DEVELOPMENT OF A CONTROLLER AND PERFORMANCE TESTING FOR PARTIAL STROKE TESTING (PST) OF FISHER ESD VALVES

By

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Dissertation submitted in partial fulfillment of
the requirements for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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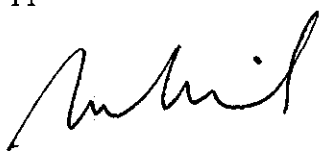
Approved:



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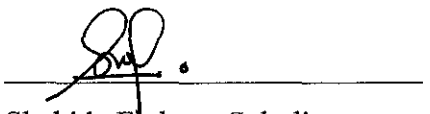
TRONOH, PERAK

JUNE 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.



Shahida Farhana Saludin

ABSTRACT

This report essentially discusses the work on the **Development of a Controller and Performance Testing for Partial Stroke Testing of FISHER ESD Valves** which deals with Yokogawa FA-M3 Controller and the FISHER Emergency Shutdown valves. The objectives of the project are on developing a controller to the Partial Stroke Testing (PST) using Programmable Logic Controller (PLC) and software tools; and conduct performance testing on the ESD valves. This report also explains the valve components and the fundamentals of PLC. The methodology explains in detail about developing the routine for PST and also the construction of ladder logic diagram using WideField2 software. The setting of AMS ValveLink software is also explained in this chapter. The data gathered from the 35 days of testing are presented in Chapter 4. Besides, the Valve Signature, PST Analyzed Data, and Digital Valve Controller (DVC) installation are also explained in details. Chapter 5 concludes what has been achieved in this project and the recommendation for future works. Throughout the project, sharing of ideas with PETRONAS engineers from the Improvement Working Group (IWG) of Skill Group 14 (SKG14) are also conducted to compare the performance of various valves for use in PETRONAS plants. The outcome of this project would be very useful for the PETRONAS to adopt on the PST strategy in their plant nationwide.

ACKNOWLEDGEMENT

First and foremost, I am very grateful to God the Almighty for His mercy as He gave me the strength and ability to complete the final year project throughout the year. I also would like to take this opportunity to thank all parties involved in making to final year project a great educational session and a success. Deepest gratitude goes to my parents, Saludin Sulong and Norpiah Sidik for their continuous motivation and moral support.

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Mr Azhar Zainal Abidin	Technician, UTP
Ir Mohd Rashdan Mahmood	Lead Engineer, PETRONAS GTS
Mr M. Firdhaus M. Hasani	Engineer, PETRONAS Gas Berhad
Mr Sinivasen Sevalingam	Senior Engineer, TRANSWATER Tenaga Sdn Bhd

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LIST OF ABBREVIATION

UTP	Universiti Teknologi PETRONAS
GTS	Group Technology Solutions
ESD	Emergency Shutdown
DVC	Digital Valve Controller
PST	Partial Stroke Valve Testing
FST	Full Stroke Valve Testing
PLC	Programmable Logic Controller
I/O	Input / Output
CPU	Central Processor Unit

CHAPTER 1
INTRODUCTION

1.1 Background of Study

Emergency Shutdown (ESD) valve is a final defense element in a pipeline of a process plant. Nowadays, the ESD valve is connected to the PLC and sensors as shown in Figure 1.1. Whenever the sensor identifies the abnormalities in the pipeline, it sends a signal to the PLC and PLC disconnects the power supply to the ESD and solenoid valve. Therefore, the valve will fully close or fully open, depending on the process loop.

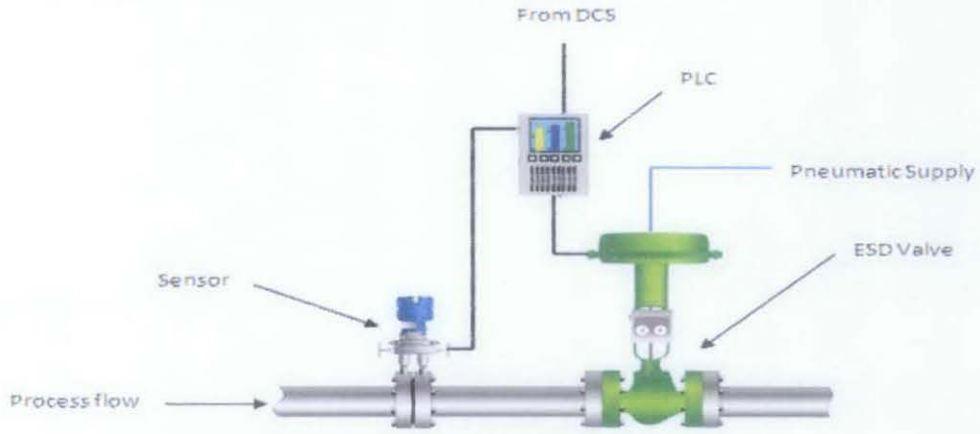


Figure 1.1: ESD valve in a pipeline

Due to the continuous process in the plants, ESD valve usually remains set in one position for a long time, thus reduce the efficiency of the valve. In addition to that, a harsh process inside the pipeline can cause the valve to stick. Therefore, the valve fails to move to safety state during emergency shutdown. This could cause a potentially dangerous condition leading to catastrophic events.

As a solution, FST and PST are introduced to exercise the valve. FST technique strokes the valves from 0% to 100% of valve travel. Implementation of this technique requires the shutdown of the process. The alternative testing is an online FST but it requires bypassing the flow to the other pipeline or reducing the flow rate which may disturb the other loop if the procedures are not properly followed [1]. The PST is an online SIS testing which involves partial stroking of the valve movement. The valve travel is set between 10%-30% of the opening or closing of the valve. This method does not require to shutdown the process.

1.2 Problem Statement

Current method applied in process plant to initiate the PST is by using mechanical devices such as mechanical limiting, position control and solenoid valves. The implementation of this method has its own pros and cons.

The use of mechanical limiting does not allow the process shutdown when emergency occurred. The position control method requires an analog positioner installation on the valve. The positioner guides the valve travel as set by pre-determined point. The disadvantage of this method is the positioner may fail during the stroking. The solenoid valve method requires the operators to hold the switch to de-energize the solenoid coil. The operators need to short certain terminals in the field with push button located at special device. Once initiated, the automated test moves the valve to the pre-determined value then returns the valve to its original position [2].

PST enters new domain in industrial automation technology. Programmable Logic Controller (PLC) based systems appear to play a central role concerning initiating, registering, and responding to PST [3]. The

implementation of PLC will not require the operators to go to the field or hazardous area just to initiate the PST. Besides, the PLC is designed for multiple inputs and outputs arrangements in a compact size which is not require large space for installation and requires much less wiring. Therefore, the usage of PLC will bring in a new chapter for PST technology.

1.3 Objectives and Scope of Study

1.3.1 Objectives

The objectives of the project are:-

- To develop a controller to perform PST and FST
- To compare the PST performance of various valves
- To study the failure mode of the valves during the test

1.3.2 Scope of Study

There are two parts of this project. The first part is the development of PLC programming to power up the valve. Therefore, it is necessary to have a broad knowledge in constructing ladder logic diagram for PLC programming. The second part of the project is to execute the PST for 90 days, gather the data and analyze the performances of the valves. The reliability and feasibility study will be carried out to achieve the objectives. Experiences during industrial internship at one of PETRONAS plants would be very helpful to relate the project to the real application in plant.

CHAPTER 2
LITERATURE REVIEW

2.1 Rotary Valve

There are two types of valves – sliding stem valve and rotary valve. The major different between these two types is the way it works when responding to signals. The sliding stem valve controls the flow of the fluids by sliding up and down of the stem. The rotary valve is controlled by a rotary motion. The butterfly valve and ball valve are from rotary type. Usually, the butterfly valve and ball valve act as a block valve.

In the process plant, the block valves are located at the beginning and ending of the process flow. The function of the block valve is to stopping or starting the flow. Its features – tight shut-off and fire-safe design make it suitable for emergency shutdown valve in the process plant since it can react very fast as soon as it receives the signals. There are varieties of block valve in the market, manufactured by different vendors with different specifications and hence will result to different performances.

Figure 2.1: Typical butterfly valve and its major components [4]

Figure 2.1 shows two major components in a valve; actuator and valve body assembly. The valve assembly typically consists of the valve body, an actuator to provide motive power to operate the valve, and a variety of additional valve accessories, which can include positioner, transducer, supply pressure regulators, and limit switch [5].

2.1.1 Ball Valve

Figure 2.2 shows a typical ball valve with its controlling device, a ball. The opening and closing of the ball valve is controlled by a handle that is attached inside the ball valve. Inside the middle of the ball valve body is a hole, which will allow the flow of the fluid if the hole is in line with both end of the valve. Referring to Figure 2.3, when the valve is closed, the hole is perpendicular to the ends of the valve, and flow is blocked. The straight through design of ball valve will reduce the pressure drop. The characteristic of ball valve allows the quickness of operation, require no lubricants and give tight sealing with low torque [4].

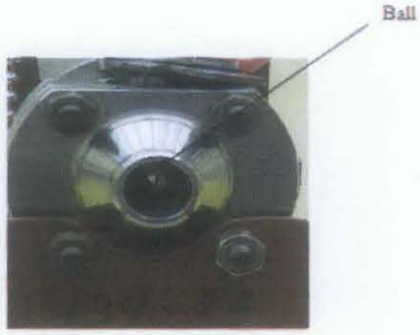


Figure 2.2: Controlling device of ball valve [6]

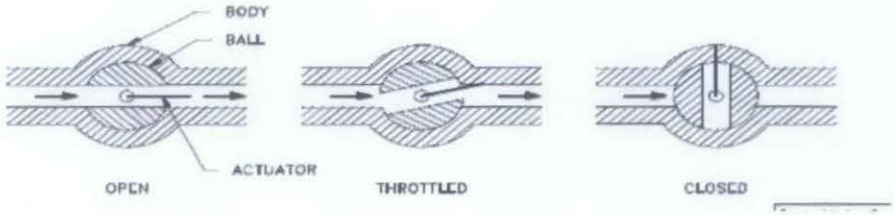


Figure 2.3: Flow movement through ball valve [7]

2.1.2 Butterfly valve

Figure 2.4 shows the typical butterfly valve. The controlling device of a butterfly valve is a circular disk at the center of the valve body. The operation of the valve is either parallel or perpendicular to the flow. The valve is in fully open position when it turns 90 degrees, which is parallel to the flow. When the valve is fully closed, the disk is turned so that it completely blocks off the passageway [7].

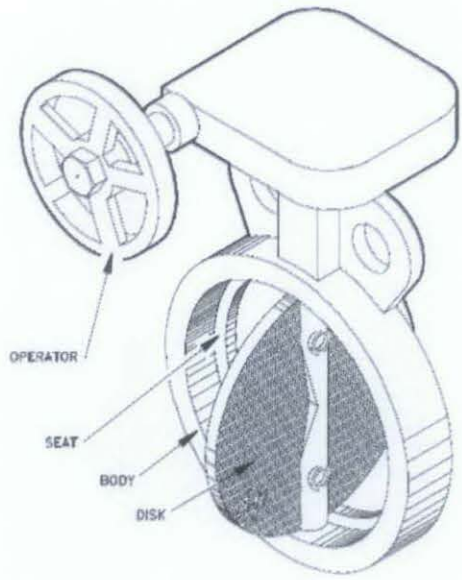


Figure 2.4: Typical butterfly valve [7]

2.1.3 Actuator

An actuator is a powered device that supplies force and motion to open or close the valves. The power sources are from pneumatic, hydraulic, or electrical. The actuator use in this project is rack and pinion actuator and is supplied by pneumatic air as shown in Figure 2.5 [4].

Figure 2.5: Typical rack and pinion actuator [4]

2.1.4 Limit Switch

Limit switch in Figure 2.6 is installed to signal when a valve is at or beyond a predetermined position. It is also operates discrete inputs to a distributed control system, signal lights, small solenoid valves, electronic relays, or alarms. Besides, it combines bus networking, pilot valve, and position sensor into a single globally certified, flammable and explosion proof enclosure, that can be attached to any automated valve [8].

Figure 2.6: VALVETOP DXP Limit Switch [8]

2.1.5 Digital Valve Controller

Figure 2.7 shows a digital valve controller or also known as smart positioner. It is a microprocessor-equipped device. It controls the opening and closing of the valve by converting the 4-20mA DC current signal input from process controller and converts it to pneumatic output signal to the actuator. Besides, it communicates via Highway Addressable Remote Transducer (HART) communication protocol to provide instrument and valve diagnostic information. The smart positioner plays an important role in Emergency Shutdown (ESD) application. It will reduce the testing time taken and manpower requirement, thus it will reduce cost. The diagnostic capability of the smart positioner reports the health of the valve, thus reducing the need for scheduled maintenance and increasing process availability.

Figure 2.7: DVC6000 Digital Valve Controller

2.1.6 Pressure Regulator

Pressure regulator in Figure 2.8 is used to regulate or reduce air pressure so that it achieves the desired value. Also known air-sets, it will reduce plant air supply to valve positioner and other control equipment. Common reduced-air-supply pressures are 20, 35 and 60 psig. The regulator mounts integrally to the positioner or nipple-mounts or bolts to the actuator [4].The parameters that limit adjustment control on the pressure range are the regulating and adjustment range.

Figure 2.8: Pressure Regulator [4]

2.1.7 Solenoid Valve

Figure 2.9 shows a solenoid valve. The functions of solenoid valve are to operate on/off pneumatic actuator and to interrupt the action of modulating valves by switching air or hydraulic pressure [4]. The solenoid valve requires power supply for it to energize. If there is no power supply, the solenoid valve will be de-energized. Thus, it will affect the state of the valve whether fully open or fully close.

Figure 2.9: Solenoid Valve [4]

2.2 Programmable Logic Controller

The Programmable Logic Controller (PLC) is in essence a device that is specifically designed to receive input signals and emit output signals according to the program logic. PLCs come in many shapes and sizes from small, self-contained, units with very limited input/output capacity to large, modular units that can be configured to provide hundreds or even thousands of inputs/outputs [9]. The PLC-based system becomes the most common choice for manufacturing controls including process plant since it can cut production cost and increase quality.

2.2.1 Advantages of Programmable Logic Controller

1. Cost effective for controlling complex system – one PLC can run on many machines [10]
2. Easily programmed and reprogrammed – can alter its sequence of operations [11]
3. Large quantities of contacts – PLC memory is getting bigger and thus can generate more contacts, coils, timers, sequencers, counters and so on
4. Maintainability – less maintenance required and PLC can live longer without failure [11]
5. Reliability – can sustain the industrial environment that has extreme temperature (typically up to 160°F, high humidity (up to 95%), electrical noise, electromagnetic interference, and mechanical vibration.[11]

2.2.2 Construction of a Programmable Logic Controller

Basically, most of the PLC in the market has several common functional parts. Figure 2.10 shows a central processor, memory, I/O, power supply, programming and peripheral device subsection [12].

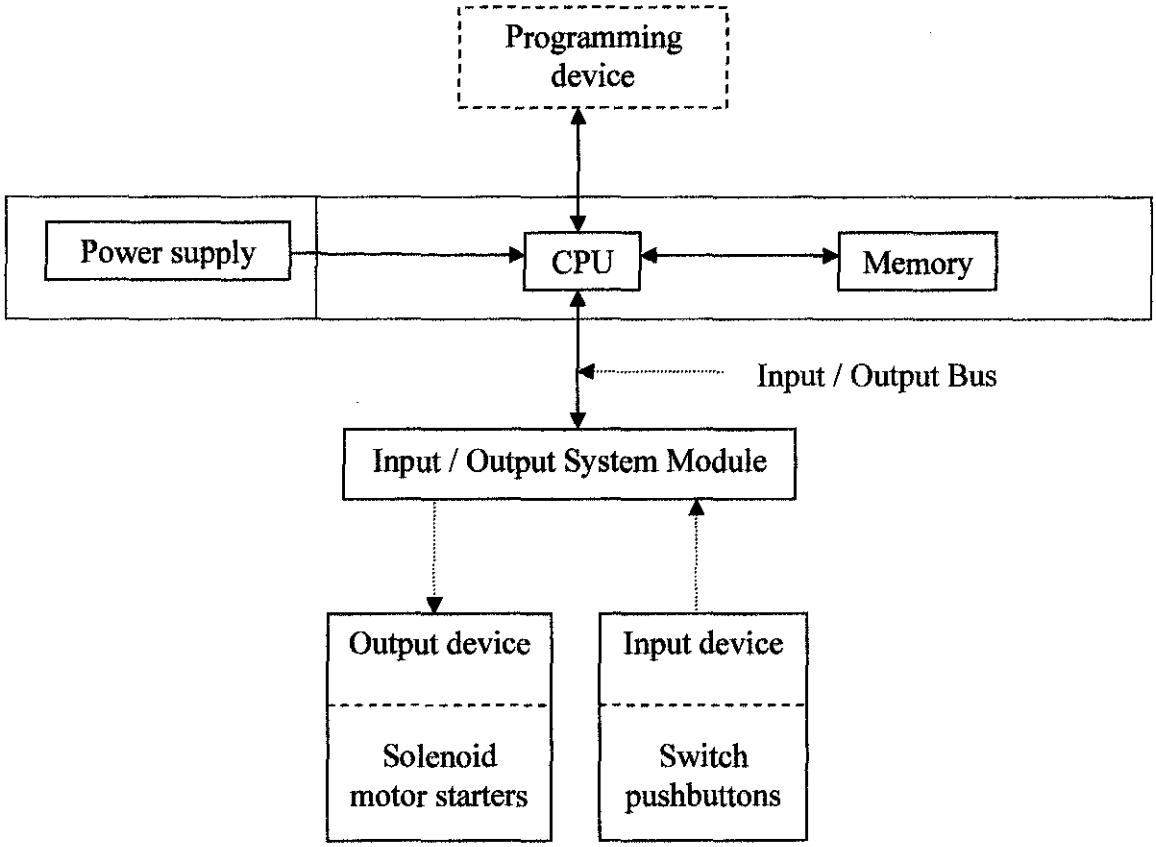


Figure 2.10: PLC architecture [12]

1. Central Processor Unit (CPU) Module

   Perform necessary tasks to fulfill PLC functions. The tasks are scanning, I/O bus traffic control, program execution, peripheral and external device communications, data handling execution (enhancement), and self diagnostic. [12]

2. Memory

   In PLC, the memory section acts as a library. It has Read Only Memory (ROM) and Random Access Memory (RAM). The ROM memory can be read but user can not modify the contents. It stores PLC operating system, driver programs, and application programs. The RAM memory can be read and written which mean user can modify the contents, but the memory contents will be lost when supply voltage fails. The user-written programs and working data are stored in RAM memory [12].

3. Input and Output Module (I/O Module)

   Connect between PLC and sensors or actuators. Each module can be connected to multiple outputs of similar characteristics. Besides, it can isolate the low signals of current and voltage which have been used by PLC internally from the higher-power electrical circuit [12].

4. Power Supply Module

   Convert available power to dc power at the levels required by the CPU and I/O module internal circuitry. The power supply drives the I/O logic signals, the central processor unit, the memory unit and also peripheral devices. Besides, it also protects the PLC internal circuitry from high-voltage line spikes [12].

2.2.3 Programmable Logic Controller Languages

There are two methods of programming language – text and graphic language. The text languages are the Instruction List and the Structured Text type. The examples of graphic languages are Sequential Function Charts, Function Block Diagrams and Ladder Logic.

Different PLC can support different languages. There are certain types of PLC that can support more than one language. These languages have their own limitation, and they complement one another to provide programmers with more programming power. [13].

Figure 2.11 shows type of programming languages for PLC.

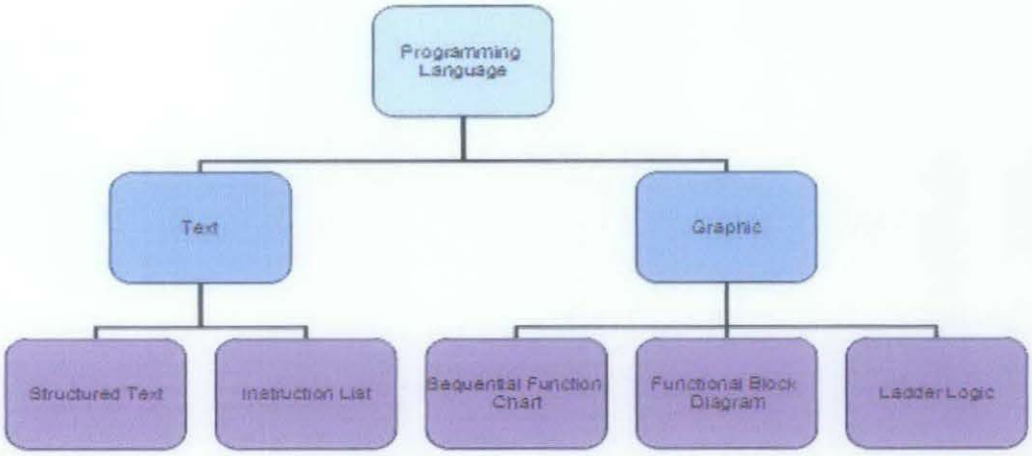


Figure 2.11: Type of programming languages

1. Structured Text

   High-level structured language designed for automation process. Statements can be used to assign values to the variables.

2. Instruction List

   Low-level programming language for smaller applications or for optimization parts of an application. It is much more like assembly language programming.

3. Sequential Function Chart

   Use graphic to describe sequential operations. It is very useful for describing sequential type processes.

4. Functional Block Diagram

   Use in applications involving the flow of signals between control blocks

5. Ladder Logic Diagram

   It is the most popular and widely used programming. It applies Boolean mnemonics to represent the process, before converting into logic diagram.

CHAPTER 3

METHODOLOGY / PROJECT WORK

3.1 Project Process Flow

Figure 3.1 shows the flow chart of the project which is then applied throughout the project.

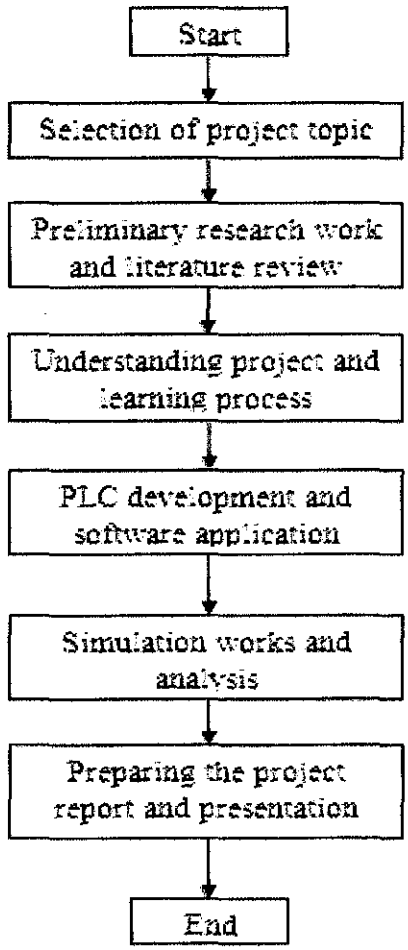


Figure 3.1: Process flow of project

The first step is to select the project topic and conduct the preliminary researches and literature review. Journals, conference papers, books and internet are referred. As the information is available, it is very crucial for the author to undergo the learning process as the valve, PST and PLC are not a familiar area to her. From the data gathered, the author gets the overview about the project. The next step is development programming for the PLC and setting the valve's software. Then, the simulation works and analysis are conducted. The following step is preparing the report that need to be submitted to the Final Year Project Committee. There is also an oral presentation which will take place towards the end of the semester.

3.2 Procedure Identification

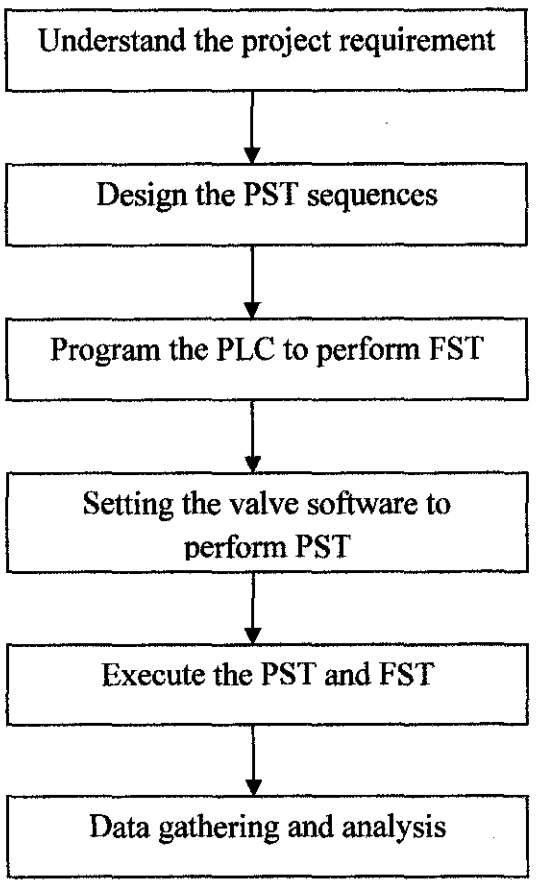


Figure 3.2: Procedure identification and flow diagram

3.2.1 Understand the Project Requirement

The main task beforehand is to understand the project requirement. This project is technology collaboration between PETRONAS Group Technology Solutions (GTS) and Universiti Teknologi PETRONAS. Besides, there are several vendors involve this project; Fisher, Metso Automation, Masoneilan, and Yokogawa Electric Corporation. Each vendor supplied the emergency shutdown valves which are ball valves and butterfly valves, while Yokogawa provided the PLC for this project. In the mean time, PETRONAS GTS has specified that for each ball and butterfly valve, the PST is to be executed 6 times a day, including 1 time PST coincides with FST. For the data to be accurate and valid, the test needs to be executed for 90 days.

3.2.2 Design the Partial Stroke Testing Sequences

The time allocate for each PST is 10 minutes. Therefore, the time taken to complete the 6 PST on a valve is 60 minutes. Table 3.1 shows the time allocation for the testing on ball valve.

Table 3.1: Time allocation for PST on ball valve

	10min	10 min	10 min	10 min	10 min	10 min
PST 1						
PST 2						
PST 3						
PST 4						
PST 5						
PST+FST						

The test is executed separately for ball and butterfly valve. The PST for the butterfly valve is executed right after the PST on ball valve. The time allocation for PST on butterfly valve is the same as ball valve.

3.2.3 Program the Programmable Logic Controller

Using the ladder logic diagram programming language, the program is developed on the Yokogawa FA-M3 PLC using the WideField2 software. The position of the Analog Input Module of the PLC consists of 4 sections as shown in Table 3.2.

Table 3.2: Sections in PLC Program

Section	Areas of data	Program
Section I	Operation mode	The area which the operation mode of each channel is stored
Section II	Operation details data	The area in which the upper and lower limit of the scaling are installed
Section III	Input data	The area which the input voltage data of each channel is installed
Section IV	Program execution	The area which the internal relay is used to execute the program

3.2.3.1 Section I – Operation Mode

In Section I, the operation mode when the sequence CPU fails is developed on a channel-by-channel basis. Channel 1 and 2 refers to FISHER ball valve and butterfly valve respectively. To set output values in a sequence CPU failure, a data location number is set to 1. The set items in operation mode in a sequence CPU failure are canceled when the power is turned off [14]. Table 3.3 shows the data location number in operation mode in a sequence CPU failure.

