Partial Stroke Testing of Emergency Shutdown Valve (Masoneilan)

By

Mohd Hafiz b Ahmad Shakir

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Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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MOHD HAFIZ BIN AHMAD SHAKIR

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Approved by,

…………………………..
AP DR NORDIN B SAAD
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
DECEMBER, 2009

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

…………………………………………

MOHD HAFIZ BIN AHMAD SHAKIR

ABSTRACT

This documentation presents the basic research on Emergency Shutdown (ESD) valves testing design requirements to conduct the valves control. The inability to conduct Full Stroke Tests (FST) during the Partial Stroke Tests (PST) has forced this research to be conducted. Basically the project is about designing and programming a controller using software for controlling the final element instrument device in this case the emergency shutdown valve to open and close. The significant of this project is to overcome the inability of Emergency Shutdown System valve in the plant or platform to operate smoothly and successfully. In current situation, most of the final element valve failed to conduct the Full Stroke Tests due to ESD valves become stuck since the ranging years for the testing is about 3 to 5 years. This project will also emphasize in designing the logic controller using Ladder Logic Diagram on a Programmable Logic Controller (PLC). There are two (2) methods being implemented to complete this project successfully which would involve designing and testing procedures. Both steps are implemented to get the data for analysis purpose in the final part of the project. In order to understand and perform well, some and further research have been done to understand the software and the instrument itself. Basic knowledge of Partial Stroke Testing and Full Stroke Testing has been mastered as well as the software for developing the system. From the early results and findings, the project has reached the basic objective that is to perform the Full Stroke Test during the Partial Stroke Test. For better analysis and results oriented, there should be some improvement to be done including the software configuration and parameters.

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

This project is about Partial Stroke Tests of Emergency Shutdown (ESD) System Valves which collaborate between PETRONAS Group Technology Solution (GTS) as the owner of the project and University Teknologi PETRONAS, who runs the testing procedures for measuring the details parameters and specifications of the valve. ESD system is one of the safety systems under Safety Instrumented System (SIS) which related to the safety control. The Emergency Shutdown System (ESD) is a system that implemented in the field whether in oil and gas platform or production plant. The system actually implemented in order to protect the people, instruments and also environment if unnecessary actions happened on the field that will caused dangerous to people and caused the production profit suffered a bad influence. For example, the ESD is a system that will act when the things such as power trip, system not stable and many more. Researchers have shown that the application of ESD system is very broad all around the world among the oil and gas industry specifically and also in generation plant generally.

The importance of the system is the availability of implementing the expected action during the day whereby unexpected things could happen. The unexpected things to happen for example, power electrical supply trip. Because of that, this testing for both Partial Stroke Test (PST) and Full Stroke Test (FST) is very important for maintaining the performance of the system that will be installed since there is no indicator when the system will trip and so on. Furthermore, one requirement for the testing is to ensure that the FST can be done during the PST. This PST testing is important to know the performance of the ESD Valve for installation decision in future.

1.2 Problem Statement

Turn-around being planned further apart, ranging from 3 to 5 years. The inability to conduct Full Stroke Tests (FST) during turn-around causing safety issues due to Emergency Shutdown (ESD) value being stuck in position due to very long period in one fixed position. A number failure in Partial Stroke Testing (PST) around the world has given rise to concerns on the reliability of PST. The project is meant for comparison and verification of the technology used for Partial Stroke Tests (PST) of ESD valves. PST is a method whereby a portion of the valve is being tested at a more frequent interval than a full test rate, an accelerated (partial) proof test while FST is in opposite form. For FST, the test is being conducted in full swing whereby the valves are opened or closed at 100%.

Basically, the recent test for the valve is conducted in one condition PST, and need to be improved for the testing can be done for FST and PST at a time. To control the testing, the opening and closing portion of valve the usage of PLC (Programmable Logic Controller) is required. PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are normally safely stored in battery-backed or non-volatile memory. A PLC is an example of a real time system since output results must be produced in response to input conditions within a bounded time, otherwise unintended operation would result. The ESD system is not going to be implemented in frequent times at plant, but somehow it must be performed if the system required it to be functioned at that particular time.

1.3 Objectives and Scope of Study

The objectives of this project are to design the Ladder Logic Diagram using the WideField2 software supplied by the vendor, Yokogawa Kontrol Sdn Bhd and perform the testing on valve's devices installed by vendors, Masoneilan, Fisher and Metso . The data is then analyzed to obtain the most efficient valve for installation in PETRONAS Group Technology Solution (GTS). The feature of the logic software is very good, easy to understand and user friendly. The logic designed is going to be as the controller for the valves' operation for opening and closing purposes in Partial Stroke Test and Full Stroke Test. The WideField2 software provides a Windows environment to develop programs which operate with FA-M3. Using this tool, the developers are able to carry out all aspects of development, from creating programs to debugging and maintenance. The implementation of the logic then performed onto the valves installed in order to obtain the data and information required for analysis purpose .

The scope of study is basically to emphasize on doing the testing for both Masoneilan Ball and Butterfly valves. There are two (2) modes of testing required for this project, which are Partial Stroke Test (PST) and Full Stroke Test (FST). For this phase, the testing is emphasized in order for completing the data collection in 90 days which will be used for analysis purpose once it is completed soon. The data is very important since it will determine the capability of the valves to operate as been required by the client, PETRONAS Group Technology Solution (GTS). The testing is conducted for verification purpose on the performance of the valves to operate in certain condition for a longer time period. The longer period is required as to identify the valves whether it can produces maintain good results in a longer time. The data then analyzed for performance purpose in future.

1.4 The relevancy of the project

This project is very important to many industries in the world at the moment. This project can affect the production and safety of the system on the platform if the appropriate steps are taken from the early of the project is launched. Particularly, in oil and gas industry the most important thing to be assured is the safety of the platform and the system that running on it in order to make sure the running production can be produced in well-mannered. We can say that, all of the oil producer companies will put the safety as their main priority in their business since this has very close relation with the production. Due to that, Emergency Shutdown System (ESD) is very important as well as the final element of the system, Valve. To make sure the system running smoothly from the beginning until the output is produced, all devices should be in good condition always especially when the ESD is being performed. We can say due to researches being done that the ESD has been implemented due to many causes and one of it is electrical trip. Since the causes can happened anytime, it is better for the devices to be in ready mode all the time. In that particular case, it has shown that is very important to do this project in order to maintain the safety and well-organized system on the platform or process plant around the world.

The main advantage of Partial Stroke Testing is that it will provide a measure of confidence that a valve is not stuck in one position and it will do so at short intervals, if required. The importance of this Partial Stroke Test is to make sure that the valves, Ball Valve and Butterfly Valve can operates well as being designed and well managed by the engineers. The main purpose is to overcome the 'stuck' situation whereby it always happened when the valves are not being tested or generated in a long period. By referring to the researches done, there are too many improvements in mechanical reliability which have permitted extending process plant turnaround periods from a traditional one or two years to five or six years. The effect is inability to conduct Full Stroke Test within the required period, causing safety issues to arise due to ESD valves being stuck in position due to the very long period in one fix position. So, the testing is a must and important for system to operate better to produce perfect outcome and maintaining safety condition in future.

1.5 Feasibility of the project within the scope and time frame

This Partial Stroking Testing of Emergency Shutdown Valve is about to do the testing of the capability and functionality of the particular valves due to the requirement needed. Basically the testing is need to be done in daily mode whereby to identify the ability of the valves and to analyzed the problems faced during the testing process. There are many phases to complete the testing which will be conducted in different particular parameters and requirements. For the first phase, the only thing to be considered is to verify the ability and functionality of both ball and butterfly valves when both Partial Stroking Testing and Full Stroking Testing are being conducted. The testing requirement days is set to be fixed at 90 days for data collection in this first phase. The testing has been completed as been planned and the project also can be continued with the next phase. There are no major problems or restrictions that will interfere the first phase testing from being completed as in the time frame. The important thing is to make sure that the software and hardware instrument working in good condition all the time to avoid the project is out of the track schedule as in time frame.

CHAPTER 2

LITERATURE REVIEW

2.1 Critical Analysis of Literature

2.1.1 Emergency Shutdown (ESD) System

An emergency action performed immediately in order to save systems and important things due to certain conditions. Normally the ESD will stop the system altogether and the process will be terminated safely. The ESD occurred due to certain criteria such as overflow, gas leaking and operating systems down during the operation being generated. This system basically consists of field-mounted sensors, valves and trip relays, system logic for processing of incoming signals and activating outputs . However for the installation it is accordance to the Cause and Effect charts defined . Since the ESD will be triggered due to many factors, it includes the existence of the detection of flame and also the gas leakage. Also to shut down the system just takes a few seconds, but to re-operate it will take hours to start the system again. Normally, nowadays the ESD system itself completed with the modern programmable system . The system offers extremely high reliability to ensure high systematic integrity level satisfied but require an appropriate level of attention to detail during design, manufacture, commissioning and operation. Due to that requirements, it is important to have such a high integrity of safety level to make sure the system operate in a good shape and precise . The examples of the programmable systems are Functional Block Diagram (FBD) and Ladder Diagram.

2.1.2 Partial Stroke Test (PST) and Full Stroke Test (FST)

In the processing plants, it contains many valves that perform safety functions such as ESD. The valves are always hoped not to be used in earnest since the usage of them means something has gone wrong and at least there is a plant to be shut down, which will disrupt the operations. However, if the ESD valves are required to be used, they have to work reliably, because the consequences of failure will be far more serious than the disruption, when they work. Due to many experiences that happened on the field, if valves are not exercised, they can stick in one position which is not good for operation purpose. The valves' sticking is due to the corrosion and also dirt around it since no movement being performed for a long time. From general perception it indicates that the sticking at its initial position is the main failure mode of safety related valves. Due to that, Partial Stroke Test (PST) and Full Stroke Test (FST) are being tested to avoid the failure.

The main advantage of PST is that it will provide a measure of confidence that a valve is not stuck in one position and it will do so at short interv als, if required. Logically, the valve movement can dislocate any dirt build-up to help prevent sticking at one place. It shows that the exercising of the valve is really important and necessary to avoid the problem from happened. However, if there are too many PST is being tested, it will cause the leakage to the valve. The leaking disadvantage is not a good choice since it can disturb the valve's operation next. Normally, t he leaking always happened between the valves' itself and the house of the valve since there is a contact between them [5].

2.1.3 Ball Valve and Butterfly Valve

A ball valve is a valve that opens by turning a handle attached to a ball inside the valve. For structure of the valve, it has a hole, or port, through the middle so that when the port is in line with both ends of the valve, flow will occur. When the valve is closed, the hole is perpendicular to the ends of the valve, and the flow is blocked by the ball. There are 3 general body styles of ball valves, split body, top entry and welded. At current situations, some ball valves are equipped with an actuator which operated pneumatically or electrically by motor. Due to these latest technology, these valves can be well performed either for on/off or flow control application [2]. A pneumatic flow control valve is also equipped with a positioner, which transforms the control signal into actuator position and valve opening accordingly. For this project ball valve, it implements the general pneumatic controller for 4-20mA power supplied. Most of the control and instrumentation device nowadays using the 4-20mA signal for communication purpose [9].

A butterfly valve is a particular type of valve that implements two types of structures either a circular vane or a disc as the shut-off mechanism for their operation. Butterfly valves have a quick opening/closing quarter-turn mechanism that is used to control the flow of liquid through a piping system. They typically pivot on axes perpendicular to the direction of flow inside the flow chamber. Compared with ball valves, butterfly valves do not have pockets to trap fluids when the valve is in the closed position. They can control various substances of air, liquid or solid currents and are situated on a spindle that allows for flow in a single direction. Butterfly valves have a lever that allows the operator to open or close the valve to control the flow. These valves are part of a family known as rotary valves, which are defined by the quarter turn operation that is used to move from the open to close position and in other way around [2].

2.1.4 PST SVI II ESD Device

The SVI II is the latest technology device designed in emergency shutdown valve automation and in-service valve partial-stroking. The SVI II ESD safety device is intended for use with industrial compressed air or sweet natural gas systems only. It is to ensure that sufficient pressure relief provision is installed when the application of the system supply pressure could cause other peripheral equipment to malfunction. Installation must be properly in parallel with local and national compressed air to ensure that the installation is following the requirement needed by systems [7]. The device is designed for it being implemented using 4-20mA signal, 0-24Vdc signal and both. The Masoneilan's company itself has come to an idea to design the SVI II ESD device as for the solution in order to increase the safety level, also to prevent and avoid the possibilities of uncontrollable situations in the processing plant. This high-technology device is functioned using the pneumatic system application whereby it gathers the data required during the PST testing is being implemented. For example, it will show the PST is running during the testing and otherwise the device shows the parameters like air pressure supplied and also the signals in current mode. To implement the device, it is mounted on a pneumatically actuated valve assembly. The function of device is to implement the PST testing as required through the parameter designed. In accordance to that, the device will position the emergency shutdown valve between the range of 0% to 100% of the valve opening and closing position. But for PST test, the range is between 5 to 30% of Masoneilan valve's closing. The PST device, SVI II ESD is different since it is not using the solenoid that is typically utilized to actuate a spring-return or double-acting actuator, while it provides the extensive online valve diagnostics. There are three (3) possible installation configurations for the device which each has different wiring scheme. They are as below:

- Analog Safety Demand (ASD)
- Discrete Safety Demand (DSD)
- Analog with Discrete Safety Demand (A/DSD)

For this project, we are using only two (2) installation configurations which are ASD and DSD. The ASD is implementing 4-20mA analogue signals while the DSD is using digital 0-24 Vdc signals to operate the SVI II device. The ASD is used only for the Ball valve to do the PST and FST while for the Butterfly valve, the configuration used is DSD. For information, the single 4-20mA solution is ideal as it is Safety Integrity Level (SIL) 3 while at 4mA, which means it allows the device to perform the safety function while still in active mode. This is the best thing since it captured the shutdown events as a full-proof test and allows the communication from the HART during the trip condition.

2.1.5 PST Travel

The allowed valve travelling movement from its' full open position condition to the partial close position and measured in percentage of travel. A typical value is 20% and the maximum allowed is 30%, and for Masoneilan valves its' from 5% to 30% range [9]. The greater the travel range, the more accurate the result from the PST Test.

2.1.6 Minimum Pressure

The minimum pressure is the allowed reduction in pressure level in the valve's actuator in order to achieve the desired PST Travel position. This value depends on the spring range and the valve/ actuator hysteresis and the data collected from the software and also can be seen in the graph displayed [9]. This pressure is relating to the valve travelling position due to the pressure applied.

