

**PARTIAL STROKE TEST (PST) OF
ROTORK EMERGENCY SHUTDOWN VALVE:
ANALYSIS AND DESIGN SIMULATION**

By

AMINUDDIN BIN AZMAN

DISSERTATION REPORT

Submitted to the Electrical & Electronics Engineering Program
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

© Copyright 2010

by

Aminuddin Bin Azman, 2010

CERTIFICATION OF APPROVAL

PARTIAL STROKE TEST (PST) OF ROTORK EMERGENCY SHUTDOWN VALVE: ANALYSIS AND DESIGN SIMULATION

by

Aminuddin Bin Azman

A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Approved:

Assoc. Prof. Dr. Nordin Bin Saad
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

December 2010

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.

(AMINUDDIN BIN AZMAN)

ABSTRACT

This report essentially discusses the basic understanding to comprehend the technology of Partial Stroke Testing (PST) of Emergency Shutdown (ESD) Valve and how it is conducted and analyzed. In general, this project deals with Yokogawa FA-M3 Controller and the FISHER, METSO, MASONEILAN and ROTORK rotary shutdown valves. The objective of the project is to perform PST to the valve and the result will be compared and verified within the other vendors. This report also explained the procedure for executing PST to the respective valve together with their components and the basic of Programmable Logic Control (PLC). In addition, the steps taken during designing plant to include flowing medium also been explained. The list of tools and equipments needed to execute the project is also available in this project. Throughout this project, author had given opportunities to share ideas with engineers from PETRONAS.GTS SKG14 for comparison of performance of various valves use in PETRONAS plants. The outcomes of this project are finalized test procedure using MASONEILAN system and verified design of plant including realistic flowing medium. These outcomes would be very useful for the PETRONAS to adopt PST strategy in their plant nationwide.

ACKNOWLEDGEMENTS

All praise to Allah the Almighty, who has helped and gave me the courage and strength to complete the dissertation report of Final Year Project II. With His Grace and Mercy, this endeavor is now a success.

My appreciation to Universiti Teknologi PETRONAS for counting me in as a student of Electrical and Electronic Engineering Departments and providing me all the necessary assets and resources, not only to accomplish my tasks, but to enrich my character and knowledge further.

My utmost appreciation and gratitude is also extended to my Supervisor, Associate Professor Dr Nordin Bin Saad for his guidance and endless support throughout the Final Year Project II. Without his assistance and advice, I would not reach this far. My gratitude also goes toward Mr. Azhar, Lab Technician who had helped me a lot through the entire period of this project and Ms. Haryattie (R&T/PETH) for her contribution on the completion of this project.

A token of appreciation also includes all colleagues for the support and kindness in providing such a great study environment. Many thanks to my family back home for their sacrifices coupled with their continuous encouragement and support and heading me towards the stars.

Last but not least, special thanks to everybody who were directly or indirectly involved in contributing to the successful completion of my course in Final Year Project II.

TABLE OF CONTENTS

LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF ABBREVIATIONS	xi
CHAPTER 1: INTRODUCTION	1
1.1 Background of Study.....	1
1.2 Problem Statement.....	1
1.3 Objective and Scope of Study.....	2
CHAPTER 2: LITERATURE REVIEW	3
2.1 Emergency Shutdown (ESD) Valve.....	3
2.1.1 <i>Ball Valve</i>	3
2.1.2 <i>Butterfly Valve</i>	4
2.2 Full Stroke Testing (FST).....	4
2.3 Partial Stroke Testing (PST).....	5
2.4 Programmable Logic Controller (PLC).....	5
2.5 Safety Integrity Level (SIL).....	7
2.6 ROTORK Emergency Shutdown (ESD) Valve....	9
2.6.1 <i>Smart Valve Monitoring</i>	9
2.6.2 <i>Analysis Software</i>	10
CHAPTER 3: METHODOLOGY	11
3.1 Procedure Identification.....	11
3.2 Tools and Equipments.....	12
3.2.1 <i>Hardware</i>	12
3.2.2 <i>Software</i>	13
3.3 Hardware Setup.....	14

CHAPTER 4: RESULTS AND DISCUSSION	15
4.1 Study on Simulation Software.....	15
4.2 Designing Small Plant.....	16
4.3 Simulate the Designed Small Plant.....	17
4.3.1 <i>Full Schematic of Designed Plant</i>	19
4.3.2 <i>Capacity of Water in the Tank</i>	20
4.3.3 <i>Analyzing a CV (Flow)</i>	21
4.4 Solution for Velocity Drop.....	22
4.4 Demonstration on Partial Stroke Testing (PST)....	22
CHAPTER 5: CONCLUSION AND	
RECOMMENDATIONS	23
5.1 Conclusion.....	23
5.2 Recommendations.....	24
REFERENCES	25
APPENDICES	26
APPENDIX A DESIGN PROCESS (I)	27
APPENDIX B DESIGN PROCESS (II)	28
APPENDIX C DESIGNED SMALL PLANT	29
APPENDIX D PROCEDURES OF PST (I)	30
APPENDIX E PROCEDURES OF PST (II)	31
APPENDIX F PROCEDURES OF PST (III)	32
APPENDIX G RESULT OF PST	33

LIST OF TABLES

Table 1: List of Available Valve.....	12
Table 2: PLC Specifications.....	13
Table 3: Result from Portable AFT Fathom 7.0.....	21

LIST OF FIGURES

Figure 1: Basic Configuration of SVM.....	9
Figure 2: Project Process Flow.....	11
Figure 3: Hardware Connections.....	14
Figure 4: Setting the Percentage of Valve Opening.....	17
Figure 5: Setting the Type of Valve (either Ball or Butterfly).....	18
Figure 6: Full Schematic used for Simulation.....	19
Figure 7: Longest Route for Water to Flow throughout System.....	20
Figure 8: PST Summary Windows.....	33
Figure 9: PST Diagnostic Graph Windows.....	33

LIST OF ABBREVIATIONS

ESD	Emergency Shutdown
PST	Partial Stroke Test
FST	Full Stroke Test
SIL	Safety Integral Level
PLC	Programmable Logic Controller
PFD	Probability of Failure in Demand (PFD)
SVM	Smart Valve Monitoring

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The title for this project is Partial Stroke Test (PST) of ROTORK Emergency Shutdown (ESD) Valve which is collaboration between PETRONAS.GTS (SKG14) and Universiti Teknologi PETRONAS. Emergency Shutdown (ESD) is a part of Safety Instrumented System (SIS). This system is implemented in oil and gas platform at production plant to protect people, instrument and environment. In addition, ESD is applied to ensure the production is still profitable during emergency period. This system will act upon to any event that may threat the plant such as power trip and unstable system.

