ACOUSTIC EMISSION ANALYSIS FOR INTERNAL VALVE LEAKS IN GAS AND LIQUID PIPELINES

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This report is submitted
in fulfillment of the requirement for the degree of
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DECLARATION

I declare that this project report entitled “Acoustic Emission Analysis For Internal Valve Leaks In Gas And Liquid Pipelines” is the result of my own work except as cited in the references

Signature : .....

Name : AMIRUL IZZUDDIN BIN SHARIFUDIN

Date : .....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature :. .....

Name of Supervisor : DR. NOR SALIM BIN MUHAMMAD

Date : .....

DEDICATION

This study is dedicated to my beloved mother and father that had always supported me during my study. They gave strength to continue and complete this study with continuous financial, moral and emotional support. This is also dedicated to my siblings, friends and classmates that are always giving advice and encouragement in completing this final year project.

ABSTRACT

Valve is the essential component in pipeline structures which is widely used in oil and gas industries. Any damage to the valve will not only affect the whole pipeline structure but also the safety of the employees. Internal leakage in the valve is one of the most major problems in the industry and the inspection of this problem is very complex. In many cases, we need to minimise the shut down time frame in order to prevent losses in production. Therefore, an inspection technique that can be applied without dismantling the valves is preferable in industry. At the same time, Acoustic Emission technique is very effective in detecting internal leakage without dismantling the valves. However, this method requires advanced skills and knowledge on acoustic wave propagation. The acoustic emission has the feasibility for the leak inspection but the procedures and standards are still in the black box. Therefore, the fundamental study for acoustic emission is very important in order to perform a proper analysis on any structure. The aim of this study is to increase fundamental knowledge of Acoustic Emission technique to identify the suitable parameters to indicate internal valve leaks and analyse the parameters for indication of severity level in internal valve leaks. A total of 10 valves consisting of 2 gas valves and 8 water valves were analysed in this study. The data processing was conducted using LabView software to filter and plot the graph for analysis. The result from the analysis shows that amplitude and energy are suitable to be used as parameters for internal valve leaks because there are significant changes in both parameters when internal leaks occur. Amplitude and energy are also able to be used in severity analysis by comparing the differences between data from the valve's body and the pipeline. The accuracy of severity analysis will be able to increase by using the average of several data from a sensor for future study.

ABSTRAK

Injap adalah salah satu komponen terpenting dalam struktur saluran paip yang digunakan secara meluas dalam industri minyak dan gas. Sebarang kerosakan pada injap bukan sahaja akan menjejaskan struktur saluran paip tetapi juga keselamatan pekerja sekeliling. Kebocoran pada injap adalah salah satu masalah utama dalam industri dan pemeriksaan injap bagi masalah ini adalah sangat kompleks. Dalam kebanyakan kes, kita perlu meminimumkan tempoh masa penutupan untuk mengelakkan kerugian dalam pengeluaran. Oleh itu, teknik pemeriksaan yang boleh digunakan tanpa membuka injap adalah lebih baik bagi industri. Pada masa yang sama, Teknik Pancaran Akustik sangat berkesan dalam mengesan kebocoran dalaman tanpa membuka injap. Walau bagaimanapun, teknik ini memerlukan kemahiran dan pengetahuan yang mendalam mengenai perambatan gelombang akustik. Teknik Pancaran Akustik berkebolehan untuk digunakan dalam mengesan kebocoran injap tetapi prosedur dan piawaian masih di dalam kotak hitam. Oleh itu, kajian mengenai asas pancaran akustik adalah amat penting bagi menjalankan analisis yang tepat pada mana-mana struktur. Matlamat kajian ini adalah bagi meningkatkan pengetahuan asas teknik pancaran akustik bagi mengenal pasti parameter yang sesuai untuk mengesan kebocoran injap dan menganalisis parameter yang boleh digunakan bagi mengukur tahap keterukan kebocoran injap tersebut. Terdapat 10 injap yang terdiri daripada 2 injap gas dan 8 injap air telah dianalisis dalam kajian ini. Pemprosesan data dijalankan menggunakan perisian LabView untuk menapis dan memplot graf untuk analisis. Hasil daripada analisis menunjukkan amplitud dan tenaga sesuai digunakan sebagai parameter untuk mengesan kebocoran injap kerana terdapat perubahan ketara bagi kedua-dua parameter apabila berlaku kebocoran dalaman. Amplitud dan tenaga juga boleh digunakan dalam analisis keterukan dengan membandingkan perbezaan antara data dari badan injap dan saluran paip. Ketepatan analisis keterukan boleh ditingkatkan dengan menggunakan purata beberapa data daripada penderia untuk kajian akan datang.