2.1.7 Maximum Time

Total time measured for doing the PST testing. It is also defined as allowed amount of time in seconds before the PST test aborts [9]. This PST travelling value can be determined by using the equation:

**Maximum Time = (Travel Range x 2 x PST Speed) + Dwell Time + 5 seconds*

2.1.8 PST Speed

The valve travel speed is measured in % Travel per second [9]. The speed travel can be varied depends on the requirement setting by the user. The higher the value set, the faster the movement of the valve to operate. For this project, the speed used is 0.5% per second.

2.1.9 Dwell Time

Dwelling time is the amount of time in seconds between the down ramp and the up ramp of valve stroke and it is displayed after the testing is completely done [9]. The time in which a penetrant or developer is in contact with the surface of the part. Dwell time also include drain time as its' part of time. In general it is also define as an intentional time delay needed during which an indenter is held against a material under load during a hardness test which it is used in order to ensure accurate hardness ratings.

2.1.10 Friction

i) High Limit

- The alarm threshold for high friction. This alarm is purposely designed to function if the analyzed friction from the PST test is more than this value [9]. Friction analyzed in every single test. Measured in (Psi, kPa, BAR). The friction data is displayed after the test is done.

ii) Low Limit

- The alarm threshold for low friction. This alarm is set up and designed to function if the analyzed friction from the PST test is less than this value [9]. Measured in (Psi, kPa, BAR) and analyzed in every single test. The friction data is displayed after the test is done.

2.1.11 Breakout Limit

The alarm threshold set up for valve breakout force. Basically it is a force that is required to move the valve from initial position to start the movement [9]. This alarm is set if the analyzed friction from the PST test is more than this value.

2.1.12 Droop Limit

The droop limit is the air pressure limit and depends on the regulators used. The alarm threshold set up for air supply inlet droop and it is specifically designed if the analyzed Air Supply Droop is more than this value, it shows a possible clogged up air filter in the air set or lack of volume feeding the SVI II ESD device [9].

CHAPTER 3

METHODOLOGY

3.1 Procedure Identification

Figure 1: Steps of Masoneilan PST Project

3.1.1 Testing

Currently, the Partial Stroke Test (PST) is at the end of the early testing phase. For Masoneilan Ball and Butterfly valves, both have completed the 90 days testing period. The testing had been performed effectively starting from the February of 2009 which had successfully ends in October 2009. As informed in previous parts, the t esting includes 5 Partial Stroke Test (PST) and 1 Full Stroke Test (FST) for each valve which conducted in daily. The importance of this testing is to obtain the data required by industry in order to do the analysis and data comparison between each vendor' s product. There are three (3) vendors involves, Masoneilan, Fisher and Metso. These collected data basically depends on the parameters that have been setup before the testing procedures are conducted. Among the important parameters that include in the tes ting are as below:

- Friction (psi and %)
- Droop (psi)
- Breakout Pressure (psi)
- Lower and upper Spring Range (psi/sec)
- Response Time during Exhaust and Fill (psi/sec)
- The Graph, Valve Position versus Pressure Applied

Basically, all these parameters values are obtain after the testing is conducted. All the parameters requirements have been setup to certain limit and values in order to identify whether the both valves are fulfill the criteria through the 'Passed' and 'Failed' indicator from the software. The graph is also important as the data collection for the smoothness of the valve's travelling during the Partial Stroke Testing. It is only shows the results of PST instead of FST. This particular project is concerned only regarding the Masoneilan valves. Figure 1 above mentioning the overall process for this project.

3.1.2 Data Analysis

Every collection of data that obtained during the testing will be finalized and analyzed after the total 90 days testing period is completed. The objective of the data analysis and compilation is to determine the pro's and con's for both valves, Ball and Butterfly for particular vendor's product. Among the data to be compiled are Droop, Friction, Response Time, Breakout Pressure and Spring Range. For certain parameter, the values have been set before the testing is conducted, for example the PST Travel Speed, Droop Level, Valve Percentage Opening and many more. All parameters settings must be same. The most important criteria to be taken into consideration are the ability of the valves to implement the PST and FST when both applications are required in particular times especially the FST during emergency shutdown condition. This criteria is need to be evaluated since when the real situation in the plant, we do not know the possibilities of the valves to perform the operation. By doing this testing we can exercise the valves once in a day in order to avoid the valves from sticking at the initial position even the signal has been forced to. This is to ensure that the valves can operate smoothly in the plant.

3.2 Project Activities

This project has its particular procedures to implement the testing requirement for the PST and FST tests. The procedures for the testing include a few simple steps which easily performed by the person in-charge. This procedure of testing are repeated in daily testing since it requires a very same methodology of it. The procedures are as below:

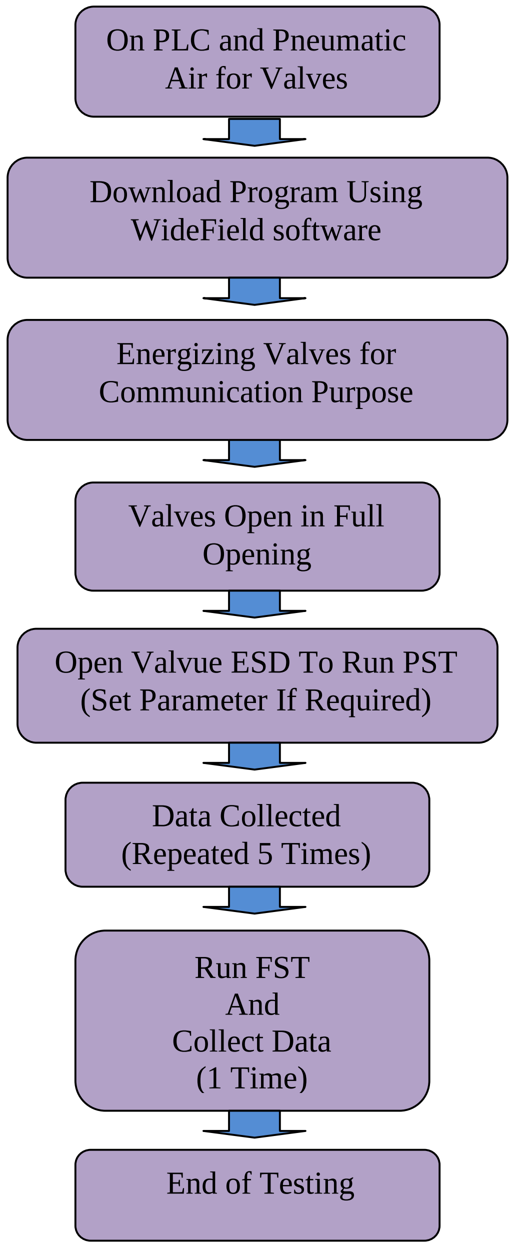

Figure 2: Flow Chart of Process

3.3 Tools and Equipment

3.3.1 Software

3.3.1.1 Yokogawa WideField2 Program

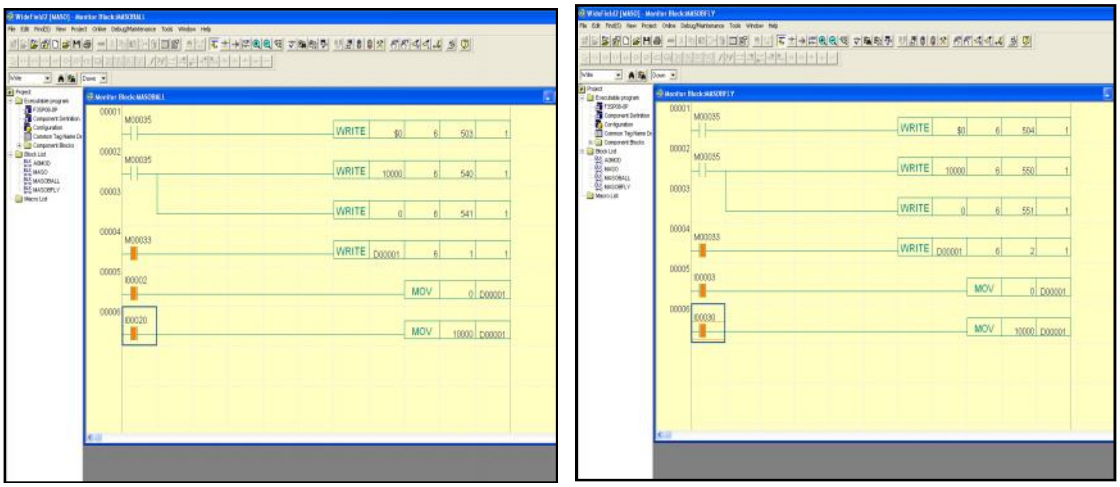

Figure 3: WideField2 Interface

For this PST project, we are using Yokogawa WideField2 Tool as the programming tool. It is used and programmed to control the communication program inside the PLC for implementing the PST and FST. It is to structure ladder programming and created with new concept. The object in which a piece of program and the related devices are assembled for each functional unit called a block. From the WideField2 interface in Figure 3, on the left is ladder programming for Ball valve and on the right is for Butterfly valve.

3.3.1.2 Valvue ESD Outlook

Figure 4: Valvue ESD Outlook

Figure 4 shows the interface in Valvue ESD Outlook which supplied by Masoneilan for PST purpose. The interface is easy to conduct since it has many of applications and can do tests for many parameters required. The interface will be appeared on the monitor screen after the communication between the Engineering Workstation and Valves is stable. Basically from the software, it shows details regarding the position, air pressure, breakout pressure and signals applied to the valves.

3.3.2 Hardware

3.3.2.1 PLC System Chassis: FA-M3 R

Figure 5: PLC System Chassis

PLC system chassis named FA-M3 R consists of a few parts such as power supply, analogue inputs, analogue outputs, digital inputs, digital outputs which had been programmed through ladder programming in WideField 2 software. The PLC inside the chassis will be the heart of the system which it will perform the programming language in order to do the PST and FST testing. The PLC is using WideField2 software as the programming tools.

3.3.2.2 ESD Partial Stroking Device

Figure 6: PST device, SVI II ESD Model

SVI II is a smart positioner newly designed by the Masoneilan vendor to implement the PST and FST. It is the using the latest technology in ESD valves automation and in service valve partial stroking. SVI II ESD is a product extension of the successful and highly reliable SVI II AP valve positioned. The product is SIL3 compliant, suitable for use in safety instrumented functions. The device will shows indication 'PST ON' during testing, and parameters like the valve's position, air-pressure supplied and signal in 4-20mA. The designated function of it can be implemented using a 4 -20mA signal, 0-24Vdc or combination of both. It provides ESD function and PST function on a single Wire Pair . By doing that, it reduced the installation cost and ESD Valve PST execution can be done from any logic solver [9].

3.3.2.3 Masoneilan Ball Valve and Butterfly Valve

i. Ball Valve

Figure 7: Ball Valve

The Masoneilan ball valve is a valve that opens by turning a handle attached to a ball inside the valve. For this Masoneilan ball valve, it is completed with the pneumatic actuator which the moving of the valve is performed by initiate the air pressure, controlling from the Engineering Workstation. The air-pressure is performed to open and close the valve when the PST and FST tests are tested. It uses ESD Valvue as the software to run the PST testing.

ii. Butterfly Valve

Figure 8: Butterfly Valve

A butterfly valve is a particular type of valve that uses either a circular vane or a disc as the shut-off mechanism. Butterfly valves have a quick opening/closing quarter-turn mechanism that is used to control the flow of liquid through a piping system. They typically pivot on axes perpendicular to the direction of flow inside the flow chamber. Compared with ball valves, butterfly valves do not have pockets to trap fluids when the valve is in the closed position. Since it has 2 sides of wings, the valve just move quarter of the cycle for performing the 100% opening [2]. This valve is using ESD Valvue to run the PST testing.

3.4 Project Design

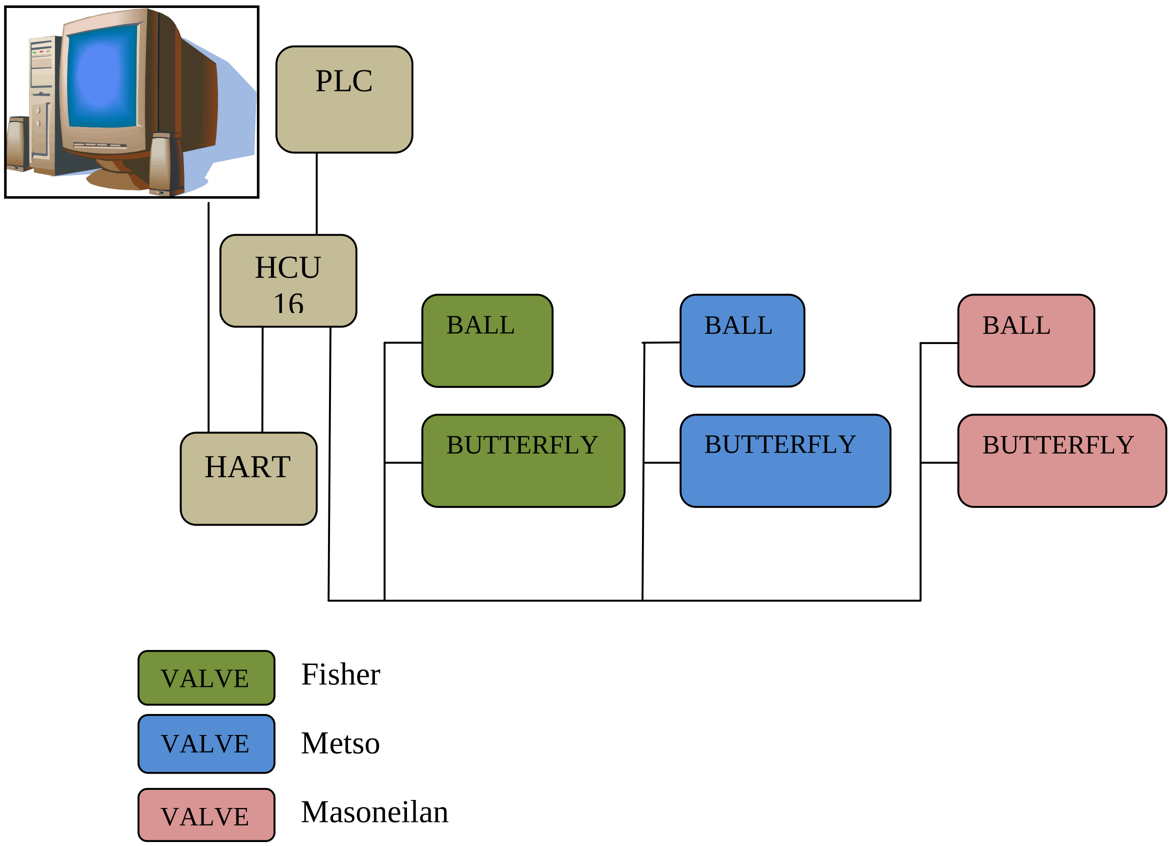

Figure 9: Hardware Connection

This is the basic layout of the ESD Valve Testing project for PST. The connection is basically from the layout of the drawing given by the ve ndor. The important devices that need to be connected are such as Hart Communication, PLC and Multiplexer, HCU 16. The Hart is functioning as the communicator between the Engineering Workstation and the PLC. The PLC then connected to the Multiplexer before it is connected to the valves from various vendors. The PLC contains programs that had been design using ladder for implementing the PST and FST while the Multiplexer acts as the device to connect more than one instruments and for this case, they are Ball and Butterfly valves from each vendors.