1.2 Problem Statement

Turn-around is being planned further apart, ranging from three to five years. The 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 fixed position. A number of failures in PST around the world have given rise to concerns on the reliability of PST. The facility is meant for comparison and verification of the technology used for partial stroke test of ESD valves. The work includes the development of the controller to execute the Full Stroke Test (FST) and Partial Stroke Test (PST) sequences, data mining and analysis.

1.3 Objectives and Scope of Study

This research is a continuation and improvement of the previous project. Since ROTORK is a new vendor for UTP, new information regarding ROTORK valve needs to be researched and studied. However, the activity will be the same as other vendor thus previous PST project can be used as references. PETRONAS is going to build the testing facility with the real medium flowing through the valves during testing to permit more realistic testing be conducted. The results will be utilized by PETRONAS in developing the PETRONAS Technical Standard, as well as verifying the capability of the valves and its software reliability as claimed by vendor. Thus, author is assign to come with a simulation and recommendations for the testing facility.

CHAPTER 2

LITERATURE REVIEW

2.1 Emergency Shutdown (ESD) Valve

Emergency shutdown valves or safety valves are used to protect processes, personnel and the environment against process disruption. It will automatically close in the event of an emergency to prevent the loss of handled media [4]. During process upsets, emergency shutdown valves are the final line of defense and are vital to minimizing the chance of possible disasters. It is an actuated valve installed in a pipeline, isolates a process unit from an upstream or downstream (gaseous or liquid) inventory upon activation of the process unit alarm and shutdown system [5]. In this project, two valves have been used as shut down valve which are Ball Valve and Butterfly Valve.

2.1.1 Ball Valves

As pointed in [6], ball valves are flow valves that are quarter-turn and straight through apparatuses. These valves would allow for shut-off or for control purpose. It has a round closure element that contains a matching pair of rounded seats that allow necessary sealing to take place.

2.1.2 *Butterfly Valves*

Butterfly valves are also a quarter-turn valve. The “butterfly” is a metal disc mounted on a pole. When the valve at the state of fully closed, the disc is turned so that it fully blocks off the passageway. When the valve at the state of fully open, the disc is rotated quarter turn so that it allows an almost unrestricted passage of the process fluid. The valve may also be opened incrementally to regulate flow [7].

2.2 **Full Stroke Testing**

Full Stroke Testing is used to demonstrate the performance of Emergency Shutdown Valve at unit turnarounds. Improvements in mechanical reliability and predictive and preventive maintenance programs have permitted the turnarounds from two to three years to extend to five or more years. Due to extend turnarounds periods, Emergency Shutdown valves are expected to go longer between function test and provide the same level of protection performance. To overcome the safety system performance degradation due to longer testing intervals, online testing of safety-related valves is conducted which requires additional facilities and possible production impacting procedures. This may cause reducing production rates, monitoring defined process variables, or executing a shutdown. FST can only be done when the plant is shutdown because the valves need to be closed fully. FST detects the remainders of the failure modes (30% of failure).

2.3 Partial Stroke Testing

Partial Stroke Testing means to partially close a valve and then return it to the initial position. Although the valve movement is so small that the impact on the process flow or pressure is negligible, it may still be adequate to enlighten different types of dangerous failures. PST is introduced to enlighten failures without disturbing the process, or else involve functional tests [8]. It is important in order to make sure that the emergency shutdown valve can perform its safety function when hazards occur. PST is performed on a portion of the valve failure modes. The remainders of the failure modes are tested by FST.

PST can be used to supplement the FST to reduce FST interval required to achieve Safety Integral Level (SIL). The valves can make test strokes between every minute up to once a year or more if desired. In this project, the test is set to be conducted every 15 minutes testing interval for 90 days.

2.4 Programmable Logic Controller (PLC)

A Programmable Logic Controller (PLC) is used to conduct the FST. PLC is an industrial computer control system that continuously monitors the state of input devices that makes decisions based upon a custom program, to control the state of output devices. PLC's were invented as less expensive replacements for older automated systems that would use hundreds or thousands of relays and timers. The advantages of using PLC are:

1. Cost effective for controlling complex system.
2. Flexible and can be reapplied to control other system easily.
3. Computational abilities to allow more sophisticated control.
4. Troubleshooting aids make programming easier and reduce downtime.

PLC is a digital operated electronics system, designed for industrial environment. It implements specific functions such as logic, sequencing, timing, counting and arithmetic to control the outputs. The function of PLC is scanning of a program which running through all conditions within a guaranteed period. A PLC consists of following main parts:

1. Inputs.
2. Central Processing Unit.
3. Outputs.

The operation of the PLC system is simple and straight forward. The Process or CPU complete three processes:

1. Scans, or reads, from the input devices.
2. Executes or solves the program logic.
3. Updates, or writes, to output devices.

There are two methods of programming language which are text and graphic language. The text languages are the Instruction List and the Structured Text type while the graphic languages are Sequential Function Chart, Function Block Diagram and Ladder Logic.

Structured Text is a high level structured language designed for automation process. Statements can be used to assign values to the variables. Instruction List is a low-level programming language for smaller applications or for optimization parts of an application. It is quite similar to assembly language programming. Both are the examples of text languages. Meanwhile, there are also graphic languages. Sequential Function Chart is using graphic to describe sequential operations. It is very useful for describing sequential type processes. Functional Block Diagram is used in applications involving the flow of signals between control blocks. Ladder Logic Diagram is the most popular and widely used programming. It applies Boolean mnemonics to represent the process, before converting into logic diagram.

Different PLC can support different languages. There are certain types of PLC that can support more than one language. These languages have their own limitations, and they complement one another to provide the best utilization by programmers.

2.5 Safety Integrity Level (SIL)

Safety Integrity Level (SIL) is one of three feasible discrete integrity levels (SIL 1, 2, or 3) of safety instrumented systems. SILs are defined in terms of their probability of failure on demand. PST is one of the most effective techniques for enabling a single valve to achieve SIL 2 performance or probably even SIL 3. The statistical measure of availability in an emergency is named the Probability of Failure in Demand (PFD). For individual components, PFD can be calculated using the following equation, which is well known and widely used in industry [9].

$$\text{PFD} = (\text{DC} \times \lambda_d \times \text{TI}_{\text{PST}}/2) + (1-\text{DC}) \times \lambda_d \times \text{TI}_{\text{FST}}/2$$

Using 70% as the breakdown of the dangerous failure rate, λ_d , the equation for the PFD can be written as follows:

$$\text{PFD} = (0.7\lambda_d \times \text{TI}_{\text{PST}}/2) + 0.3\lambda_d \times \text{TI}_{\text{FST}}/2$$

DC = Diagnostic Coverage Factor

λ_d = Dangerous Failure Rate = 1/MTBF (Mean Time Between Dangerous Failure)

TI_{PST} = Testing Interval for PST (On-line Test)

TI_{FST} = Testing Interval for Partial Stroke Test (Off-line Test)

Probability of Failure in Demand (PFD) equation

PFD Calculations consists of two parts: On-line Testing and Off-line Testing. When dealing with safety valves, the On-line diagnostic part relates to PST and the Off-line part to periodic maintenance. Toward achieve lower PFD; it is possible to frequent On-line Testing, better diagnostic coverage, shorter mean times for repair and good communication methods [9].