ACKNOWLEDGEMENT

Firstly, I would like express my deepest appreciation to my supervisor Dr. Nor Salim Bin Muhammad for the guidance, advices and supports to complete this final year project. His guidance with expert knowledge has been very helpful to me and it would be hard for me to complete this study without his support in solving problems during this study.

I am very grateful to my parents and family that always pray and support me until the end of my study. I am also thankful to my friends and classmates that have been giving advice and encouragement to me for completing this study.

Lastly, I am very grateful to Allah for giving me the opportunity to complete this project with guidance and a healthy body.

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LIST OF ABBEREVATIONS

NDT	Non-Destructive Testing
AE	Acoustic Emission
RT	Radiographic Testing
UT	Ultrasonic Testing
MIC	Methyl-Isocyanate
SQL	Structured Query Language
SS	Signal Strength
RMS	Root Mean Square

CHAPTER 1

INTRODUCTION

1.1 Background

Valve is one of the most important component in pipeline structure. Valve with defects may cause major problems in a system and lead to losses of production time and quality. This study is conducted in order to learn how we can detect valve leaks and monitor the leakage severity before it may cause major problems in the system. When there are unidentified valve leaks, many unexpected shutdown and maintenance need to be done due to facilities failure and this will cause major loss to the company. Moreover, structure inspection that need to disassemble the components requires high cost and consumed a lot of time. There are also devices that cannot be disassembled or dangerous to be disassembled such as valves in the piping since the valves may be exposed to the hazardous substances. Therefore, Acoustic Emission Testing (AE) which is a non-destructive testing (NDT) technique may perform well to identify the valve leaks in the system. In some cases, we need to inspect a large structure and normal inspection methods cannot be applied. This is one of the benefit of AE which it can analyze the entire structure.

Non-destructive testing (NDT) used to inspect, test and evaluate the characteristics of the materials or components to find any defects and flaws without altering, harming and disassemble the components (Sandeep et al., 2017). This is a safe method to be conducted and it will not damage the components or disturb the system. Some of other non-

destructive testing methods are Radiographic Testing (RT) and Ultrasonic Testing (UT). By using AE, we will able to detect early defect activity and reduced unscheduled shutdown and other industrial problems or accidents.

There are some fatal industrial accidents due to leakage. For example, the Bhopal Gas Tragedy that occurred on 13 December 1984 in the city in India, Bhopal. The accident happened at night where there was a leakage of deadly Methyl-Isocyanate (MIC) gas from one of the tank of Union Carbide plant (Bisarya et al., 2005). There were 520,000 people exposed to the gases. During the first week only, around 8000 people died and more than 100,000 people got permanent injuries (Ingrid, 2005). There was another gas leakage accident occurred in India which is Vizag Gas Tragedy. This accident occurred in Visakhapatnam, India on 7 May 2020 where there was a leakage of styrene from the LG polymers chemical plant. The reported death were 12 people while more than 1000 were hospitalized (Tanaya, 2020).

Acoustic Emission Testing is a very great technique in order to indicate the valve leaks but it also have some challenges. AE technique requires advance skills and knowledge on acoustic emission wave propagation so experts will be needed in order to obtain reliable results. Since AE is a new technique in the industry, the investment for the researches are quite low and there are limited number of experts and technologies. Therefore, the cost needed for hiring the experts and buying the equipment will be expensive.

1.2 Problem Statement

One of the challenge in Acoustic Emission technique is that it requires specific skills and knowledge for conducting the technique to obtained reliable results. Lack of experience in AE testing may cause misinterpretation of the data and the results produced may have some extra or miss of defects in the structures. Therefore, the fundamental study for acoustic emission is very important in order to determine the parameters for the analysis by increasing the understanding in AE. The aim of this study is to analyse the data of AE technologies for inspection of valve leaks and indication of severity level of the leak condition from the recorded AE data.

1.3 Objective

The objectives of this project are:

1. Identify suitable parameters to indicate internal valve leaks.
2. Analyze parameters for indication of severity level in internal valve leaks.

1.4 Scope of Project

The scope of this project are:

1. This project analyzed data that obtained through experiment. From the data, suitable parameters will be identified to be used to indicate existence and severity of internal valve leaks.
2. Study on how the AE parameters affected when there is an internal valve leak.
3. Signal processing of recorded AE data using LabVIEW.