CHAPTER 4

RESULTS & DISCUSSION

4.1 Findings, Data Gathering & Analysis

This Partial Stroke Testing project required the testing to be done in 90 days. The testing should be done every day as scheduled to ensure the efficiency of the ESD valves, both Ball and Butterfly valves. The valves are being tested for a 90 days period to obtain and analyze the data. Each valve has to be tested in six (6) times for PST including the one for FST in PST. The estimation time for each testing is about 3 minutes per testing. The importance of the testing is to observe the movement for the valves to avoid the valves to stick at one place only. If the valves are not moving for longer time it will produce dust and dirt which will make the valves unmoved or stick at its place even when the valves are forced to move during the operation. The affect of the sticking position is making the valves fail to perform the ESD operation when there is real time situation is happened at the field. It is a very dangerous situation which can cause problems in terms of business and maintenance sides. The valves are required to do the 20% of movement testing as the requirement. The failure of the valves to function will affect the overall operation, cost, and profit.

From the 90 days testing, there are several findings and problems happened. The problems are stated as below:

- The inability of the communication between the Workstation and the Valves.
- The inability of the valves to produce perfect constant PST results.
- The disability of the valve to move after signal has been forced.
- The corruption of the PLC file which caused delayed in testing.

From the failure of communication between the workstation and the valves, it is believe to happen due to the unstable functionality of the Hart communication tools, MTL. The failure in communication will caused the output devices not to be connected for PST testing. It is a device that operates in between both the input and outputs. Basically it functions like a multiplexer which will be a bridge in connection between both for detecting the output devices. For this MTL, the testing uses Master-Slave system which every slave MTL is controlled by their master for operation. For example, the testing project has one (1) Master and one (1) slave MTL. Every slave can have connection to until 16 output valves while every master can control until 4 MTL slaves. The valves also failed to produce constant successfully results meaning sometimes it produces 'Failed' for the PST testing. The failure in PST testing is due to the signal detection and communication between the input and output devices. The failure is happened when the PST is in running mode. In the middle of the PST testing, suddenly the software indicates that the PST is failed to operate. However, the PST failure is not a big major problem since it is rare to happen during these 90 days of testing.

In addition, another problem faced is the inability of the valve to open and close after the signal value is forced. The unwanted result rare to happen during this testing but sometime when it happen it will caused the overall testing operation since no signal to energize the valve can be done. To open and close the valve in 100% mode, energize the valve is a must step before the PST can be run for testing. However, the problem not always to happen and it managed to be solved after doing a few trial and error sessions. The major concern is, the stability and constantly producing the expected results are required because the system is going to be installed in the platform which need the highly demand in accuracy. Another problem which happened is corruption in PLC file. The corruption has caused the delay in testing for several days. It is believed that the file is corrupted due to the power trip during the PST in running mode. Until now the real cause is failed to be proved and determined since the initial power trip cause is not too strong to support the condition. However, almost of these problems managed to be solved even for the temporary time in order to complete the 90 days testing.

Below are the examples of results in Day 62 of the testing.

BALL VALVE
PST 1

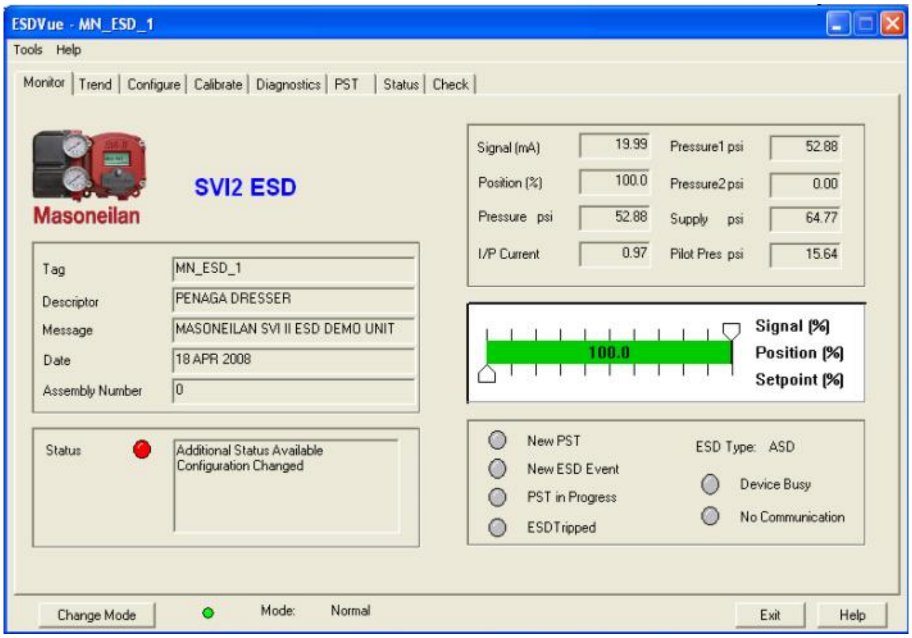

Figure 10: PST Main Window

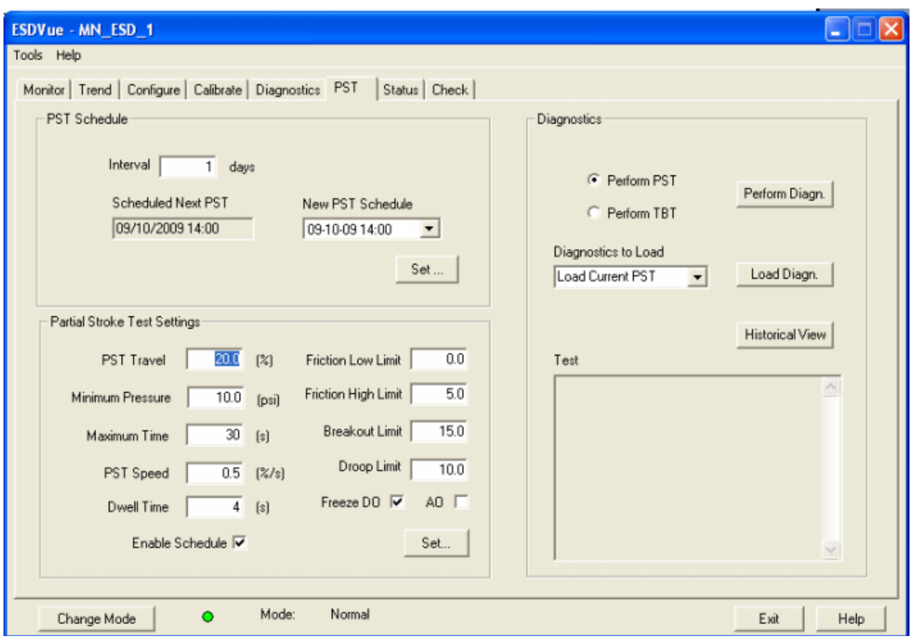

Figure 11: PST Parameter Window

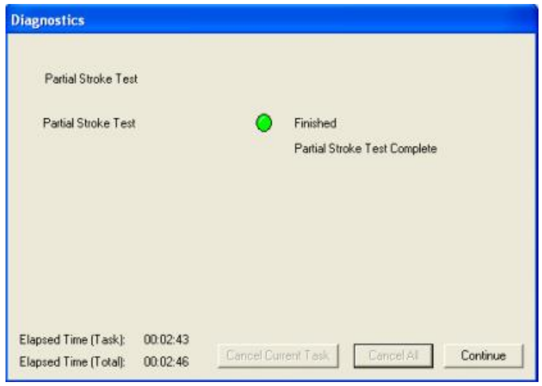

Figure 12: Diagnostic PST Indicator

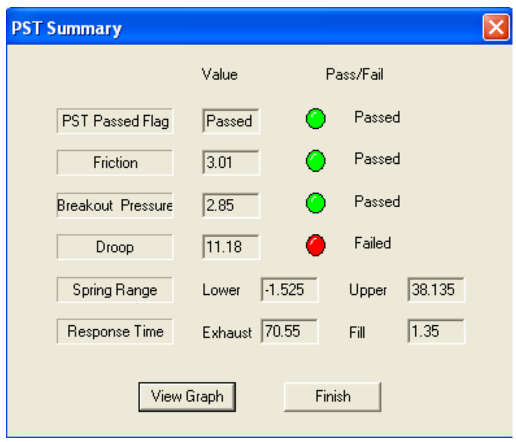

Figure 13: PST Output Summary

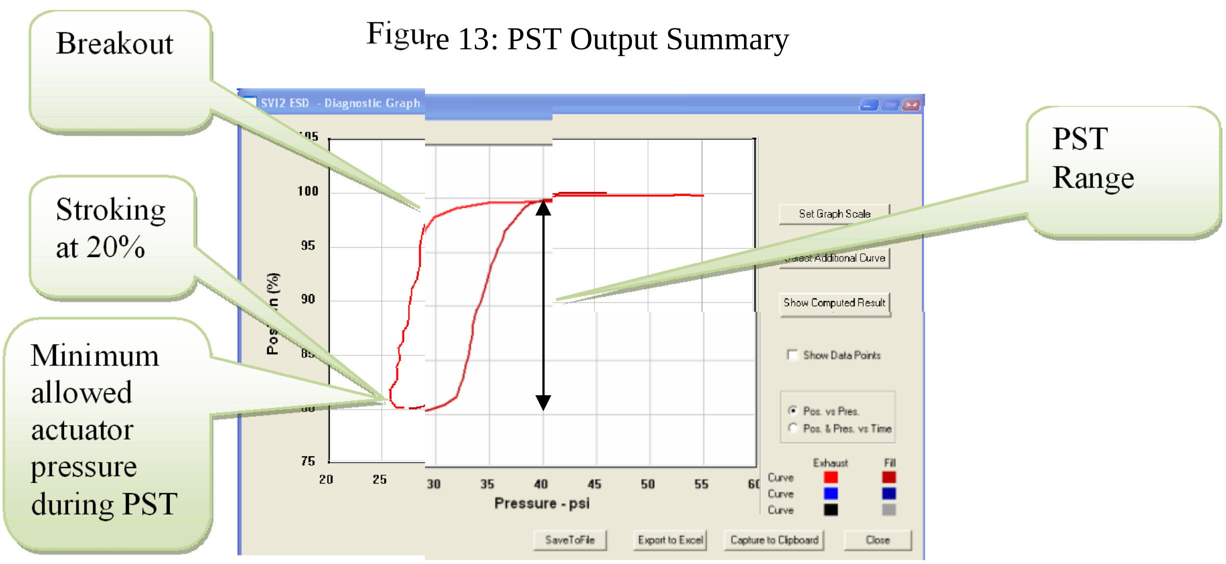

Figure 14: Graph

PST + FST

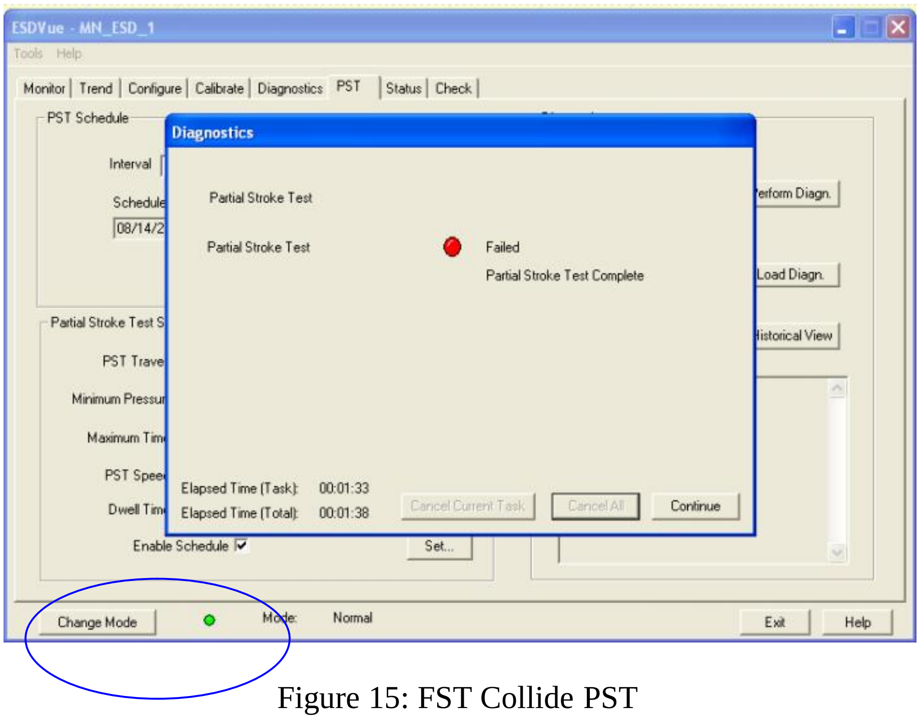

Figure 15: FST Collide PST

The results show PST Testing is successfully completed and failed during the FST. During FST, the system is running in ‘Normal’ mode to show that the system is ‘Tripped’ instead of ‘Shutdown’. The ESD SVI II is doing the diagnostics on that time. For this mode, there is a communication between the valve positioned SVI II ESD with the HART communicator which means that the systems is in SIL 3 and still being active. The benefit of this condition is, the device is still executing the safety function and captu ring the shutdown events as a full-proof test while allowing the communication during a trip condition . The uniqueness of the device is the SIL 3 at 4mA which indicate that the shutdown event is captured and it confirms the ESD operations. For this valve, the safety input is between 4-20mA range while the current signal for the trip condition is below or equal to 5.6mA (<=5.6mA).