Table 3.3: Data location number in operation mode in a sequence CPU failure

Set items	Channel 1	Channel 2
Operation mode	501	502

For this setting, a special module WRITE instruction is used. Figure 3.3 shows a WRITE symbols.

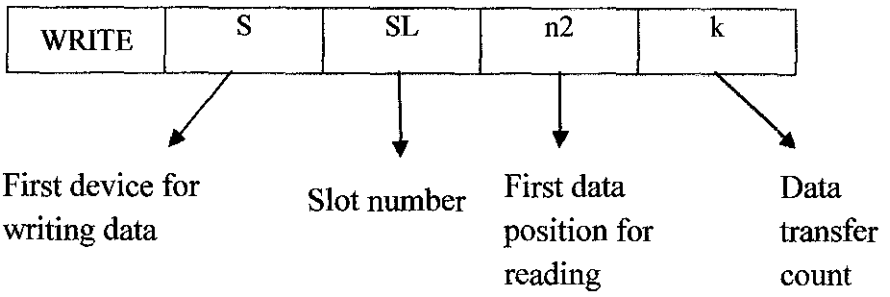


Figure 3.3: WRITE symbols

Figure 3.4 and Figure 3.5 show the WRITE instruction for power failure in rung 1 for ball valve program and butterfly valve program, respectively.

Figure 3.4: Rung 1 for ball valve program

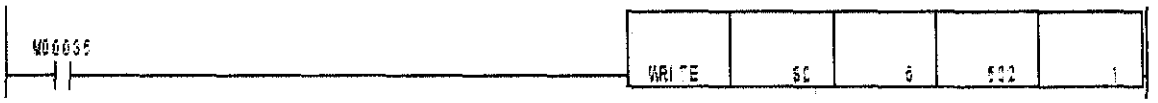


Figure 3.5: Rung 1 for butterfly valve program

3.2.3.2 Section II - Operation Details Data

Digital input values corresponding to upper-and-lower limit values in the output signal range is set to 0 and 10000, which 0 is 4mA and 10000 is 20mA [15]. Besides, the data location numbers for scaling have been set on a channel-by-channel basis. Table 3.4 shows the data location numbers for scaling.

Table 3.4: Data location numbers for scaling

Set Items	**Channel 1**	**Channel 2**
Digital input values corresponding to upper limit values in the output signal range	520	530
Digital input values corresponding to lower limit values in the output signal range	521	531

Figure 3.6 and Figure 3.7 shows the rung 2 and rung 3 for ball valve program and butterfly valve program, respectively.

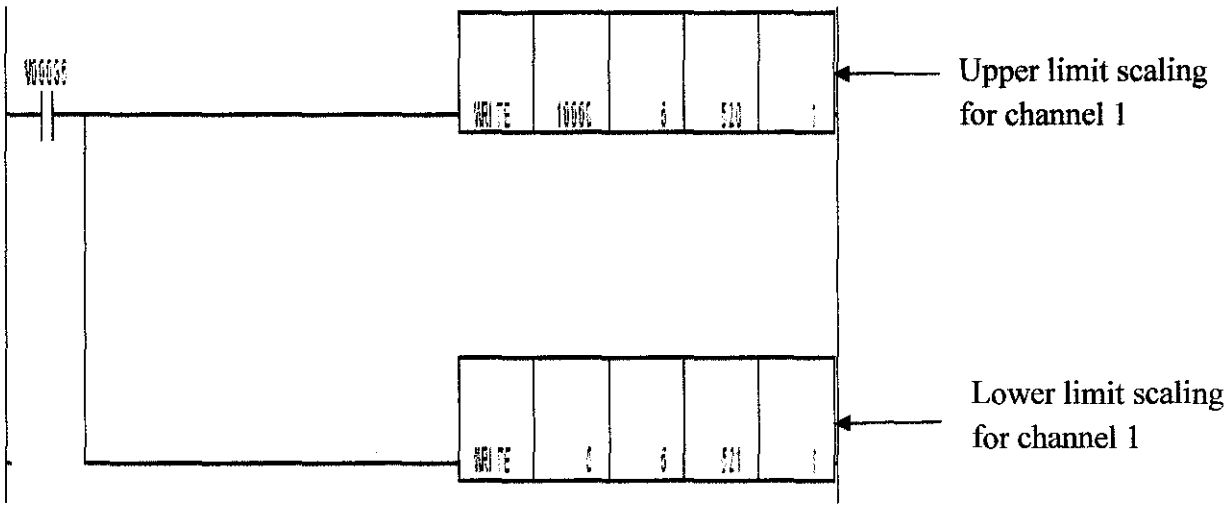


Figure 3.6: Rung 2 and 3 for ball valve program

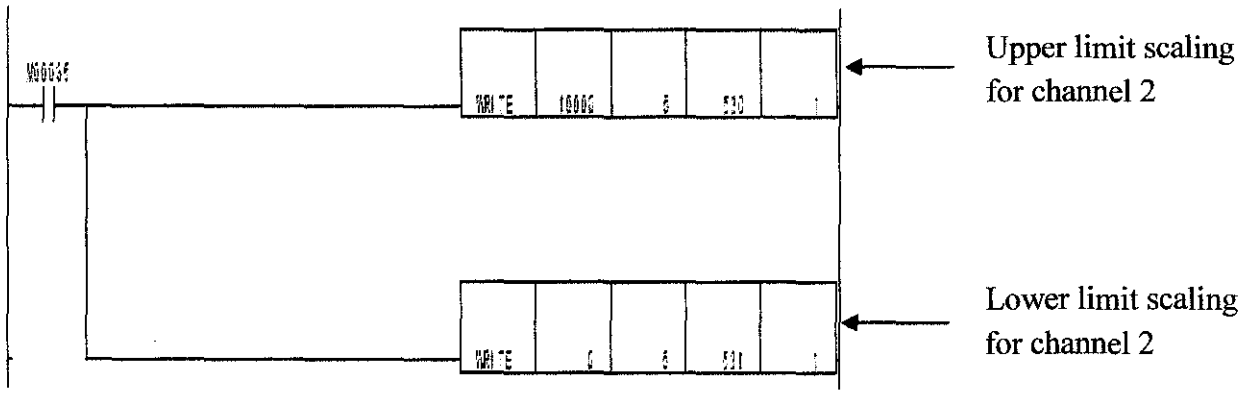


Figure 3.7: Rung 2 and 3 for butterfly valve program

The M0035 used in rung 1, 2 and 3 is a special relay. It has a specific function such as indicating operation and error states of the CPU [14]. M0035 enables 1 scan when operation is started.

3.2.3.3 Section III – Output data

In rung 4, the output data is pointed to data register, D00001. Channel 1 is used for input signal range from 4~20 mA. Figure 3.8 and Figure 3.9 show the rung 4 for ball valve program and butterfly valve program, respectively.

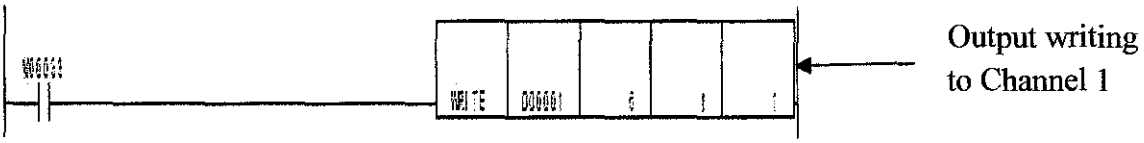


Figure 3.8: Rung 4 for ball valve

Figure 3.9: Rung 4 for butterfly valve

The special relay, M0033 is used to initialize the program and give a permanent high level (always ON).

Section 3.2.3.4: Section IV – Program Execution

In rung 5, the Internal Relay I0002 is used to move the lower limit value of output signal (0) to the data register, D0001. By forced set the I0002, PLC energizes the solenoid valve and sends 4mA to the DVC. Figure 3.10 shows the rung 5 for ball valve programming.

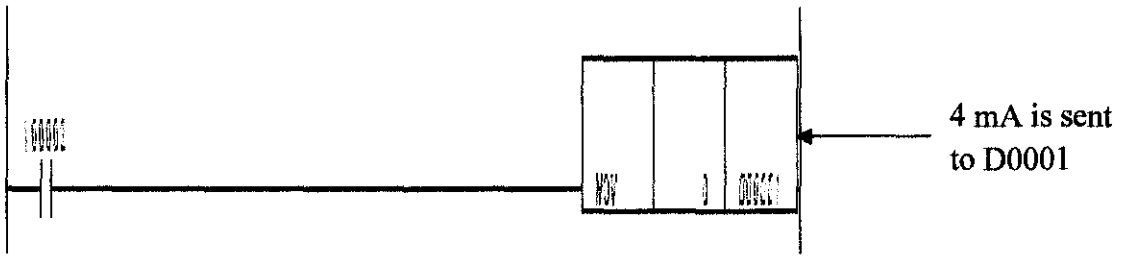


Figure 3.10: Rung 5 for ball valve

At rung 6 as shown in Figure 3.11, by forced reset the I0020, the valve opened. To send the FST signal, the I0020 is forced set and PLC sends the 20mA to DVC the valve closed.

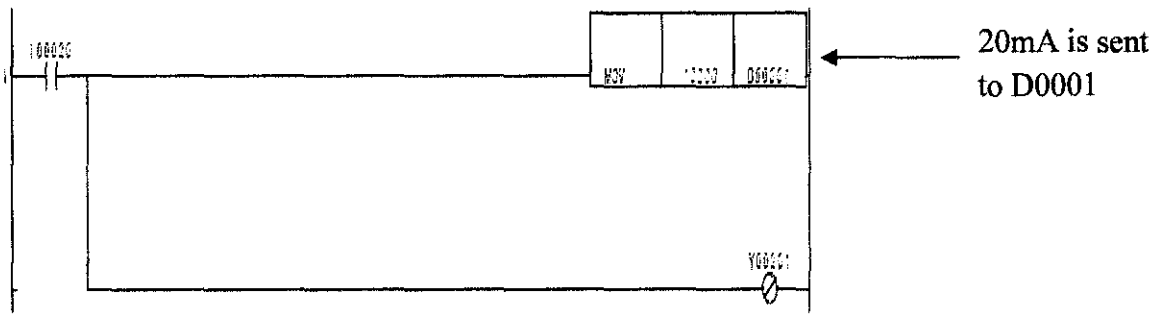


Figure 3.11: Rung 6 for ball valve

Refer to Appendix I and II for a complete programming for ball valve and butterfly valve, respectively.

3.2.4 Setting the AMS ValveLink Software

The instrument must be configured to run the PST. Below are the basic requirements to perform the PST. Figure 3.12 to Figure 3.16 shows the screenshots to setting the AMS ValveLink software.

i. Instrument is connected to the network

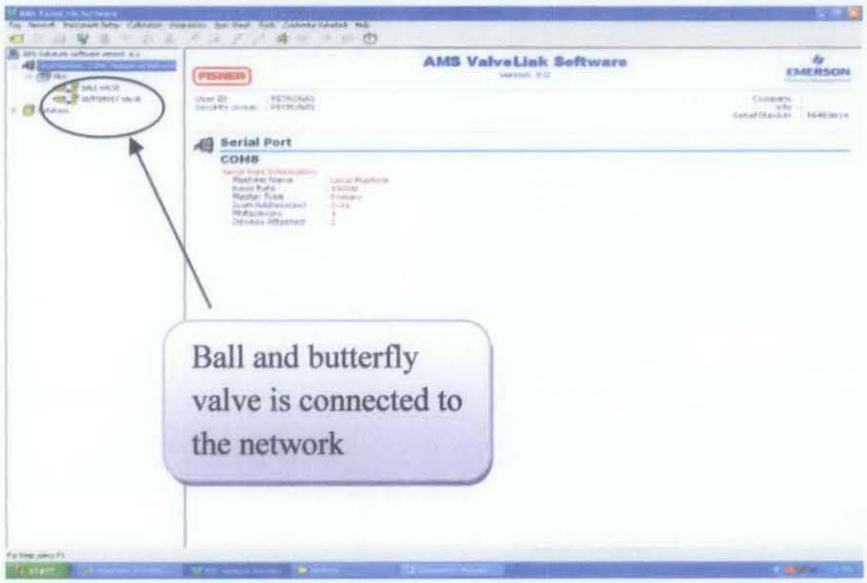


Figure 3.12: Ball and butterfly valve are connected to the network

ii. Instrument Mode set to Out of Service

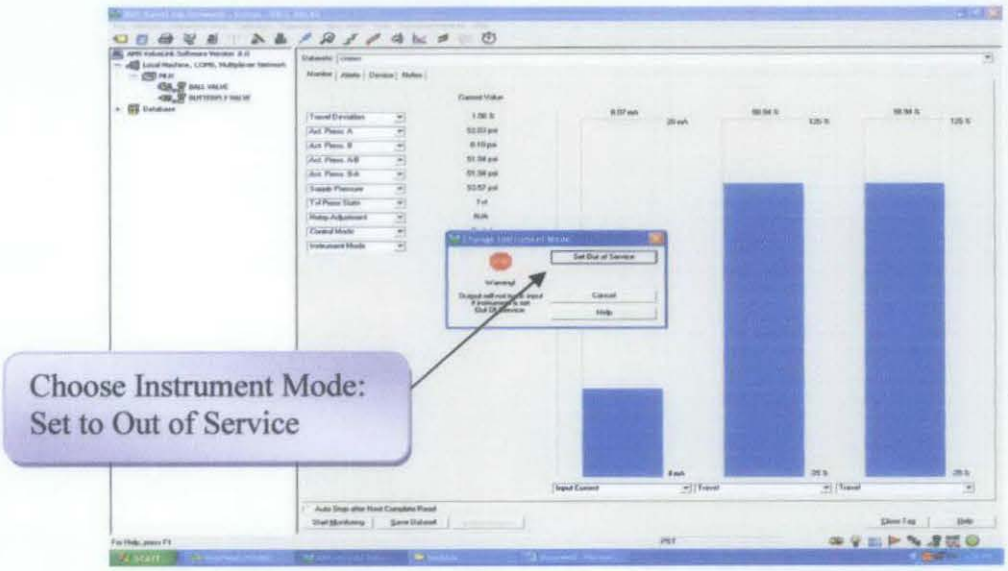


Figure 3.13: Instrument Mode setting

iii. Instrument Protection set to NONE.

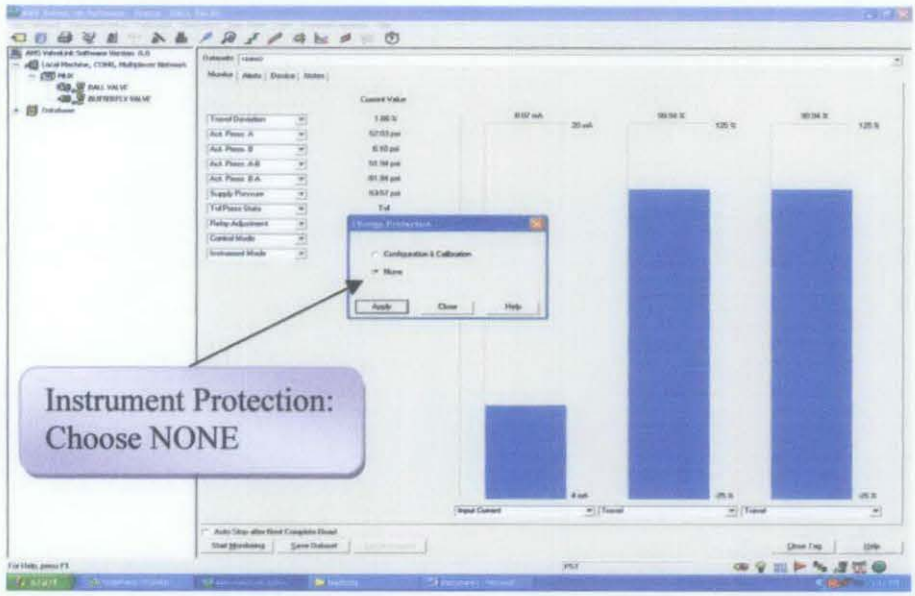


Figure 3.14: Instrument Protection Setting

iv. A 4 mA current is supplied to the Digital Valve Controller (DVC) of butterfly valve and 24VDC is supplied to ball valve DVC

- Butterfly valve

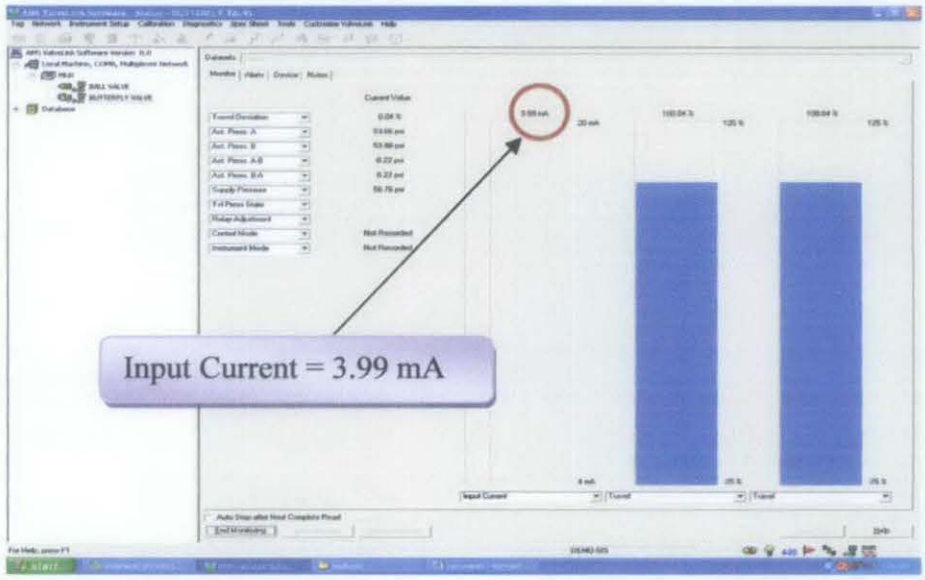


Figure 3.15: Input current to the butterfly valve

- Ball valve

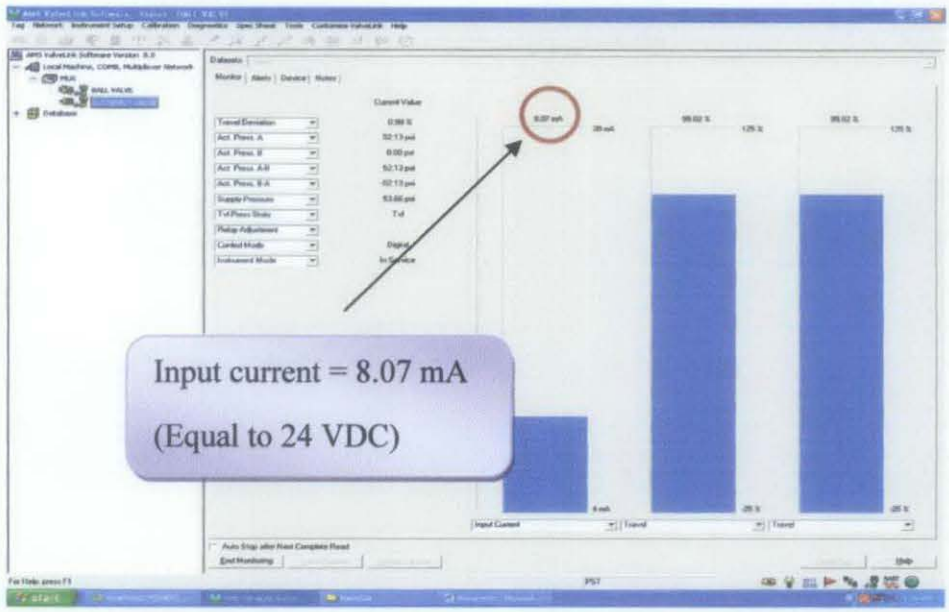


Figure 3.16: Input current to ball valve

Besides, the Partial Stroke Parameters are set to get in order to do PST. Table 3.5 shows the parameters setting in Partial Stroke menu.

Table 3.5: Parameters setting in Partial Stroke menu

No	**Parameter**	**Setting**
1	Partial Stroke Enabled	Enabled
2	Test Start Point	Valve Open
3	Maximum Travel Movement	20%
4	Test Speed	0.5%/s
5	Test Pause Time	5 sec
6	Auto Test Interval (day)	0

3.2.5 Partial Stroke Testing Execution

Figure 3.17 shows the flow of PST execution.

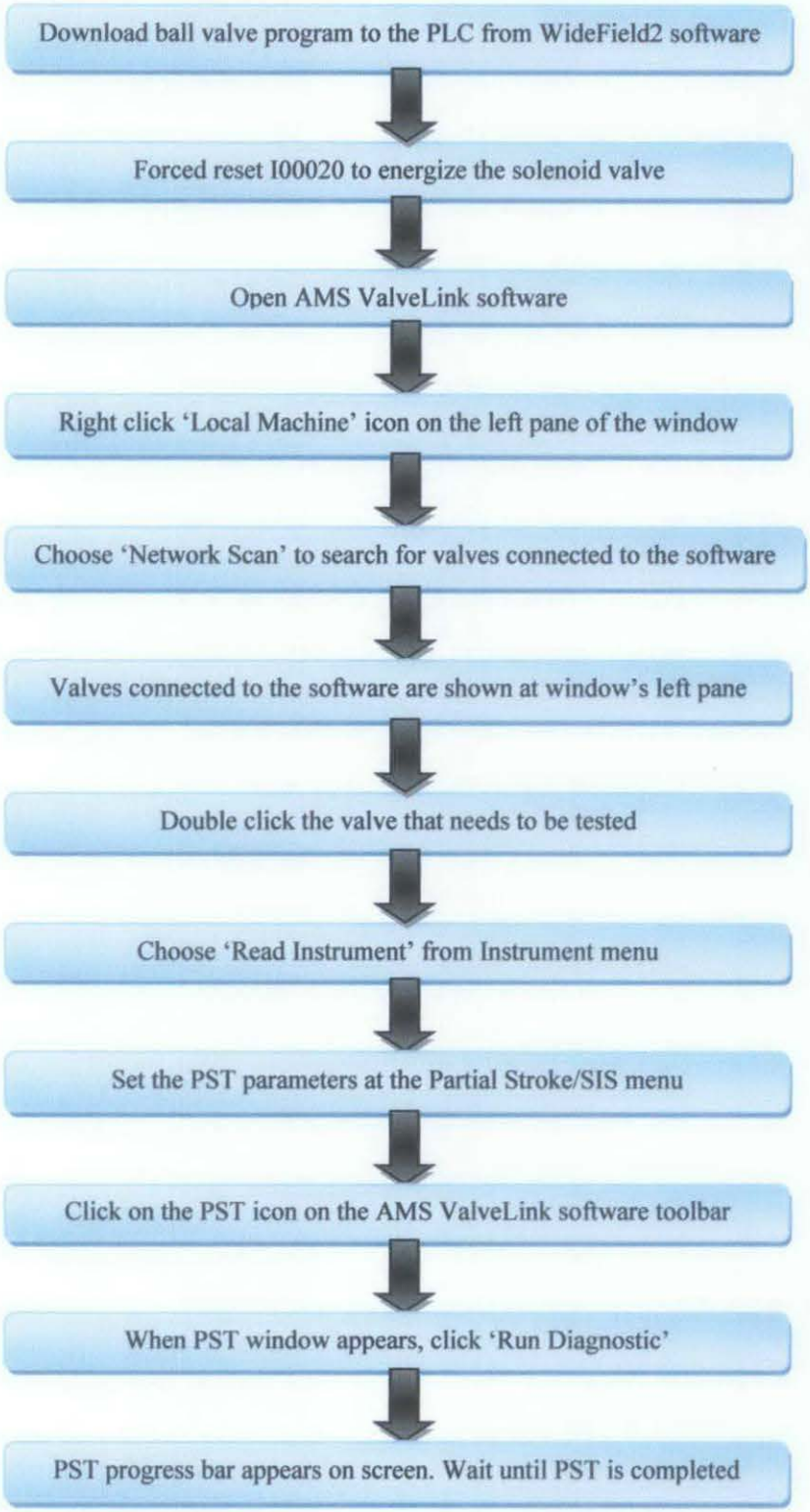


Figure 3.17: Flow of PST execution

3.2.5 Data gathering and analysis

AMS ValveLink has a feature that able to generate the report of the testing after the testing was conducted. Figure 4.8 shows the steps taken to analyze the data. The Analyzed Data Section in PST report was generated from the AMS ValveLink software. The report provides the testing result in graphs such Valve Signature, Dynamic Error Band and Travel Signal. These graphs were also represented in numerical value as shown in Analyzed Data section (red circle). The Analyzed Data section consists of the Dynamic Error, Dynamic Linearity, Ranged Travel and Bench Set. The value of the errors was varied according to the valve specification and condition. Then, the data were converted to table form. Next, the graphs were plotted according to the value of the parameters in Analyzed Data section, and the valve performances are analyzed. (Note that the graphs on the next pages are not generated from the software. Refer to Appendix V and VI for the summary of Analyzed Data values in table form for PST on ball and butterfly valves)

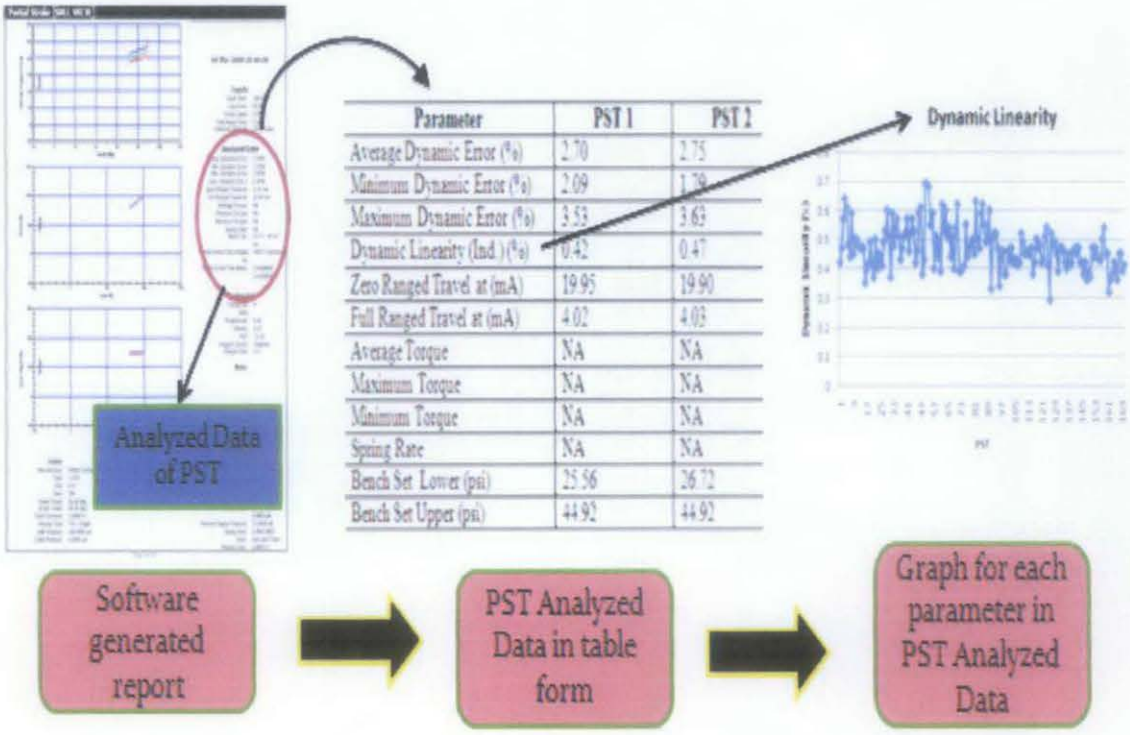


Figure 3.18: Steps taken to analyzed the PST data

3.3 Tools Required

3.3.1 Hardware Requirement

The hardware requirements for this project are as follow:-

1. Valves

There are 2 types of valves use throughout this project; ball valve and butterfly valve. Table 3.6 shows the general specification for each valve.