CHAPTER 2

LITERATURE REVIEW

2.1 Acoustic Emission Principle

Acoustic Emission testing is a non-destructive testing (NDT) technique that used to detect and monitor conditions and defects of components. When a component or material undergo deformation due to stress, they will produce sound and sound that has frequency higher than 20 kHz is considered and can be detected as acoustic emission signal (Scruby, 1987). AE usually associated with high frequency sound and vibration with range of 20 kHz – 1 MHz. There are two types acoustic emission signals which are burst and continuous signal. Burst signal is a signal that can detected several times in a certain duration while continuous signal is a signal that emitted continuously from the source (Scruby, 1987). Example of source that emit burst signal is a crack and example for the continuous signal is a leaks. The figure below shows the different between these two types of AE signals.

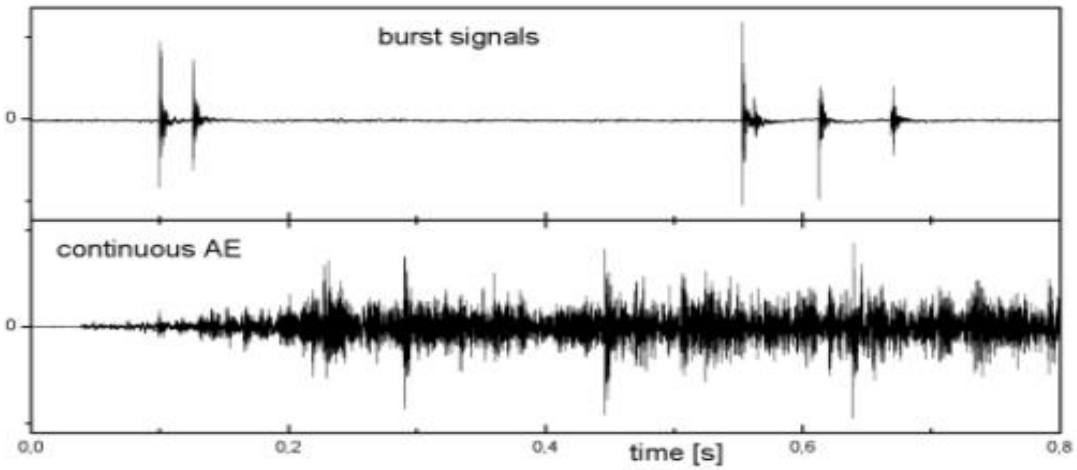

Figure 2.1: Burst and Continuous Signal (Grosse, 2008)

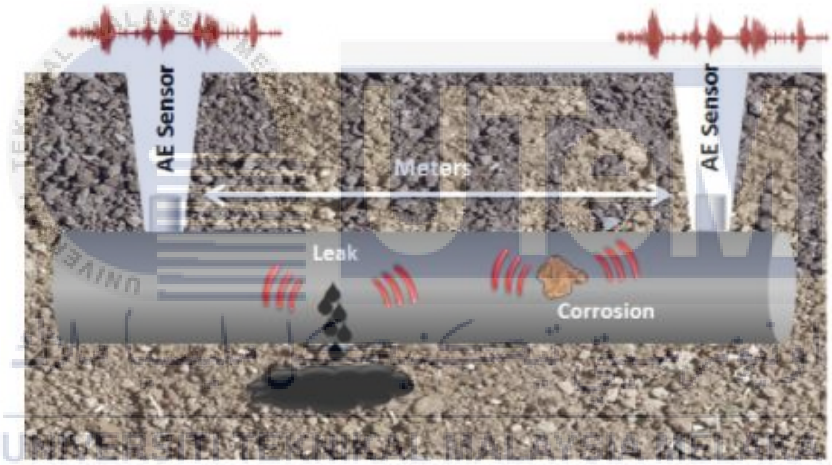

Figure 2.2: Acoustic Emission Detecting Defects

Figure 2.2 shows a pipeline with defects which are leaks and corrosion. The defects emit the AE signals that will be detected by two AE sensors. These two sensors cannot be too distant from each other since they cannot get the readings if the distance is too long. The sensors will detect the AE signal and convert it to electrical signal. Preamplifier will convert the weak electrical signal into a stronger signal that can go through further processes. The signal will be detected, measured and display as data by the AE measurement equipment. The flow of the process are shown in Figure 2.3.