BUTTERFLY VALVE
PST 1

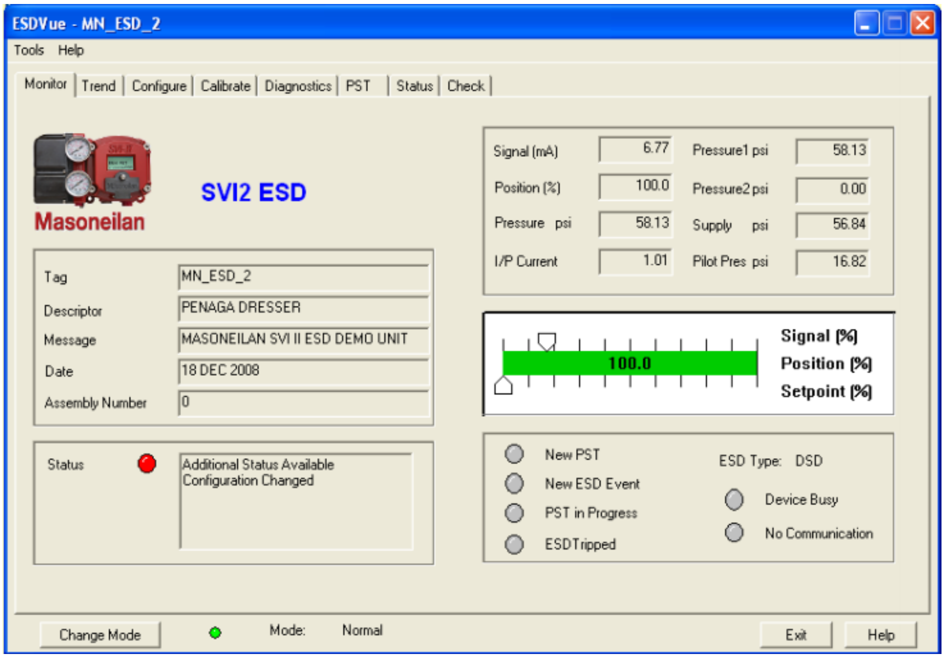

Figure 16: PST Main Window

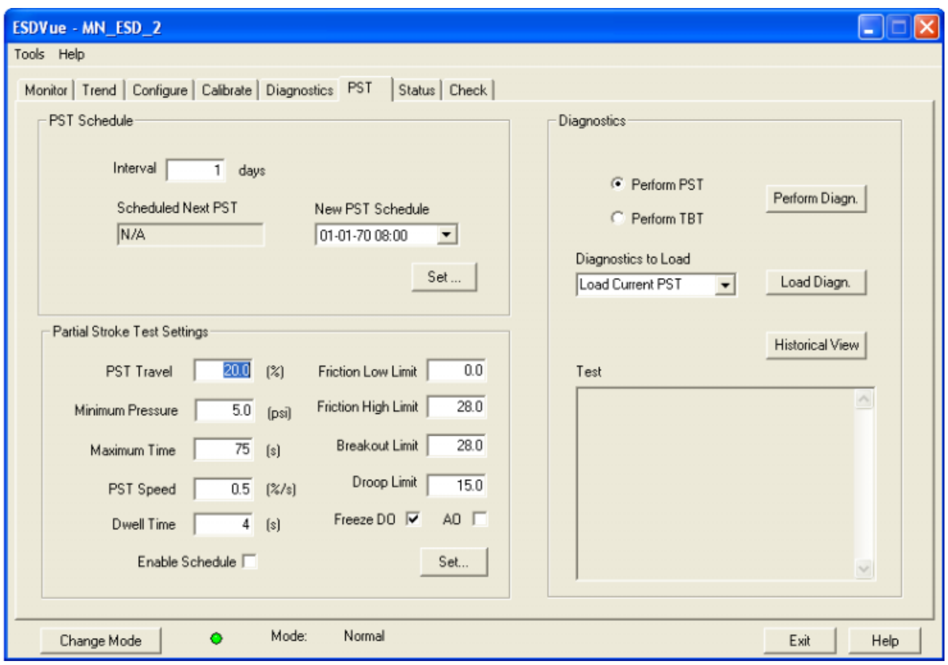

Figure 17: PST Parameter Window

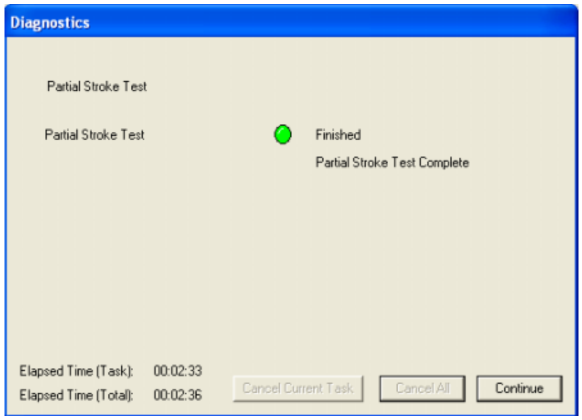

Figure 18: Diagnostic PST Indicator

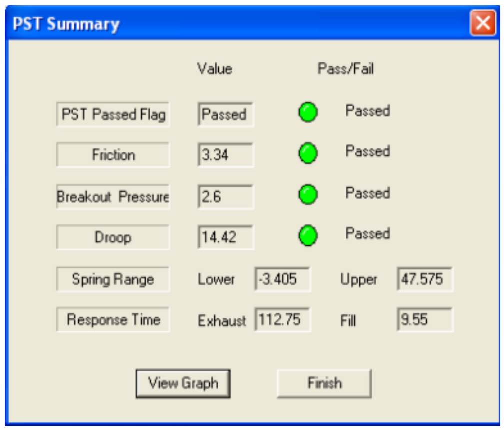

Figure 19: PST Output Summary

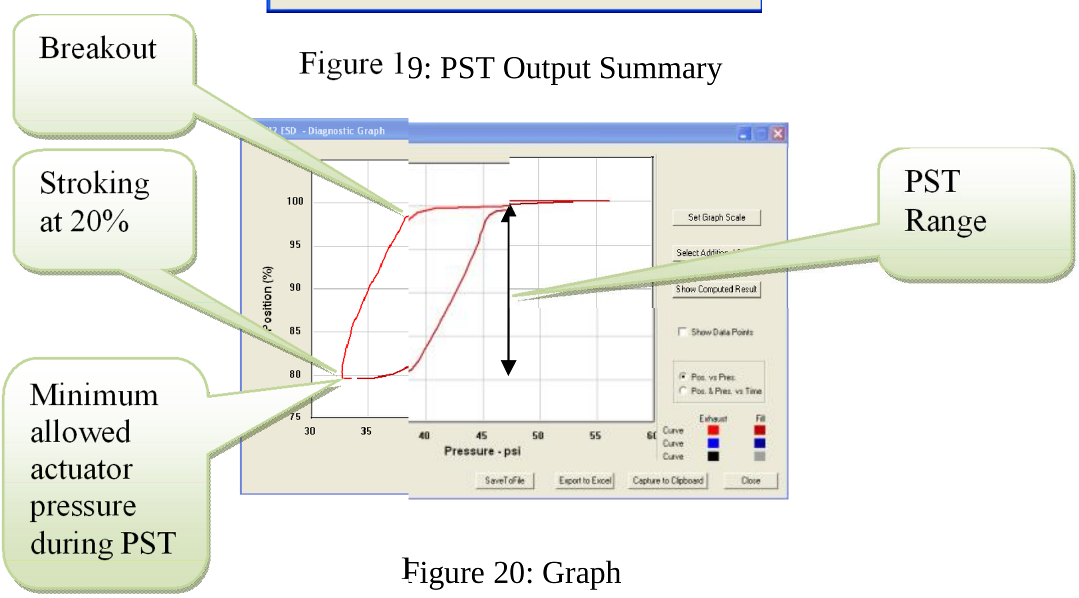

Figure 20: Graph

PST + FST

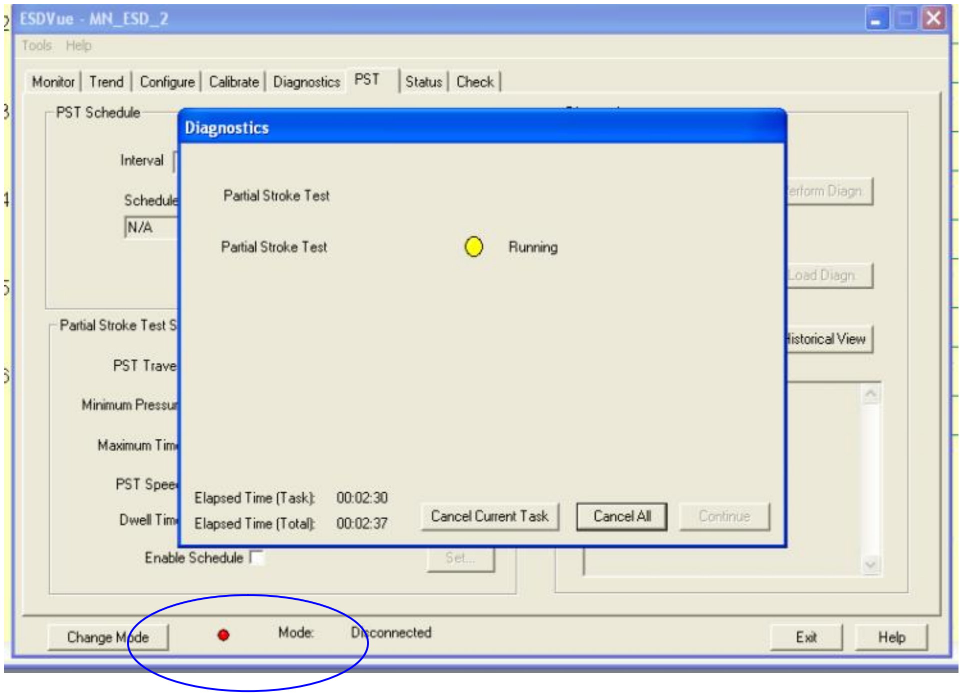

Figure 21: FST Collide PST

The result shows the Butterfly valve has been totally disconnected from the system during the Partial Stroke test (PST) in order to perform Full Stroke test (FST). The disconnecting mode is shown by the Red in colour indicator and the disconnected indicato r. The result indicates that the valve is having ‘Shutdown’ condition during the FST. Compared to the Ball valve, the Butterfly valve does not have ‘Tripped’ mode which can force the device to do the diagnostic during FST mode in while maintaining the conn ection with the system. For this device, the signal range is between 0 -20Vdc for discrete mode and the device is trip on 0Vdc.

Table 1: Breakout Pressure Data

VALVE	BALL						BUTTERFLY					
TEST	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**AVG**	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**AVG**
DAY 1	5.325	3.625	4.835	4.065	5.975	**4.765**	3.66	3.56	2.58	3.54	3.52	**3.372**
DAY 2	3.07	5.31	3.39	5.365	5.54	**4.535**	3.88	3.885	2.545	3.595	3.66	**3.513**
DAY 3	3.36	3.85	4.83	3.08	4.535	**4.535**	3.935	2.665	3.535	3.47	3.305	**3.382**
DAY 4	5.325	3.625	4.835	4.065	5.975	**4.765**	3.66	3.56	2.58	3.54	3.52	**3.372**
DAY 5	3.07	5.31	3.39	5.365	5.54	**4.535**	3.88	3.885	2.545	3.595	3.66	**3.513**
DAY 6	3.36	3.85	4.83	3.08	4.535	**3.931**	3.935	2.665	3.535	3.47	3.305	**3.382**
DAY 7	4.745	4.79	5.09	4.065	4.565	**4.651**	2.785	3.76	2.775	3.73	3.545	**3.319**
DAY 8	3	3.55	2.945	5.1	4.525	**3.824**	2.92	4.125	3.47	3.225	3.3	**3.408**
DAY 9	4.075	5.73	4.23	5.325	4.295	**4.731**	2.97	3.725	3.24	3.445	4.18	**3.512**
DAY 10	3.455	3.88	5.14	4.505	5.44	**4.484**	3.27	3.55	3.075	3.66	3.735	**3.458**
DAY 11	3.265	4.5	5.265	4.93	4.435	**4.479**	4.09	3.5	4.045	4.165	4.22	**4.004**
DAY 12	3.66	3.875	3.875	5.005	4.845	**4.252**	3.325	4.09	3.335	3.61	3.35	**3.542**
DAY 13	4.625	4.025	4.145	4.545	4.745	**4.417**	2.97	3.99	3.87	3.755	3.705	**3.658**
DAY 14	4.345	5.12	4.95	5.49	4.49	**4.879**	2.615	3.42	3.775	3.62	3.55	**3.396**
DAY 15	4.755	4.465	4.34	5.165	4.67	**4.679**	3.005	3.765	3.18	3.71	3.49	**3.43**
DAY 16	3.8	3.935	5.79	4.155	3.555	**4.247**	3.16	3.47	3.68	3.71	3.895	**3.583**
DAY 17	3.295	3.94	6.45	4.91	4.82	**4.683**	3.07	3.89	3.61	3.42	3.42	**3.482**
DAY 18	4.165	4.215	5.275	4.27	4.46	**4.477**	2.985	3.94	3.62	3.81	3.5	**3.571**
DAY 19	3.025	3.66	5.915	5.405	5.375	**4.676**	3.2	3.7	3.255	2.77	3.645	**3.314**
DAY 20	4.39	4.795	5.175	4.745	5.455	**4.912**	2.99	3.76	3.495	3.285	3.305	**3.367**
DAY 21	4.085	5.65	4.72	5.44	5.43	**5.065**	3.91	2.78	2.89	3.585	3.535	**3.34**
DAY 22	2.74	4.165	2.12	4.06	4.915	**3.6**	3.91	2.78	2.89	3.585	3.535	**3.34**
DAY 23	3.98	4.125	5.435	4.67	4.32	**4.506**	3.84	3.62	3.6	3.44	3.425	**3.585**
DAY 24	3.865	3.72	6.125	3.52	4.95	**4.436**	F	4.05	3.555	3.845	3.77	**3.741**
DAY 25	5.215	5.15	5.575	3.925	4.725	**4.918**	3.325	3.72	3.28	3.535	2.82	**3.336**
DAY 26	3.345	3.415	4.885	4.08	5.295	**4.204**	3.34	3.72	3.265	3.265	3.375	**3.393**
DAY 27	4.825	3.545	4.03	4.435	3.58	**4.083**	3.05	3.695	3.61	3.275	3.415	**3.409**
DAY 28	3.635	4.86	4.815	4.595	4.72	**4.525**	2.905	3.605	3.425	3.485	3.65	**3.414**
DAY 29	3.27	4.32	4.025	4.115	4.815	**4.109**	3.285	3.67	3.52	3.34	3.225	**3.408**
DAY 30	3.12	5.35	5.625	4.37	4.37	**4.567**	3.43	3.315	3.42	3.395	3.385	**3.389**