2.6 ROTORK Emergency Shutdown (ESD) Valve

For the preparation before performing Partial Stroke Testing on ROTORK ESD Valve, the details on the valve need to analyze.

2.6.1 Smart Valve Monitoring

Smart Valve Monitoring (SVM) is a system used by ROTORK to execute Partial Stroke Test that can be used on hydraulic or pneumatically on/off valves available in market. This system do not needs to be installed on the actuator as it can operate separately which the system can be mounting in hazardous area around the valve or in the control room. This preference let the system itself to not have contact with any valve or actuator, consequently, not disturbing the normal operation of valve or actuator. The SVM system consists of a control unit that connects to the power supply to the solenoid valve and also a pressure transmitter to offer feedback for the analysis of the valve performance. [10]

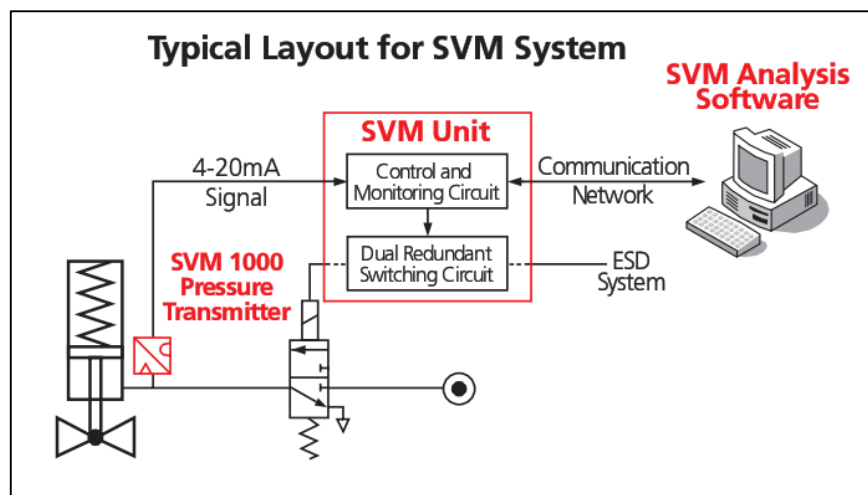


Figure 1: Basic Configuration of SVM [11]

SVM Unit is consisting of two circuits:

1. Control and Monitoring Circuit.
2. Dual Redundant Switching Circuit.

The measured variable from the system will be connected to control and monitoring circuit. All the data from this circuit will be send to SVM Analysis Software. This software also can give instruction to the Control and Monitoring system.

The Dual Redundant Switching Circuit is function to perform PST and FST. For the system to perform PST, SVM Analysis Software will send instructions to the Control and Monitoring system. The system will instruct the switching circuit to partially close the valve. If emergency occur, ESD system will overwrite the instruction from Control and Monitoring system to switching circuit for the valve to fully open.

2.6.2 *Analysis Software*

The software that been used by ROTORK is SW803. The advantage of using SW803 software analysis is the functions that put in single package. It also has graphical and tabular data presentation. Aside of that, the interface is look and feel like Windows.

CHAPTER 3 METHODOLOGY

3.1 Procedure Identification

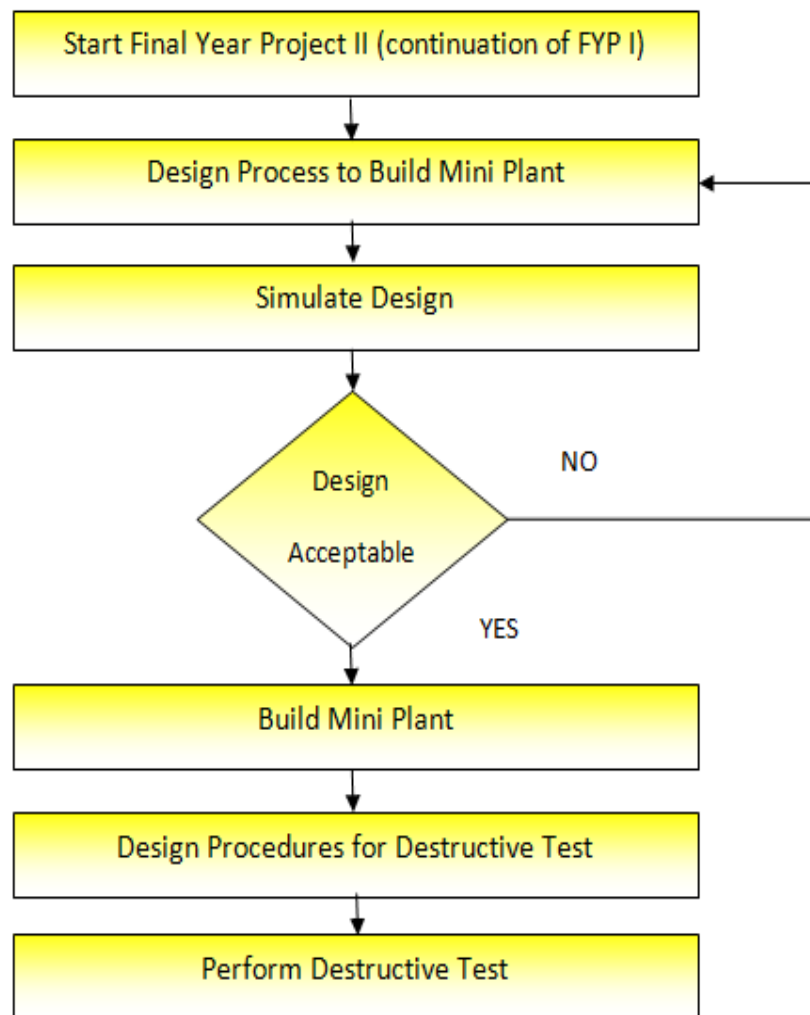


Figure 2: Project Process Flow

3.2 Tools and Equipment

3.2.1 Hardware

The hardware requirements for this project are as follow:

