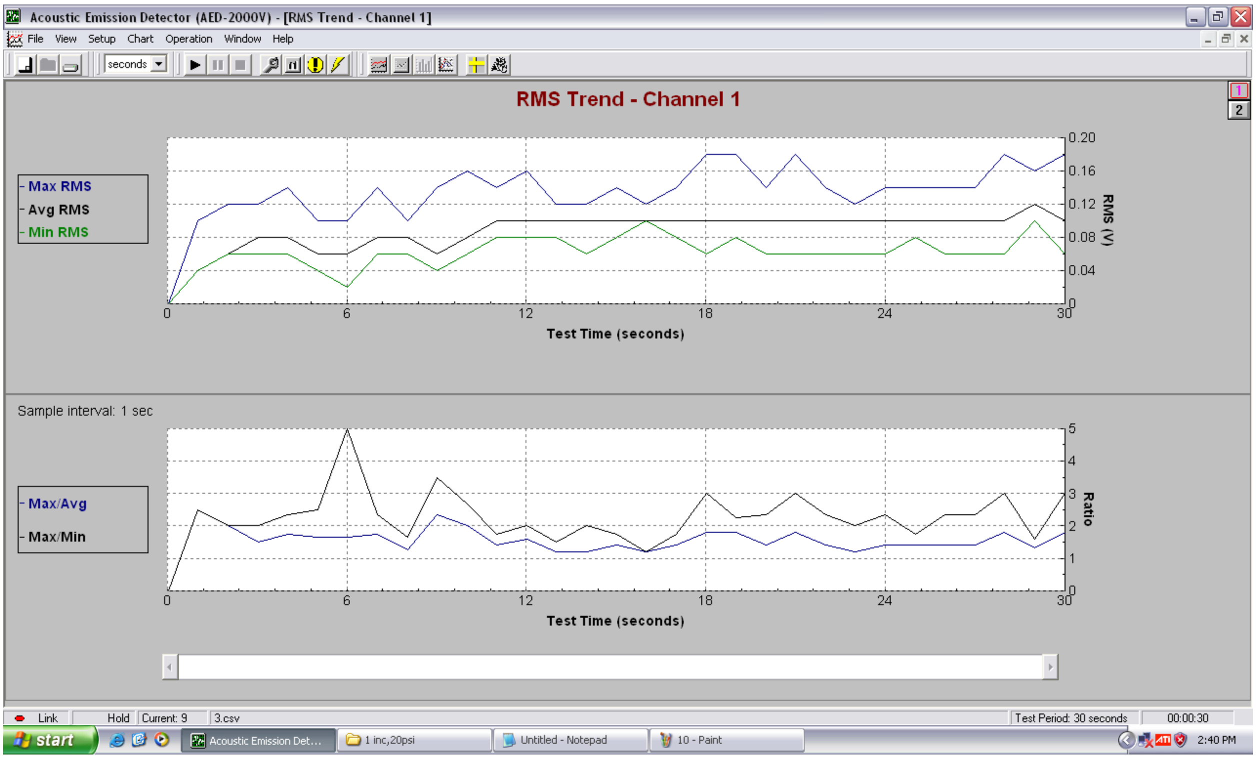
APPENDIX C

The example of AE signal that viewed using Acoustic Emission Detector 2.1.3 software






Acoustic Emission Detector (AED-2000V) - [RMS Trend - Channel 1]
RMS Trend - Channel 1
Max RMS
Avg RMS
Min RMS
Test Time (seconds)
RMS (V)
Sample interval: 1 sec
Max/Avg
Max/Min
Ratio
Link
Hold
Current: 9
2.csv
Test Period: 30 seconds
00:00:30
2:14 PM


Acoustic Emission Detector (AED-2000V) - [RMS Trend - Channel 1]
RMS Trend - Channel 1
Max RMS
Avg RMS
Min RMS
Test Time (seconds)
RMS (V)
Sample interval: 1 sec
Max/Avg
Max/Min
Ratio
Link
Hold
Current: 9
3.csv
Test Period: 30 seconds
00:00:30
2:40 PM

APPENDIX D

The example of the test data gained for every pipe condition.

Test data: 1inch pipe diameter at pressure 10 Psi (point 1)

Channel	Test Time	Avg RMS	Alarm	Min RMS	Max RMS	Threshold (v)	Threshold (dB)	Var Gain	Fixed Gain
1	1	0		0	0.06	1	57	23	0
1	2	0		0	0.02	1	57	23	0
1	3	0		0	0.02	1	57	23	0
1	4	0		0	0	1	57	23	0
1	5	0		0	0	1	57	23	0
1	6	0		0	0	1	57	23	0
1	7	0		0	0.02	1	57	23	0
1	8	0		0	0.02	1	57	23	0
1	9	0		0	0	1	57	23	0
1	10	0		0	0.04	1	57	23	0
1	11	0		0	0	1	57	23	0
1	12	0		0	0	1	57	23	0
1	13	0		0	0.02	1	57	23	0
1	14	0		0	0.06	1	57	23	0
1	15	0		0	0.02	1	57	23	0
1	16	0		0	0.08	1	57	23	0
1	17	0		0	0.04	1	57	23	0
1	18	0		0	0	1	57	23	0
1	19	0		0	0.06	1	57	23	0
1	20	0		0	0.06	1	57	23	0
1	21	0		0	0.06	1	57	23	0
1	22	0		0	0.06	1	57	23	0
1	23	0		0	0.08	1	57	23	0
1	24	0		0	0.02	1	57	23	0
1	25	0		0	0	1	57	23	0