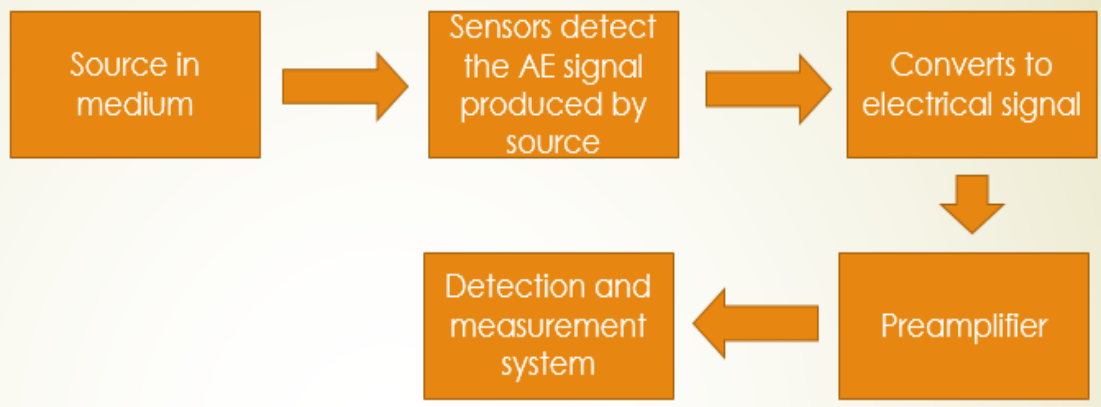

Figure 2.3: Process of Detecting AE Signal

When there is a leak, there will be a turbulent flow through the leak hole at high velocity as shown in Figure 2.4. The turbulent flow is a flow that is quite random and it may have smaller currents flow in all directions that is also known as eddies. Eddies is a swirling or a circular current of fluid. Due to the turbulent flow through the leak hole, there will be an impact force between the fluid and area around the leak point. This will produced stress around the leak point which create a detectable acoustic wave.

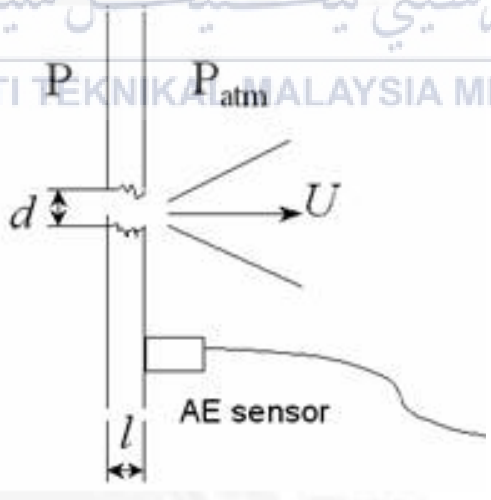

Figure 2.4: Acoustic Emission in Valve Leaks

2.2 Acoustic Emission Parameters

Figure 2.5 shows the parameters in Acoustic Emission (AE) which are amplitude, duration, rise time, counts, and energy. Amplitude is the output from the AE sensors and there is a peak amplitude which is the maximum amplitude detected in a duration. Duration is the time interval between first and last signals that cross the threshold. Threshold represent as minimum strength or current that is necessary to produce a readable indication of defects. Rise time shown in the figure is the time interval between first signal that cross the threshold and the peak amplitude. Counts shows the number of threshold crossing in a duration and the energy is the measurement of the area under the signals (Ono, 2014).