Table 3.6: General Specification for Valves

Manufacturers	**Valves**	**Size (inch)**	**Input**	**Minimum Pressure (psi)**	**Operational Temperature (^{0}C)**
FISHER	Ball	6	24 VDC	5 psi	-40 – +80
	Butterfly	4	4-20 mA	5 psi	-40 – +80
METSO	Ball	6	4-20 mA	36 psi	-40 – +85
	Butterfly	6	4-20 mA	36 psi	-40 – +85
MASONEILAN	Ball	6	24 VDC	3 psi	-40 – +85
	Butterfly	6	4-20 mA	3 psi	-40 – +85

Figure 3.19 shows the configuration for the Yokogawa FA-M3 Controller.

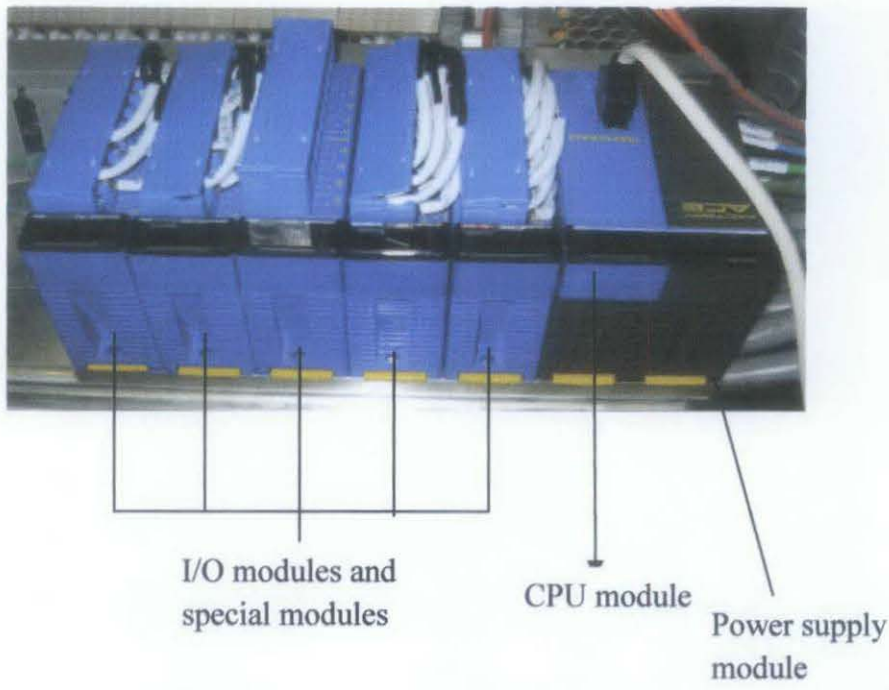


Figure 3.20: Yokogawa FA-M3 Controller configuration

3. Personal Computer
4. 24 VDC Power Supply
5. Multiplexer
6. Pressure supply

3.3.2 Software Requirement

Table 3.8 lists out the softwares use in this project.

Table 3.8: Softwares use in this project

	Software	**Vendor**	**Application**
1	WinField2	Yokogawa	Yokogawa FA-M3 Controller
2	ValveLink	Fisher	Fisher Ball Valve and Butterfly Valve
3	FieldCare	Metso	Metso Ball Valve and Butterfly Valve
4	Valvue ESD	Masoneilan	Masoneilan Ball Valve and Butterfly Valve

3.4 Hardware Preparation

This project involves 6 valves from different manufacturers. The valves will be controlled by PLC and Personal Computer (PC). The PLC is needed to trigger the demand and execute the FST according to the project requirements. Thus, it is important to develop the right hardware system between input and output devices. A complete wiring connection will ensure the communications between each device are successful. Figure 3.20 shows the hardware connections between PLC, PC, valves and multiplexer.

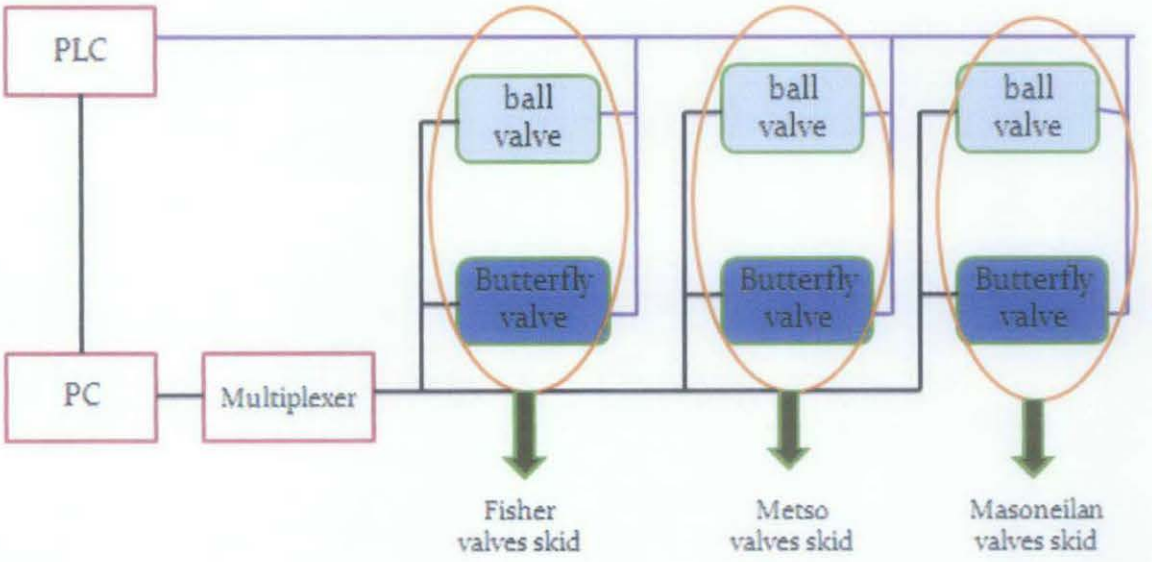


Figure 3.21: Hardware connection between the valves, PLC, PC and multiplexer

Figure 3.22 shows the hardware connection for power supply and pressure supply to the valves.

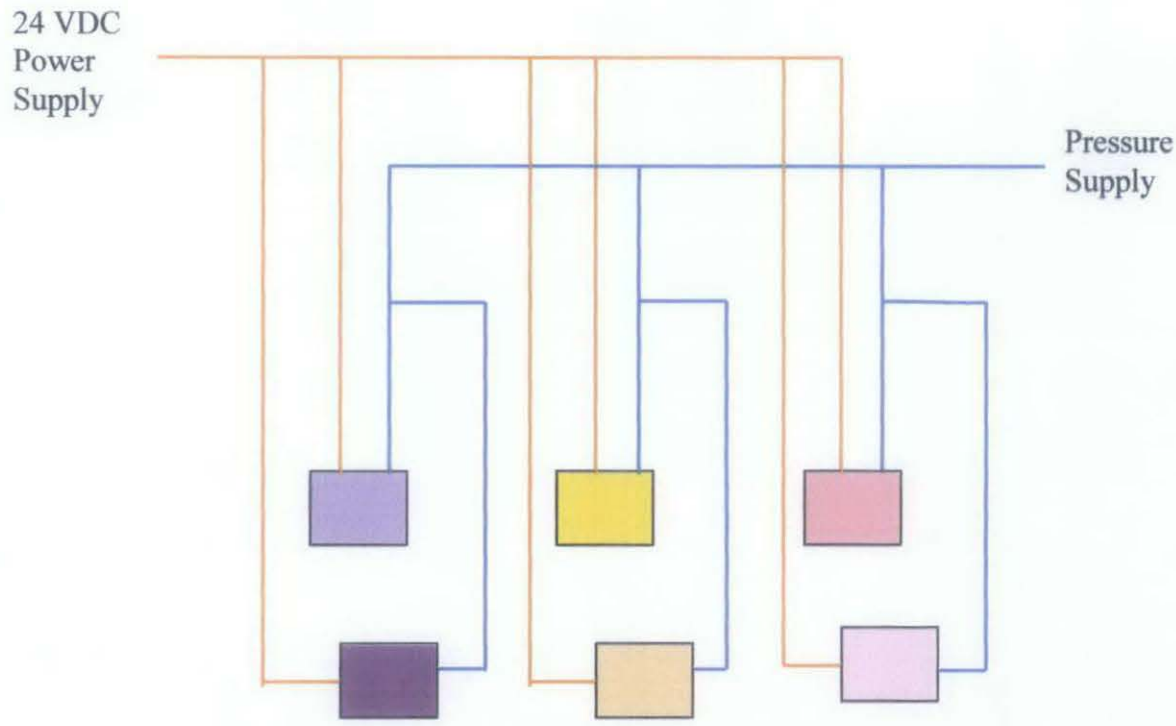
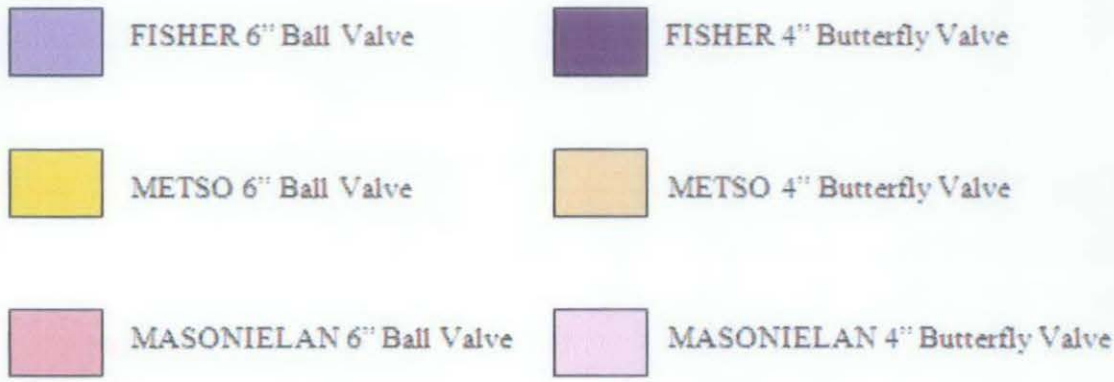


Figure 3.22: Wiring connection for power supply and pressure supply

Legends:-



CHAPTER 4
RESULTS & DISCUSSION

4.1 Partial Stroke Testing

The PST has been executed for 35 days, which means each valve has performed 175 times PST and 35 times PST coincides with FST. Figure 4.1 shows the valve signature of a PST executed on ball valve on 1st February 2009. (Refer to Appendix III and IV for full report (software generated) on PST testing for ball valve and butterfly valve).

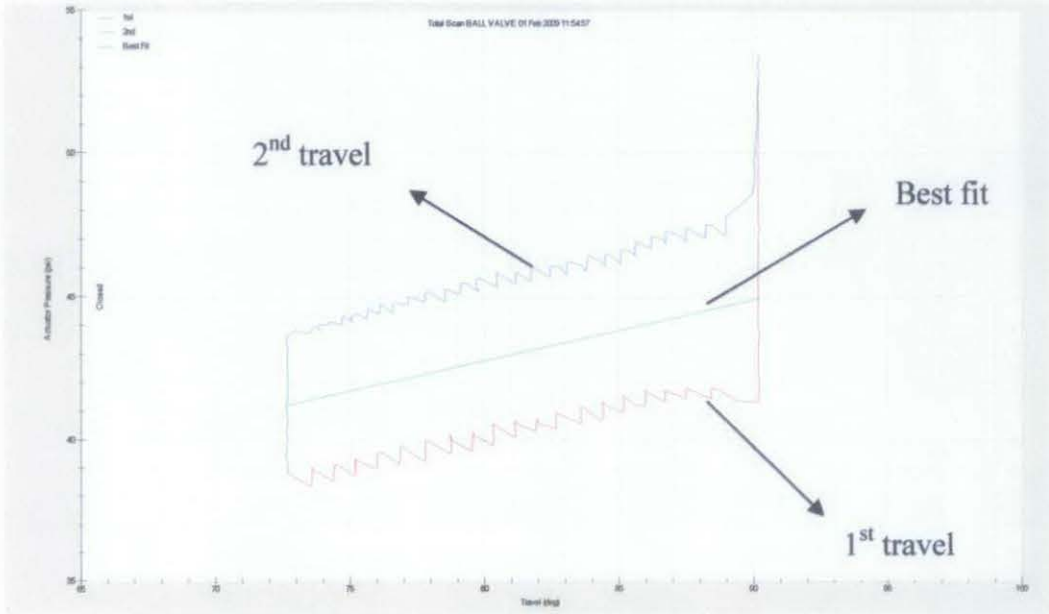


Figure 4.1: Valve signature for ball valve

The y-axis of the graph is the actuator pressure and the x-axis is the travel in degree. The valve is in fully open position at 90 degree and according to Partial Stroke parameters setting; the maximum travel is 20% which is 18 degree.

Referring to Figure 4.1, the first travel is from 90.5 degree to 72.5 degree. At 90.5 degree, the actuator pressure dropped abruptly from 52.5 psi to 41.5 psi. It is because the valve needs much torque to overcome the break force in order to cause the valve to move. In order to perform PST, the valve bleed out the air and the pressure is continuously dropped until it reached the maximum travel set earlier in Section 3.2. At the starting point of second travel, the pressure is increased from 38.8 psi to 43.8 psi. Then, the pressure is steadily increased until it reached 100% opening.

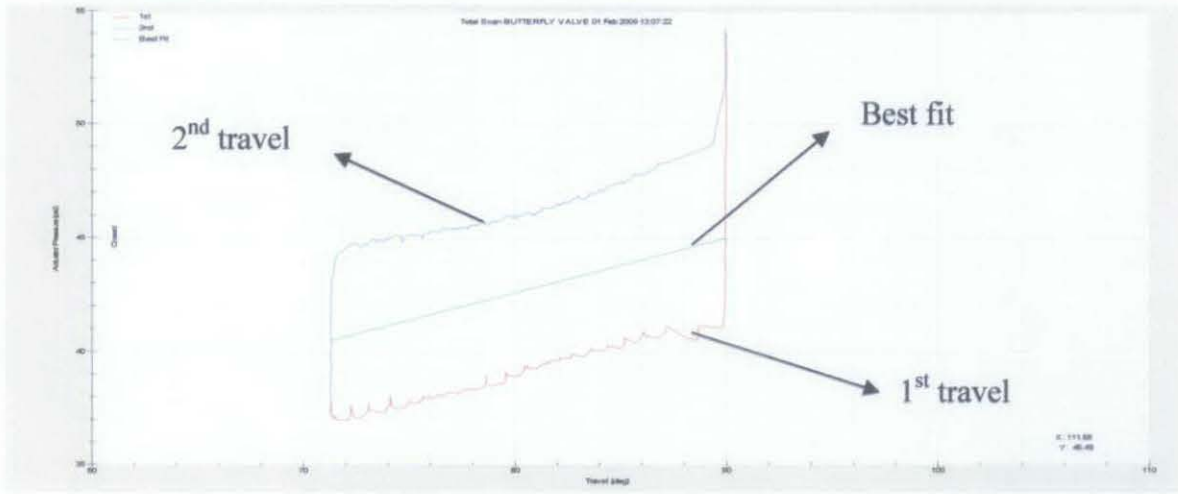


Figure 4.2: Valve signature for butterfly valve

Referring to Figure 4.2, the pattern of the signature is the same as the ball valve. The valve started its first travel at 90 degree with 54 psi and drop 41 psi. The pressure drop occurred to cause the valve to move from its seat. The pressure dropped steadily until it reached 80% of travel. Then, the pressure is increased from 37 psi to 44.5 psi when the valve started to move from 80% to 100% during second travel. The pressure is continuously increased until it reached 100% opening.

4.2 Partial Stroke Testing Coincides with Full Stroke Testing

For this test, the FST signal is given to the valve when the valve is 90% opened during first travel. Figure 4.3 and Figure 4.4 show the graph of the test for ball and butterfly valve.

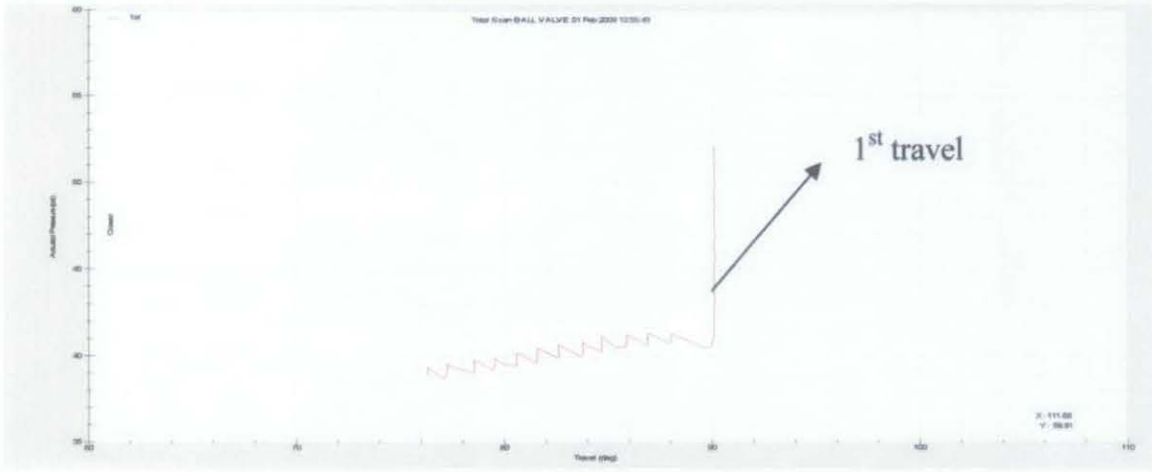


Figure 4.3: Graph for PST coincides with FST on ball valve

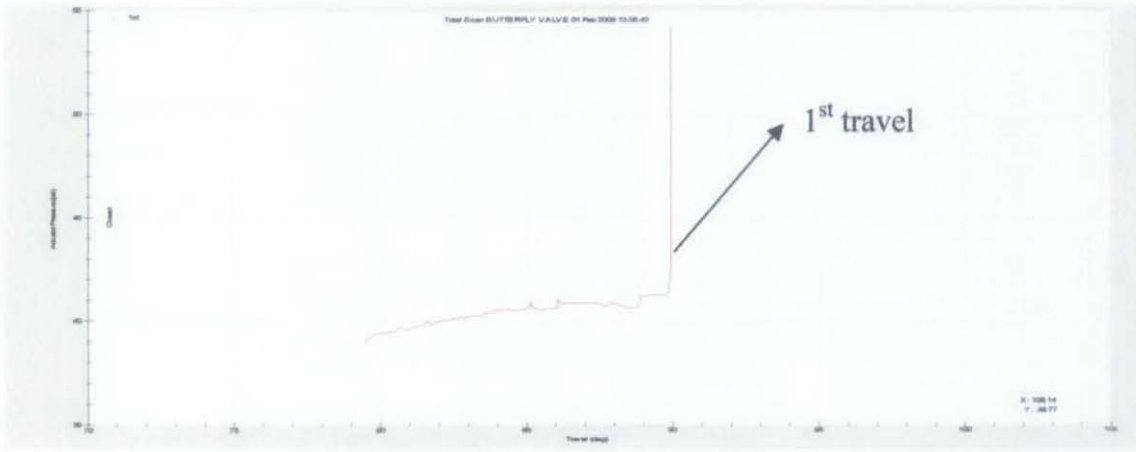


Figure 4.4: Graph for PST coincides with FST on butterfly valve

The maximum travel setting for this test was the same as the PST which is 20%. When the valve started to move, it released the pressure for the valve to move. The FST signal is sent at 81 degree cause the valve to automatically close once it received the signal.

4.3 DVC6000 Installation

There are 2 types of DVC6000 installation:-

a) 4-wire system

b) 2-wire system

4.3.1 4-wire system

The 4 wire system installation allows the DVC6000 to continue to communicate even during emergency shutdown condition. The advantage of 4-wire system is it has 2 different sources being supplied to instruments. The 24 volts is supplied to power up the solenoid valve and the 4-20mA is supplied to the DVC. During shutdown, the voltage supply will be cut off and hence there is no power supply to the solenoid valve. The analog signal to the digital valve control enables the operators to monitor the current information of the valve although the valve is not operating.

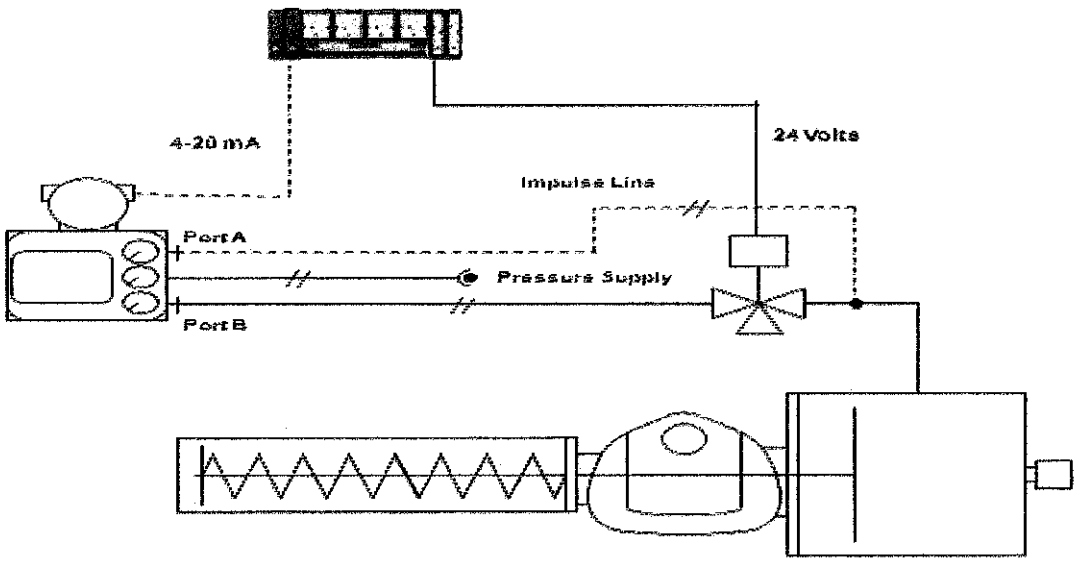


Figure 4.5: 4-wire system

On 26th February 2009, the solenoid valve on FISHER Ball Valve was removed from the valve actuator. Then, a 24 VDC is supplied to the valve instead of the current. As a result, the FISHER ball valve will no longer operate using the 4-20 mA current. With the solenoid valve bypassed, the pressure line A was eliminated as shown in Figure 4.13. The middle gauge at the DVC6000 measures the pressure supplied to the actuator. The output pressure A energizes the solenoid valve and the output pressure B measures the pressure drops.

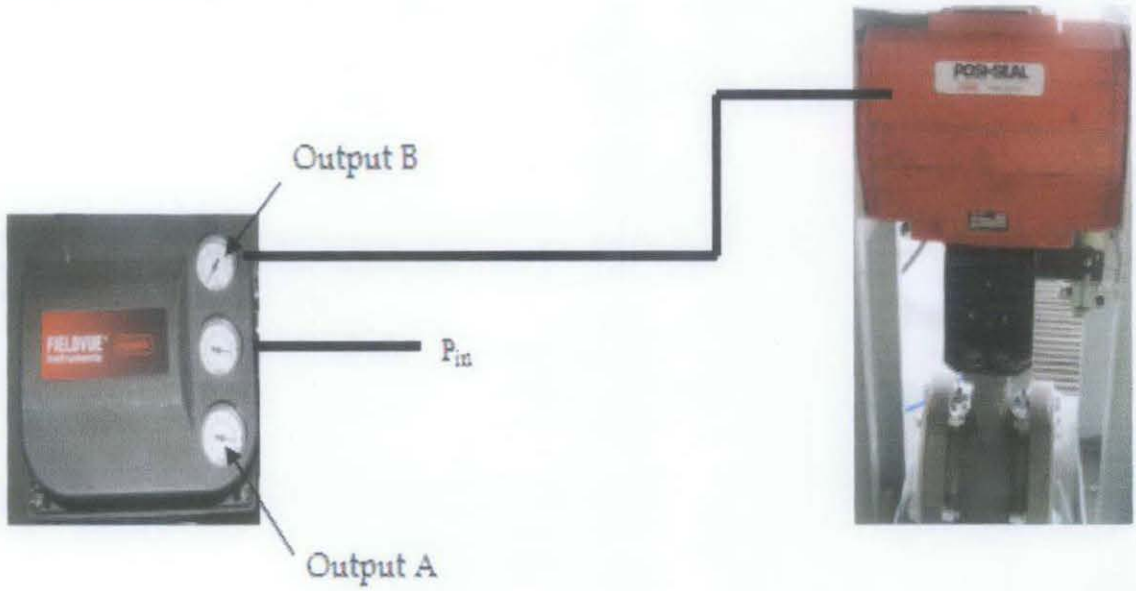


Figure 4.6: Bypass the solenoid valve

4.3.2 2-wire system

The DVC installation became a 2-wire system when solenoid is bypassed. Figure 4.7 shows the 2-wire system with line conditioner connected to the DVC. The line conditioner acts as a barrier because the valve cannot receive 24VDC supply directly from the PLC.

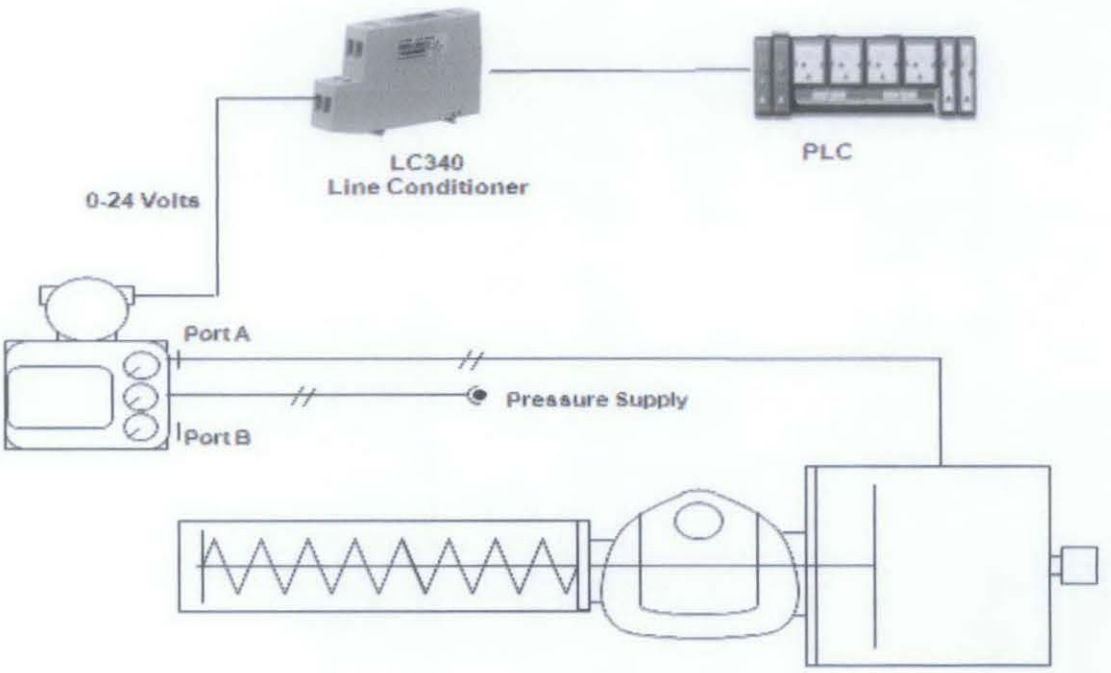


Figure 4.7: 2-wire system

Parallel with the bypassing of solenoid valve and the operating mode of the valve, there were some changes of the instrument parameters as shown in Table 4.1.