VALVE	BALL						BUTTERFLY					
TEST	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**AVG**	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**AVG**
DAY 31	3.12	5.35	5.625	4.37	4.37	**4.567**	3.43	3.315	3.42	3.395	3.385	**3.389**
DAY 32	2.53	5.065	4.425	5.835	3.675	**4.306**	2.73	3.045	3.205	2.57	2.57	**2.824**
DAY 33	3.12	5.35	5.625	4.37	4.37	**4.567**	3.43	3.315	3.42	3.395	3.385	**3.389**
DAY 34	3.155	4.7	4.5	4.58	4.83	**4.33**	3.065	3.07	3.365	3.2	3.3	**3.2**
DAY 35	4.88	4.13	4.565	4.43	5.885	**4.778**	2.92	3.485	3.3	3.065	3.145	**3.183**
DAY 36	4.035	3.66	4.89	4.715	4.56	**4.372**	3.12	3.1	2.155	2.455	2.535	**2.673**
DAY 37	3.41	4.69	3.72	4.595	3.745	**4.032**	2.95	3.165	3.27	3.14	3.135	**3.132**
DAY 38	4.09	3.8	3.5	3.255	4.17	**3.763**	3.04	3.1	3.065	2.87	3.27	**3.069**
DAY 39	5.14	3.82	5.305	3.905	3.425	**4.319**	2.71	3.125	3.135	3.27	3.11	**3.07**
DAY 40	3.12	5.35	5.625	4.37	4.37	**4.567**	3.43	3.315	3.42	3.395	3.385	**3.389**
DAY 41	2.965	5.3	4.23	4.33	4.22	**4.209**	2.985	3.185	3.11	3.485	2.515	**3.056**
DAY 42	3.935	5.56	4.87	4.6	4.245	**4.642**	2.925	3.11	3.185	3.22	3.12	**3.112**
DAY 43	2.645	3.18	3.265	3.385	3.16	**3.127**	3.175	4.37	4.16	4.38	4.215	**4.06**
DAY 44	3.75	4	4.41	5.345	4.48	**4.397**	2.855	3.03	2.645	2.455	3.15	**2.827**
DAY 45	2.775	3.865	4.45	4.185	3.92	**3.839**	3.18	3.195	3.115	3.295	3.12	**3.181**
DAY 46	3.21	3.655	4.175	2.53	4.28	**3.57**	6.675	3.04	6.675	3.335	3.13	**4.571**
DAY 47	2.775	3.24	3.25	5.335	4.94	**3.908**	3.065	3.305	3.12	3.01	3.21	**3.142**
DAY 48	5.06	4.83	2.575	3.91	3.17	**3.909**	3.17	3.09	3.335	3.27	3.28	**3.229**
DAY 49	3.605	3.035	3.085	3.02	5.505	**3.65**	3.205	3.18	3.06	3.23	3.23	**3.181**
DAY 50	3.96	3.475	6.155	6.395	5.14	**5.025**	F	2.9	2.8	2.47	2.69	**2.715**
DAY 51	4.985	3.24	4.03	5.77	5.44	**4.693**	2.98	3.15	3.085	3.13	3.255	**3.12**
DAY 52	3.33	4.17	3.67	4.39	6.065	**4.325**	3.02	3.03	3.2	3.055	3.04	**3.069**
DAY 53	4.88	4.13	4.565	4.57	4.43	**4.515**	2.92	3.485	3.3	3.065	3.145	**3.183**
DAY 54	4.035	3.66	4.89	4.715	4.56	**4.372**	3.12	3.1	2.515	2.55	2.535	**2.764**
DAY 55	3.21	3.655	4.175	4.035	4.28	**3.871**	6.675	3.04	6.675	3.335	3.13	**4.571**
DAY 56	3.29	4.135	3.765	4.2	6	**4.278**	2.86	3.11	2.51	2.49	2.86	**2.766**
DAY 57	3.16	2.695	2.65	3.585	2.715	**2.961**	3.175	2.875	2.9	2.88	2.85	**2.936**
DAY 58	2.645	2.925	3.35	2.77	3.91	**3.12**	2.64	3.135	2.895	2.86	2.815	**2.869**
DAY 59	3.51	2.53	4.37	2.665	3.09	**3.233**	2.655	2.9	2.8	2.47	2.69	**2.703**
DAY 60	2.77	3.715	2.12	3.895	3.29	**3.158**	2.38	2.92	2.725	2.905	2.96	**2.778**

VALVE	BALL						BUTTERFLY					
TEST	PST 1	PST 2	PST 3	PST 4	PST 5	AVG	PST 1	PST 2	PST 3	PST 4	PST 5	AVG
DAY 61	3.925	3.48	5.475	4.585	3.565	**4.206**	2.67	2.925	2.9	2.87	2.725	**2.818**
DAY 62	2.65	3.605	2.69	2.715	3.055	**2.983**	2.6	2.895	2.84	2.87	2.865	**2.814**
DAY 63	2.225	2.775	4.615	3.74	3.455	**3.362**	2.38	2.86	2.985	2.645	2.84	**2.742**
DAY 64	4.085	2.265	2.955	2.7	3.19	**3.039**	2.4	2.945	2.87	2.86	2.87	**2.789**
DAY 65	2.695	2.765	3.45	4.935	3.745	**3.518**	2.695	2.95	2.81	2.89	2.83	**2.835**
DAY 66	2.225	2.775	4.615	3.74	3.455	**3.362**	2.38	2.86	2.985	2.645	2.84	**2.742**
DAY 67	2.85	3.35	2.69	2.715	3.055	**2.932**	2.6	2.895	2.84	2.87	2.85	**2.811**
DAY 68	3.925	3.48	5.475	4.585	3.565	**4.206**	3.925	3.48	5.475	4.585	3.565	**4.206**
DAY 69	3.465	2.59	2.34	2.34	2.47	**2.641**	3.465	2.59	2.34	2.34	2.47	**2.641**
DAY 70	3.48	3.45	3.59	4.725	4.215	**3.892**	2.42	2.91	2.935	2.85	2.915	**2.806**
DAY 71	2.285	2.43	2.89	2.75	2.17	**2.505**	2.775	2.89	2.85	2.42	2.86	**2.759**
DAY 72	2.85	3.755	2.42	2.885	2.37	**2.856**	2.735	3.17	2.95	3.045	2.99	**2.978**
DAY 73	2.68	2.52	2.925	2.69	3.16	**2.795**	2.595	2.87	3.05	3.055	2.895	**2.893**
DAY 74	3.47	4.305	3.215	4.185	4.855	**4.006**	2.795	2.83	2.875	2.49	2.835	**2.765**
DAY 75	2.8	3.375	3.215	4.41	3.905	**3.541**	3.135	2.94	2.93	2.08	3.02	**2.821**
DAY 76	3.82	3.66	3.135	3.29	3.29	**3.439**	2.54	3.055	2.855	2.95	2.77	**2.834**
DAY 77	3.745	2.66	3.035	3.37	3.52	**3.266**	2.62	2.74	2.835	2.975	3.06	**2.846**
DAY 78	3.035	4.445	3.59	4.955	3.305	**3.866**	2.675	2.5	2.87	2.865	2.865	**2.755**
DAY 79	2.44	2.795	2.98	3.69	3.63	**3.107**	2.535	2.935	2.99	2.86	2.825	**2.829**
DAY 80	2.395	3.26	2.83	2.435	4.735	**3.131**	2.5	3.005	2.945	3.095	2.825	**2.874**
DAY 81	2.605	2.955	3.59	3.585	3.82	**3.311**	2.54	3.03	3.015	3.02	2.435	**2.808**
DAY 82	2.44	2.795	2.98	3.69	3.835	**3.148**	2.535	2.935	2.99	2.86	2.825	**2.829**
DAY 83	2.865	4.345	4.265	3.725	3.46	**3.732**	2.865	2.995	2.77	3.03	2.915	**2.915**
DAY 84	2.235	3.195	5.185	3.155	4.9	**3.734**	2.825	3	2.965	2.65	2.855	**2.859**
DAY 85	2.715	3.045	3.45	5.205	3.85	**3.653**	3.315	2.98	3.03	3.16	3.005	**3.098**
DAY 86	2.14	2.7	3.485	3.525	3.635	**3.097**	2.745	2.995	2.935	2.785	2.84	**2.86**
DAY 87	2.92	3.055	4.15	3.33	4.38	**3.567**	2.92	3.055	4.915	3.33	4.38	**3.72**
DAY 88	4.5	2.97	3.9	4.21	4.44	**4.004**	2.695	3.025	2.995	3.03	3.04	**2.957**
DAY 89	4.505	4.825	4.615	4.84	5.04	**4.765**	2.775	2.965	2.79	2.715	2.89	**2.827**
DAY 90	3.59	4.845	4.055	3.82	5.73	**4.408**	2.64	2.91	2.88	3.16	2.565	**2.831**