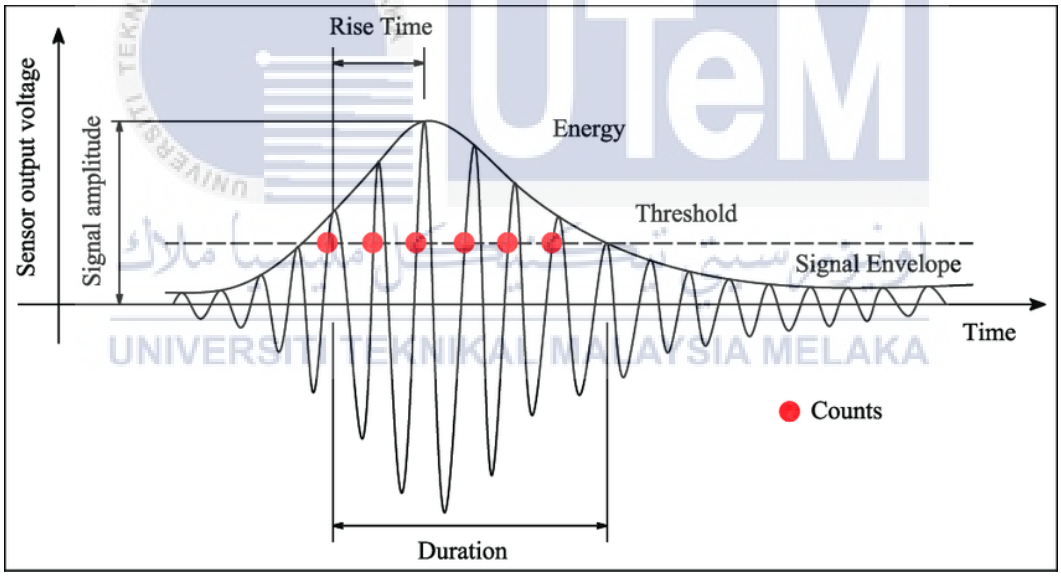

Figure 2.5: Acoustic Emission Parameters

AE parameters:

1. Amplitude ,
2. Duration
3. Rise Time
4. Counts
5. Energy

2.3 Vallen System and the Recorded Data Set

In Acoustic Emission Testing, AE sensor will receive signals and convert it into digital data sets that can be stored in storage device or online analysis software. The stored data set can be process and analyze later on. For online data processing, there will be several types of data files. The database format that been used is SQLite. SQL stands for Structured Query Language which is a programming language that manage the data in the database management system. SQL help the user to communicate with the database to either retrieve, store or edit the data in the database.

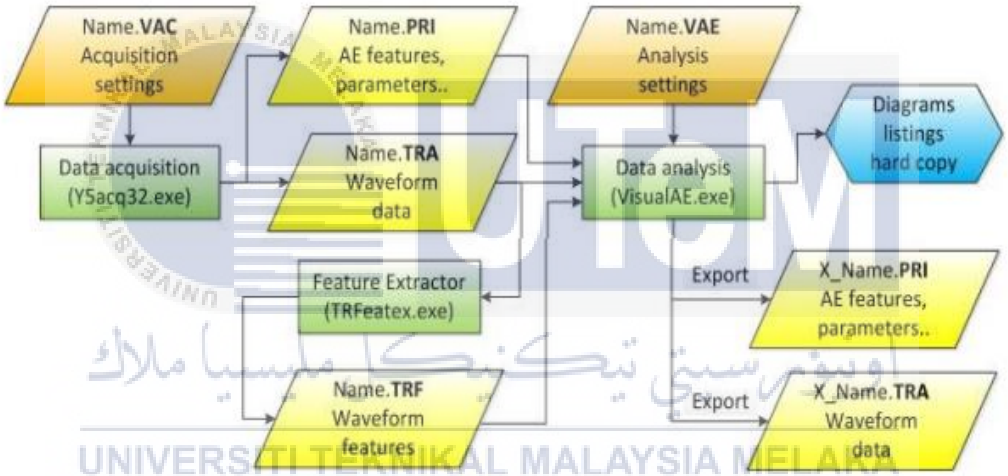

Figure 2.6: Online Data Processing and Data File Types (Vallen et al., n.d.)

Through online data processing, the recorded AE data set can be retrieved from two type of files. The first file is Primary Database (PRI) that consist of AE data such as AE parameters. The second file is Transient Database (TRA) that stored the waveform data. Figure 2.7 and Figure 2.8 shows the data structure and format of the stored AE data set in the primary file. There are lot of columns for every parameters that been recorded and the data set can be read as shown in Figure 2.8. One of the advantages of SQLite is that it can shows True Energy (E) and Signal Strength (SS) simultaneously. This is the limitation of

the previous binary AE data format which it can only put either True Energy or Signal Energy for data acquisition (Vallen et al., n.d.).