Table 4.1: Parameters change of the ball valve

Group	Parameters	Before(Analog)	After(Digital)
Initial Setup	**Restart Cont Mode**	Analog RSP	**Digital**
	Zero Power Condition	Valve Open	**Valve Closed**
	Travel / Pressure Cutoff Lo (%)	0.5	**50**
	Relay Type	Relay B	**Relay A or C**
	Travel Sensor Motion	Clockwise	**Counter-clockwise**
Travel History Alerts	Cycle Count	331	338
	Travel Accumulator (%)	22576	23243
Deviation & Other Alerts	Drive Signal Alert Enable	Yes	No
	Supply Pressure Alert Enable	Yes	No
SIS/Partial Stroke	Partial Stroke Pressure Limit	16 psi	18 psi
	5 sec	5 sec	10 sec
	Action on Failed Test	Ramp Back	Step Back
Alert Records & Commands	Instrument Clock	24 Feb 2009,1:50	25 Feb 2009,2:26
	Alert Record Not Empty Enable	Yes	No
	Alert Record Full Enable	Yes	No
Travel/ Pressure Control	**Travel/Pressure Cutoff Lo (%)**	0.5	**50**
	Travel/Pressure Cutoff High (%)	99.46	**50**
	Pressure Set Point	52.1 psi	51.8 psi
Informational Status	Inst Time Invalid Enable	Yes	No
	Diag Data Avail Enable	Yes	No
	Integrator Sat Hi Enable	Yes	No
	Integrator Sat Lo Enable	Yes	No
	Press Ctrl Active Enable	Yes	No
Electronics Alerts	Shutdown Activated Alert Enable	Yes	No
Actuator	**Volume Booster/Quick Release**	-	**No**

The parameters in blue are the parameters that changed when the valve operation mode is changed from analog operated to digital operated mode. The Relay Type is changed from Relay Type A to Relay Type B. The Relay Type B allows the valve to automatically close during the power failure. Previously, the valve is set to open whenever the power fails. This setting is not suitable for the emergency shutdown valve because the valve is in fully open during normal operation.

4.4 Analyzed Data of Partial Stroke Testing for Ball Valve

4.4.1 Average Dynamic Error

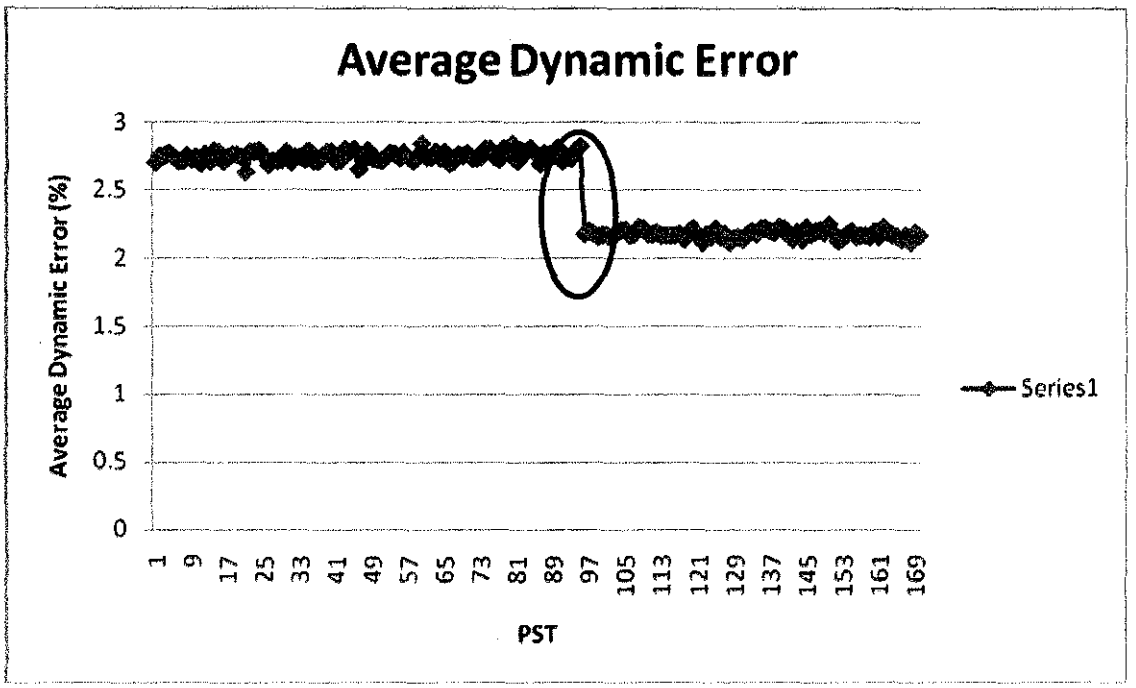


Figure 4.8: Average Dynamic Error vs No of PST

4.4.2 Maximum Dynamic Error

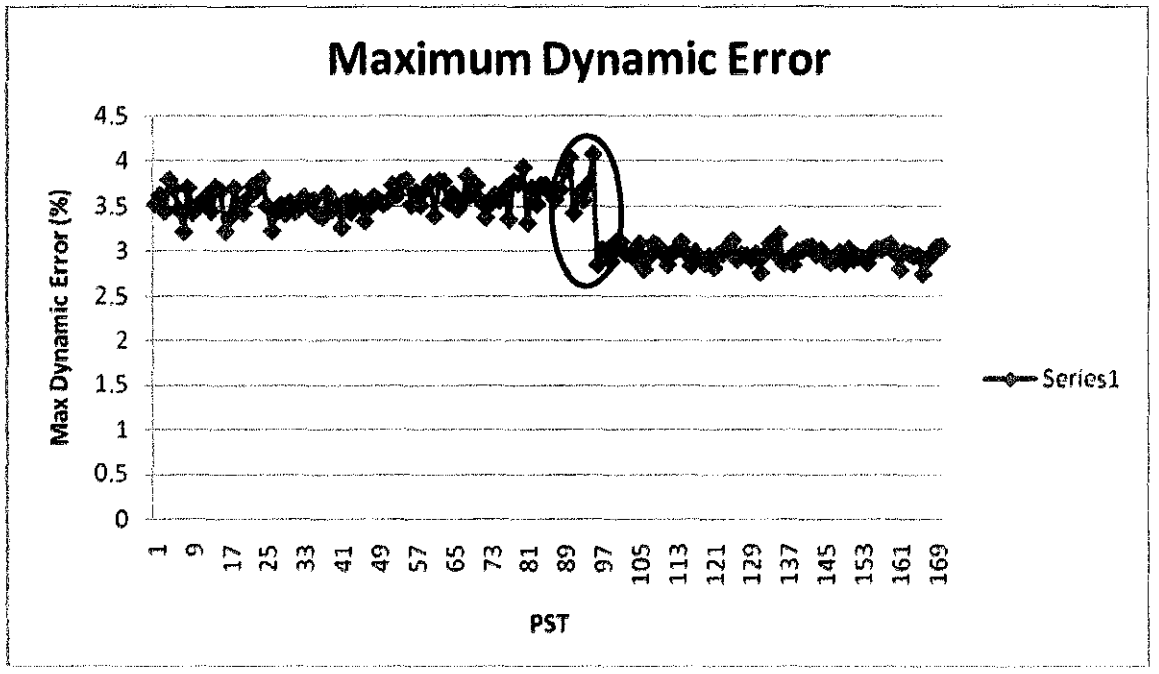


Figure 4.9: Maximum Dynamic Error versus no of PST

4.4.3 Minimum Dynamic Error

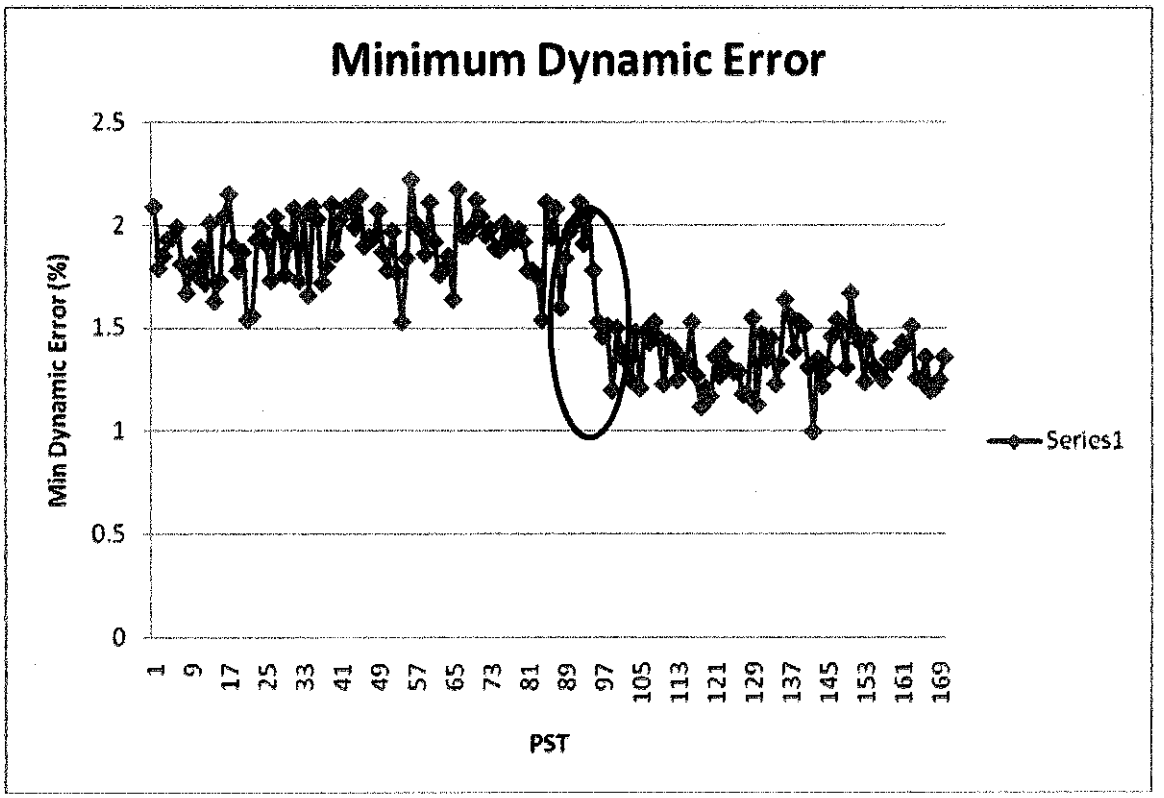


Figure 4.10: Minimum Dynamic Error versus no of PST

AMS ValveLink software analyzed the dynamic error curve from 5% travel to 95% travel and calculates the average, maximum and minimum difference between opening and closing curves. Referring to Figure 14, the plot shows that initially the valve Average Dynamic Error was around 2.75%. Referring to Figure 4.8, after the 95th testing (red circle), the Average Dynamic Error reduced to around 2.25% in total reduced to 0.5% error. For the Maximum Dynamic Error, the reading was reduced from 3.7% to 3.1% as shown in Figure 4.9. This happened because previously, the DVC output was connected to the solenoid and the solenoid was connected to the actuator. During the operation, the DVC has a restriction when air goes through the solenoid and to actuator. After removing the solenoid, the output of DVC become smooth where there is no restriction in between the actuator and the DVC

4.4.4 Dynamic Linearity

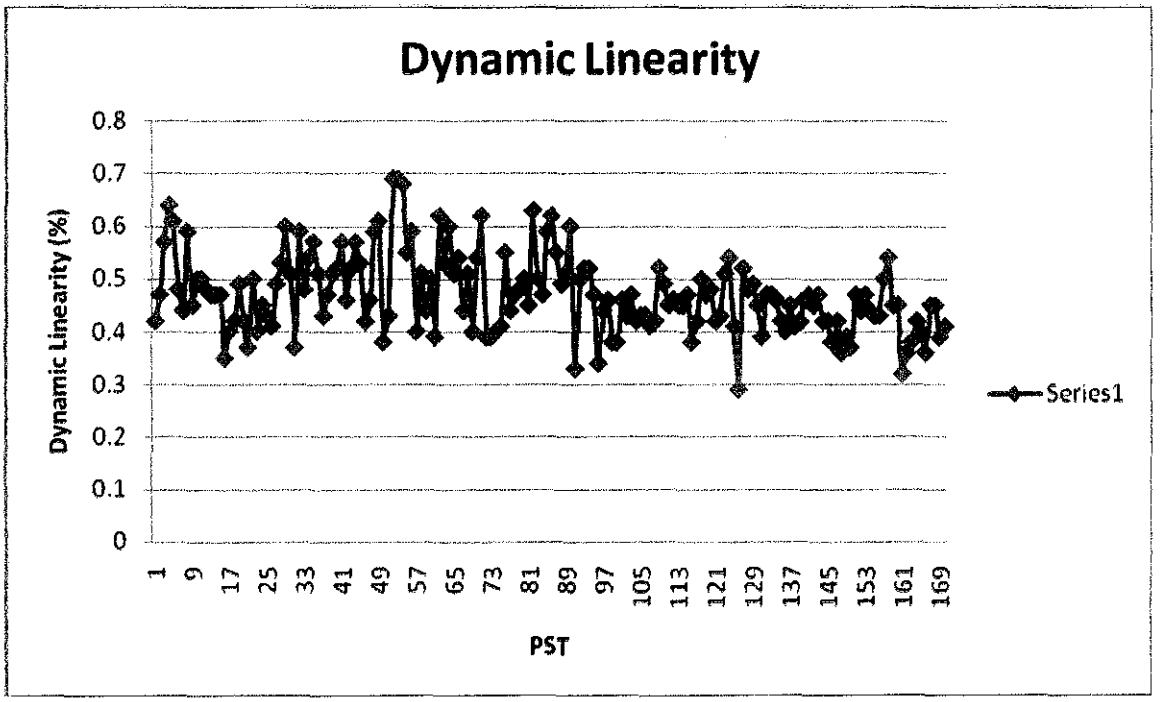


Figure 4.11: Dynamic Linearity versus No of PST

Linearity is the maximum deviation from a straight line best fit to the opening and closing curve and line representing the average value of those curves. Based on Figure 4.11, the Dynamic Linearity varies along the number of PST executed and does not affected by the solenoid.

4.4.5 Zero Ranged Travel

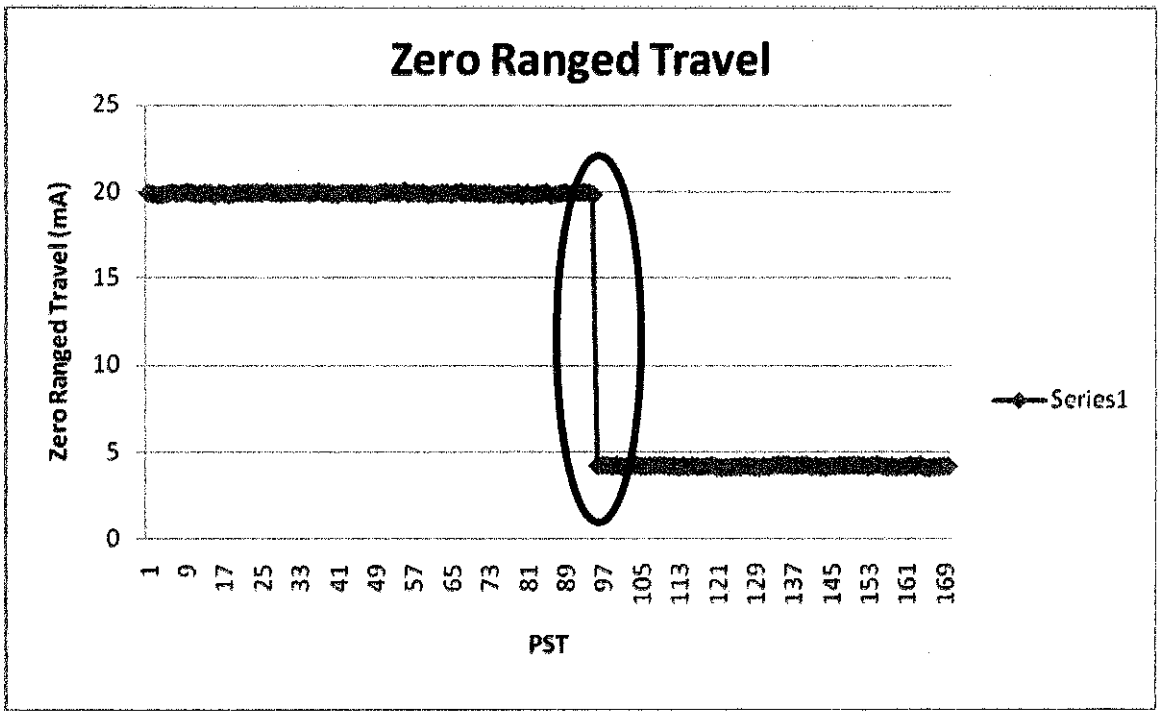


Figure 4.12: Zero Ranged Travel versus No of PST

AMS ValveLink Software establishes a best fit line through the Dynamic Error Band and projects this to a ranged travel of zero. It converts the X-axis point where the ranged travel is zero, from input percent to milliamps (mA). The Zero Ranged Travel was ranging from 19.92mA to 20.04 mA. Referring to Figure 4.12, at 95th PST the values were dropped to 4.21 mA and continued stabilizing. This drop was due to the changed of operating mode from analog to digital. Initially, the valve was configured at zero ranged valve opens. This is only applicable for Relay Type B special. This relay has been removed when the solenoid was bypassed and being replaced by Relay Type A. For Relay Type A, it is configured that valve close when zero power condition occurred. Therefore, the 4~20 mA signal changed at the plot.

4.4.6 Full Ranged Travel

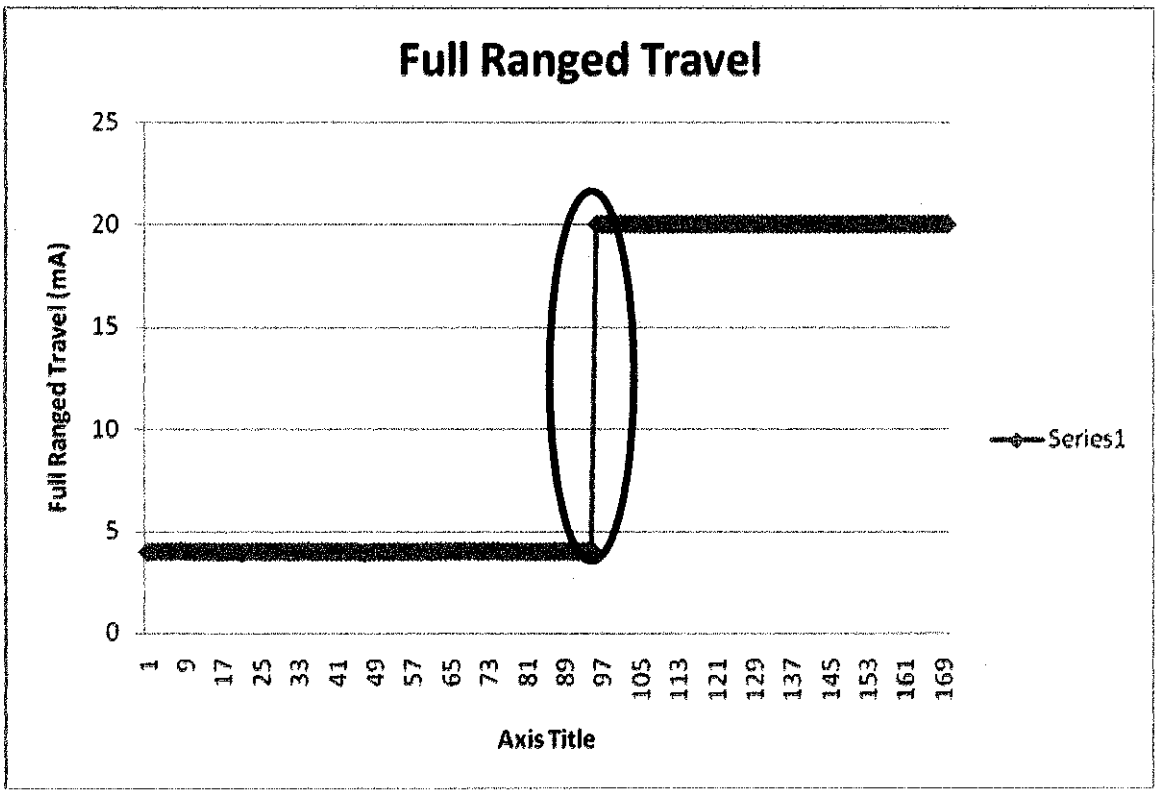


Figure 4.13: Full Range Travel versus No of PST

Full Ranged Travel is the point where the travel no longer increases with an increase in current. There was a sudden rise at 95th PST as shown in Figure 4.13. Previously, the Zero Power Condition was set the valve to open when power fails. After changing the operation mode of the valve (from analog operated to digital), the Zero Power Condition is set to close which cause the valve to fully close when power fails. Initially, at full range the valve was configured closed position. After changing the setting of Zero Power Condition, the valve goes to open position as it is configured as open at full range

Lower Bench Set is the amount of pneumatic pressure required to begin actuator movement. For air-to-open valve, it is the pressure required to begin valve opening travel. Figure 4.14 and 4.15 show that the pressure reading is reduced after 95th PST. Upper Bench Set displays the amount of pneumatic pressure required to drive the actuator through the full range of travel. For air-to-open valve, it is the pressure required to move the valve to the fully open position. Note that the pressure required to moving the valve is also reduced after 95th PST. The valve requires less pressure to move from its seat when the solenoid is bypassed. Previously, the pressure is supplied to both solenoid valve and DVC to operate the valve. After bypassing the solenoid valve, the pressure is only supplied to the DVC.

4.5 Analyzed Data of Partial Stroke Testing for Butterfly Valve

4.5.1 Average Dynamic Error

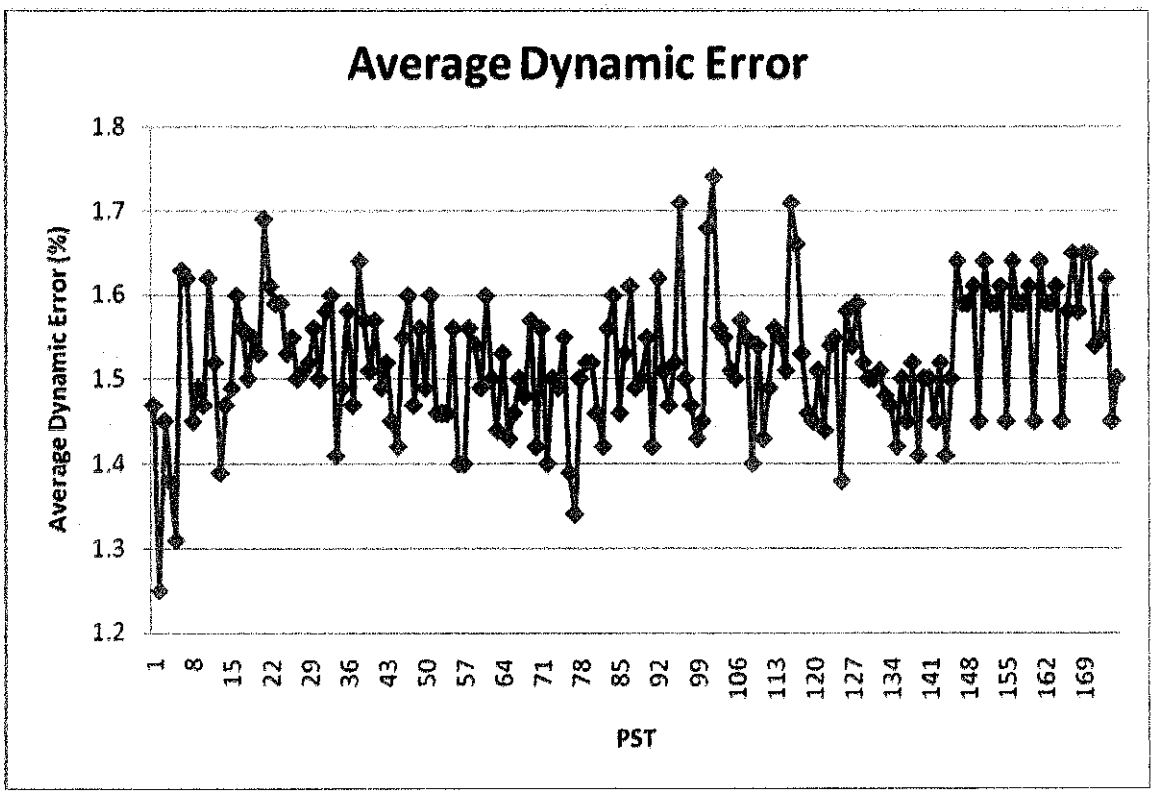


Figure 4.16: Average Dynamic Error versus no of PST

Dynamic Error Curve is the difference between opening and closing curve from 5% to 95% of valve travel. From the curve, the AMS ValveLink software calculates the average, maximum and minimum difference of the opening and closing curve. The graphs are plotted to observe the differences and its effect to the valve. Figure 4.16 shows the Average Dynamic Error plot which ranging from 1.2% to 1.8%. With 0.6% variation, the graph is acceptable.