1. Valve

The valve that been used in this project is consist of two types which are Ball Valve and Butterfly Valve. Table shows the valves that are available in this project:

Table 1: List of Available Valve

Valve	Ball	Butterfly
METSO	6	3
FISHER	6	4
MASONEILAN	6	6
ROTORK	6	6

2. Yokogawa FA-M3 Controller

The Programmable Logic Controller (PLC) that been used in this project is Yokogawa FA-M3 Controller. Table shows the specification for this PLC:

Table 2: PLC Specifications

Item	Specifications
Supply Voltage	24 VDC
Leakage Current	-
Operational Temperature	0 – 55 °C
Operating Environment	Free of corrosive and flammable gases or heavy dust
Cooling Method	Natural-air cooled

3. Personal Computer
4. 24 VDC Power Supply
5. Pressure Supply

3.2.2 *Software*

Softwares that had been used for this project are:

1. WinField2
2. ValveLink
3. FieldCare
4. ValvueESD
5. ASPEN HYSIS
6. AFT Fathom 7.0

3.3 Hardware Setup

This project consists of eight valves from four different vendors. The valve is controlled by Programmable Logic Controller and Personal Computer. A well connection needs to be done to ensure the communications between each device are successful. Figure shows the hardware connections between PLC, PC and valves.

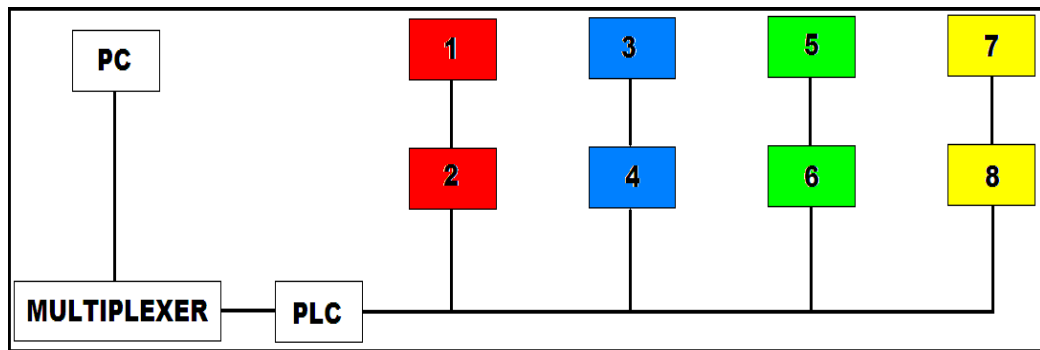


Figure 3: Hardware Connections

1. Fisher Ball Valve
2. Fisher Butterfly Valve
3. METSO Ball Valve
4. METSO Butterfly Valve
5. MASONEILAN Ball Valve
6. MASONEILAN Butterfly Valve
7. ROTORK Ball Valve
8. ROTORK Butterfly Valve

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Study on Simulation Software

During the early stage of design simulation, author had been recommends by supervisor and lecturers to use ASPEN HYSIS software. ASPEN HYSIS is software that used to simulate plant model to check on the variables of a designed plant. It had been used widely by Process Control Engineer throughout the world. However, author had discovered that ASPEN HYSIS is not reliable to be use as simulation software for this project. ASPEN HYSIS is built to monitor on designed plant with chemical flowing medium and user need to specify the characteristics of the flowing medium and its environment which involved temperature, pressure, flow and thermodynamic properties. For the author to perform the simulation using ASPEN HYSIS, it is quite impossible for author to collect all the data in given time as the current data that available are still not enough.

After consulting with project supervisor, author had been analyzing other software that is much simpler compare to ASPEN HYSIS. Two softwares had been recognized as reliable to be used as simulation software. The softwares are:

1. Pipe Flow Expert
2. Portable AFT Fathom 7.0

Pipe Flow Expert and Portable AFT Fathom 7.0 had quite similar characteristics. However, Portable AFT Fathom had a Valve Specifications property that Pipe Flow Expert had not. With Valve Specifications property, user may determine the percentage of valve opening in a specific time. User also can choose the type of valve which is listed in the Valve Data Source. For this project, the available valves are Ball Valve and Butterfly Valve. Thus, this software is able to simulate Partial Stroke Testing for the design simulation purpose.

4.2 Designing Small Plant

Currently, Partial Stroke Test and Full Stroke Test are done without any flowing medium. As the issues had been arises, a small plant needs to design with consist of vessels and piping system. The design process is done by the information taken from the FYP II for semester Jan 2010. The designed small plant is shown on the appendices. The examples of calculation are shown in Appendix A and Appendix B while Appendix C shows the designed small plant.

4.3 Simulate the Designed Small Plant

Portable AFT Fathom 7.0 is software that had been used to simulate the designed plant for this project. As discussed in previous topic, this software is reliable to simulate PST of ROTORK emergency shutdown valve because of the variation of valve available in this software and its function that can determine the percentage of valve opening in a given time as shown in *Figure 4* and *Figure 5*.