Test data: 1 inch pipe diameter at pressure 15Psi (point 1)

Channel	Test Time	Avg RMS	Alarm	Min RMS	Max RMS	Threshold (v)	Threshold (dB)	Var Gain	Fixed Gain
1	1	0.1		0.06	0.16	1	57	23	0
1	2	0.1		0.06	0.16	1	57	23	0
1	3	0.1		0.1	0.18	1	57	23	0
1	4	0.1		0.1	0.14	1	57	23	0
1	5	0.12		0.1	0.16	1	57	23	0
1	6	0.1		0.06	0.14	1	57	23	0
1	7	0.1		0.08	0.14	1	57	23	0
1	8	0.1		0.1	0.14	1	57	23	0
1	9	0.1		0.1	0.16	1	57	23	0
1	10	0.12		0.06	0.18	1	57	23	0
1	11	0.12		0.06	0.16	1	57	23	0
1	12	0.12		0.1	0.16	1	57	23	0
1	13	0.12		0.12	0.16	1	57	23	0
1	14	0.1		0.1	0.14	1	57	23	0
1	15	0.06		0.04	0.1	1	57	23	0
1	16	0.1		0.08	0.12	1	57	23	0
1	17	0.1		0.06	0.14	1	57	23	0
1	18	0.1		0.06	0.18	1	57	23	0
1	19	0.1		0.1	0.18	1	57	23	0
1	20	0.1		0.06	0.12	1	57	23	0
1	21	0.1		0.06	0.16	1	57	23	0
1	22	0.1		0.06	0.18	1	57	23	0
1	23	0.1		0.1	0.14	1	57	23	0
1	24	0.1		0.06	0.14	1	57	23	0
1	25	0.1		0.1	0.12	1	57	23	0

Test data: ¾ inch pipe diameter at pressure 10 Psi (point 1)

Channel	Test Time	Avg RMS	Alarm	Min RMS	Max RMS	Threshold (v)	Threshold (dB)	Var Gain	Fixed Gain
1	1	0.08		0.06	0.16	1	37	23	20
1	2	0.08		0.06	0.12	1	37	23	20
1	3	0.08		0.06	0.1	1	37	23	20
1	4	0.08		0.06	0.12	1	37	23	20
1	5	0.06		0.06	0.1	1	37	23	20
1	6	0.08		0.06	0.16	1	37	23	20
1	7	0.06		0.06	0.08	1	37	23	20
1	8	0.08		0.06	0.1	1	37	23	20
1	9	0.08		0.06	0.16	1	37	23	20
1	10	0.08		0.06	0.14	1	37	23	20
1	11	0.08		0.06	0.16	1	37	23	20
1	12	0.08		0.06	0.12	1	37	23	20
1	13	0.08		0.06	0.14	1	37	23	20
1	14	0.08		0.06	0.1	1	37	23	20
1	15	0.08		0.06	0.12	1	37	23	20
1	16	0.08		0.06	0.16	1	37	23	20
1	17	0.08		0.06	0.12	1	37	23	20
1	18	0.08		0.08	0.1	1	37	23	20
1	19	0.08		0.08	0.1	1	37	23	20
1	20	0.08		0.08	0.14	1	37	23	20
1	21	0.08		0.06	0.1	1	37	23	20
1	22	0.08		0.08	0.1	1	37	23	20
1	23	0.08		0.06	0.12	1	37	23	20
1	24	0.08		0.06	0.12	1	37	23	20
1	25	0.08		0.06	0.1	1	37	23	20
1	26	0.08		0.06	0.16	1	37	23	20
1	27	0.08		0.08	0.12	1	37	23	20
1	28	0.08		0.08	0.12	1	37	23	20

Test data: ¾ inch pipe diameter at pressure 15 Psi (point 1)

Channel	Test Time	Avg RMS	Alarm	Min RMS	Max RMS	Threshold (v)	Threshold (dB)	Var Gain	Fixed Gain
1	1	0.68		0.56	0.82	1	37	23	20
1	2	0.68		0.48	0.9	1	37	23	20
1	3	0.66		0.48	0.8	1	37	23	20
1	4	0.66		0.48	0.84	1	37	23	20
1	5	0.64		0.52	0.84	1	37	23	20
1	6	0.7		0.6	0.9	1	37	23	20
1	7	0.68		0.52	0.94	1	37	23	20
1	8	0.66		0.5	0.8	1	37	23	20
1	9	0.64		0.54	0.78	1	37	23	20
1	10	0.7		0.54	0.86	1	37	23	20
1	11	0.6		0.44	0.8	1	37	23	20
1	12	0.7		0.56	0.92	1	37	23	20
1	13	0.7		0.6	0.8	1	37	23	20
1	14	0.62		0.48	0.84	1	37	23	20
1	15	0.66		0.52	0.86	1	37	23	20
1	16	0.66		0.5	0.9	1	37	23	20
1	17	0.72		0.5	0.88	1	37	23	20
1	18	0.62		0.48	0.86	1	37	23	20
1	19	0.52		0.38	0.66	1	37	23	20
1	20	0.56		0.38	0.74	1	37	23	20
1	21	0.68		0.46	0.94	1	37	23	20
1	22	0.62		0.48	0.78	1	37	23	20
1	23	0.66		0.46	0.84	1	37	23	20
1	24	0.66		0.48	0.84	1	37	23	20
1	25	0.64		0.5	0.82	1	37	23	20