4.5.3 Minimum Dynamic Error

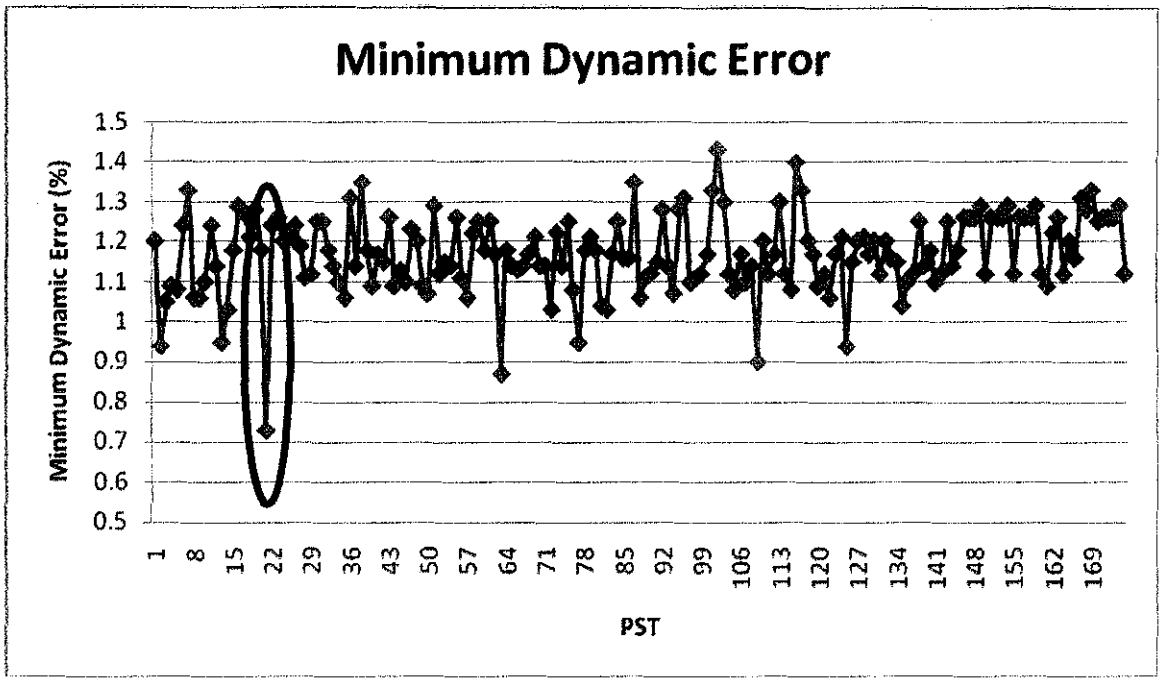


Figure 4.18: Minimum Dynamic Error versus no of PST

Figure 4.18 shows the Minimum Dynamic Error graph of PST. The variation is ranging from 0.9% to 1.7%. The spike at 21st PST is 0.73%. Tightening valve packing cause one of the minimum dynamic error overshoot.

4.5.4 *Dynamic Linearity*

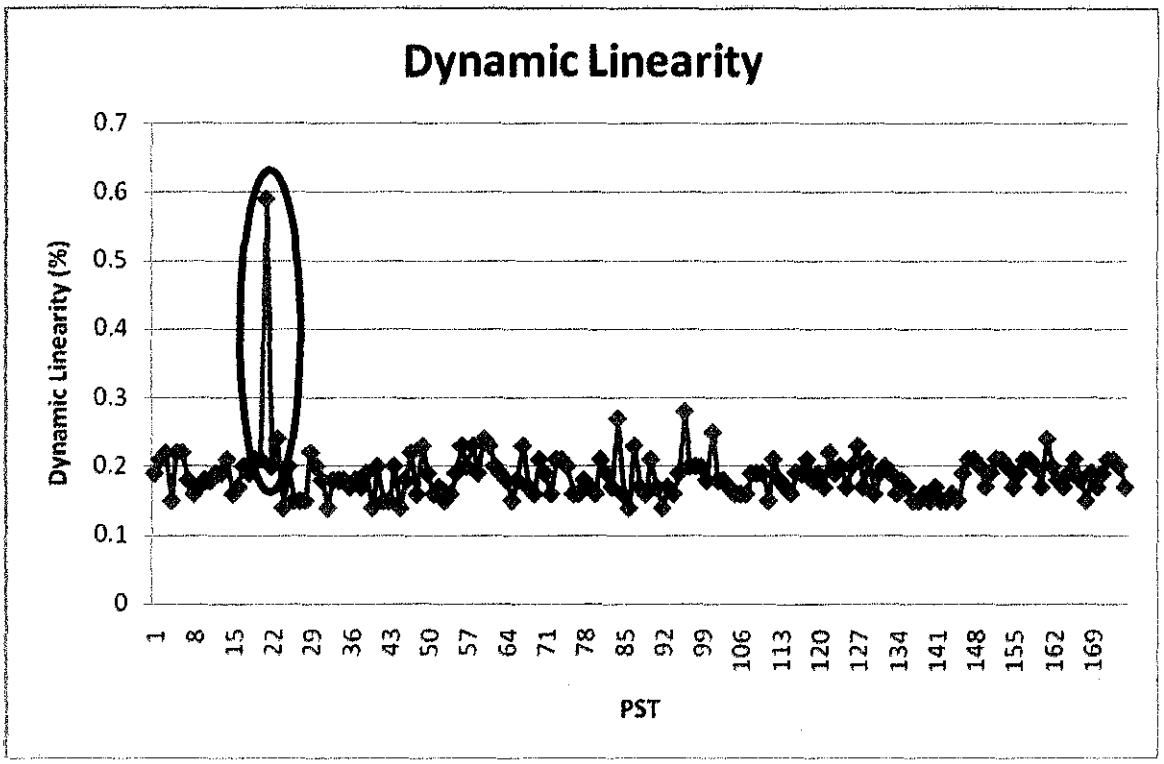


Figure 4.19: Dynamic Linearity graph versus no of PST

Figure 4.19 shows the Dynamic Linearity graph. Linearity is the maximum deviation from a straight line best fit to the opening and closing curves and a line representing the average value of those curves. The readings are ranged from 0.1% to 0.3%. Tightening the valve packing causes the value of dynamic linearity at 21st PST to be out of range.

4.5.5 Zero Ranged Travel

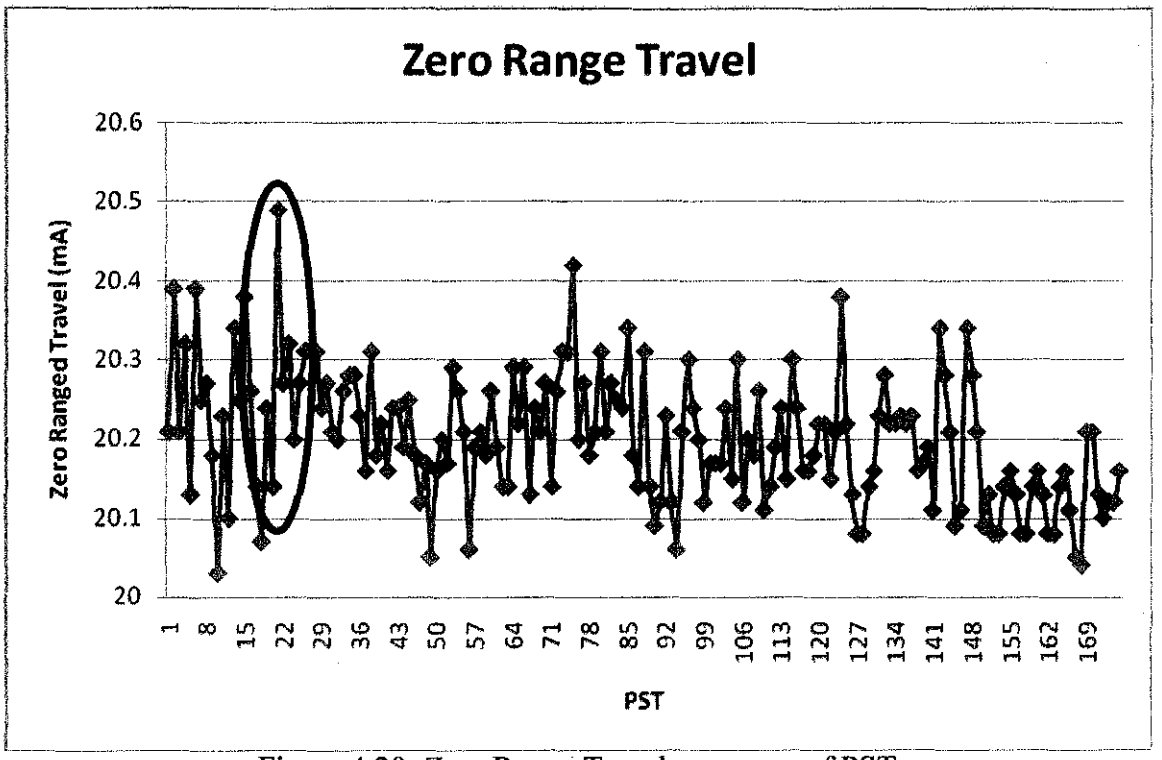


Figure 4.20: Zero Range Travel versus no of PST

Using the Dynamic Error Band, the AMS ValveLink software establishes a best fit line and projects this to a ranged travel of zero. AMS ValveLink Software converts the X axis point of dynamic band graph where the ranged travel is zero, from input percent to milliamps. Referring to Figure 4.20, the Zero Range Travel is ranging from 20mA to 20.5 mA. The reading at 21st PST is the highest among all due to tightening the valve packing.

4.5.6 *Full Ranged Travel*

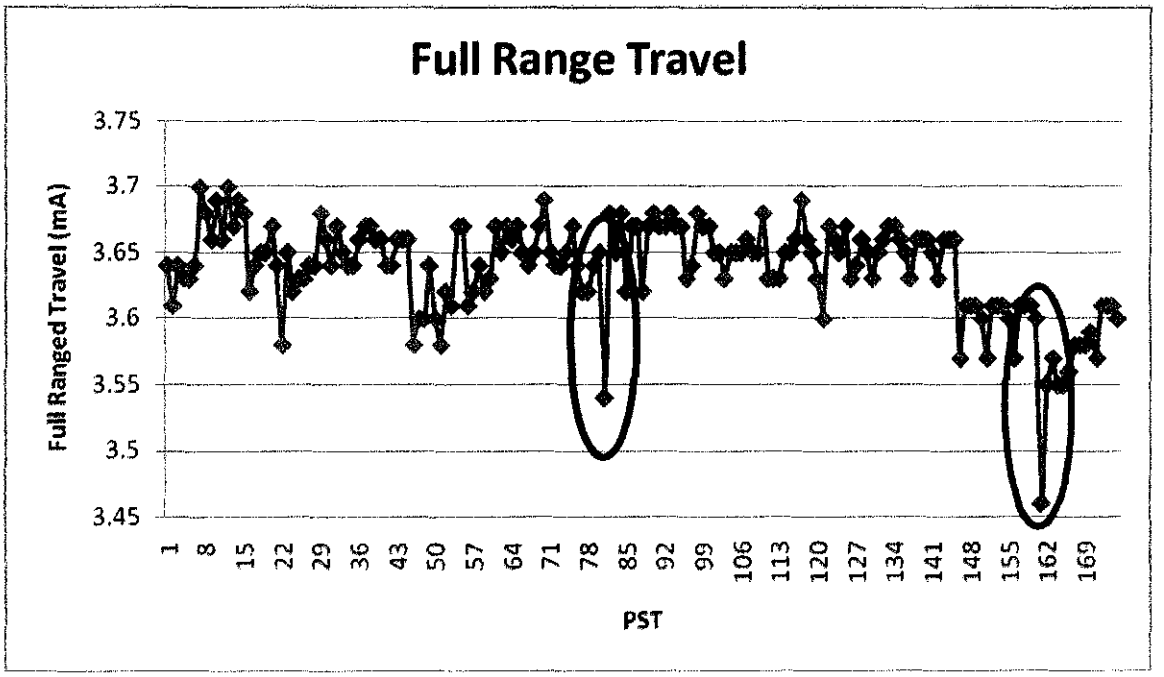


Figure 4.21: Full Range Travel versus no of PST

Full Range Travel is the point where the travel no longer increases with an increase in current. The value of full range travel is between 3.5mA to 3.7mA. At 81st and 161st PST, the value is out of ranges which are 3.54 mA and 3.46 mA, respectively as shown in Figure 4.21.

4.5.7 Lower Bench Set

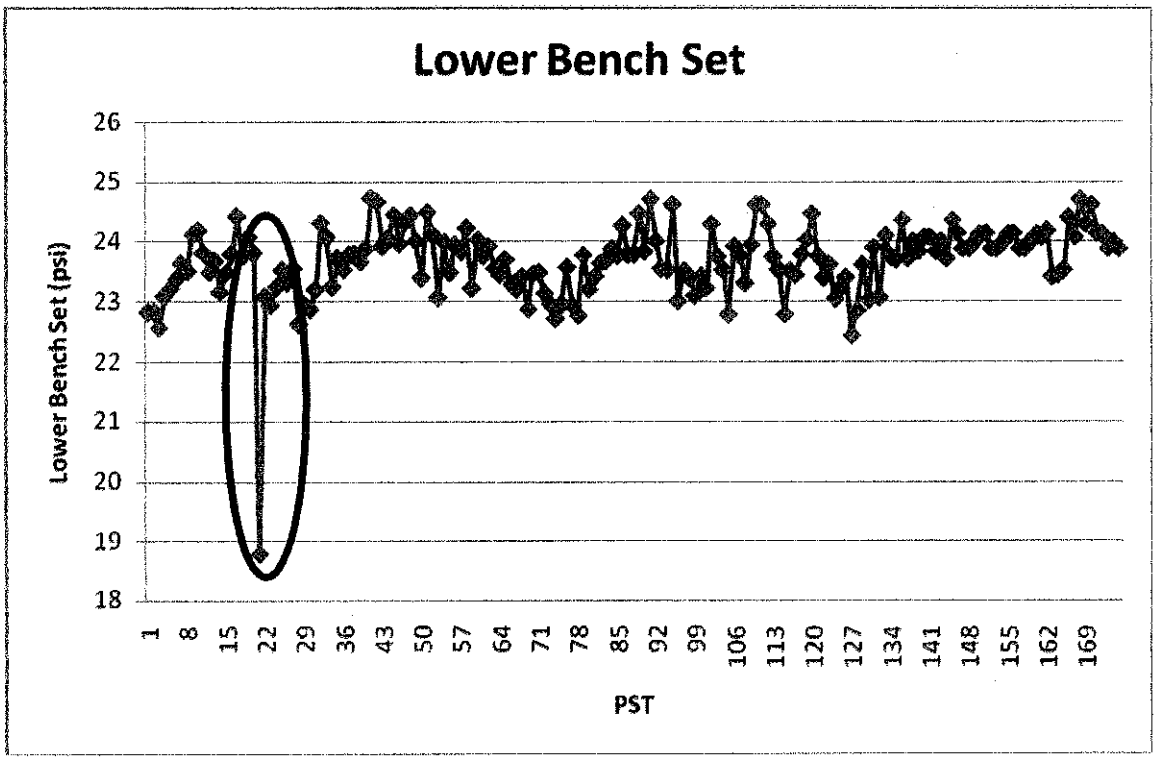


Figure 4.22: Lower Bench Set versus no of PST

Figure 4.22 shows the Lower Bench Set plot. Lower Bench Set is the amount of pnuematic pressure required to begin actuator movement. For air-to-open valves, it is the pressure required to begin valve-opening travel. The reading is ranging from 22 psi to 25 psi. The overshoot occurred at 21st PST due to tightening the valve packing.

4.5.8 Upper Bench Set

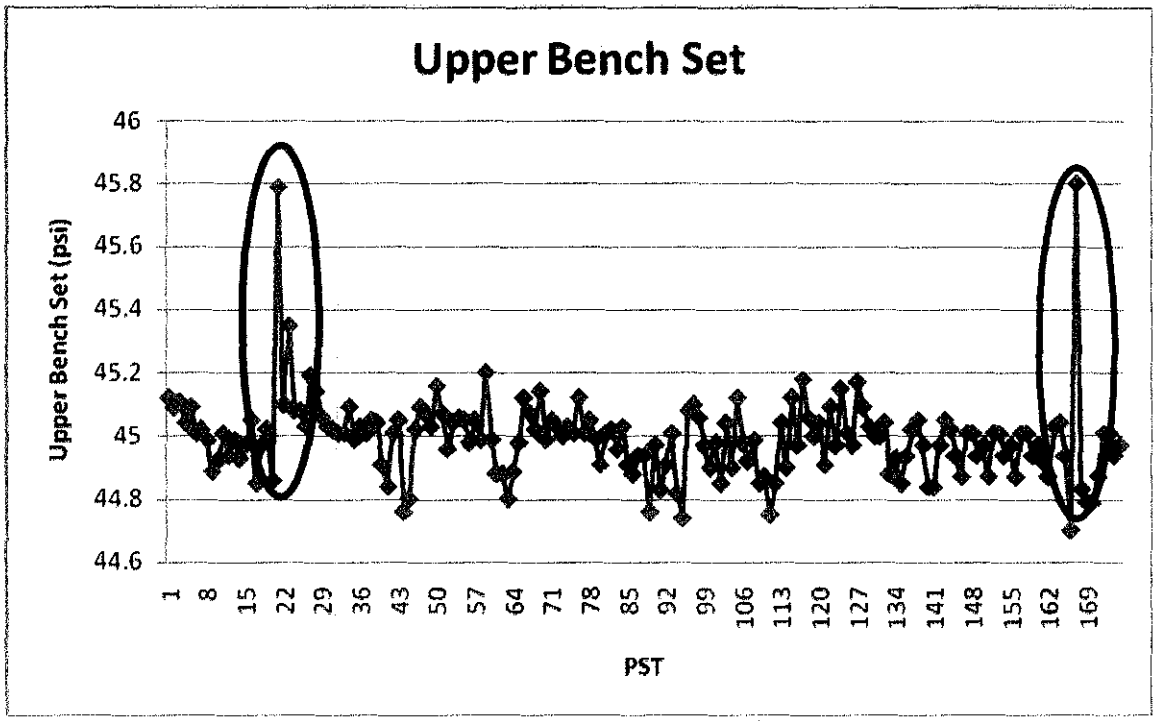


Figure 4.23: Upper Bench Set

Upper Bench Set displays the amount of pnuematic pressure required to drive the actuator through the full range of travel. For air-to-open valve, it is the pressure required to move the valve to the fully open position. The reading ranges from 44.6 psi to 45.2 psi which varies about 0.6 psi. Figure 4.23 shows the overshoots occurred at 21th PST due to tightening the valve packing activities.

CHAPTER 5
CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

Below is the summary of the project outcomes:-

5.1.1 Development of a controller to perform PST and FST

- Programming was developed in order to perform PST and FST. The functions of the programming are to initiate the PST and execute the FST. The programming was built separately for each ball valve and butterfly valve.

5.1.2. Compare the PST performance of ball valve and butterfly valve

5.1.2.1 Valve Signature of Partial Stroke Testing

- Ball valve requires much pressure at the beginning of the opening compared to butterfly valve. It is because the actuator size of ball valve is bigger than butterfly valve. Inside the actuator, there is a spring to control the ball or disk movement. The spring inside the ball valve is bigger; hence it needs much torque to cause the valve to move.

5.1.2.2 Bypass the solenoid valve

- Bypass the solenoid valve reduced the pressure supplied to the DVC. The value of dynamic error and bench set proved that the pressure supplied to the ball valve was reduced after removing the solenoid valve from the actuator. It is because air can go through the actuator from DVC without restriction from solenoid valve.

5.1.2.3 2-wire system versus 4-wire system

- Removing the solenoid valve make the DVC installation became a 2-wire system which requires less wiring and would reduce the cost, but the 2-wire system also requires installation of line conditioner which would add up to the total cost of installation.

5.1.3 Failure mode of the valves during the test

- Tightening quarterly the gland packing would require much pressure to be supplied to the valve. It is because the valve needs to overcome higher torque in order to cause the valve to move.

5.2 Recommendations

5.2.1 Continuous Testing

- Currently, the author has executed the PST for 35 days. It is highly recommended to continue the testing to gather 90-days data in order to get a better and accurate result.

5.2.2 Varying the PST parameters

- As being discussed in Section 4.5: Analyzed Data for PST of Butterfly Valve shows that tightening the valve packing has an effect on the valve performance. Therefore, the future work the author would suggest varying the PST parameters such as the stroking travel and testing speed to determine their effect in valve performance.

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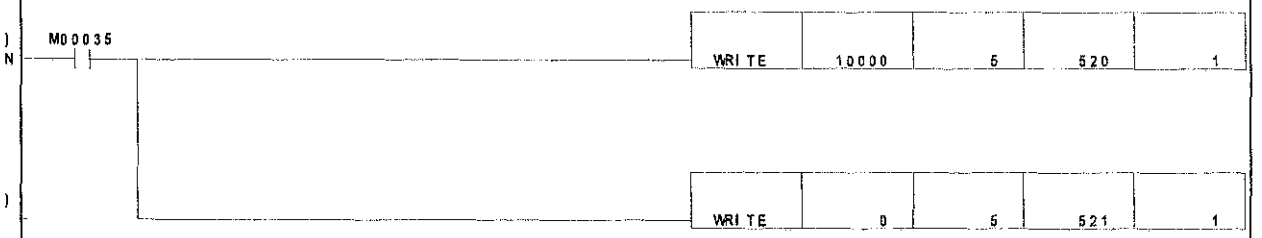
APPENDIX I

Ladder Logic Diagram for Ball Valve

Power Failure Condition- 1st cycle- module 5

0035 (FISHER, 00001N, LD), (FISHER, 00003N, LD)

Upper Limit and Lower Limit Setting 4 & 20 mA 1st cylce



0035 (FISHER, 00001N, LD), (FISHER, 00003N, LD)

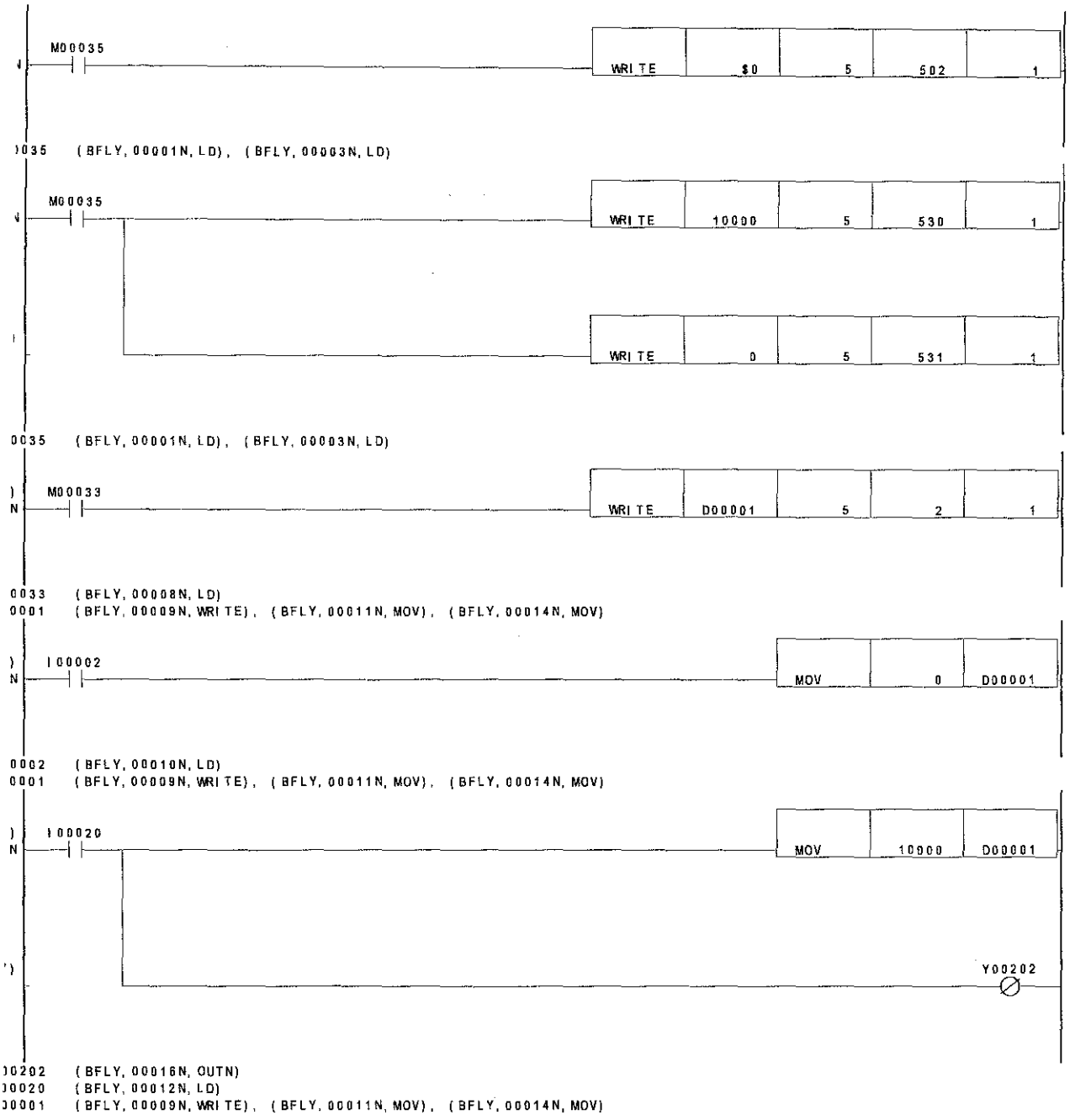
0033 (FISHER, 00008N, LD)
0001 (FISHER, 00009N, WRITE), (FISHER, 00011N, MOV), (FISHER, 00014N, MOV)

00002 (FISHER, 00010N, LD)
00001 (FISHER, 00009N, WRITE), (FISHER, 00011N, MOV), (FISHER, 00014N, MOV)

00201 (FISHER, 00016N, OUTN)
00020 (FISHER, 00012N, LD)
00001 (FISHER, 00008N, WRITE), (FISHER, 00011N, MOV), (FISHER, 00014N, MOV)

APPENDIX II

Ladder Logic Diagram for Butterfly Valve


M00035
WRITE $0 5 502 1
0035 (BFLY, 00001N, LD), (BFLY, 00003N, LD)
M00035
WRITE 10000 5 530 1
WRITE 0 5 531 1
0035 (BFLY, 00001N, LD), (BFLY, 00003N, LD)
M00033
WRITE D00001 5 2 1
0033 (BFLY, 00008N, LD)
0001 (BFLY, 00009N, WRITE), (BFLY, 00011N, MOV), (BFLY, 00014N, MOV)
I00002
MOV 0 D00001
0002 (BFLY, 00010N, LD)
0001 (BFLY, 00009N, WRITE), (BFLY, 00011N, MOV), (BFLY, 00014N, MOV)
I00020
MOV 10000 D00001
Y00202
0202 (BFLY, 00016N, OUTN)
0020 (BFLY, 00012N, LD)
0001 (BFLY, 00009N, WRITE), (BFLY, 00011N, MOV), (BFLY, 00014N, MOV)

APPENDIX III

Daily Report of PST for Ball Valve

(Software generated)

BALL VALVE

DVC6000 SIS

HART Tag Name	PST
Valve Style	ROTARY
Actuator Style	Piston - Sgl w/ Spring
Instrument S/N	18477410
Valve S/N	18477410
Firmware Revision	7
Hardware Revision	1

strument Configuration [BALL VALVE] - Basic

01 Feb 2009 11:52:29

General	
HART Tag	PST
Message	
Descriptor	18477410
Date	02/18/08
Valve Serial Number	18477410
ıstrument Serial Number	18477410
Polling Address	0
Initial Setup	
Control Mode	Analog (RSP)
Restart Cont. Mode	Analog (RSP)
Zero Power Condition	Valve Open
avel / Pressure Cutoff Lo (%)	0.5
Valve Style	Rotary Shaft
Actuator Style	Piston - Sgl w/ Spring
Relay Type	Relay B
Feedback Connection	Rotary-All/SS-Roller
Travel Sensor Motion	Clockwise
Aux Terminal Mode	Push Button Partial Stroke Test
Partial Stroke Start Pt.	Valve Open
Inputs	
Analog Input Units	mA
Temperature Units	F
Input Characterization	
Input Characteristic	Linear