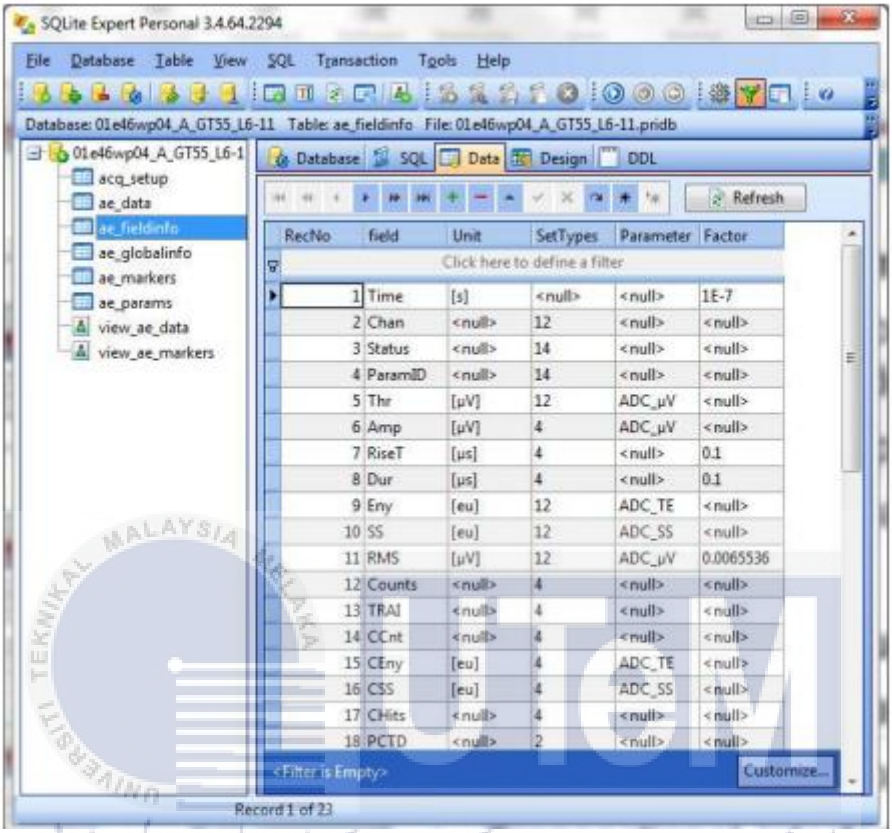

Figure 2.7: SQLite Structure and Content (Vallen et al., n.d.)

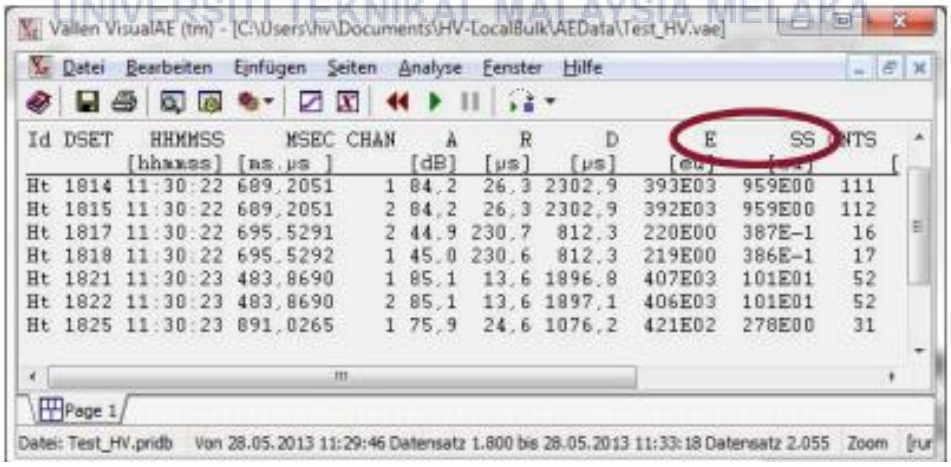

Figure 2.8: AE Data Set in SQLite (Vallen et al., n.d.)

2.4 The Previous Study on Acoustic Emission

2.4.1 Screening of Cracks in Structure

Crack is one of the common defect in any structure. Acoustic emission can perform well in crack detection and the AE signal of the crack detection are burst type signal. From Ohno and Ohtsu (2010), they investigate on crack classification in concrete based on acoustic emission. In this investigation, they experimented with concrete specimens in three test which are four point bending test of normal concrete, four point bending test of reinforced concrete and hydrostatic expansion test of concrete. There were eight AE sensors of 150 kHz resonance used to detect the AE signals. Pre-amplifier and DiSP system also used to amplify the AE wave with 40dB gain and 20dB gain respectively. The threshold of 42dB was set up for all of the test. They used RA value and the average frequency as parameters to identify their relationship.

Where; RA = rise time / maximum amplitude

Average frequency = AE ringdown-count / duration

Result of the parameter analysis show all of the detected AE hits. There were two type of analysis that conducted which are parameter analysis and SiGMA analysis. Then, they classified the crack by using the data of the parameter analysis and SiGMA analysis into three classification which are tensile crack, mixed-mode crack and shear crack. At the end of their investigation, they came up with several conclusion. They found out that tensile crack usually occurred in bending test while shear crack occurred in diagonal shear failure and hydrostatic expansion test (Ohno et al., 2010).