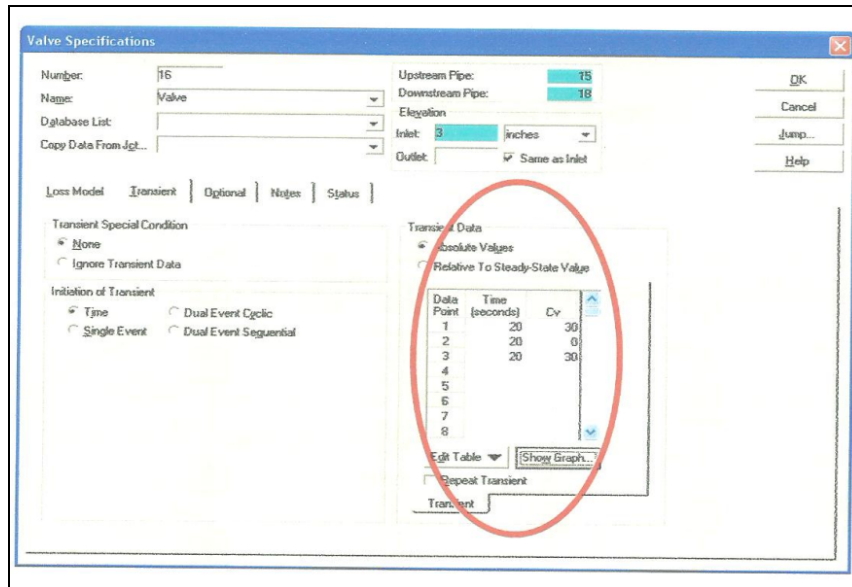


Figure 4: Setting the Percentage of Valve Opening at Specified Time

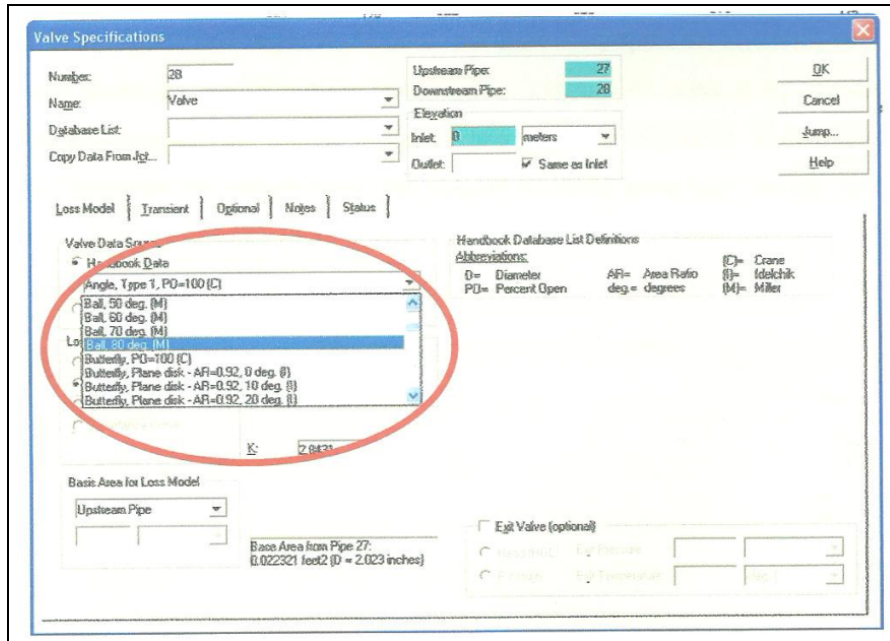


Figure 5: Setting the Type of Valve (either Ball or Butterfly)

4.3.1 Full Schematic of Designed Plant

As shown in *Figure 6*, author had built the full schematic of the designed plant by using Portable AFT Fathom 7.0. Until this report is written, author had managed to determine the capacity of water in the tank and analyze the characteristics of the flow through the piping system.

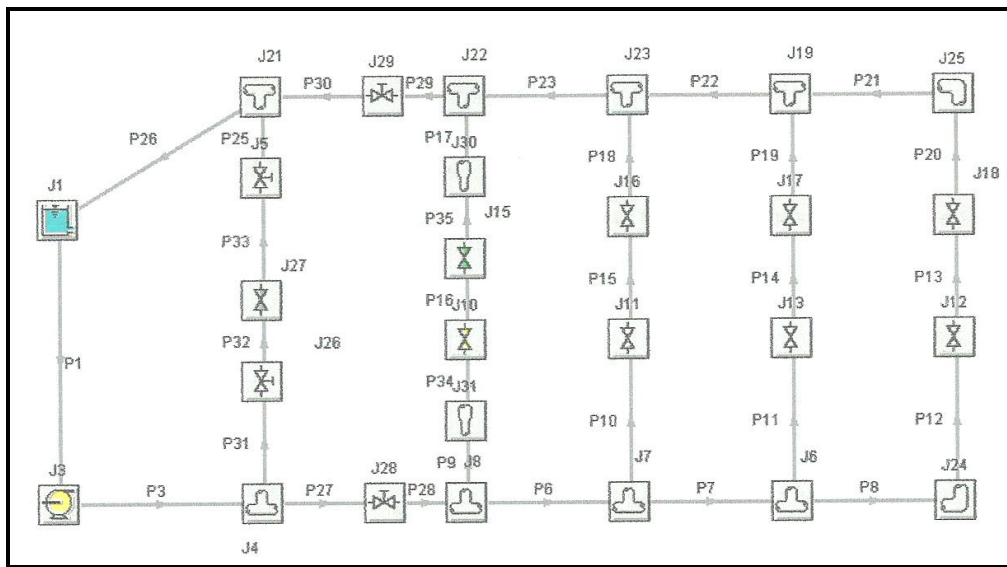


Figure 6: Full Schematic used for simulation in Portable AFT Fathom 7.0

4.3.2 Capacity of Water in the Tank

Capacity of the water in the tank can be determined by simulate the longest route possible for the water to flow throughout the flowing system (*refer Figure 7*). If the water is capable to flow in a complete cycle throughout the plant system, we can conclude that the capacity of the water in the tank is enough for the plant to be operated.

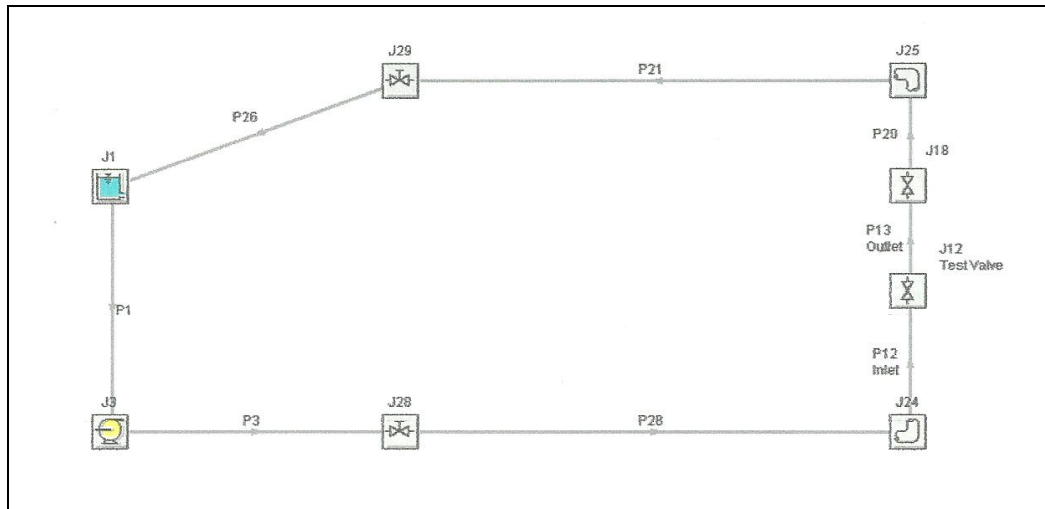


Figure 7: Longest route possible for the water to flow throughout the system

4.3.3 Analyzing a CV (Flow)

Table 3: Result from Portable AFT Fathom 7.0

The screenshot shows the 'Output' window of AFT Fathom 7.0. It contains two main tables: 'Valve Summary' and 'Pipes'. The 'Valve Summary' table lists four valves (12, 18, 28, 29) with their respective flow rates, mass flows, dP stag, dH, P Inlet Static, Cv, K, Valve State, and Open Percentage. The 'Pipes' table lists various pipe segments (1, 3, 12, 13, 20, 21, 26, 28) with their flow rates, velocities, elevations, dP stag, dP static, dP gravity, dH, P static in, and P static out. A red circle highlights the velocity values for Pipe 12 (71.195), Pipe 13 (9.150), and Pipe 20 (9.150), with a text box labeled 'Velocity drop' pointing to these values.