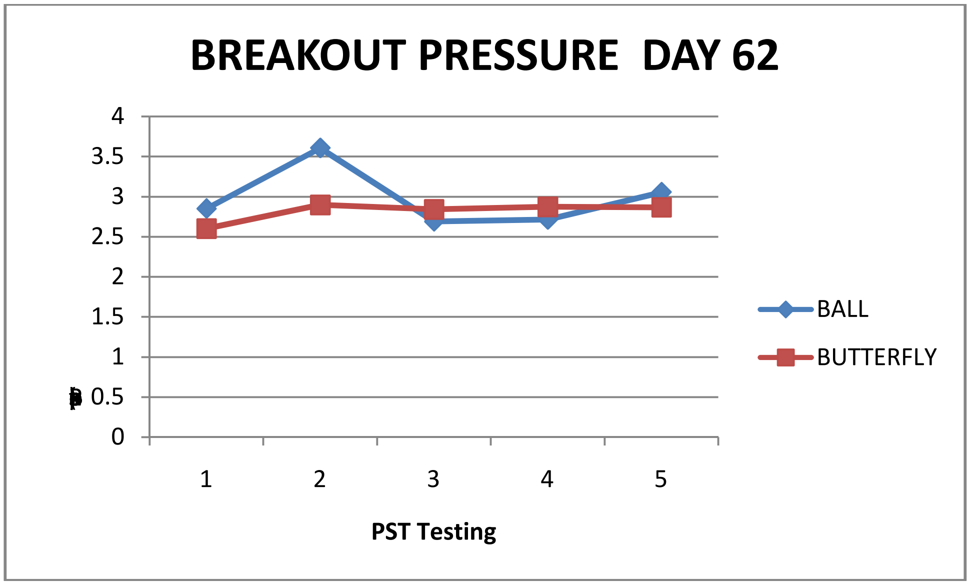

Figure 22: Breakout Pressure Day 62

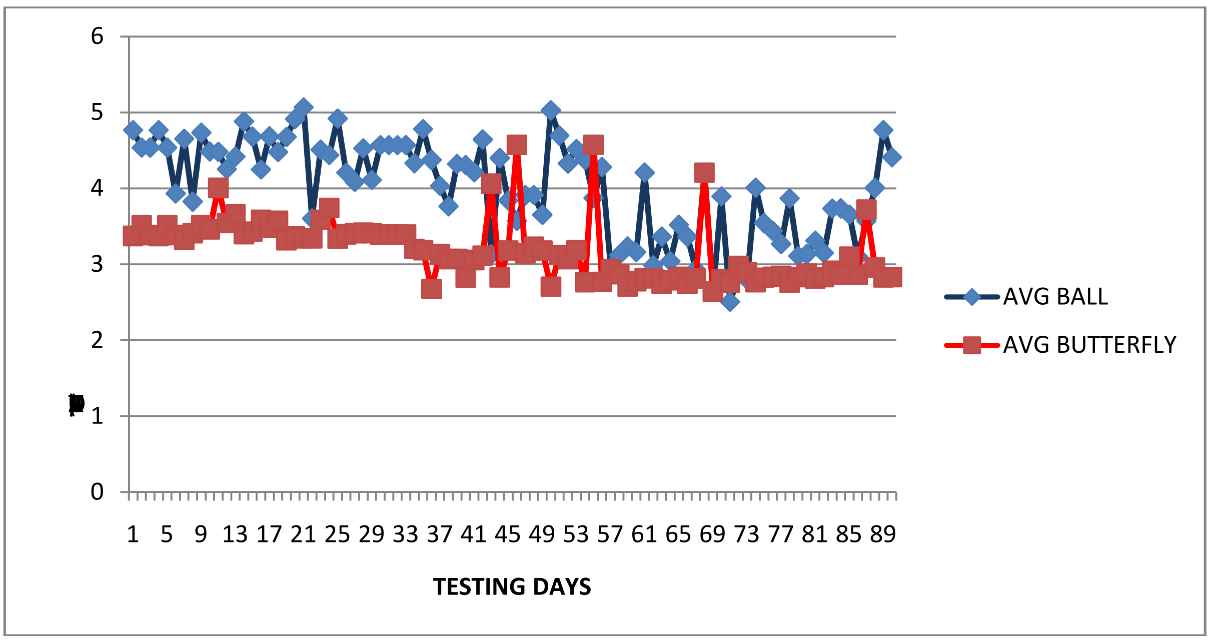

Figure 23: Average of Breakout Pressure

Table 2: Droop

VALVE	BALL						BUTTERFLY					
TEST	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**AVG**	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**AVG**
DAY 1	9.19	8.795	8.605	8.7	9.135	**8.885**	10.32	10.24	10.34	10.34	10.36	**10.32**
DAY 2	9.28	8.695	9.21	8.78	9.25	**9.043**	10.05	9.985	10.65	10.12	10.41	**10.24**
DAY 3	8.285	9.165	8.37	8.665	9.01	**8.699**	10.2	9.945	10.07	9.985	10.07	**10.05**
DAY 4	9.19	8.795	8.605	8.7	9.135	**8.885**	10.32	10.45	10.24	10.34	10.36	**10.34**
DAY 5	9.28	8.695	9.21	8.78	9.25	**9.043**	10.05	9.985	10.65	10.12	10.41	**10.24**
DAY 6	8.85	9.165	8.37	8.665	9.01	**8.812**	10.2	9.945	10.07	9.985	10.07	**10.05**
DAY 7	8.445	8.375	8.845	9.2	8.195	**8.612**	10.08	10.12	10.17	10.57	10.21	**10.23**
DAY 8	8.895	8.56	8.945	8.78	8.84	**8.804**	10.11	9.985	10.07	10.05	9.945	**10.03**
DAY 9	9.28	9.11	8.595	8.845	8.785	**8.923**	10.26	10.09	10.05	10.31	10.02	**10.14**
DAY 10	9.215	9.145	8.83	9.185	9.145	**9.104**	9.745	9.94	9.86	9.99	10.02	**9.91**
DAY 11	8.775	8.45	8.64	8.56	9.21	**8.727**	9.825	10.49	10.5	10.06	9.995	**10.17**
DAY 12	8.915	9.12	8.575	8.825	8.57	**8.801**	10	10.24	10.18	10.05	10.28	**10.15**
DAY 13	9.135	8.37	9.135	8.97	8.845	**8.891**	10.35	10.47	11.01	10.61	10.38	**10.56**
DAY 14	8.855	8.975	8.975	9.005	8.61	**8.884**	10.06	10.2	10.21	10.58	10.56	**10.32**
DAY 15	9.055	8.205	8.715	8.62	8.845	**8.688**	9.92	10.3	10.35	10.45	10.38	**10.28**
DAY 16	8.38	8.38	8.885	8.385	8.64	**8.534**	10.21	10.39	10.19	10.26	10.19	**10.25**
DAY 17	8.255	8.205	8.265	8.895	8.515	**8.427**	10.08	10.17	10.57	9.915	10.61	**10.27**
DAY 18	8.645	9.175	8.63	8.965	8.97	**8.877**	9.795	10.37	9.92	10.02	10.02	**12.48**
DAY 19	9.3	9.015	8.57	9.6	8.72	**9.041**	9.89	9.945	9.845	10.11	10.07	**9.971**
DAY 20	9.285	8.645	9	8.555	9.26	**8.946**	10.29	9.93	10.11	10.14	10.21	**10.14**
DAY 21	8.475	8.725	9.06	8.265	8.635	**8.632**	9.91	9.98	10.59	10.04	9.89	**10.08**
DAY 22	8.89	8.675	8.985	8.745	8.65	**8.789**	9.91	9.98	10.59	10.04	9.89	**10.08**
DAY 23	9.21	8.695	8.645	8.93	9.27	**8.95**	9.695	9.935	9.81	9.93	9.915	**9.857**
DAY 24	8.605	8.26	8.46	8.38	8.705	**8.482**	F	9.925	9.935	10.43	10.01	**10.17**
DAY 25	8.9	9.27	8.68	8.78	8.475	**8.821**	9.97	9.845	9.875	10.12	9.91	**9.943**
DAY 26	8.775	8.625	8.95	8.82	9.22	**8.878**	9.93	10.15	10.39	10.1	9.975	**10.11**
DAY 27	8.635	8.565	8.86	8.45	8.925	**8.687**	10.37	9.79	10.03	9.905	10.08	**10.03**
DAY 28	8.75	8.65	8.625	9.485	8.875	**8.877**	10.24	10.62	10.08	10.65	10.94	**10.5**
DAY 29	9.315	8.5	8.295	9.16	9.2	**8.894**	10.14	10.13	10.09	9.955	10.07	**10.08**
DAY 30	9.365	8.97	9.375	8.495	9.31	**9.103**	10.51	10.24	10.3	10.24	10.95	**10.45**

VALVE	BALL						BUTTERFLY					
TEST	PST 1	PST 2	PST 3	PST 4	PST 5	AVG	PST 1	PST 2	PST 3	PST 4	PST 5	AVG
DAY 31	9.365	8.97	9.375	8.495	9.31	**9.103**	10.51	10.24	10.3	10.24	10.95	**10.45**
DAY 32	8.515	9.15	9.04	9.21	8.975	**8.978**	10.17	10.31	10.37	11.02	10.53	**10.48**
DAY 33	9.365	8.97	9.375	8.495	9.31	**9.103**	10.51	10.24	10.3	10.24	10.95	**10.45**
DAY 34	9.31	9.085	8.895	8.755	8.775	**8.964**	9.92	9.87	9.765	9.91	9.94	**9.881**
DAY 35	8.845	9.025	8.745	8.77	8.615	**8.8**	10.03	10.2	10.31	10.27	10.71	**10.3**
DAY 36	9.125	8.525	8.84	8.965	8.73	**8.837**	10.55	11.18	10.57	10.51	10.57	**10.67**
DAY 37	8.46	8.445	9.135	9.495	9.06	**8.919**	9.57	10.87	10.44	10.43	10.55	**10.37**
DAY 38	9.435	8.68	9.01	8.47	8.6	**8.839**	10	10.85	10.33	10.36	10.92	**10.49**
DAY 39	8.47	8.395	9.405	9	8.615	**8.777**	9.915	10.99	10.46	10.47	10.54	**10.47**
DAY 40	9.365	8.97	9.375	8.495	9.31	**9.103**	10.51	10.24	10.3	10.24	10.95	**10.45**
DAY 41	9.1	8.72	8.515	8.645	8.835	**8.763**	9.965	10.39	10.41	10.2	10.46	**10.28**
DAY 42	8.54	8.4	8.505	8.185	9.03	**8.532**	10.32	10.55	10.2	10.3	10.42	**10.36**
DAY 43	8.695	8.92	8.39	8.415	8.4	**8.564**	10.17	10.36	11.26	10.46	10.56	**10.56**
DAY 44	8.97	8.43	8.615	8.83	8.345	**8.638**	9.965	10.43	10.62	10.68	10.46	**10.43**
DAY 45	8.92	8.51	8.785	8.215	9.275	**8.741**	9.985	10.5	10.77	10.53	10.54	**10.46**
DAY 46	8.79	8.875	9.165	8.515	9.15	**8.899**	10.65	10.91	10.65	10.4	11.21	**25.6**
DAY 47	8.705	9.09	8.785	8.75	9.215	**8.909**	9.745	10.3	10.39	10.4	10.36	**10.24**
DAY 48	8.74	8.72	9.13	8.72	8.605	**8.783**	10.44	9.99	10.06	10.33	10.31	**10.22**
DAY 49	8.755	9.115	8.775	9.405	8.85	**8.98**	9.885	10.23	10.16	10.2	10.13	**10.12**
DAY 50	8.74	9.085	8.675	8.695	8.47	**8.733**	F	14.61	14.68	14.75	14.77	**14.83**
DAY 51	9.19	9.32	8.805	8.97	8.815	**9.02**	9.945	10.14	10.21	10.04	10.17	**10.1**
DAY 52	8.86	9.005	8.915	9.34	8.7	**8.964**	10.11	10.33	10.81	10.27	10.94	**10.49**
DAY 53	8.845	9.025	8.745	8.375	8.77	**8.752**	10.03	10.2	10.31	10.27	10.71	**10.3**
DAY 54	9.125	8.525	8.84	8.965	8.73	**8.837**	10.55	11.18	10.57	10.51	10.57	**10.67**
DAY 55	8.79	8.875	9.165	9.125	9.15	**9.021**	10.65	10.91	10.65	10.4	11.21	**10.76**
DAY 56	8.345	9.13	8.56	8.565	8.71	**8.662**	9.815	10.48	15.24	14.68	16.36	**13.31**
DAY 57	11.11	11.12	11.46	11.63	11.09	**11.28**	15.1	14.85	14.86	14.15	14.61	**14.71**
DAY 58	10.75	12	10.97	11.71	11.31	**11.35**	14.64	14.85	14.64	15.83	15.79	**15.15**
DAY 59	11.87	10.89	11.48	10.87	11.63	**11.35**	15.37	14.61	14.68	14.75	14.77	**14.83**
DAY 60	10.53	10.8	10.78	10.46	10.86	**10.69**	16.12	14.87	14.84	14.66	15.54	**15.21**

VALVE	BALL						BUTTERFLY					
TEST	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**AVG**	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**AVG**
DAY 61	10.56	10.94	11.61	11.11	11.17	**11.08**	14.54	16.06	15.01	15.29	14.8	**15.14**
DAY 62	11.18	8.755	10.4	10.44	10.12	**10.18**	14.42	14.85	14.82	14.8	15.62	**14.9**
DAY 63	11	11.4	11.4	12.13	11.39	**11.46**	14.38	14.61	14.5	14.92	14.74	**14.63**
DAY 64	12.67	11.45	11.53	11.4	11.39	**11.69**	14.47	15.19	15.29	13.85	14.56	**14.67**
DAY 65	11.44	11.11	11.15	11.69	11.2	**11.32**	14.64	14.59	14.98	14.14	14.41	**14.55**
DAY 66	11	11.4	11.4	12.13	11.39	**11.46**	14.38	14.61	14.5	14.92	14.74	**14.63**
DAY 67	11.18	10.97	10.4	10.44	10.12	**10.62**	14.42	14.85	14.82	14.8	15.62	**14.9**
DAY 68	10.56	10.94	11.65	11.11	11.17	**11.08**	14.54	16.06	15.01	15.29	14.8	**15.14**
DAY 69	11.24	11.49	11.72	11.49	12.25	**11.64**	14.29	14.11	15.11	15.15	14.69	**14.67**
DAY 70	11.52	11.52	11.09	11.31	11.43	**11.37**	14.13	14.76	14.45	14.55	14.14	**14.4**
DAY 71	11.18	11.03	11.56	11.37	11.82	**11.39**	14.37	14.59	13.8	14.71	14.85	**14.46**
DAY 72	12.04	11.44	11.55	11.19	12.87	**11.82**	15.71	14.85	13.91	15.65	14.35	**14.89**
DAY 73	12.04	11.44	11.55	11.19	12.87	**11.82**	15.71	14.85	13.91	15.65	14.35	**14.89**
DAY 74	11.89	11.23	11.25	11.21	11.86	**11.49**	15.28	14.63	14.03	13.79	14.41	**14.43**
DAY 75	10.61	11.04	11.16	10.56	11.22	**10.92**	15.75	14.05	14.58	14.84	14.33	**14.71**
DAY 76	11.2	11.27	11.38	11.82	11.02	**11.33**	16.25	14.18	2.825	13.8	14.57	**12.32**
DAY 77	11.87	11.73	11.64	11.11	11.03	**11.48**	14.41	15.21	15	14.87	14.25	**14.75**
DAY 78	11.3	10.78	11.26	10.95	10.57	**10.97**	14.59	15.19	13.84	14.06	15.46	**14.63**
DAY 79	11.92	11.7	11.46	11.33	11.51	**11.58**	15.93	14.16	15.22	15.04	15.38	**15.14**
DAY 80	11.74	11.95	11.73	11.18	11.49	**11.61**	14.03	14.6	13.66	15.88	14.59	**14.55**
DAY 81	11.84	11.25	11.59	11.43	11.6	**11.54**	14.5	15.57	13.91	14.82	14.4	**14.64**
DAY 82	11.46	11.59	11.47	12.24	11.81	**11.71**	15.24	14.57	15.56	16.31	14.36	**15.2**
DAY 83	11.37	10.98	11.71	11.78	11.14	**11.39**	14.08	15.17	14.63	14.54	14.15	**14.51**
DAY 84	11.84	11.62	11.6	12.82	12.24	**12.02**	15.31	16.01	15.35	14.56	14.97	**15.24**
DAY 85	11.26	11.47	11.7	11.18	11.86	**11.49**	14.25	15.76	15.26	15.17	15.92	**15.27**
DAY 86	11.63	12.1	12.18	11.53	11.76	**11.84**	14.93	14.58	14.43	14.46	14.27	**14.53**
DAY 87	11.31	11.84	11.9	11.07	11.5	**11.52**	15.9	14.61	14.06	15.68	14.97	**15.04**
DAY 88	12.08	11.48	11.42	11.83	11.05	**11.57**	14.96	14.62	14.82	13.97	14.54	**14.58**
DAY 89	11.31	11.79	11.39	11.35	11.49	**11.47**	14.85	15.19	13.95	14.12	13.92	**14.4**
DAY 90	11.3	12.33	14.65	11.46	11.68	**12.28**	15.08	15.31	15.85	16.28	15.25	**15.55**