Pressure	
Max Supply Pressure	60 psi
Pressure Units	psi
Tuning	
Travel Control	
Travel Control Tuning Set	H
Proportional	8.4
Enable Integral Control	No
Integral Gain (reps/min)	9.4
Integral Settings	
Integral Dead Zone (%)	0.26
Integral Limit (%)	50
Pressure Control	
Pressure Control Tuning Set	H
Proportional	4.2
Enable Integral Control	Yes
Integral Gain (reps/sec)	0.1
SIS / Partial Stroke	
Partial Stroke Enable	Enabled
Test Start Point	
Partial Stroke Press Limit	16 psi
Max. Travel Movement (%)	20
Test Speed	0.5%/s
Test Pause Time	5 sec
Auto Test Interval (days)	0.00
SIS Options	
DVC Power Up	Auto Reset
Action on Failed test	Ramp Back

Travel/Pressure Control	
Travel/Pressure Control	
Travel / Pressure Select	Travel
Travel / Pressure Cutoff Lo (%)	0.5
Travel / Pressure Cutoff Hi (%)	99.46
End Point Press. Control	
End Point Control Enable	Enabled
Control End	
Pressure Set Point	52.1 psi
Pressure Saturation Time (sec)	45
Dynamic Response	
Set Point Rate Limits	
SP Rate Open (%/sec)	0
SP Rate Close (%/sec)	0
Set Point Filter	
Lag Time (sec)	0

strument Configuration [BALL VALVE] - Alerts

01 Feb 2009 11:52:29

Self Test Shut Down	
Flash ROM Fail Enable	No
No Free Time Enable	No
Reference Voltage Fail Enable	No
NVM Fail Enable	No
Temp Sensor Fail Enable	No
Travel Sensor Fail Enable	No
Drive Current Fail Enable	No
Travel History Alerts	
Cycle Count Alert Enable	No
cle Count Deadband (%)	2.93
Cycle Count Alert Point	2147483646
Cycle Count	300
Trav Acc Alert Enable	No
vl Accum Deadband (%)	2.93
Tvl Accum Alert Pt (%)	2147483646
Travel Accumulator (%)	21655

Deviation & Other Alerts	
Travel Dev Alert Enable	Yes
Travel Dev Alert Pt (%)	5
Travel Dev Time (sec)	9.99
Pressure Dev Alert Enable	Yes
Pressure Dev Alert Pt	2 psi
Pressure Dev Time (sec)	9.99
Drive Signal Alert Enable	Yes
Supply Pressure Alert Point	0 psi
Supply Pressure Alert Enable	Yes
Travel Alerts	
Tvl Alert Lo Enable	No
Tvl Alert Hi Enable	No
Tvl Alert Lo Lo Enable	No
Tvl Alert Hi Hi Enable	No
Lo Point (%)	-25
Hi Point (%)	125
Lo Lo Point (%)	-25
Hi Hi Point (%)	125
Deadband (%)	1
Tvl Limit/Cutoff Lo Enable	No
Tvl Limit/Cutoff Hi Enable	No

Alert Record and Commands	
Instrument Clock	01 FEB 2009 11:52
Valve Alerts Enable	No
Failure Alerts Enable	Yes
Misc Alerts Enable	No
Burst Mode Enable	No
Burst Command	3
Cmd #3 (Trending)	A
Pressure	
Alert Record Not Empty Enable	Yes
Alert Record Full Enable	Yes
Informational Status	
Inst Time Invalid Enable	Yes
Cal in Progress Enable	No
Autocal in Progress Enable	No
Diag in Progress Enable	No
Diag Data Avail Enable	Yes
Integrator Sat Hi Enable	Yes
Integrator Sat Lo Enable	Yes
Press Ctrl Active Enable	Yes
Multi-Drop Alert Enable	No
Electronic Alerts	
Shutdown Activated Alert Enable	Yes
Power Starvation Alert Enable	No
Non-Critical NVM Alert Enable	No

strument Configuration [BALL VALVE] - Spec Sheet

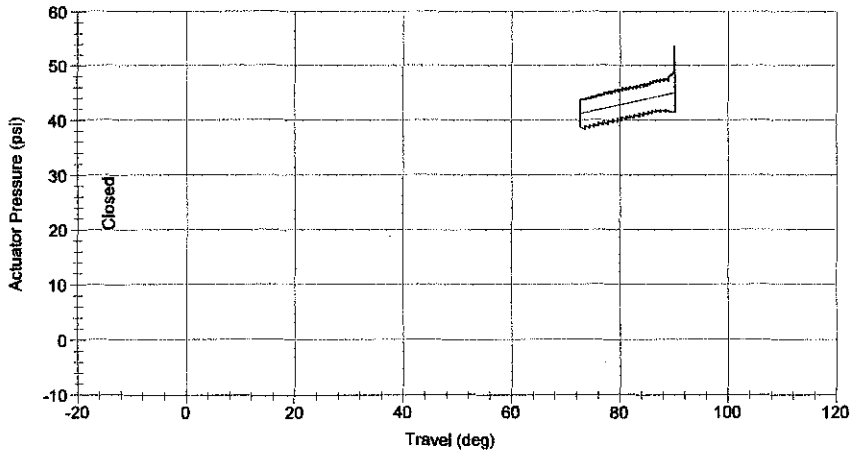
01 Feb 2009 11:52:29

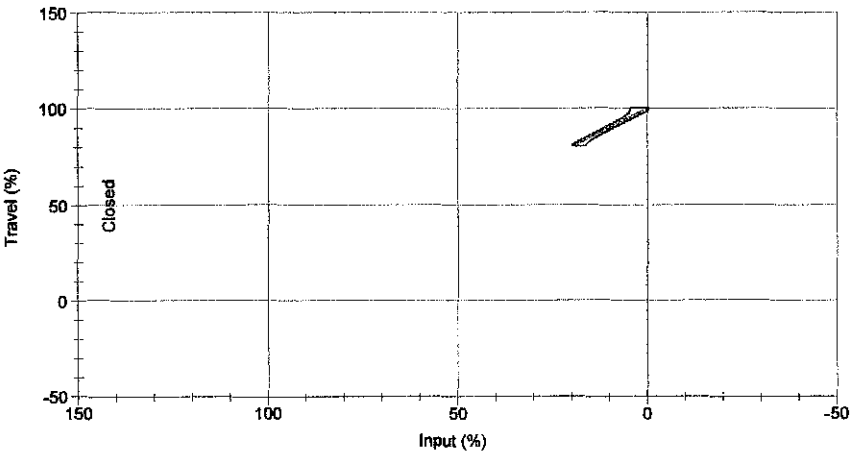
Spec Sheet Units	
Pressure Units	psi
Travel Units	deg
Length Units	in
Area Units	in2
Torque Units	lbf.in
Spring Rate Units	lbf/in
Valve	
Valve Mfg.	Fisher Controls
Valve Model	V-250
Size	6 in
Class	300
Rated Travel	90.0 deg
Actual Travel	90.0 deg
Stem Diameter	2.0 in
Packing Type	TFE / Single
Inlet Pressure	100.0 psi
Outlet Pressure	0.0 psi

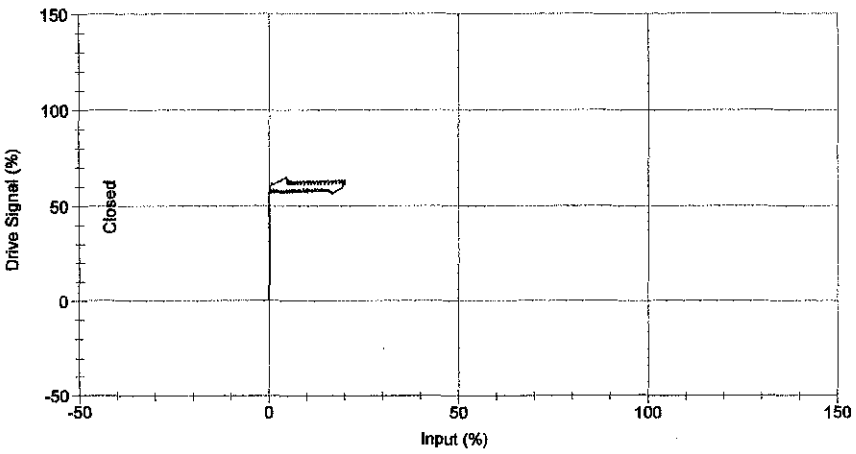
Trim	
Seat Type	Metal
Leak Class	V
Port Diameter	6.0 in
Actuator	
Actuator Mfg.	Fisher Controls
Actuator Model	1035
Actuator Size	40
Effective Area	0.0 in2
Air	Closes
Volume Booster/Quick Release	Unknown
Lower Bench Set	0.0 psi
Upper Bench Set	0.0 psi
Nominal Supply Pressure	70.0 psi
Spring Rate	0.0 lbf/in
Lever Style	Rack and Pinion
Moment Arm	0.0 in

Reference	
Trim Style 1	
Trim Style 2	
Stroking Time Open (sec)	0
Stroking Time Closed (sec)	0
Dynamic Torque	0.0 lbf.in
Breakout Torque	0.0 lbf.in

rtial Stroke [BALL VALVE]







01 Feb 2009 11:52:44

Inputs

Input Start:	100.0 %
Input End:	80.0 %
Stroke Speed	0.5%/s
Test Pause Time:	5 sec
Collection Interval:	150.0 msec.

Analyzed Data

Avg. Dynamic Error:	2.71%
Min. Dynamic Error:	1.99%
Max. Dynamic Error:	3.47%
Dyn. Linearity (Ind.):	0.48%
Zero Ranged Travel at:	20.00 mA
Full Ranged Travel at:	4.05 mA
Average Torque:	NA
Minimum Torque:	NA
Maximum Torque:	NA
Spring Rate:	NA
Bench Set:	25.9 - 44.89 psi
Partial Stroke Test initiated by:	HART Command
Partial Stroke Test status:	Completed Successfully

Tuning Set

Tuning Set:	H
Gains	
Proportional:	8.40
Velocity:	4.20
MLF:	31.00
Integral Control:	Disabled
Integral Gain:	9.4

Notes

Valve

Manufacturer:	Fisher Controls
Type:	V-250
Size:	6 in
Class:	300
Rated Travel:	90.00 deg
Actual Travel:	90.00 deg
Shaft Diameter:	2.0000 in
Packing Type:	TFE / Single
Inlet Pressure:	100.0000 psi
Outlet Pressure:	0.0000 psi

Trim

Seat Type:	Metal
Leakage Class:	V
Port Diameter:	6.0000 in

Actuator

Manufacturer:	Fisher Controls
Type:	1035
Size:	40
Effective Area:	0.00 in2
Air:	Closes
Bench Set:	0.0000 psi- 0.0000 psi
Nominal Supply Pressure:	70.0000 psi
Spring Rate:	0.0000 lbf/in
Style:	Rack and Pinion
Moment Arm:	0.0000 in

strument Configuration [BALL VALVE] - Basic

01 Feb 2009 12:11:03

General	
HART Tag	PST
Message	
Descriptor	18477410
Date	02/18/08
Valve Serial Number	18477410
strument Serial Number	18477410
Polling Address	0
Initial Setup	
Control Mode	Analog (RSP)
Restart Cont. Mode	Analog (RSP)
Zero Power Condition	Valve Open
avel / Pressure Cutoff Lo (%)	0.5
Valve Style	Rotary Shaft
Actuator Style	Piston - Sgl w/ Spring
Relay Type	Relay B
Feedback Connection	Rotary-All/SS-Roller
Travel Sensor Motion	Clockwise
Aux Terminal Mode	Push Button Partial Stroke Test
Partial Stroke Start Pt.	Valve Open
Inputs	
Analog Input Units	mA
Temperature Units	F
Input Characterization	
Input Characteristic	Linear

Pressure	
Max Supply Pressure	60 psi
Pressure Units	psi
Tuning	
Travel Control	
Travel Control Tuning Set	H
Proportional	8.4
Enable Integral Control	No
Integral Gain (reps/min)	9.4
Integral Settings	
Integral Dead Zone (%)	0.26
Integral Limit (%)	50
Pressure Control	
Pressure Control Tuning Set	H
Proportional	4.2
Enable Integral Control	Yes
Integral Gain (reps/sec)	0.1
SIS / Partial Stroke	
Partial Stroke Enable	Enabled
Test Start Point	
Partial Stroke Press Limit	16 psi
Max. Travel Movement (%)	20
Test Speed	0.5%/s
Test Pause Time	5 sec
Auto Test Interval (days)	0.00
SIS Options	
DVC Power Up	Auto Reset
Action on Failed test	Ramp Back

Travel/Pressure Control	
Travel/Pressure Control	
Travel / Pressure Select	Travel
Travel / Pressure Cutoff Lo (%)	0.5
Travel / Pressure Cutoff Hi (%)	99.46
End Point Press. Control	
End Point Control Enable	Enabled
Control End	
Pressure Set Point	52.1 psi
Pressure Saturation Time (sec)	45
Dynamic Response	
Set Point Rate Limits	
SP Rate Open (%/sec)	0
SP Rate Close (%/sec)	0
Set Point Filter Lag Time (sec)	0

strument Configuration [BALL VALVE] - Alerts

01 Feb 2009 12:11:03

Self Test Shut Down	
Flash ROM Fail Enable	No
No Free Time Enable	No
Reference Voltage Fail Enable	No
NVM Fail Enable	No
Temp Sensor Fail Enable	No
Travel Sensor Fail Enable	No
Drive Current Fail Enable	No
Travel History Alerts	
Cycle Count Alert Enable	No
cle Count Deadband (%)	2.93
Cycle Count Alert Point	2147483646
Cycle Count	296
Trav Acc Alert Enable	No
vl Accum Deadband (%)	2.93
Tvl Accum Alert Pt (%)	2147483646
Travel Accumulator (%)	21351

Deviation & Other Alerts	
Travel Dev Alert Enable	Yes
Travel Dev Alert Pt (%)	5
Travel Dev Time (sec)	9.99
Pressure Dev Alert Enable	Yes
Pressure Dev Alert Pt	2 psi
Pressure Dev Time (sec)	9.99
Drive Signal Alert Enable	Yes
Supply Pressure Alert Point	0 psi
Supply Pressure Alert Enable	Yes
Travel Alerts	
Tvl Alert Lo Enable	No
Tvl Alert Hi Enable	No
Tvl Alert Lo Lo Enable	No
Tvl Alert Hi Hi Enable	No
Lo Point (%)	-25
Hi Point (%)	125
Lo Lo Point (%)	-25
Hi Hi Point (%)	125
Deadband (%)	1
Tvl Limit/Cutoff Lo Enable	No
Tvl Limit/Cutoff Hi Enable	No

Alert Record and Commands	
Instrument Clock	01 FEB 2009 11:52
Valve Alerts Enable	No
Failure Alerts Enable	Yes
Misc Alerts Enable	No
Burst Mode Enable	No
Burst Command	3
Cmd #3 (Trending)	A
Pressure	
Alert Record Not Empty Enable	Yes
Alert Record Full Enable	Yes
Informational Status	
Inst Time Invalid Enable	Yes
Cal in Progress Enable	No
Autocal in Progress Enable	No
Diag in Progress Enable	No
Diag Data Avail Enable	Yes
Integrator Sat Hi Enable	Yes
Integrator Sat Lo Enable	Yes
Press Ctrl Active Enable	Yes
Multi-Drop Alert Enable	No
Electronic Alerts	
Shutdown Activated Alert Enable	Yes
Power Starvation Alert Enable	No
Non-Critical NVM Alert Enable	No

strument Configuration [BALL VALVE] - Spec Sheet

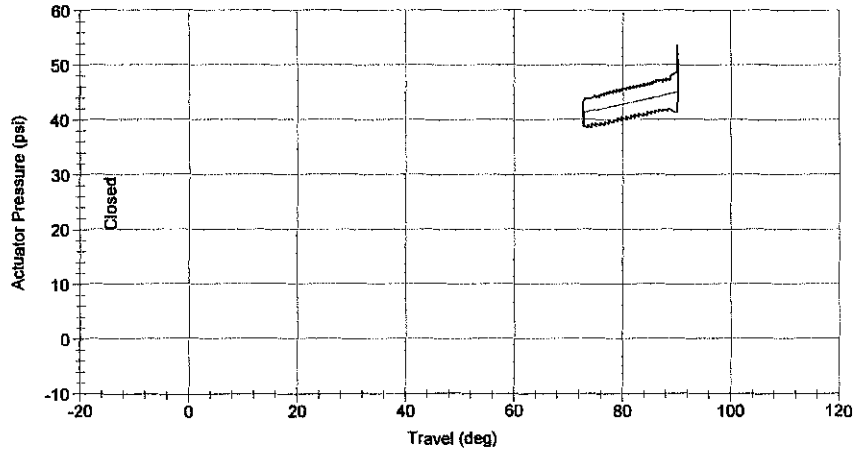
01 Feb 2009 12:11:03

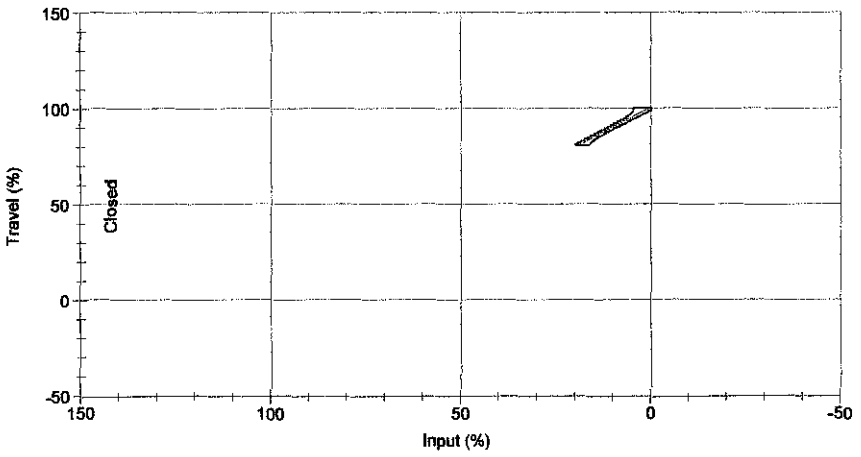
Spec Sheet Units	
Pressure Units	psi
Travel Units	deg
Length Units	in
Area Units	in2
Torque Units	lbf.in
Spring Rate Units	lbf/in
Valve	
Valve Mfg.	Fisher Controls
Valve Model	V-250
Size	6 in
Class	300
Rated Travel	90.0 deg
Actual Travel	90.0 deg
Stem Diameter	2.0 in
Packing Type	TFE / Single
Inlet Pressure	100.0 psi
Outlet Pressure	0.0 psi

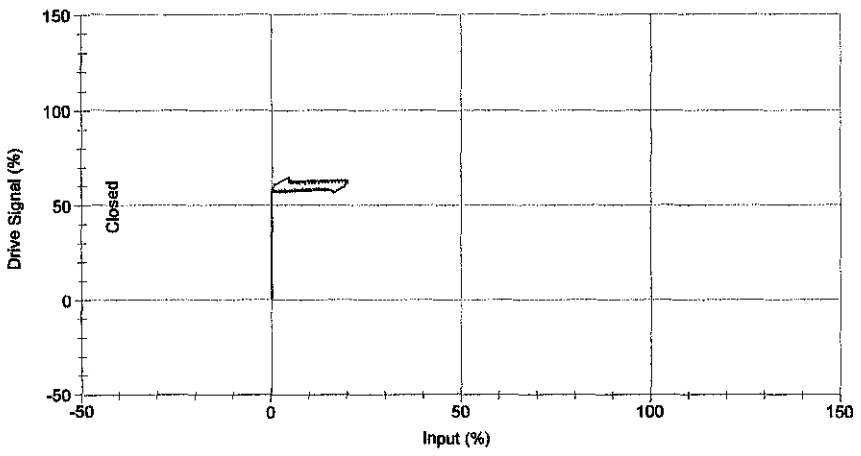
Trim	
Seat Type	Metal
Leak Class	V
Port Diameter	6.0 in
Actuator	
Actuator Mfg.	Fisher Controls
Actuator Model	1035
Actuator Size	40
Effective Area	0.0 in2
Air	Closes
Volume Booster/Quick Release	Unknown
Lower Bench Set	0.0 psi
Upper Bench Set	0.0 psi
Nominal Supply Pressure	70.0 psi
Spring Rate	0.0 lbf/in
Lever Style	Rack and Pinion
Moment Arm	0.0 in

Reference	
Trim Style 1	
Trim Style 2	
Stroking Time Open (sec)	0
Stroking Time Closed (sec)	0
Dynamic Torque	0.0 lbf.in
Breakout Torque	0.0 lbf.in

rtial Stroke [BALL VALVE]







01 Feb 2009 12:11:24

Inputs

Input Start:	100.0 %
Input End:	80.0 %
Stroke Speed	0.5%/s
Test Pause Time:	5 sec
Collection Interval:	150.0 msec.

Analyzed Data

Avg. Dynamic Error:	2.71%
Min. Dynamic Error:	1.81%
Max. Dynamic Error:	3.22%
Dyn. Linearity (Ind.):	0.44%
Zero Ranged Travel at:	19.94 mA
Full Ranged Travel at:	4.05 mA
Average Torque:	NA
Minimum Torque:	NA
Maximum Torque:	NA
Spring Rate:	NA
Bench Set:	25.48 - 44.92 psi
Partial Stroke Test initiated by:	HART Command
Partial Stroke Test status:	Completed Successfully

Tuning Set

Tuning Set:	H
Gains	
Proportional:	8.40
Velocity:	4.20
MLF:	31.00
Integral Control:	Disabled
Integral Gain:	9.4

Notes

Valve

Manufacturer:	Fisher Controls
Type:	V-250
Size:	6 in
Class:	300
Rated Travel:	90.00 deg
Actual Travel:	90.00 deg
Shaft Diameter:	2.0000 in
Packing Type:	TFE / Single
Inlet Pressure:	100.0000 psi
Outlet Pressure:	0.0000 psi

Trim

Seat Type:	Metal
Leakage Class:	V
Port Diameter:	6.0000 in

Actuator

Manufacturer:	Fisher Controls
Type:	1035
Size:	40
Effective Area:	0.00 in2
Air:	Closes
Bench Set:	0.0000 psi- 0.0000 psi
Nominal Supply Pressure:	70.0000 psi
Spring Rate:	0.0000 lbf/in
Style:	Rack and Pinion
Moment Arm:	0.0000 in

strument Configuration [BALL VALVE] - Basic

01 Feb 2009 12:22:15

General	
HART Tag	PST
Message	
Descriptor	18477410
Date	02/18/08
Valve Serial Number	18477410
strument Serial Number	18477410
Polling Address	0
Initial Setup	
Control Mode	Analog (RSP)
Restart Cont. Mode	Analog (RSP)
Zero Power Condition	Valve Open
avel / Pressure Cutoff Lo (%)	0.5
Valve Style	Rotary Shaft
Actuator Style	Piston - Sgl w/ Spring
Relay Type	Relay B
Feedback Connection	Rotary-All/SS-Roller
Travel Sensor Motion	Clockwise
Aux Terminal Mode	Push Button Partial Stroke Test
Partial Stroke Start Pt.	Valve Open
Inputs	
Analog Input Units	mA
Temperature Units	F
Input Characterization	
Input Characteristic	Linear

Pressure	
Max Supply Pressure	60 psi
Pressure Units	psi
Tuning	
Travel Control	
Travel Control Tuning Set	H
Proportional	8.4
Enable Integral Control	No
Integral Gain (reps/min)	9.4
Integral Settings	
Integral Dead Zone (%)	0.26
Integral Limit (%)	50
Pressure Control	
Pressure Control Tuning Set	H
Proportional	4.2
Enable Integral Control	Yes
Integral Gain (reps/sec)	0.1
SIS / Partial Stroke	
Partial Stroke Enable	Enabled
Test Start Point	
Partial Stroke Press Limit	16 psi
Max. Travel Movement (%)	20
Test Speed	0.5%/s
Test Pause Time	5 sec
Auto Test Interval (days)	0.00
SIS Options	
DVC Power Up	Auto Reset
Action on Failed test	Ramp Back

Travel/Pressure Control	
Travel/Pressure Control	
Travel / Pressure Select	Travel
Travel / Pressure Cutoff Lo (%)	0.5
Travel / Pressure Cutoff Hi (%)	99.46
End Point Press. Control	
End Point Control Enable	Enabled
Control End	
Pressure Set Point	52.1 psi
Pressure Saturation Time (sec)	45
Dynamic Response	
Set Point Rate Limits	
SP Rate Open (%/sec)	0
SP Rate Close (%/sec)	0
Set Point Filter Lag Time (sec)	0

strument Configuration [BALL VALVE] - Alerts

01 Feb 2009 12:22:15

Self Test Shut Down	
Flash ROM Fail Enable	No
No Free Time Enable	No
Reference Voltage Fail Enable	No
NVM Fail Enable	No
Temp Sensor Fail Enable	No
Travel Sensor Fail Enable	No
Drive Current Fail Enable	No
Travel History Alerts	
Cycle Count Alert Enable	No
cle Count Deadband (%)	2.93
Cycle Count Alert Point	2147483646
Cycle Count	298
Trav Acc Alert Enable	No
vl Accum Deadband (%)	2.93
Tvl Accum Alert Pt (%)	2147483646
Travel Accumulator (%)	21390

Deviation & Other Alerts	
Travel Dev Alert Enable	Yes
Travel Dev Alert Pt (%)	5
Travel Dev Time (sec)	9.99
Pressure Dev Alert Enable	Yes
Pressure Dev Alert Pt	2 psi
Pressure Dev Time (sec)	9.99
Drive Signal Alert Enable	Yes
Supply Pressure Alert Point	0 psi
Supply Pressure Alert Enable	Yes
Travel Alerts	
Tvl Alert Lo Enable	No
Tvl Alert Hi Enable	No
Tvl Alert Lo Lo Enable	No
Tvl Alert Hi Hi Enable	No
Lo Point (%)	-25
Hi Point (%)	125
Lo Lo Point (%)	-25
Hi Hi Point (%)	125
Deadband (%)	1
Tvl Limit/Cutoff Lo Enable	No
Tvl Limit/Cutoff Hi Enable	No