Jct	Name	Valve Type	Vol. Flow (liter/min)	Mass Flow (lbm/sec)	dP Stag. (bar)	dH (inches)	P Inlet Static (bar)	Cv	K	Valve State	Open Percentage (Percent)
12	Test Valve	REGULAR	45.00	1.649	1.077E-03	0.4337	1.405	95.01	100.000	Open	N/A
18	Valve	REGULAR	45.00	1.649	9.724E-04	0.3915	1.404	100.00	90.271	Open	N/A
28	Valve	REGULAR	45.00	1.649	9.724E-04	0.3915	1.422	100.00	1.491	Open	N/A
29	Valve	REGULAR	45.00	1.649	9.724E-04	0.3915	1.417	100.00	1.491	Open	N/A

Pipe	Name	Vol. Flow Rate (liter/min)	Velocity (feet/min)	Elevation Inlet (feet)	Elevation Outlet (feet)	dP Stag. Total (psid)	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psia)	P Static Out (psia)
1	Pipe	45.00	71.195			-1.19539797	-1.19539797	-1.27648	0.18755564	14.69	15.88
3	Pipe	45.00	71.195			0.00472994	0.00472994	0.00000	0.01094132	20.63	20.62
12	Inlet	45.00	9.150	6.000	6.000	0.00001275	0.00001275	0.00000	0.00002950	20.38	20.38
13	Outlet	45.00	9.150	6.000	8.000	0.00005101	0.00005101	0.00000	0.00011799	20.37	20.37
20	Pipe	45.00	9.150	6.000	6.000	0.00001275	0.00001275	0.00000	0.00002950	20.36	20.36
21	Pipe	45.00	71.195	2.000	0.000	-0.05667780	-0.05667780	-0.07205	0.03555930	20.49	20.55
26	Pipe	45.00	71.195	0.000	35.433	5.84591532	5.84591532	1.27648	10.57004351	20.53	14.69
28	Pipe	45.00	71.195	0.000	2.000	0.08742243	0.08742243	0.07205	0.03555930	20.61	20.52

Jct	Name	P Static In (psia)	P Static Out (psia)	P Stag. In (psia)	P Stag. Out (psia)	Vol. Flow Rate Thru Jct (gal/min)	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
1	Reservoir	14.70	14.70	14.70	14.70	N/A	N/A	0.0000
3	Pump	15.88	20.63	15.89	20.64	11.89	1.649	0.0000
12	Test Valve	20.38	20.37	20.39	20.37	11.89	1.649	100.0000
18	Valve	20.37	20.36	20.37	20.36	11.89	1.649	90.2710
24	Bend	20.52	20.38	20.53	20.39	11.89	1.649	0.2274
25	Bend	20.36	20.49	20.36	20.50	11.89	1.649	0.1843
28	Valve	20.62	20.61	20.63	20.62	11.89	1.649	1.4910
29	Valve	20.55	20.53	20.56	20.54	11.89	1.649	1.4910

From Table 3 shown above, author had identified that there are velocity drop in the flow. The velocity drop is occurring through Pipe 12, Pipe 13 and Pipe 20. These pipes are representing the pipeline connected to the ROTORK valves. Thus, it is vital for author to analyze the velocity drop.

By observing the result, when the medium flow through Pipe 1 to Pipe 26, the pressure at Pipe 1 and Pipe 26 are smaller compare to other pipes. From Pipe 1, the pressure is increased at Pipe 3 by installing Pump J3. From Pipe 3 to Pipe 21, the pressure is maintained and drops back at Pipe 26. The pressure drop at Pipe 26 is due to the medium flows into the tank from the upper side of the tank and effected by gravitational force.

From those judgments, by maintaining the pressure, the velocity drop can be neglected. So, the author concluded that the design is feasible to be used in building the mini plant after considering the stable pressure value and neglect the velocity drop.

4.4 Solution for Velocity Drop

Although the velocity drop can be neglected, the author had discovered a solution to counter the problem. However, due to restriction of time, the author cannot come out with a reasonable solution for the problem of velocity drop. The solution that been suggested is by changing Pump J3 specifications. As a result, the flowing medium may have high velocity at the Pipe 3 onwards. Thus, aside of dropping in high value, the flowing medium just slightly drop when reaching Pipe 12 onwards.

4.5 Demonstration on Partial Stroke Testing (PST)

As the ROTORK valve not yet been installed in the lab, author had been assigned to follow the demonstration perform by MASONEILAN team. The procedures and results for the PST are shown in the Appendix D, Appendix E, Appendix F and Appendix G.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

As PETRONAS policies, every new technology must be tested first before it can be implemented. Rather than conduct it in industry, the more convenient way is use third party as is independent from the plant and further development can be done. Thus, this project is done based on that reason.

This project will be a good platform for end user such as PETRONAS to evaluate and compare the performance of Partial Stroke Testing of different vendors in order to come out with a confirmation on which vendor's system is reliable to be used. If at the end of the project, all four systems recorded no problem then it indicates that all the four vendors meet their expectation.

As the conclusion, the Partial Stroke Testing (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 performance.

5.2 Recommendations

Several problems had been identified by the author throughout the completion of this project and the author is gladly to propose some suggestions to counter the problems.

The author had expected to perform Partial Stroke Testing with real flowing medium by this semester. However, due to delay in the design finalization, the testing facility cannot be installed until the end of this semester. So, the author is suggesting if the testing facility can be installed by next semester for the benefits of FYP II Jan 2011 students which will continue this project.

As the author simulated the designed mini plant, the author had noticed the velocity drop at the pipelines connecting ROTORK valves. Due to time constraint, the author is not able to complete to find solution for this problem. Although the velocity drop can be neglected, it is better if the problem is noted by the FYP II Jan 2011 students.

Hopefully, by considering those suggestions, Universiti Teknologi PETRONAS and PETRONAS.GTS (SKG. 14) may get a better result during the next phase of this project.