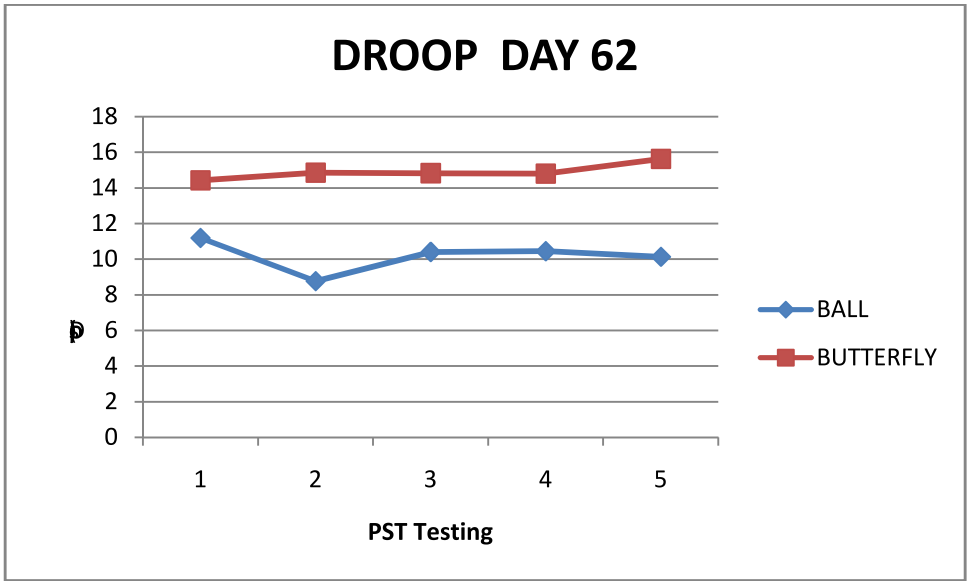

Figure 24: Droop Day 62

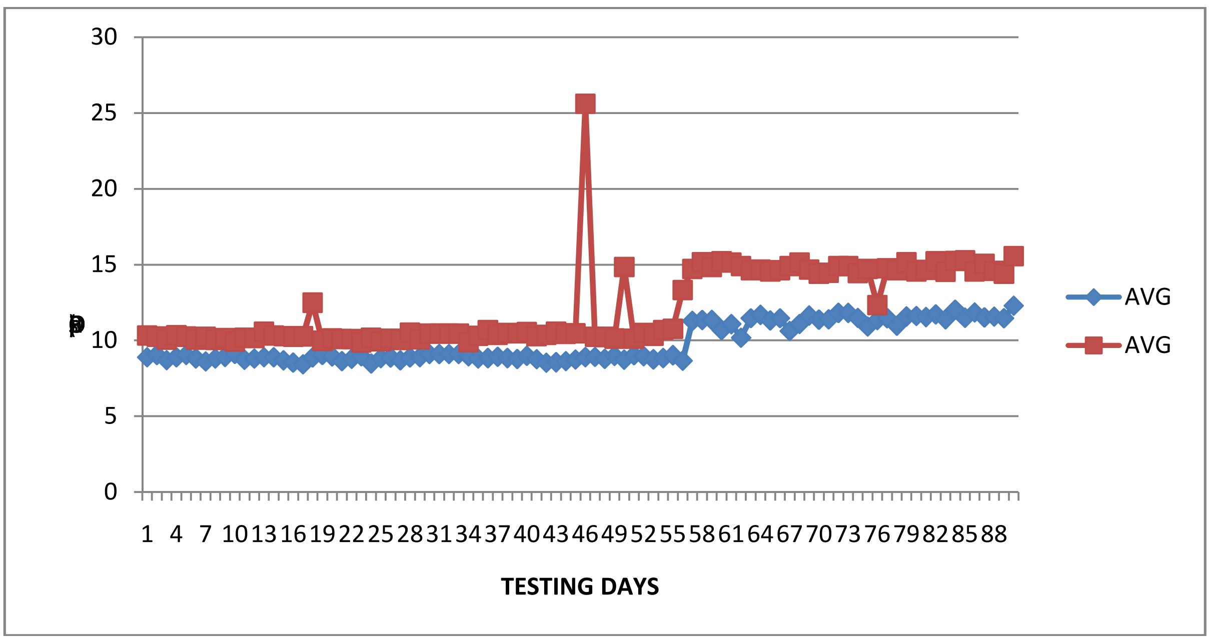

Figure 25: Average Droop

Table 3: Friction

VALVE	BALL						BUTTERFLY					
TEST	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**AVG**	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**AVG**
DAY 1	3.425	3.745	3.27	3.62	3.755	**3.563**	3.24	3.24	3.425	3.265	3.335	**3.301**
DAY 2	3.615	3.95	3.515	3.615	3.745	**3.688**	3.19	3.335	3.42	3.255	3.31	**3.302**
DAY 3	3.675	3.795	3.77	3.49	3.785	**3.703**	3.25	3.405	3.25	3.32	3.335	**3.312**
DAY 4	3.425	3.745	3.27	3.62	3.755	**3.563**	3.24	3.24	3.425	3.265	3.335	**3.301**
DAY 5	3.615	3.925	3.515	3.615	3.745	**3.683**	3.19	3.335	3.42	3.255	3.31	**3.302**
DAY 6	3.675	3.795	3.77	3.49	3.785	**3.703**	3.25	3.405	3.25	3.32	3.335	**3.312**
DAY 7	3.535	3.79	3.38	3.885	4.055	**3.729**	3.39	3.27	3.38	3.2	3.285	**3.305**
DAY 8	3.605	3.855	3.5	3.62	3.78	**3.672**	3.395	3.205	3.265	3.32	3.35	**3.307**
DAY 9	3.595	3.745	3.97	3.87	4.045	**3.845**	3.41	3.155	3.25	3.275	3.295	**3.277**
DAY 10	3.625	3.73	3.785	3.815	3.835	**3.758**	3.435	3.215	3.295	3.325	3.285	**3.311**
DAY 11	3.44	3.91	3.805	4.03	4	**3.837**	3.225	3.305	3.32	3.32	3.27	**3.288**
DAY 12	3.695	3.72	3.855	3.81	3.8	**3.776**	3.565	3.28	3.355	3.35	3.395	**3.389**
DAY 13	3.435	3.695	3.715	3.81	3.965	**3.724**	3.415	3.28	3.31	3.365	3.4	**3.354**
DAY 14	3.61	3.71	3.755	3.81	3.885	**3.754**	3.475	3.23	3.27	3.345	3.38	**3.34**
DAY 15	3.34	3.78	3.895	3.95	3.99	**3.791**	3.395	3.215	3.29	3.325	3.365	**3.318**
DAY 16	3.495	3.865	3.91	4.005	4.125	**3.88**	3.45	3.195	3.325	3.295	3.35	**3.323**
DAY 17	3.53	3.89	3.855	4.085	4.13	**3.898**	3.415	3.185	3.25	3.29	3.345	**3.297**
DAY 18	3.465	3.715	3.7	3.82	3.795	**3.699**	3.475	3.185	3.255	3.28	3.325	**3.304**
DAY 19	3.5	3.86	3.85	3.86	3.92	**3.798**	3.465	3.25	3.32	3.375	3.41	**3.364**
DAY 20	3.615	3.8	3.83	3.86	3.88	**3.797**	3.445	3.2	3.285	3.36	3.425	**3.343**
DAY 21	3.435	3.69	3.875	3.845	3.835	**3.736**	3.21	3.55	3.355	3.36	3.41	**3.377**
DAY 22	3.49	3.8	3.89	3.93	3.975	**3.817**	3.21	3.35	3.355	3.36	3.41	**3.337**
DAY 23	3.5	3.865	3.84	3.865	3.98	**3.81**	3.205	3.3	3.28	3.315	3.335	**3.287**
DAY 24	3.72	3.82	3.72	3.955	3.91	**3.825**	F	3.34	3.385	3.475	3.445	**3.448**
DAY 25	3.405	3.775	3.865	4.11	4.095	**3.85**	3.48	3.3	3.345	3.395	3.455	**3.395**
DAY 26	3.505	3.92	3.965	4.085	4.01	**3.897**	3.515	3.3	3.345	3.425	3.44	**3.405**
DAY 27	3.3	3.81	3.895	4.015	4.12	**3.828**	3.485	3.28	3.325	3.415	3.44	**3.389**
DAY 28	3.555	3.76	3.89	3.92	3.925	**3.81**	3.495	3.325	3.35	3.415	3.4	**3.397**
DAY 29	3.405	3.63	3.84	3.885	3.925	**3.737**	3.495	3.29	3.39	3.42	3.47	**3.413**
DAY 30	3.5	3.755	3.83	4.075	4.095	**3.851**	3.39	3.295	3.34	3.385	3.42	**3.366**

VALVE	BALL						BUTTERFLY					
TEST	PST 1	PST 2	PST 3	PST 4	PST 5	AVG	PST 1	PST 2	PST 3	PST 4	PST 5	AVG
DAY 31	3.5	3.755	3.83	4.075	4.095	**3.851**	3.39	3.295	3.34	3.385	3.42	**3.366**
DAY 32	3.375	3.59	3.77	3.785	3.925	**3.689**	3.475	3.31	3.315	3.415	3.48	**3.399**
DAY 33	3.5	3.755	3.83	4.075	4.095	**3.851**	3.39	3.295	3.34	3.385	3.42	**3.366**
DAY 34	3.535	3.68	3.825	3.835	3.84	**3.743**	3.45	3.34	3.33	3.385	3.4	**3.381**
DAY 35	3.445	3.73	3.865	3.99	3.9	**3.786**	3.465	3.315	3.37	3.455	3.47	**3.415**
DAY 36	3.375	3.79	3.775	3.985	3.92	**3.769**	3.42	3.305	3.39	3.425	3.425	**3.393**
DAY 37	3.285	3.515	3.7	3.725	3.84	**3.613**	3.515	3.27	3.32	3.36	3.415	**3.376**
DAY 38	3.145	3.425	3.655	3.73	3.855	**3.562**	3.52	3.31	3.33	3.41	3.385	**3.391**
DAY 39	3.075	3.47	3.565	3.705	3.81	**3.525**	3.485	3.27	3.33	3.36	3.425	**3.374**
DAY 40	3.5	3.755	3.83	4.075	4.095	**3.851**	3.39	3.295	3.34	3.385	3.42	**3.366**
DAY 41	3.355	3.665	3.935	4.03	4.115	**3.82**	3.52	3.3	3.345	3.315	3.455	**3.387**
DAY 42	3.34	3.69	3.77	3.89	3.965	**3.731**	3.52	3.36	3.37	3.39	3.435	**3.415**
DAY 43	3.455	3.305	3.365	3.375	3.41	**3.382**	3.465	3.77	3.98	4.01	4.06	**3.857**
DAY 44	3.495	3.705	3.97	3.93	4.03	**3.826**	3.535	3.345	3.375	3.375	3.415	**3.409**
DAY 45	3.41	3.745	3.875	3.845	3.98	**3.771**	3.535	3.34	3.38	3.38	3.435	**3.414**
DAY 46	3.315	3.82	3.98	3.98	4.06	**3.831**	1.945	3.41	1.945	3.47	3.505	**2.855**
DAY 47	3.18	3.45	3.46	3.545	3.57	**3.441**	3.255	3.43	3.69	3.55	3.78	**3.541**
DAY 48	3.255	3.43	3.69	3.55	3.78	**3.541**	3.26	3.285	3.365	3.36	3.415	**3.337**
DAY 49	3.17	3.415	3.62	3.73	3.585	**3.504**	3.545	3.36	3.41	3.445	3.455	**3.443**
DAY 50	3.01	3.18	3.235	3.315	3.41	**3.23**	F	3.29	3.295	3.295	3.315	**3.299**
DAY 51	3.235	3.615	3.69	3.815	3.87	**3.645**	3.535	3.34	3.39	3.42	3.425	**3.422**
DAY 52	3.195	3.595	3.82	3.74	3.815	**3.633**	3.53	3.34	3.395	3.44	3.475	**3.436**
DAY 53	3.445	3.73	3.9	3.99	3.9	**3.793**	3.465	3.315	3.37	3.455	3.47	**3.415**
DAY 54	3.375	3.79	3.775	3.985	3.92	**3.769**	3.42	3.305	3.39	3.425	3.425	**3.393**
DAY 55	3.315	3.82	3.98	3.375	4.06	**3.71**	1.945	3.41	1.945	3.47	3.505	**2.855**
DAY 56	3.115	3.33	3.62	3.525	3.55	**3.428**	3.6	3.405	3.265	3.255	3.27	**3.359**
DAY 57	3.085	3.325	3.505	3.35	3.54	**3.361**	3.37	3.325	3.305	3.325	3.345	**3.334**
DAY 58	3.17	3.39	3.55	3.665	3.64	**3.483**	3.285	3.245	3.285	3.31	3.32	**3.289**
DAY 59	2.855	3.245	3.36	3.455	3.525	**3.288**	3.415	3.34	3.345	3.325	3.365	**3.358**
DAY 60	2.98	3.23	3.39	3.33	3.535	**3.293**	3.335	3.28	3.3	3.3	3.31	**3.305**

VALVE	BALL						BUTTERFLY					
TEST	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**AVG**	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**AVG**
DAY 61	3.225	3.38	3.425	3.505	3.62	**3.431**	3.36	3.295	3.305	3.32	3.335	**3.323**
DAY 62	3.01	3.18	3.235	3.315	3.41	**3.23**	3.34	3.29	3.295	3.295	3.315	**3.307**
DAY 63	3.015	3.315	3.345	3.41	3.525	**3.322**	3.33	3.285	3.305	3.335	3.355	**3.322**
DAY 64	2.86	3.23	3.16	3.47	3.355	**3.215**	3.225	3.225	3.32	3.275	3.335	**3.276**
DAY 65	2.92	3.1	3.325	3.36	3.535	**3.248**	3.41	3.36	3.355	3.35	3.35	**3.365**
DAY 66	3.015	3.315	3.345	3.41	3.525	**3.322**	3.33	3.285	3.305	3.335	3.355	**3.322**
DAY 67	3.01	3.225	3.235	3.315	3.41	**3.239**	3.34	3.29	3.295	3.295	3.315	**3.307**
DAY 68	3.225	3.38	3.425	3.505	3.62	**3.431**	3.36	3.295	3.305	3.32	3.335	**3.323**
DAY 69	2.835	3.175	3.365	3.38	3.335	**3.218**	3.38	2.865	3.3	3.315	3.345	**3.241**
DAY 70	2.77	3.11	3.315	3.34	3.32	**3.171**	3.285	3.27	3.295	3.325	3.31	**3.297**
DAY 71	2.905	3.175	3.185	3.37	3.435	**3.214**	3.385	3.285	3.3	3.295	3.295	**3.312**
DAY 72	3.01	3.265	3.475	3.51	3.645	**3.381**	3.505	3.43	3.47	3.45	3.47	**3.465**
DAY 73	3.18	3.515	3.495	3.605	3.6	**3.479**	3.435	3.335	3.34	3.345	3.345	**3.36**
DAY 74	2.865	3.3	3.4	3.515	3.72	**3.36**	3.415	3.34	3.34	3.35	3.365	**3.362**
DAY 75	2.885	3.065	3.42	3.47	3.535	**3.275**	3.4	3.335	3.355	3.355	3.4	**3.369**
DAY 76	3.04	3.495	3.705	3.63	3.585	**3.491**	3.39	3.315	3.315	3.33	3.37	**3.344**
DAY 77	2.92	3.255	3.24	3.395	3.505	**3.263**	3.455	3.315	3.325	3.335	3.345	**3.355**
DAY 78	3.53	3.72	3.85	3.855	3.865	**3.764**	3.36	3.31	3.3	3.325	3.345	**3.328**
DAY 79	2.855	3.23	3.47	3.485	2.935	**3.195**	3.42	3.34	3.33	3.355	3.35	**3.359**
DAY 80	2.885	3.09	3.385	3.5	3.38	**3.248**	3.31	3.255	3.27	3.29	3.305	**3.286**
DAY 81	3.025	3.56	3.765	3.97	3.94	**3.652**	3.335	3.24	3.255	3.3	3.35	**3.296**
DAY 82	2.93	3.215	3.305	3.475	3.63	**3.311**	3.405	3.33	3.33	3.33	3.38	**3.355**
DAY 83	3.085	3.515	3.765	3.85	4.055	**3.654**	3.52	3.44	3.45	3.44	3.46	**3.462**
DAY 84	3.455	3.645	3.7	3.96	3.7	**3.692**	3.445	3.36	3.34	3.38	3.37	**3.379**
DAY 85	3.095	3.37	3.455	3.555	3.775	**3.45**	3.53	3.545	3.54	3.515	3.545	**3.535**
DAY 86	2.99	3.4	3.53	3.63	3.64	**3.438**	3.495	3.37	3.385	3.395	3.405	**3.41**
DAY 87	3.025	3.46	3.35	3.57	3.615	**3.404**	3.385	3.33	3.34	3.37	3.36	**3.357**
DAY 88	3.29	3.64	3.8	3.83	3.84	**3.68**	3.5	3.39	3.41	3.4	3.44	**3.428**
DAY 89	3.4	3.615	3.65	3.69	3.755	**3.622**	3.48	3.37	3.395	3.405	3.395	**3.409**
DAY 90	3.165	3.605	3.775	3.91	3.835	**3.658**	3.47	3.35	3.365	3.355	3.395	**3.387**