Alert Record and Commands	
Instrument Clock	01 FEB 2009 12:02
Valve Alerts Enable	No
Failure Alerts Enable	Yes
Misc Alerts Enable	No
Burst Mode Enable	No
Burst Command	3
Cmd #3 (Trending)	A Pressure
Alert Record Not Empty Enable	Yes
Alert Record Full Enable	Yes
Informational Status	
Inst Time Invalid Enable	Yes
Cal in Progress Enable	No
Autocal in Progress Enable	No
Diag in Progress Enable	No
Diag Data Avail Enable	Yes
Integrator Sat Hi Enable	Yes
Integrator Sat Lo Enable	Yes
Press Ctrl Active Enable	Yes
Multi-Drop Alert Enable	No
Electronic Alerts	
Shutdown Activated Alert Enable	Yes
Power Starvation Alert Enable	No
Non-Critical NVM Alert Enable	No

strument Configuration [BALL VALVE] - Spec Sheet

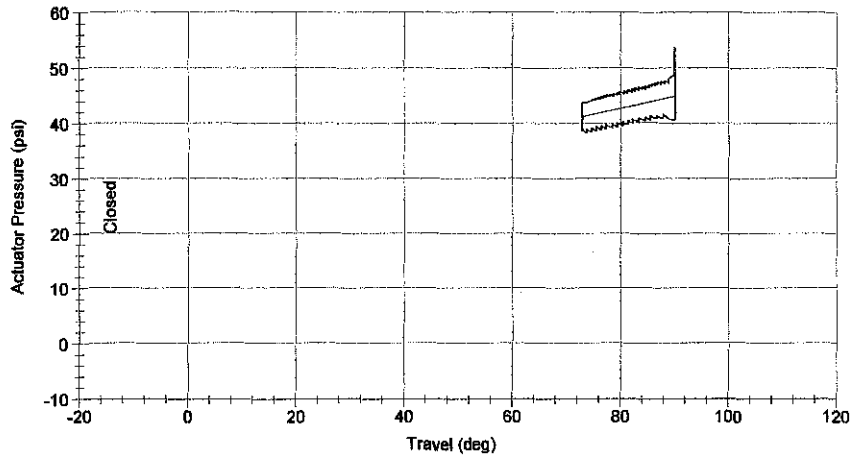
01 Feb 2009 12:22:15

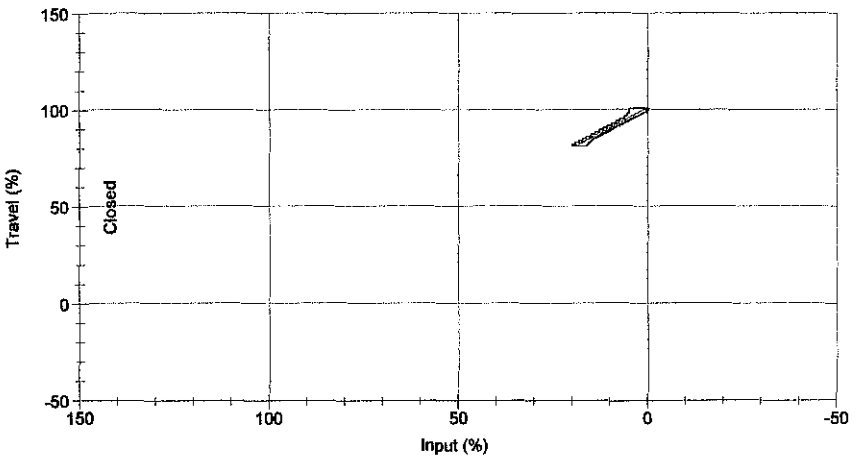
Spec Sheet Units	
Pressure Units	psi
Travel Units	deg
Length Units	in
Area Units	in2
Torque Units	lbf.in
Spring Rate Units	lbf/in
Valve	
Valve Mfg.	Fisher Controls
Valve Model	V-250
Size	6 in
Class	300
Rated Travel	90.0 deg
Actual Travel	90.0 deg
Stem Diameter	2.0 in
Packing Type	TFE / Single
Inlet Pressure	100.0 psi
Outlet Pressure	0.0 psi

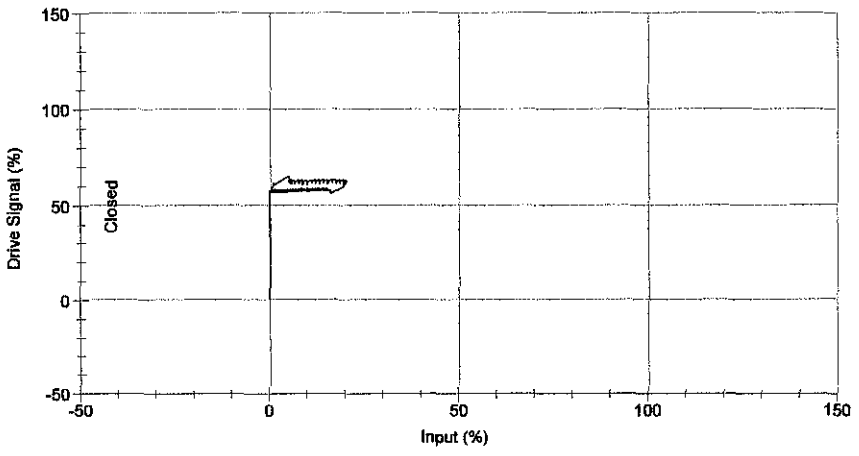
Trim	
Seat Type	Metal
Leak Class	V
Port Diameter	6.0 in
Actuator	
Actuator Mfg.	Fisher Controls
Actuator Model	1035
Actuator Size	40
Effective Area	0.0 in2
Air	Closes
Volume Booster/Quick Release	Unknown
Lower Bench Set	0.0 psi
Upper Bench Set	0.0 psi
Nominal Supply Pressure	70.0 psi
Spring Rate	0.0 lbf/in
Lever Style	Rack and Pinion
Moment Arm	0.0 in

Reference	
Trim Style 1	
Trim Style 2	
Stroking Time Open (sec)	0
Stroking Time Closed (sec)	0
Dynamic Torque	0.0 lbf.in
Breakout Torque	0.0 lbf.in

rtial Stroke [BALL VALVE]







01 Feb 2009 12:24:06

Inputs

Input Start:	100.0 %
Input End:	80.0 %
Stroke Speed	0.5%/s
Test Pause Time:	5 sec
Collection Interval:	150.0 msec.

Analyzed Data

Avg. Dynamic Error:	2.75%
Min. Dynamic Error:	1.67%
Max. Dynamic Error:	3.71%
Dyn. Linearity (Ind.):	0.59%
Zero Ranged Travel at:	19.93 mA
Full Ranged Travel at:	4.06 mA
Average Torque:	NA
Minimum Torque:	NA
Maximum Torque:	NA
Spring Rate:	NA
Bench Set:	26.16 - 44.69 psi
Partial Stroke Test initiated by:	HART Command
Partial Stroke Test status:	Completed Successfully

Tuning Set

Tuning Set:	H
Gains	
Proportional:	8.40
Velocity:	4.20
MLF:	31.00
Integral Control:	Disabled
Integral Gain:	9.4

Notes

Valve

Manufacturer:	Fisher Controls
Type:	V-250
Size:	6 in
Class:	300
Rated Travel:	90.00 deg
Actual Travel:	90.00 deg
Shaft Diameter:	2.0000 in
Packing Type:	TFE / Single
Inlet Pressure:	100.0000 psi
Outlet Pressure:	0.0000 psi

Trim

Seat Type:	Metal
Leakage Class:	V
Port Diameter:	6.0000 in

Actuator

Manufacturer:	Fisher Controls
Type:	1035
Size:	40
Effective Area:	0.00 in2
Air:	Closes
Bench Set:	0.0000 psi-0.0000 psi
Nominal Supply Pressure:	70.0000 psi
Spring Rate:	0.0000 lbf/in
Style:	Rack and Pinion
Moment Arm:	0.0000 in

strument Configuration [BALL VALVE] - Basic

01 Feb 2009 12:32:09

General	
HART Tag	PST
Message	
Descriptor	18477410
Date	02/18/08
Valve Serial Number	18477410
strument Serial Number	18477410
Polling Address	0
Initial Setup	
Control Mode	Analog (RSP)
Restart Cont. Mode	Analog (RSP)
Zero Power Condition	Valve Open
avel / Pressure Cutoff Lo (%)	0.5
Valve Style	Rotary Shaft
Actuator Style	Piston - Sgl w/ Spring
Relay Type	Relay B
Feedback Connection	Rotary-All/SS-Roller
Travel Sensor Motion	Clockwise
Aux Terminal Mode	Push Button Partial Stroke Test
Partial Stroke Start Pt.	Valve Open
Inputs	
Analog Input Units	mA
Temperature Units	F
Input Characterization	
Input Characteristic	Linear

Pressure	
Max Supply Pressure	60 psi
Pressure Units	psi
Tuning	
Travel Control	
Travel Control Tuning Set	H
Proportional	8.4
Enable Integral Control	No
Integral Gain (reps/min)	9.4
Integral Settings	
Integral Dead Zone (%)	0.26
Integral Limit (%)	50
Pressure Control	
Pressure Control Tuning Set	H
Proportional	4.2
Enable Integral Control	Yes
Integral Gain (reps/sec)	0.1
SIS / Partial Stroke	
Partial Stroke Enable	Enabled
Test Start Point	
Partial Stroke Press Limit	16 psi
Max. Travel Movement (%)	20
Test Speed	0.5%/s
Test Pause Time	5 sec
Auto Test Interval (days)	0.00
SIS Options	
DVC Power Up	Auto Reset
Action on Failed test	Ramp Back

Travel/Pressure Control	
Travel/Pressure Control	
Travel / Pressure Select	Travel
Travel / Pressure Cutoff Lo (%)	0.5
Travel / Pressure Cutoff Hi (%)	99.46
End Point Press. Control	
End Point Control Enable	Enabled
Control End	
Pressure Set Point	52.1 psi
Pressure Saturation Time (sec)	45
Dynamic Response	
Set Point Rate Limits	
SP Rate Open (%/sec)	0
SP Rate Close (%/sec)	0
Set Point Filter	
Lag Time (sec)	0

strument Configuration [BALL VALVE] - Alerts

01 Feb 2009 12:32:09

Self Test Shut Down	
Flash ROM Fail Enable	No
No Free Time Enable	No
Reference Voltage Fail Enable	No
NVM Fail Enable	No
Temp Sensor Fail Enable	No
Travel Sensor Fail Enable	No
Drive Current Fail Enable	No
Travel History Alerts	
Cycle Count Alert Enable	No
cle Count Deadband (%)	2.93
Cycle Count Alert Point	2147483646
Cycle Count	300
Trav Acc Alert Enable	No
vl Accum Deadband (%)	2.93
Tvl Accum Alert Pt (%)	2147483646
Travel Accumulator (%)	21430

Deviation & Other Alerts	
Travel Dev Alert Enable	Yes
Travel Dev Alert Pt (%)	5
Travel Dev Time (sec)	9.99
Pressure Dev Alert Enable	Yes
Pressure Dev Alert Pt	2 psi
Pressure Dev Time (sec)	9.99
Drive Signal Alert Enable	Yes
Supply Pressure Alert Point	0 psi
Supply Pressure Alert Enable	Yes
Travel Alerts	
Tvl Alert Lo Enable	No
Tvl Alert Hi Enable	No
Tvl Alert Lo Lo Enable	No
Tvl Alert Hi Hi Enable	No
Lo Point (%)	-25
Hi Point (%)	125
Lo Lo Point (%)	-25
Hi Hi Point (%)	125
Deadband (%)	1
Tvl Limit/Cutoff Lo Enable	No
Tvl Limit/Cutoff Hi Enable	No

Alert Record and Commands	
Instrument Clock	01 FEB 2009 12:12
Valve Alerts Enable	No
Failure Alerts Enable	Yes
Misc Alerts Enable	No
Burst Mode Enable	No
Burst Command	3
Cmd #3 (Trending)	A Pressure
Alert Record Not Empty Enable	Yes
Alert Record Full Enable	Yes
Informational Status	
Inst Time Invalid Enable	Yes
Cal in Progress Enable	No
Autocal in Progress Enable	No
Diag in Progress Enable	No
Diag Data Avail Enable	Yes
Integrator Sat Hi Enable	Yes
Integrator Sat Lo Enable	Yes
Press Ctrl Active Enable	Yes
Multi-Drop Alert Enable	No
Electronic Alerts	
Shutdown Activated Alert Enable	Yes
Power Starvation Alert Enable	No
Non-Critical NVM Alert Enable	No

strument Configuration [BALL VALVE] - Spec Sheet

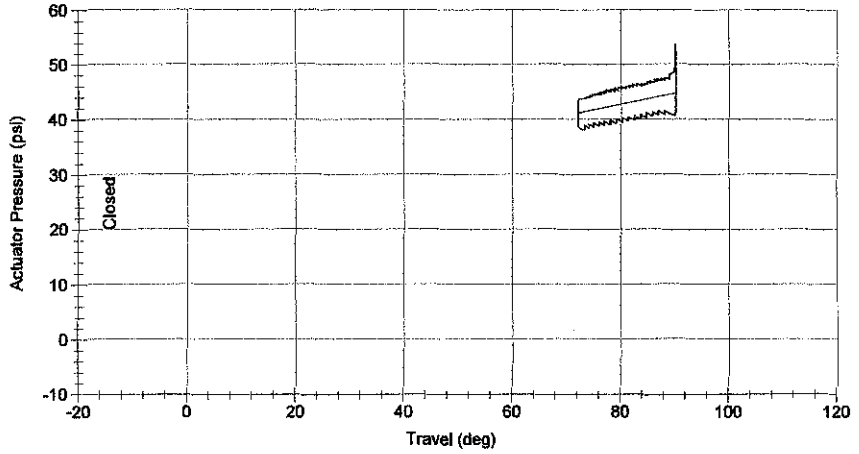
01 Feb 2009 12:32:09

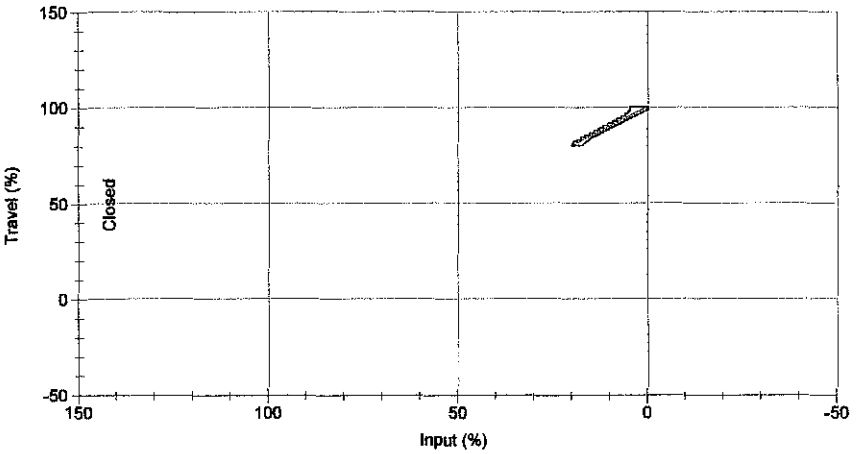
Spec Sheet Units	
Pressure Units	psi
Travel Units	deg
Length Units	in
Area Units	in2
Torque Units	lbf.in
Spring Rate Units	lbf/in
Valve	
Valve Mfg.	Fisher Controls
Valve Model	V-250
Size	6 in
Class	300
Rated Travel	90.0 deg
Actual Travel	90.0 deg
Stem Diameter	2.0 in
Packing Type	TFE / Single
Inlet Pressure	100.0 psi
Outlet Pressure	0.0 psi

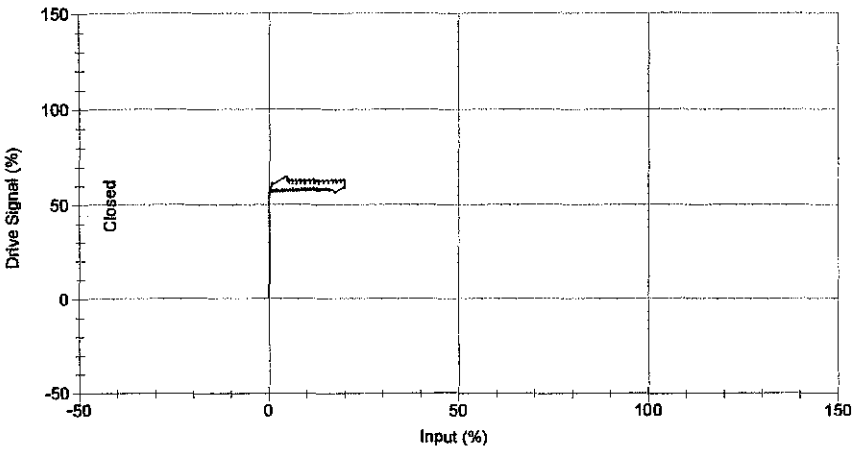
Trim	
Seat Type	Metal
Leak Class	V
Port Diameter	6.0 in
Actuator	
Actuator Mfg.	Fisher Controls
Actuator Model	1035
Actuator Size	40
Effective Area	0.0 in2
Air	Closes
Volume Booster/Quick Release	Unknown
Lower Bench Set	0.0 psi
Upper Bench Set	0.0 psi
Nominal Supply Pressure	70.0 psi
Spring Rate	0.0 lbf/in
Lever Style	Rack and Pinion
Moment Arm	0.0 in

Reference	
Trim Style 1	
Trim Style 2	
Stroking Time Open (sec)	0
Stroking Time Closed (sec)	0
Dynamic Torque	0.0 lbf.in
Breakout Torque	0.0 lbf.in

rtial Stroke [BALL VALVE]







01 Feb 2009 12:32:22

Inputs

Input Start:	100.0 %
Input End:	80.0 %
Stroke Speed	0.5%/s
Test Pause Time:	5 sec
Collection Interval:	150.0 msec.

Analyzed Data

Avg. Dynamic Error:	2.72%
Min. Dynamic Error:	1.81%
Max. Dynamic Error:	3.43%
Dyn. Linearity (Ind.):	0.45%
Zero Ranged Travel at:	20.00 mA
Full Ranged Travel at:	4.05 mA
Average Torque:	NA
Minimum Torque:	NA
Maximum Torque:	NA
Spring Rate:	NA
Bench Set:	27.06 - 44.65 psi
Partial Stroke Test initiated by:	HART Command
Partial Stroke Test status:	Completed Successfully

Tuning Set

Tuning Set:	H
Gains	
Proportional:	8.40
Velocity:	4.20
MLF:	31.00
Integral Control:	Disabled
Integral Gain:	9.4

Notes

Valve

Manufacturer:	Fisher Controls
Type:	V-250
Size:	6 in
Class:	300
Rated Travel:	90.00 deg
Actual Travel:	90.00 deg
Shaft Diameter:	2.0000 in
Packing Type:	TFE / Single
Inlet Pressure:	100.0000 psi
Outlet Pressure:	0.0000 psi

Trim

Seat Type:	Metal
Leakage Class:	V
Port Diameter:	6.0000 in

Actuator

Manufacturer:	Fisher Controls
Type:	1035
Size:	40
Effective Area:	0.00 in2
Air:	Closes
Bench Set:	0.0000 psi- 0.0000 psi
Nominal Supply Pressure:	70.0000 psi
Spring Rate:	0.0000 lbf/in
Style:	Rack and Pinion
Moment Arm:	0.0000 in

strument Configuration [BALL VALVE] - Basic

01 Feb 2009 12:42:30

General	
HART Tag	PST
Message	
Descriptor	18477410
Date	02/18/08
Valve Serial Number	18477410
ıstrument Serial Number	18477410
Polling Address	0
Initial Setup	
Control Mode	Analog (RSP)
Restart Cont. Mode	Analog (RSP)
Zero Power Condition	Valve Open
avel / Pressure Cutoff Lo (%)	0.5
Valve Style	Rotary Shaft
Actuator Style	Piston - Sgl w/ Spring
Relay Type	Relay B
Feedback Connection	Rotary-All/SS-Roller
Travel Sensor Motion	Clockwise
Aux Terminal Mode	Push Button Partial Stroke Test
Partial Stroke Start Pt.	Valve Open
Inputs	
Analog Input Units	mA
Temperature Units	F
Input Characterization	
Input Characteristic	Linear

Pressure	
Max Supply Pressure	60 psi
Pressure Units	psi
Tuning	
Travel Control	
Travel Control Tuning Set	H
Proportional	8.4
Enable Integral Control	No
Integral Gain (reps/min)	9.4
Integral Settings	
Integral Dead Zone (%)	0.26
Integral Limit (%)	50
Pressure Control	
Pressure Control Tuning Set	H
Proportional	4.2
Enable Integral Control	Yes
Integral Gain (reps/sec)	0.1
SIS / Partial Stroke	
Partial Stroke Enable	Enabled
Test Start Point	
Partial Stroke Press Limit	16 psi
Max. Travel Movement (%)	20
Test Speed	0.5%/s
Test Pause Time	5 sec
Auto Test Interval (days)	0.00
SIS Options	
DVC Power Up	Auto Reset
Action on Failed test	Ramp Back

Travel/Pressure Control	
Travel/Pressure Control	
Travel / Pressure Select	Travel
Travel / Pressure Cutoff Lo (%)	0.5
Travel / Pressure Cutoff Hi (%)	99.46
End Point Press. Control	
End Point Control Enable	Enabled
Control End Pressure Set Point	52.1 psi
Pressure Saturation Time (sec)	45
Dynamic Response	
Set Point Rate Limits	
SP Rate Open (%/sec)	0
SP Rate Close (%/sec)	0
Set Point Filter Lag Time (sec)	0

strument Configuration [BALL VALVE] - Alerts

01 Feb 2009 12:42:30

Self Test Shut Down	
Flash ROM Fail Enable	No
No Free Time Enable	No
Reference Voltage Fail Enable	No
NVM Fail Enable	No
Temp Sensor Fail Enable	No
Travel Sensor Fail Enable	No
Drive Current Fail Enable	No
Travel History Alerts	
Cycle Count Alert Enable	No
cle Count Deadband (%)	2.93
Cycle Count Alert Point	2147483646
Cycle Count	302
Trav Acc Alert Enable	No
vl Accum Deadband (%)	2.93
Tvl Accum Alert Pt (%)	2147483646
Travel Accumulator (%)	21472

Deviation & Other Alerts	
Travel Dev Alert Enable	Yes
Travel Dev Alert Pt (%)	5
Travel Dev Time (sec)	9.99
Pressure Dev Alert Enable	Yes
Pressure Dev Alert Pt	2 psi
Pressure Dev Time (sec)	9.99
Drive Signal Alert Enable	Yes
Supply Pressure Alert Point	0 psi
Supply Pressure Alert Enable	Yes
Travel Alerts	
Tvl Alert Lo Enable	No
Tvl Alert Hi Enable	No
Tvl Alert Lo Lo Enable	No
Tvl Alert Hi Hi Enable	No
Lo Point (%)	-25
Hi Point (%)	125
Lo Lo Point (%)	-25
Hi Hi Point (%)	125
Deadband (%)	1
Tvl Limit/Cutoff Lo Enable	No
Tvl Limit/Cutoff Hi Enable	No

Alert Record and Commands	
Instrument Clock	01 FEB 2009 12:22
Valve Alerts Enable	No
Failure Alerts Enable	Yes
Misc Alerts Enable	No
Burst Mode Enable	No
Burst Command	3
Cmd #3 (Trending)	A
Pressure	
Alert Record Not Empty Enable	Yes
Alert Record Full Enable	Yes
Informational Status	
Inst Time Invalid Enable	Yes
Cal in Progress Enable	No
Autocal in Progress Enable	No
Diag in Progress Enable	No
Diag Data Avail Enable	Yes
Integrator Sat Hi Enable	Yes
Integrator Sat Lo Enable	Yes
Press Ctrl Active Enable	Yes
Multi-Drop Alert Enable	No
Electronic Alerts	
Shutdown Activated Alert Enable	Yes
Power Starvation Alert Enable	No
Non-Critical NVM Alert Enable	No

strument Configuration [BALL VALVE] - Spec Sheet

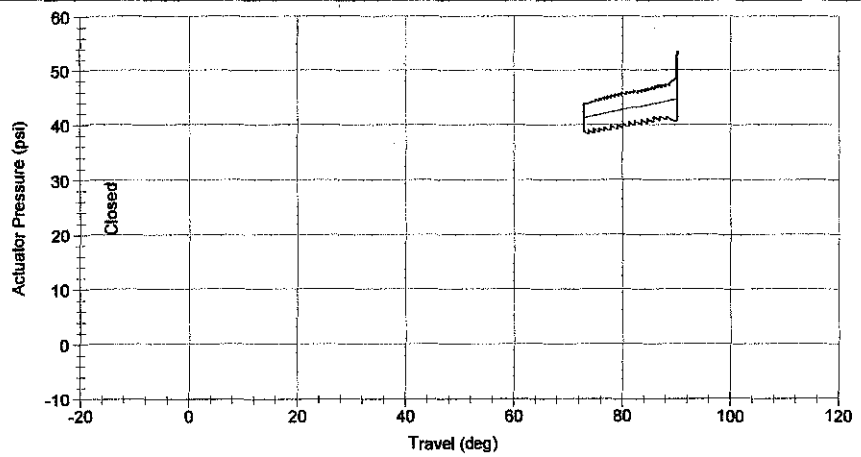
01 Feb 2009 12:42:30

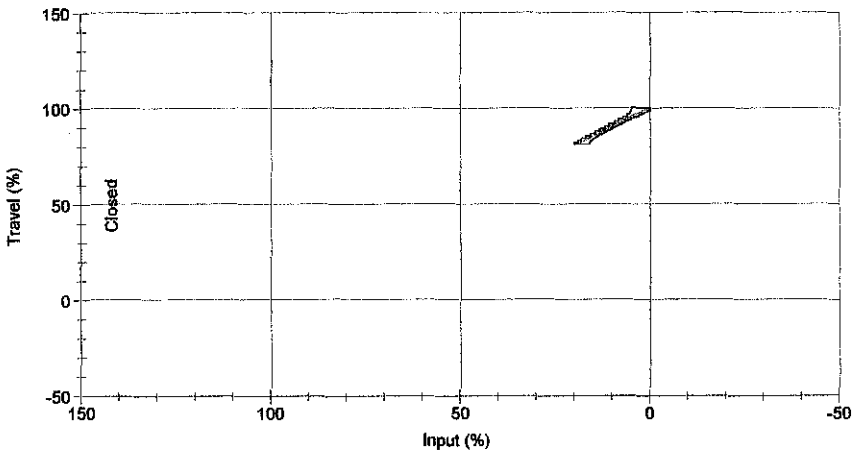
Spec Sheet Units	
Pressure Units	psi
Travel Units	deg
Length Units	in
Area Units	in2
Torque Units	lbf.in
Spring Rate Units	lbf/in
Valve	
Valve Mfg.	Fisher Controls
Valve Model	V-250
Size	6 in
Class	300
Rated Travel	90.0 deg
Actual Travel	90.0 deg
Stem Diameter	2.0 in
Packing Type	TFE / Single
Inlet Pressure	100.0 psi
Outlet Pressure	0.0 psi

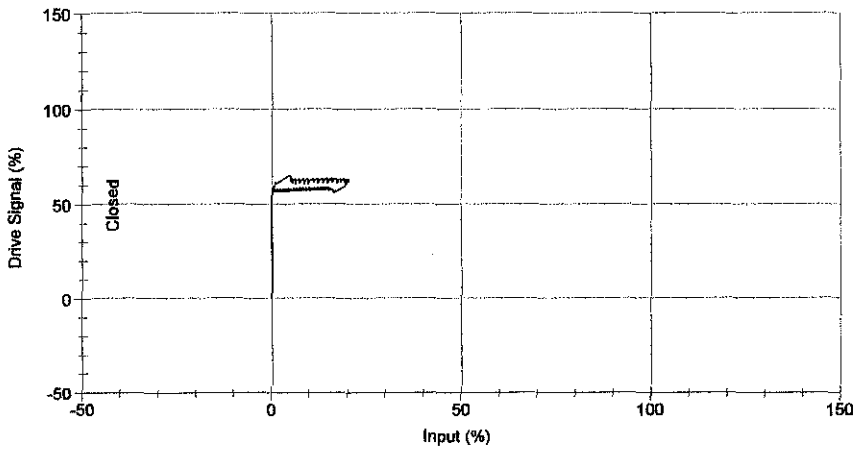
Trim	
Seat Type	Metal
Leak Class	V
Port Diameter	6.0 in
Actuator	
Actuator Mfg.	Fisher Controls
Actuator Model	1035
Actuator Size	40
Effective Area	0.0 in2
Air	Closes
Volume Booster/Quick Release	Unknown
Lower Bench Set	0.0 psi
Upper Bench Set	0.0 psi
Nominal Supply Pressure	70.0 psi
Spring Rate	0.0 lbf/in
Lever Style	Rack and Pinion
Moment Arm	0.0 in

Reference	
Trim Style 1	
Trim Style 2	
Stroking Time Open (sec)	0
Stroking Time Closed (sec)	0
Dynamic Torque	0.0 lbf.in
Breakout Torque	0.0 lbf.in

rtial Stroke [BALL VALVE]







01 Feb 2009 12:42:48

Inputs

Input Start:	100.0 %
Input End:	80.0 %
Stroke Speed	0.5%/s
Test Pause Time:	5 sec
Collection Interval:	150.0 msec.