REFERENCES

- [1] Mohd Hafiz Bin Ahmad Shakir: Partial Stroke Tests of Emergency Shutdown Valves (MASONEILAN). December 2009. Electrical and Electronics Engineering Department, UTP.
- [2] Nor Nadiah Binti Ab Muntalib: Partial Stroke Testing for Fisher Shutdown Valve. December 2009. Electrical and Electronics Engineering Department, UTP.
- [3] Siti Farhana Bt Sudarman: PARTIAL STROKE TEST OF EMERGENCY SHUTDOWN VALVE- METSO NELES. December 2009. Electrical and Electronics Engineering Department, UTP.
- [4] Thomas E. Marlin: Process Control Designing Processes and Control Systems For Dynamic Performance. 1995. McGraw-Hill.
- [5] *Emergency shut-off valves (ESV)*. http://flow-control.globalspec.com/IndustrialDirectory/emergency_shut_down_valve
- [6] *More about Ball Valves*. <http://www.thomasnet.com/about/ball-valves-90370206.html>
- [7] *VALVE TYPES*. <http://www.tpub.com/fireman/69.htm>
- [8] Mary Ann Lundteigen, Marvin Rausand, “Journal of Loss Prevention in the Process Industries”, *Partial stroke testing of process shutdown valves: How to determine the test coverage*, Vol.21, Issue 6, November 2008, pp. 579-588.
- [9] Juha Yli-Peta ys, “Flow Control”, *The value of safety valve*, Automation 3, 2008.
- [10] Rotork Fluid Systems, “Smart Valve Monitoring”, Draft v2, Issue 04/08.
- [11] Rotork Fluid Systems, “SVM Range”, Publication F902E, Issue 09/08.

APPENDICES

APPENDIX A

EXAMPLE OF DESIGN PROCESS (I)

Upgrading of PST test rig UTP

Design Objective:

To proposed the tank size and the pump capacity. To proposed the layout in 3-D.

Description:

Initially is to estimate the biggest volume flow of the piping. This must be known because we want to calculate the required size of the tank. The biggest volume will be the flow through the four 6" valves. Using the known information about the size of valves, and the assumption to use a 45 liter/min pump (available commercially), the proposal is to have the size of the tank (r =radius and h =height) to be $r=0.25m$ and $h=1m$. The calculation is as below. Attached is the 3D drawing of the PST Test rig with flow, in the interim version.

Detail Calculation:

Volume for 2" pipe radius

$$r = 1" = 0.0254 \text{ m}$$

$$l = 0.5 + 0.5 + 0.25 + 0.7 + 0.7 + 4 + 1 + 1.4 + 1 = 10.05\text{m}$$

$$A = \pi r^2 = \pi(0.0254)^2 = 0.00203\text{m}^2$$

$$V = Al = 0.00203 \times 10.05 = 0.0204\text{m}^3$$

Volume for 6" pipe radius

$$r = 3" = 0.0762$$

$$l = 3.75$$

$$A = \pi r^2 = \pi(0.0762)^2 = 0.01824\text{m}^2$$

$$V = Al = 0.01824 \times 3.75 = 0.0684\text{m}^3$$

$$V_{\text{total}} = V_{2"} + V_{6"} = 0.0204 + 0.0684 = 0.0888\text{m}^3$$

The output discharge of the available pump is $45 \text{ l}/\text{min} = 0.045 \text{ m}^3/\text{min}$

APPENDIX B

EXAMPLE OF DESIGN PROCESS (II)

∴ Volumetric flow rate, \hat{V}

$$\hat{V} = \frac{V}{t}$$

$$t = \frac{V}{\hat{V}} = \frac{0.0888}{0.045} = 1.97 \text{ min} = 118.4 \text{ s} \approx 120 \text{ s}$$

$$t_{\text{testing}} = 80 \text{ s}$$

$$\# \text{ Total time required} = t + t_{\text{testing}} = 120 + 80 = 200 \text{ s} = 3.333 \text{ min}$$

$$\therefore \text{ minimum volume tank required} = V_{\text{piping}} = 0.045 \text{ m}^3/\text{min} \times 3.333 \text{ min} = 0.15 \text{ m}^3$$

#Note: By using hand valves at beginning and ending of each branch, the **Total time has been reduced** since the flow is directed to either of the branches depending on the location of the valve to be tested. This is because only one valve will be tested at one time.

Check back the volume of the tank with the specified r and h

$$V_{\text{tank}} = \pi r^2 h = \pi \times 0.25^2 \times 1 = 0.196 \text{ m}^3$$

Thus the size of the tank is valid because

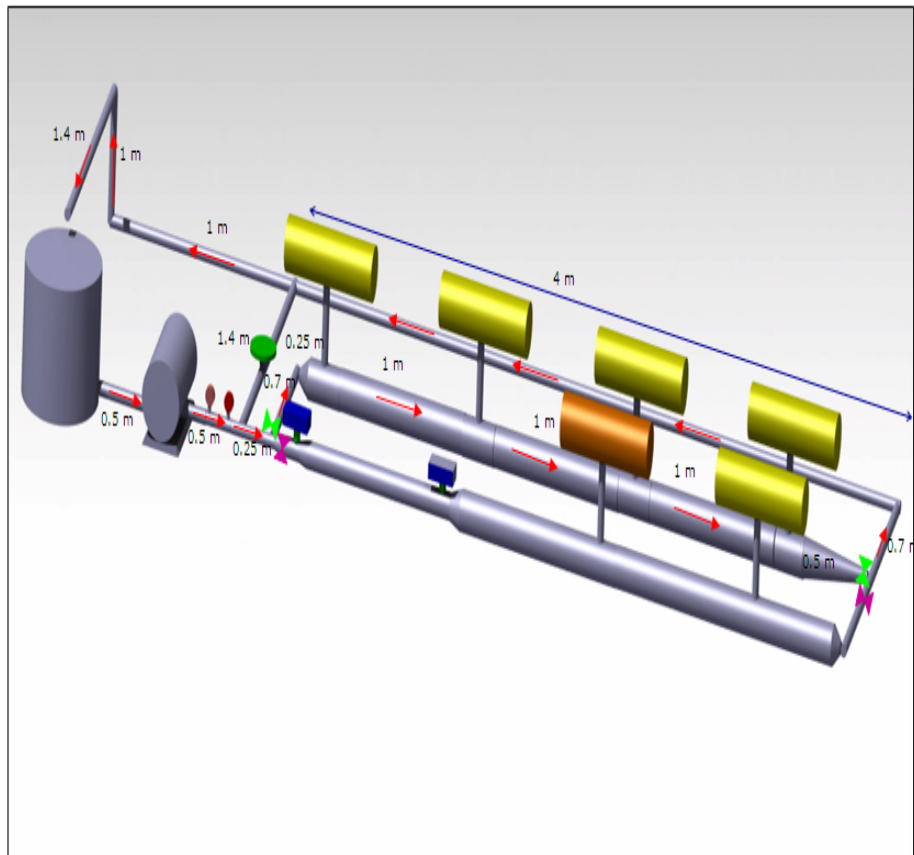
$$V_{\text{tank}} > V_{\text{piping}}$$

$$0.196 \text{ m}^3 > 0.15 \text{ m}^3$$

APPENDIX C

DESIGNED SMALL PLANT

3D drawing of the PST Test rig with flow



▶ Green Hand Valves are used for branch that contained biggest volume (Four 6" Valves).