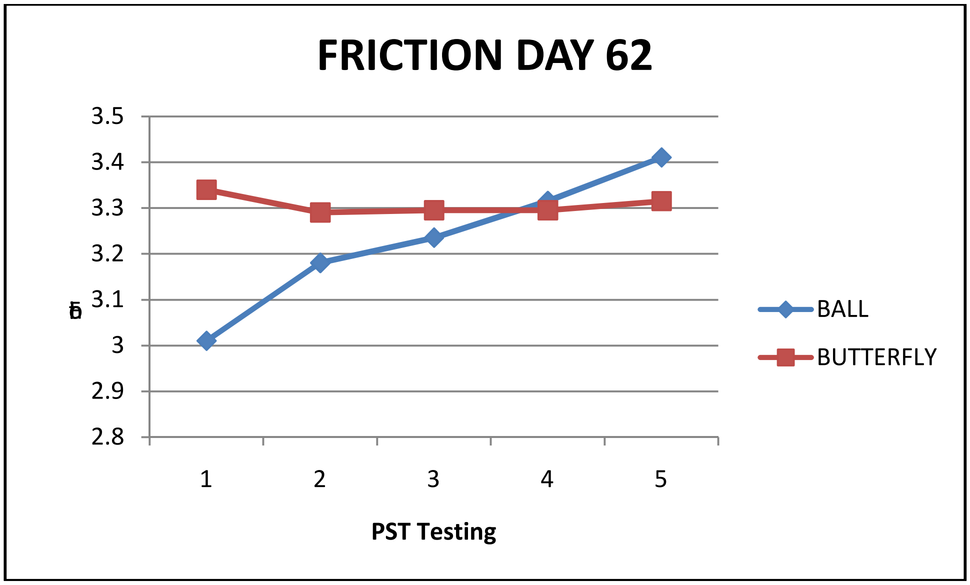

Figure 26: Friction Day 62

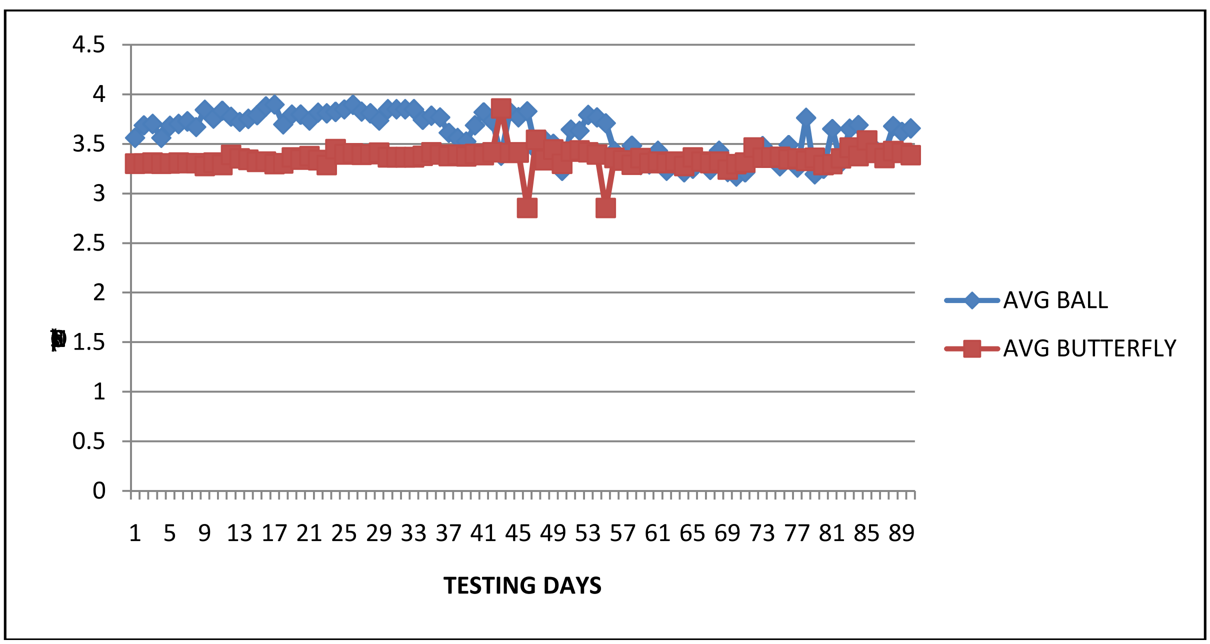

Figure 27: Average Friction

Table 4: PST and FST Failures

VALVE	BALL						BUTTERFLY					
TEST	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**FST**	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**FST**
DAY 1												
DAY 2												
DAY 3												
DAY 4												
DAY 5												
DAY 6												
DAY 7												
DAY 8												
DAY 9												
DAY 10												
DAY 11												
DAY 12												
DAY 13												
DAY 14												
DAY 15												
DAY 16												
DAY 17												
DAY 18												
DAY 19												
DAY 20												
DAY 21												
DAY 22												
DAY 23												
DAY 24							**X**					
DAY 25												
DAY 26												
DAY 27												
DAY 28												
DAY 29												
DAY 30												

VALVE	BALL						BUTTERFLY					
TEST	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**FST**	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**FST**
DAY 31												
DAY 32												
DAY 33												
DAY 34												
DAY 35												
DAY 36												
DAY 37												
DAY 38												
DAY 39												
DAY 40												
DAY 41												
DAY 42						**X**						**X**
DAY 43												
DAY 44												
DAY 45												
DAY 46												
DAY 47												
DAY 48												
DAY 49												
DAY 50							**X**					
DAY 51												
DAY 52												
DAY 53												
DAY 54												
DAY 55												
DAY 56												
DAY 57												
DAY 58												
DAY 59												
DAY 60												

VALVE	BALL						BUTTERFLY					
TEST	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**FST**	**PST 1**	**PST 2**	**PST 3**	**PST 4**	**PST 5**	**FST**
DAY 61												
DAY 62												
DAY 63												
DAY 64												
DAY 65												
DAY 66												
DAY 67												
DAY 68												
DAY 69												
DAY 70						**X**						
DAY 71												
DAY 72												
DAY 73												
DAY 74												
DAY 75												
DAY 76												
DAY 77												
DAY 78												
DAY 79												
DAY 80												
DAY 81												
DAY 82												
DAY 83												
DAY 84												
DAY 85												
DAY 86												
DAY 87												
DAY 88												
DAY 89												
DAY 90												

4.1.1 Discussion and data analysis

From the data and results in day 62, the Partial Stroke Test (PST) and Full Stroke Test (FST) are successfully conducted in well mannered condition. The results obtained indicate that there are no major errors and mistakes ha ve happened during the testing. All the data for 90 days have been collected and analyzed for documenting purpose in future. For PST, the valve travelling is set to 20% closing. The air supplied pressure always in between 55 psi to 65psi.

4.1.1.1 Ball Valve Testing

The valve performance is good since managed to give expected results from the testing. From the results for Ball valve, all the PST parameters results give the constant good performance such as Breakout Pressure, Friction, PST Passed Flag and Droop. The Droop performance sometimes produced 'Failed' indication since the pressure given is exceeding the value setting. But, that is not the major problem since the PST still successfully done even the Droop is in 'Failed' mode. Besides, the Ball valve also operates in the limit under the Response Time and Spring Range. The graph also gives a precise indication of the smoothness of the PST travelling which shows the valve's position versus pressure force d. The smoothness of the movement is shown by the graph line. The more straight the graph, the more smoothness it is. If the valve has movement problem, the graph will not produce the straight line. For the FST testing, it is also successfully tested. Most of the time, the Ball valve managed to perform the Full Stroke Test (FST) in each testing day. The Ball valve managed to do the 'Tripped' operation when the signal is forced by tripping the system and do not 'Shutdown' the system. The valve is still commu nicating with the workstation even though the valve is completely closed. During this time, the ESD SVI II is doing the diagnostics. To perform the 'Tripped' condition, the signal applied must be not much enough to perform the 'Shutdown' condition, so the 'Tripped' condition can be performed on demand basis. For example, the valve is using analogue 4 -20mA signal to do the operation. For 'Shutdown' operation, lowest signal is applied, 4mA and to energize the valve, maximum signal, 20mA is used. For 'Tripped ' condition, the signal applied is only about 6mA. If the device is tripped, in Normal, Manual and Setup modes, the set point and the control mode are not affected by the device trip, and as soon as the trip condition is removed, the valve goes back to the state prior to the trip.

4.1.1.2 Butterfly Valve Testing

The Butterfly is also giving the good and expected result. It managed to completely passing successfully the parameters testing such as Droop, Breakout Pressure, Friction, Spring Range and Response Time. All the conditions are in under control mode and rarely giving unwanted results. For PST, sometimes the Droop is out of the limit but since it is not affected the PST testing, it can be tolerated. The graph also showing that the movement of the Butterfly valve is smooth without having problems during the PST testing in running mode. For FST, the ESD SVI II no diagnostics performed since the application is applicable for the Ball valve only. So it has to shutdown the system for FST test. For Butterfly valve, it uses the digital signal which only operate in ‘0’ Volt or ‘24’ Volt. There is no such thing to operate in the middle of the High and Low range of signal.

4.1.1.3 Breakout Pressure Data

The breakout pressure data is the pressure that is supplied by the regulator to initiate the movement of the valve from its initial condition. We can say that the pressure is the force that generated to move the valve from sticking condition for implementing the PST testing. Besides, it can be considered as the alarm threshold for valve breakout force (force to initiate valve movement). This alarm is set if the analyzed friction from the PST test is more than this value. Basically, in this PST testing it involves five (5) times of PST testing and one (1) FST testing daily. For every single PST testing, it has different value of Breakout Pressure Data obtained. The every single data shows that the pressure used to move the valve on that particular testing and all the data are collected and analyzed in order to find whether the pressure is exceed the required limit as being set before. For this breakout pressure data range, it is just between the 2.5psi to 5.0psi for overall data collected. We can refer the data from the Table 1 and the graph from the Figure 23 which shows the collected data for both Ball and Butterfly valves.

The data for Figure 23 shows the graph for Average Breakout Pressure for both valves. Basically the breakout pressure for Ball valve is slightly higher than the breakout pressure for the Butterfly valve since the measurement of physical features for the Ball valve is bigger compared to the Butterfly valve. There is no problems regarding the breakout pressure since the data collected is in a good shape and meet the requirement set and it is also verified by the 'Green Passed' parameter indicator during the PST testing is being conducted. The consumption of pressure for these two valves is differed from each other. The Butterfly valve is using smaller amount of pressure compared to the Ball valve.

4.1.1.4 Droop Data

The droop data is showing the alarm threshold for air supply inlet droop. This alarm is set if the analyzed Air Supply Droop from the PST test is more than this value, indicating a possible clogged up air filter in the air set or lack of volume feeding the SVI II ESD [7]. The data of the droop shows the exhaustion of the air supply after the PST SVI II Device is completing the PST testing. The droop for every single PST is different from each other and it is also different for both valves. The droop limit for Ball valve is set at 10psi compared to Butterfly valve which is 15psi. The data obtained for every testing is tabulated in Table 2 and for the graph it is on the Figure 25. The graph shows the average droop for the Ball valve and the Butterfly valve for every day. From the graph it shows that the droop for the Butterfly valve is higher than the Ball valve and also the plotted graph shows that the data for each valve is almost constant for each testing. Due to the limit of the droop set, the Ball valve droop is always exceeded the limit. The data obtained always slightly higher than the limit of 10. Most of the time, the indicator will result that the droop for Ball valve is in failure mode. However, the failure of the droop is not effecting the PST testing since the PST testing is still successfully been conducted. Only for the droop parameter for the Ball valve is fail to meet the requirement. Meanwhile, for the Butterfly vale, there is no problem regarding the droop failure since the output results showing that the droop is under the limit set.

4.1.1.5 Friction Data

The data collected in the Table 3 shows that the friction that appeared during the testing period from Day 1 to Day 90. The readings of the results are obtained from every single testing that conducted. Basically the friction values are different between B all valve and Butterfly valve since it is influenced and depends on the surface that being contacted. Since the Ball valve has the much bigger area contact, then it produces a slight higher of friction compare to the Butterfly valve. It is also due to the mechanism of movement of the valve actually. The Butterfly valve just move using the actuator that attached to the valve and it consume very little amount of contact area that exposed to friction. Compare to Ball valve, it uses the whole outside ball area to be contacted as friction. The importance of getting friction data is because to indicate the smoothness of the valve's movement. It is very important in operation since it will determine whether the valve is in slow motion or fast motion. In addition, it will help the operation team to determine the pressure used to move the valves and to indicate the capability of the valves to perform the operation, PST and FST.

4.1.1.6 PST and FST Failures Data

The data in Table 4 shows the overall PST and FST failures during the testing from day 1 to day 90. The data is collected from the daily testing in the lab which is determined by the software used, Outlook ESD Valvue. The result of the testing of PST and FST are shown after the testing is being conducted. Basically the output of the testing result will show the testing is successfully conducted. From the data collected, we can conclude that most of the time the PST and FST testing are successfully tested and meet the requirem ent which has been set before. For the performance overview, the PST for the Ball valve does not have any problem during the daily testing period. It means that the valve is managed to perform the PST testing successfully without having problems such as st icking at initial place even though the signal has been given. Compared to the Butterfly valve, the PST of the valve is having a double failure for PST number 1 in day 24 and day 50 of the testing. However the rest of the PST testing on the same day and on that particular period is successfully tested.

For the FST testing mode, for Ball valve it cause a problem during the both day 42 and day 70 while for the Butterfly valve it failed to perform the operation for FST on day 70. The unable to perform the operation can be seen from the movement of the valve itself. The valve sometimes cannot even make a slight move even though the signal has been given. However the problem is rare to happen. The failures on that time maybe due to the lack of signal communication between the output devices and the engineering workstation controller. The problem can be fixed by implementing the more stable communication system between the both devices.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As the conclusion, the Partial Stroke Test (PST) is the best way to measure and indicate the characteristics of the valves. By implementing the PST, there are many types of testing parameters and features that can be verified in order to understand more on the valves performances. For this project, the testing has successfully finished until day 90. The testing never faced any major problems such as instrument damaged, or unsolved PLC problem. The only minor problem which always happened is no stable communication between bot h input and output valves. The data and results are really satisfying for analyzing purpose since i t shows the real results that needed. The analyzing is really important since to determine the efficiency and verify the ability of the valves when conductin g the Partial Stroking operation for Emergency Shutdown (ESD) system.

5.2 Recommendation

For recommendation purpose, there should has an interface to show the FST result for both Ball and Butterfly valves from the Valvue ESD software. Due to that interface, the outcome will be looked more reliable and dependable. For the next phase purpose, the factors to be considered for modification of testing are listed as below:

- Packing Friction
- Liquid Test
- Air Pressure
- Load Performance

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APPENDIX I

LADDER PROGRAMMING FOR MASONEILAN
BALL VALVE
BUTTERFLY VALVE

APPENDIX II

ENGINEERING DRAWING LAYOUT
MASONEILAN VALVES

APPENDIX III

KEY MILESTONE
FINAL YEAR PROJECT

Milestone for the Second Semester of 2 Semester Final Year Project

No	Detail/ Week	1	2	3	4	5	6	7	8	9		10	11	12	13	14
1	Project Work Continue	■	■	■	■	■	■	■	■		MID-TERM BREAK					
2	Submission of Progress Report 1								●							
3	Project Work Continue								■	■						
4	Seminar (Compulsary)									■		■	■			
5	Project Work Continue								■	■		■	■			
6	Poster Exhibiton											●				
7	Submission of Dissertation (Soft bound)													●		
8	Oral Presentation														●	
9	Submission of Project Dissertation (Hard bound)															●

Final Year Semester 2 Schedule