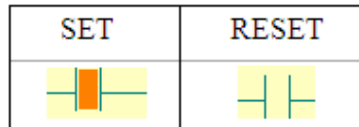
▶ Purple Hand Valves are used for branch contained less volume (3", 4", and two 6" Valves).

APPENDIX D
PROCEDURES OF PST FOR MASONEILAN (I)

1. Check instrument air supply to the valve is in open condition.
2. To start using the program. Select and double click on *WideField2 Icon* to start using PLC program-Wide Field Software by Yokogawa.
3. Select and click "*Open Project*" tab to open existing project file.
4. Select folder "*masotest*" and click *Open*.
5. Then, Select "*FISHER*" folder and click *Open*.
6. Next, select "*FISHER*" file and click *Open*.
 - a. *To test Masoneilan Ball Valve: Select "BALL" from "Block List", click "Select" (which will appear under "Block Name") and then click "OK".*
 - b. *To test Masoneilan Butterfly Valve: Select "BFLY" from "Block List", click "Select" (which will appear under "Block Name") and then click "OK".*
7. Select and double click on "*Component Definition*".
8. To download project file. Go to "*Online*", select "*Download*" and click on "*Project*".
9. A prompt will appear and select "*YES*".
10. Next prompt will appear and select "*YES*".
11. Next prompt will appear and select "*YES*" again.
12. Transferring configuration will start to download and a prompt will appear.
13. Wait until transfer configuration completed. Then, a prompt will appear. Select "*YES*".
14. Next, to start program monitor. Go to "*Online*" and select "*Program Monitor*".

APPENDIX E
PROCEDURES OF PST FOR MASONEILAN (II)

15. For testing of Ball Valve: Double click on “BALL” to upload the ladder diagram. For testing of Butterfly valve: Double click on “BFLY” to upload the ladder diagram.
16. Upon successful uploading the ladder diagram will be displayed.
17. Ensure M00033, I00002, I00020 and M00033, I00002 for ball valve and butterfly valve respectively are “Forced Set”. The symbol for set and reset is as follows:



18. Valve is put to open position to stimulate normal operation. To initiate opening of the valve
 - a. *For ball valve: Right click at I00022 and select “Forced Set”.*
 - b. *For butterfly valve: Right click at I00020 and select “Forced Reset”.*
19. Then proceed to open AMS Valvue ESD Software. To start using the program. Select and double click on “Valvue ESD” Icon.
20. Valvue ESD Lookout window will appear.
21. From ‘Valvue ESD Lookout’, go to 1) ‘Tools’ menu and select 2) ‘Mux Reset’.
22. ‘Device Address’ popup will appear then enter ‘1’ value.
23. Key in following data to ‘Multiplexor Setup’ and click ‘OK’ button.

APPENDIX F

PROCEDURES OF PST FOR MASONEILAN (III)

24. Go back to *Valvue ESD Lookout* dialog box and click '*Re-Scan*'. Wait until all LEDs on **MTL 4842** (HART multiplexer in Partial Stroke Valve Control Panel) turn red, then click '*Re-Scan*' again.
NOTE: ValVue ESD will scan ALL devices (Masoneilan or otherwise) in the network. When the Masoneilan SVI II ESD is detected, it will be displayed on the ValVue ESD Lookout.
25. Highlight the tag name required and click *Select*.
26. *ESDVue* will be launched for the particular unit.
27. Select '*PST*' parameter tab:
 - a. Set '*PST Travel*' to 20%.
 - b. Set '*PST Speed*' to 0.5 %/s.
28. Click on '*Perform Diagram*' for analysis.
29. A prompt will appear showing that the PST Testing is running.
30. A prompt shows that PST Data is being loaded.
31. A prompt shows that PST Testing has completed.
32. Click "*continue*". A prompt will appear. It displays the Summary Analysis.
33. Next click "*view graph*", a prompt displays the Testing Measurement Graph will appears.
34. To perform FST while PST is running. Initiate FST from WideField when the valve travel reached 90% by initiating "Forced Set" for Ball to the I00020.

Note: *The way of operating the software is differ for METSO, MASONEILAN, FISHER and ROTORK.*

APPENDIX G

RESULT OF PST FOR MASONEILAN

1. Summary Analysis

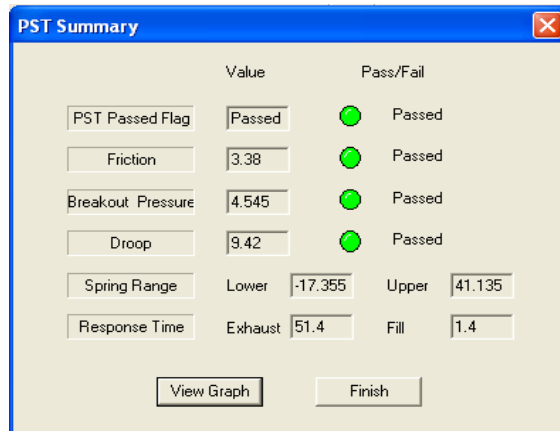


Figure 8: PST Summary Windows

2. Viewing Graph.

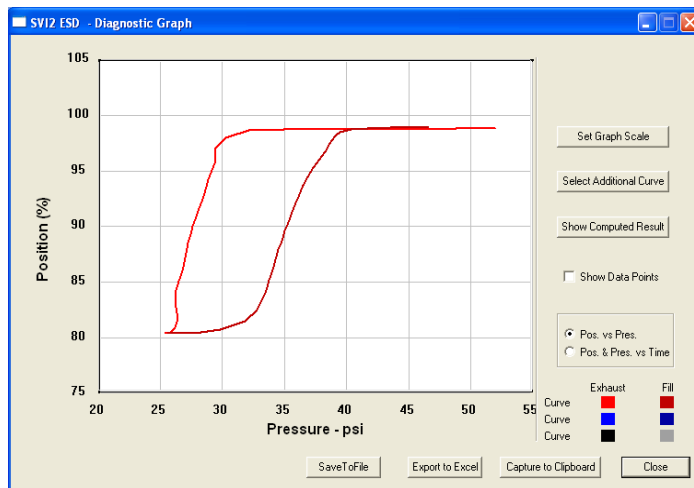


Figure 9: PST Diagnostic Graph Windows