Analyzed Data

Avg. Dynamic Error:	2.74%
Min. Dynamic Error:	1.76%
Max. Dynamic Error:	3.51%
Dyn. Linearity (Ind.):	0.50%
Zero Ranged Travel at:	19.98 mA
Full Ranged Travel at:	4.05 mA
Average Torque:	NA
Minimum Torque:	NA
Maximum Torque:	NA
Spring Rate:	NA
Bench Set:	26.66 - 44.65 psi
Partial Stroke Test initiated by:	HART Command
Partial Stroke Test status:	Completed Successfully

Tuning Set

Tuning Set:	H
Gains	
Proportional:	8.40
Velocity:	4.20
MLF:	31.00
Integral Control:	Disabled
Integral Gain:	9.4

Notes

Valve

Manufacturer:	Fisher Controls
Type:	V-250
Size:	6 in
Class:	300
Rated Travel:	90.00 deg
Actual Travel:	90.00 deg
Shaft Diameter:	2.0000 in
Packing Type:	TFE / Single
Inlet Pressure:	100.0000 psi
Outlet Pressure:	0.0000 psi

Trim

Seat Type:	Metal
Leakage Class:	V
Port Diameter:	6.0000 in

Actuator

Manufacturer:	Fisher Controls
Type:	1035
Size:	40
Effective Area:	0.00 in2
Air:	Closes
Bench Set:	0.0000 psi- 0.0000 psi
Nominal Supply Pressure:	70.0000 psi
Spring Rate:	0.0000 lbf/in
Style:	Rack and Pinion
Moment Arm:	0.0000 in

strument Configuration [BALL VALVE] - Basic

01 Feb 2009 12:53:25

General	
HART Tag	PST
Message	
Descriptor	18477410
Date	02/18/08
Valve Serial Number	18477410
strument Serial Number	18477410
Polling Address	0
Initial Setup	
Control Mode	Analog (RSP)
Restart Cont. Mode	Analog (RSP)
Zero Power Condition	Valve Open
avel / Pressure Cutoff Lo (%)	0.5
Valve Style	Rotary Shaft
Actuator Style	Piston - Sgl w/ Spring
Relay Type	Relay B
Feedback Connection	Rotary-All/SS-Roller
Travel Sensor Motion	Clockwise
Aux Terminal Mode	Push Button Partial Stroke Test
Partial Stroke Start Pt.	Valve Open
Inputs	
Analog Input Units	mA
Temperature Units	F
Input Characterization	
Input Characteristic	Linear

Pressure	
Max Supply Pressure	60 psi
Pressure Units	psi
Tuning	
Travel Control	
Travel Control Tuning Set	H
Proportional	8.4
Enable Integral Control	No
Integral Gain (reps/min)	9.4
Integral Settings	
Integral Dead Zone (%)	0.26
Integral Limit (%)	50
Pressure Control	
Pressure Control Tuning Set	H
Proportional	4.2
Enable Integral Control	Yes
Integral Gain (reps/sec)	0.1
SIS / Partial Stroke	
Partial Stroke Enable	Enabled
Test Start Point	
Partial Stroke Press Limit	16 psi
Max. Travel Movement (%)	20
Test Speed	0.5%/s
Test Pause Time	5 sec
Auto Test Interval (days)	0.00
SIS Options	
DVC Power Up	Auto Reset
Action on Failed test	Ramp Back

Travel/Pressure Control	
Travel/Pressure Control	
Travel / Pressure Select	Travel
Travel / Pressure Cutoff Lo (%)	0.5
Travel / Pressure Cutoff Hi (%)	99.46
End Point Press. Control	
End Point Control Enable	Enabled
Control End	
Pressure Set Point	52.1 psi
Pressure Saturation Time (sec)	45
Dynamic Response	
Set Point Rate Limits	
SP Rate Open (%/sec)	0
SP Rate Close (%/sec)	0
Set Point Filter	
Lag Time (sec)	0

strument Configuration [BALL VALVE] - Alerts

01 Feb 2009 12:53:25

Self Test Shut Down	
Flash ROM Fail Enable	No
No Free Time Enable	No
Reference Voltage Fail Enable	No
NVM Fail Enable	No
Temp Sensor Fail Enable	No
Travel Sensor Fail Enable	No
Drive Current Fail Enable	No
Travel History Alerts	
Cycle Count Alert Enable	No
cle Count Deadband (%)	2.93
Cycle Count Alert Point	2147483646
Cycle Count	304
Trav Acc Alert Enable	No
vl Accum Deadband (%)	2.93
Tvl Accum Alert Pt (%)	2147483646
Travel Accumulator (%)	21511

Deviation & Other Alerts	
Travel Dev Alert Enable	Yes
Travel Dev Alert Pt (%)	5
Travel Dev Time (sec)	9.99
Pressure Dev Alert Enable	Yes
Pressure Dev Alert Pt	2 psi
Pressure Dev Time (sec)	9.99
Drive Signal Alert Enable	Yes
Supply Pressure Alert Point	0 psi
Supply Pressure Alert Enable	Yes
Travel Alerts	
Tvl Alert Lo Enable	No
Tvl Alert Hi Enable	No
Tvl Alert Lo Lo Enable	No
Tvl Alert Hi Hi Enable	No
Lo Point (%)	-25
Hi Point (%)	125
Lo Lo Point (%)	-25
Hi Hi Point (%)	125
Deadband (%)	1
Tvl Limit/Cutoff Lo Enable	No
Tvl Limit/Cutoff Hi Enable	No

Alert Record and Commands	
Instrument Clock	01 FEB 2009 12:33
Valve Alerts Enable	No
Failure Alerts Enable	Yes
Misc Alerts Enable	No
Burst Mode Enable	No
Burst Command	3
Cmd #3 (Trending) Pressure	A
Alert Record Not Empty Enable	Yes
Alert Record Full Enable	Yes
Informational Status	
Inst Time Invalid Enable	Yes
Cal in Progress Enable	No
Autocal in Progress Enable	No
Diag in Progress Enable	No
Diag Data Avail Enable	Yes
Integrator Sat Hi Enable	Yes
Integrator Sat Lo Enable	Yes
Press Ctrl Active Enable	Yes
Multi-Drop Alert Enable	No
Electronic Alerts	
Shutdown Activated Alert Enable	Yes
Power Starvation Alert Enable	No
Non-Critical NVM Alert Enable	No

strument Configuration [BALL VALVE] - Spec Sheet

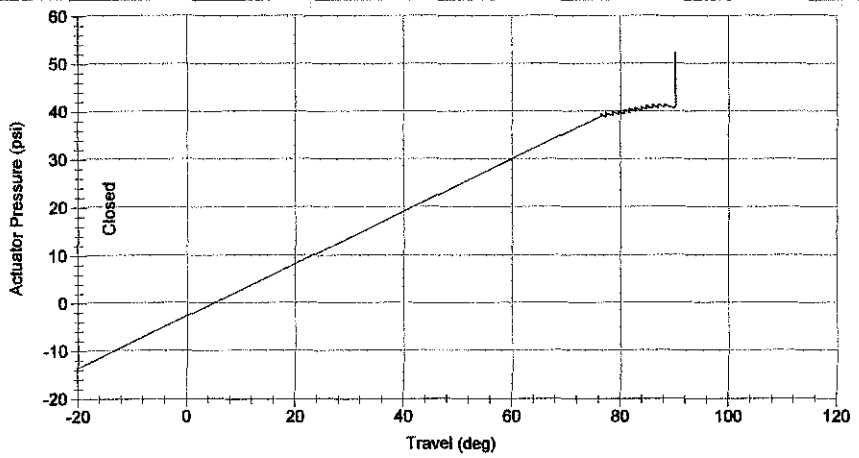
01 Feb 2009 12:53:25

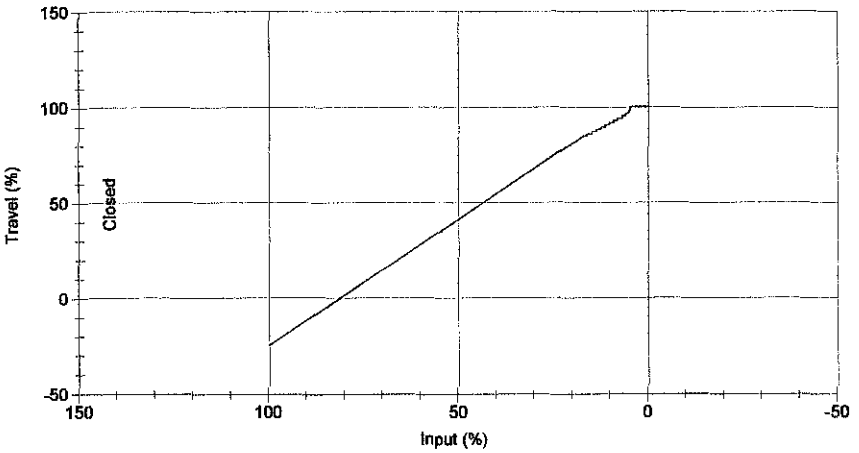
Spec Sheet Units	
Pressure Units	psi
Travel Units	deg
Length Units	in
Area Units	in2
Torque Units	lbf.in
Spring Rate Units	lbf/in
Valve	
Valve Mfg.	Fisher Controls
Valve Model	V-250
Size	6 in
Class	300
Rated Travel	90.0 deg
Actual Travel	90.0 deg
Stem Diameter	2.0 in
Packing Type	TFE / Single
Inlet Pressure	100.0 psi
Outlet Pressure	0.0 psi

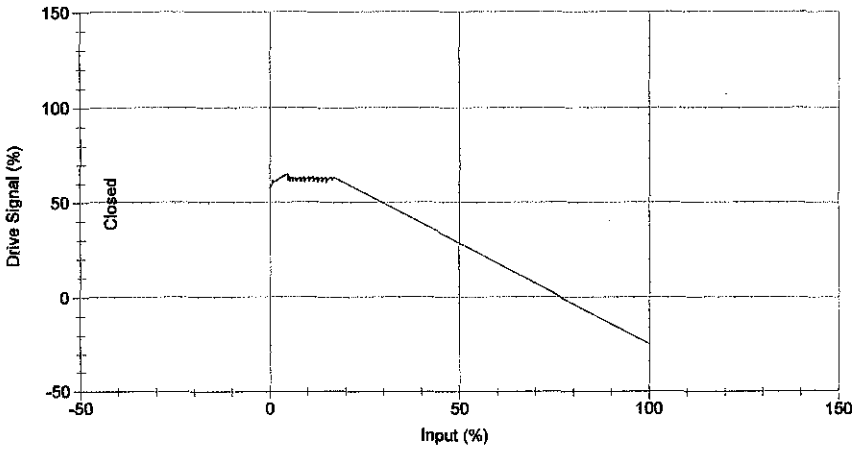
Trim	
Seat Type	Metal
Leak Class	V
Port Diameter	6.0 in
Actuator	
Actuator Mfg.	Fisher Controls
Actuator Model	1035
Actuator Size	40
Effective Area	0.0 in2
Air	Closes
Volume Booster/Quick Release	Unknown
Lower Bench Set	0.0 psi
Upper Bench Set	0.0 psi
Nominal Supply Pressure	70.0 psi
Spring Rate	0.0 lbf/in
Lever Style	Rack and Pinion
Moment Arm	0.0 in

Reference	
Trim Style 1	
Trim Style 2	
Stroking Time Open (sec)	0
Stroking Time Closed (sec)	0
Dynamic Torque	0.0 lbf.in
Breakout Torque	0.0 lbf.in

rtial Stroke [BALL VALVE]







01 Feb 2009 12:54:14

Inputs

Input Start:	100.0 %
Input End:	80.0 %
Stroke Speed	0.5%/s
Test Pause Time:	5 sec
Collection Interval:	150.0 msec.

Analyzed Data

Avg. Dynamic Error:	-10000.00%
Min. Dynamic Error:	-10000.00%
Max. Dynamic Error:	-10000.00%
Dyn. Linearity (Ind.):	-10000.00%
Zero Ranged Travel at:	-10000.00 mA
Full Ranged Travel at:	-10000.00 mA
Average Torque:	NA
Minimum Torque:	NA
Maximum Torque:	NA
Spring Rate:	NA
Bench Set:	NA
Partial Stroke Test initiated by:	HART Command
Partial Stroke Test status:	Failed - Emergency Occurred

Tuning Set

Tuning Set:	H
Gains	
Proportional:	8.40
Velocity:	4.20
MLF:	31.00
Integral Control:	Disabled
Integral Gain:	9.4

Notes

Valve

Manufacturer:	Fisher Controls
Type:	V-250
Size:	6 in
Class:	300
Rated Travel:	90.00 deg
Actual Travel:	90.00 deg
Shaft Diameter:	2.0000 in
Packing Type:	TFE / Single
Inlet Pressure:	100.0000 psi
Outlet Pressure:	0.0000 psi

Trim

Seat Type:	Metal
Leakage Class:	V
Port Diameter:	6.0000 in

Actuator

Manufacturer:	Fisher Controls
Type:	1035
Size:	40
Effective Area:	0.00 in2
Air:	Closes
Bench Set:	0.0000 psi- 0.0000 psi
Nominal Supply Pressure:	70.0000 psi
Spring Rate:	0.0000 lbf/in
Style:	Rack and Pinion
Moment Arm:	0.0000 in

APPENDIX IV

Daily Report of PST for Butterfly Valve

(Software generated)

BUTTERFLY VALVE **DVC6000 SIS**	HART Tag Name: DEMO-SIS Valve Style: ROTARY Actuator Style: Piston - Sgl w/ Spring Instrument S/N: 16013812 Valve S/N: 16013812 Firmware Revision: 7 Hardware Revision: 1

strument Configuration [BUTTERFLY VALVE] - Basic

01 Feb 2009 13:06:33

General	
HART Tag	DEMO-SIS
Message	
Descriptor	DEMO-SIS
Date	01/23/06
Valve Serial Number	16013812
strument Serial Number	16013812
Polling Address	0
Initial Setup	
Control Mode	Analog (RSP)
Restart Cont. Mode	Analog (RSP)
Zero Power Condition	Valve Open
avel / Pressure Cutoff Lo (%)	50
Valve Style	Rotary Shaft
Actuator Style	Piston - Sgl w/ Spring
Relay Type	Relay B - Special App.
Feedback Connection	Rotary-All/SS-Roller
Travel Sensor Motion	Counter-clockwise
Aux Terminal Mode	Push Button Partial Stroke Test
Partial Stroke Start Pt.	Valve Open
Inputs	
Analog Input Units	mA
Temperature Units	F
Input Characterization	
Input Characteristic	Linear

Pressure	
Max Supply Pressure	70 psi
Pressure Units	psi
Tuning	
Travel Control	
Travel Control Tuning Set	C
Proportional	4.4
Enable Integral Control	No
Integral Gain (reps/min)	9.4
Integral Settings	
Integral Dead Zone (%)	0.26
Integral Limit (%)	30
Pressure Control	
Pressure Control Tuning Set	C
Proportional	2.2
Enable Integral Control	Yes
Integral Gain (reps/sec)	0.1
SIS / Partial Stroke	
Partial Stroke Enable	Enabled
Test Start Point	
Partial Stroke Press Limit	17 psi
Max. Travel Movement (%)	20
Test Speed	0.5%/s
Test Pause Time	10 sec
Auto Test Interval (days)	0.00
SIS Options	
DVC Power Up	Auto Reset
Action on Failed test	Ramp Back

Travel/Pressure Control	
Travel/Pressure Control	
Travel / Pressure Select	Travel
Travel / Pressure Cutoff Lo (%)	50
Travel / Pressure Cutoff Hi (%)	50
End Point Press. Control	
End Point Control Enable	Enabled
Control End	
Pressure Set Point	54.9 psi
Pressure Saturation Time (sec)	45
Dynamic Response	
Set Point Rate Limits	
SP Rate Open (%/sec)	0
SP Rate Close (%/sec)	0
Set Point Filter Lag Time (sec)	0

trument Configuration [BUTTERFLY VALVE] - Alerts

01 Feb 2009 13:06:33

Self Test Shut Down	
Flash ROM Fail Enable	No
No Free Time Enable	No
Reference Voltage Fail Enable	No
NVM Fail Enable	No
emp Sensor Fail Enable	No
avel Sensor Fail Enable	No
rive Current Fail Enable	No
Travel History Alerts	
ycle Count Alert Enable	No
e Count Deadband (%)	3
Cycle Count Alert Point	2147483647
Cycle Count	2147483647
Trav Acc Alert Enable	No
l Accum Deadband (%)	3
Tvl Accum Alert Pt (%)	2147483647
Travel Accumulator (%)	2147483647

Deviation & Other Alerts	
Travel Dev Alert Enable	Yes
Travel Dev Alert Pt (%)	6.91
Travel Dev Time (sec)	9.99
Pressure Dev Alert Enable	Yes
Pressure Dev Alert Pt	2 psi
Pressure Dev Time (sec)	9.99
Drive Signal Alert Enable	Yes
Supply Pressure Alert Point	9 psi
Supply Pressure Alert Enable	Yes
Travel Alerts	
Tvl Alert Lo Enable	No
Tvl Alert Hi Enable	No
Tvl Alert Lo Lo Enable	No
Tvl Alert Hi Hi Enable	No
Lo Point (%)	2
Hi Point (%)	9
Lo Lo Point (%)	1
Hi Hi Point (%)	98.97
Deadband (%)	3
Tvl Limit/Cutoff Lo Enable	No
Tvl Limit/Cutoff Hi Enable	No

Alert Record and Commands	
Instrument Clock	01 FEB 2009 01:06
Valve Alerts Enable	Yes
Failure Alerts Enable	Yes
Misc Alerts Enable	Yes
Burst Mode Enable	No
Burst Command	3
Cmd #3 (Trending)	B Pressure
Alert Record Not Empty Enable	Yes
Alert Record Full Enable	Yes
Informational Status	
Inst Time Invalid Enable	Yes
Cal in Progress Enable	No
Autocal in Progress Enable	No
Diag in Progress Enable	Yes
Diag Data Avail Enable	Yes
Integrator Sat Hi Enable	Yes
Integrator Sat Lo Enable	Yes
Press Ctrl Active Enable	Yes
Multi-Drop Alert Enable	No
Electronic Alerts	
Shutdown Activated Alert Enable	Yes
Power Starvation Alert Enable	No
Non-Critical NVM Alert Enable	No

strument Configuration [BUTTERFLY VALVE] - Spec Sheet

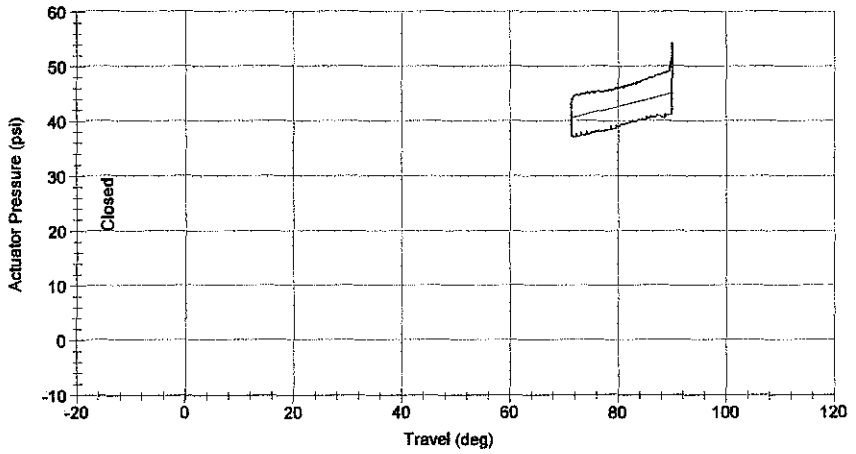
01 Feb 2009 13:06:33

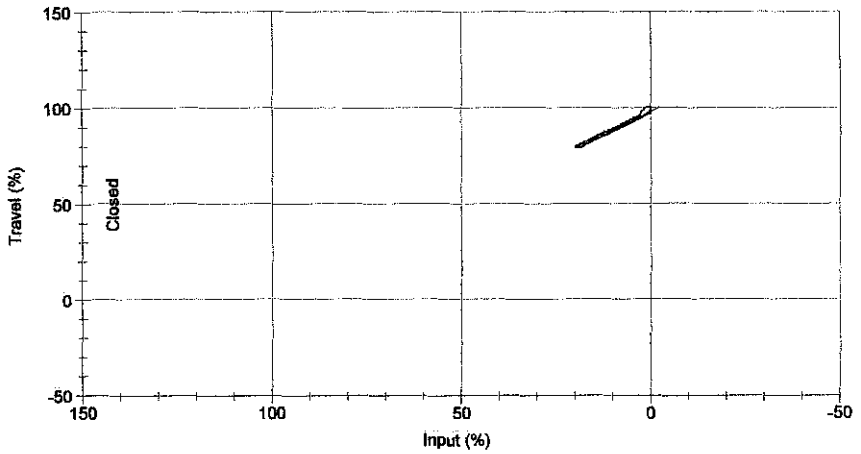
Spec Sheet Units	
Pressure Units	psi
Travel Units	deg
Length Units	in
Area Units	in2
Torque Units	lbf.in
Spring Rate Units	lbf/in
Valve	
Valve Mfg.	Fisher Controls
Valve Model	8560
Size	4 in
Class	300
Rated Travel	90.0 deg
Actual Travel	90.0 deg
Stem Diameter	2.0 in
Packing Type	TFE / Single
Inlet Pressure	100.0 psi
Outlet Pressure	0.0 psi

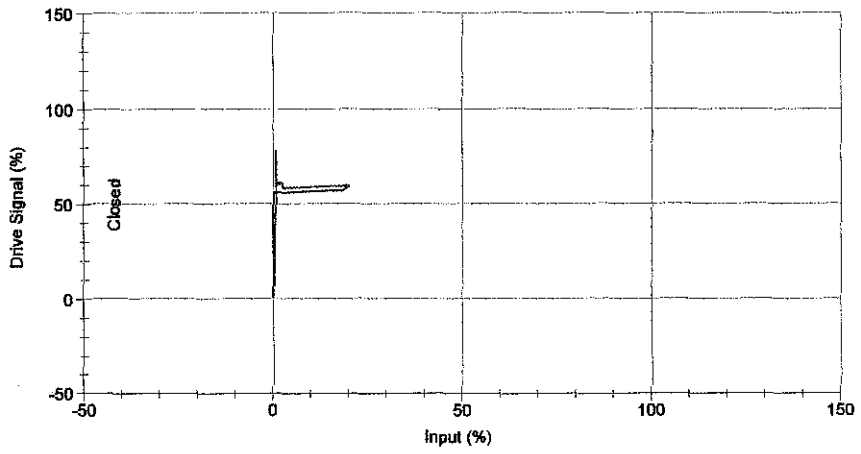
Trim	
Seat Type	
Leak Class	Unknown
Port Diameter	0.0 in
Actuator	
Actuator Mfg.	Fisher Controls
Actuator Model	1035
Actuator Size	20
Effective Area	0.0 in2
Air	Closes
Volume Booster/Quick Release	Unknown
Lower Bench Set	0.0 psi
Upper Bench Set	0.0 psi
Nominal Supply Pressure	0.0 psi
Spring Rate	0.0 lbf/in
Lever Style	Rack and Pinion
Moment Arm	0.0 in

Reference	
Trim Style 1	
Trim Style 2	
Stroking Time Open (sec)	0
Stroking Time Closed (sec)	0
Dynamic Torque	0.0 lbf.in
Breakout Torque	0.0 lbf.in

tial Stroke [BUTTERFLY VALVE]







01 Feb 2009 13:07:22

Inputs

Input Start:	100.0 %
Input End:	80.0 %
Stroke Speed	0.5%/s
Test Pause Time:	10 sec
Collection Interval:	150.0 msec.

Analyzed Data

Avg. Dynamic Error:	1.63%
Min. Dynamic Error:	1.24%
Max. Dynamic Error:	1.98%
Dyn. Linearity (Ind.):	0.22%
Zero Ranged Travel at:	20.39 mA
Full Ranged Travel at:	3.64 mA
Average Torque:	NA
Minimum Torque:	NA
Maximum Torque:	NA
Spring Rate:	NA
Bench Set:	23.37 - 45.01 psi
Partial Stroke Test initiated by:	HART Command
Partial Stroke Test status:	Completed Successfully

Tuning Set

Tuning Set:	C
Gains	
Proportional:	4.40
Velocity:	3.00
MLF:	35.00
Integral Control:	Disabled
Integral Gain:	9.4

Notes

Valve

Manufacturer:	Fisher Controls
Type:	8560
Size:	4 in
Class:	300
Rated Travel:	90.00 deg
Actual Travel:	90.00 deg
Shaft Diameter:	2.0000 in
Packing Type:	TFE / Single
Inlet Pressure:	100.0000 psi
Outlet Pressure:	0.0000 psi

Trim

Seat Type:	
Leakage Class:	
Port Diameter:	0.0000 in

Actuator

Manufacturer:	Fisher Controls
Type:	1035
Size:	20
Effective Area:	0.00 in2
Air:	Closes
Bench Set:	0.0000 psi- 0.0000 psi
Nominal Supply Pressure:	0.0000 psi
Spring Rate:	0.0000 lbf/in
Style:	Rack and Pinion
Moment Arm:	0.0000 in

strument Configuration [BUTTERFLY VALVE] - Basic

01 Feb 2009 13:16:04

General	
HART Tag	DEMO-SIS
Message	
Descriptor	DEMO-SIS
Date	01/23/06
Valve Serial Number	16013812
strument Serial Number	16013812
Polling Address	0
Initial Setup	
Control Mode	Analog (RSP)
Restart Cont. Mode	Analog (RSP)
Zero Power Condition	Valve Open
avel / Pressure Cutoff Lo (%)	50
Valve Style	Rotary Shaft
Actuator Style	Piston - Sgl w/ Spring
Relay Type	Relay B - Special App.
Feedback Connection	Rotary-All/SS-Roller
Travel Sensor Motion	Counter-clockwise
Aux Terminal Mode	Push Button Partial Stroke Test
Partial Stroke Start Pt.	Valve Open
Inputs	
Analog Input Units	mA
Temperature Units	F
Input Characterization	
Input Characteristic	Linear

Pressure	
Max Supply Pressure	70 psi
Pressure Units	psi
Tuning	
Travel Control	
Travel Control Tuning Set	C
Proportional	4.4
Enable Integral Control	No
Integral Gain (reps/min)	9.4
Integral Settings	
Integral Dead Zone (%)	0.26
Integral Limit (%)	30
Pressure Control	
Pressure Control Tuning Set	C
Proportional	2.2
Enable Integral Control	Yes
Integral Gain (reps/sec)	0.1
SIS / Partial Stroke	
Partial Stroke Enable	Enabled
Test Start Point	
Partial Stroke Press Limit	17 psi
Max. Travel Movement (%)	20
Test Speed	0.5%/s
Test Pause Time	10 sec
Auto Test Interval (days)	0.00
SIS Options	
DVC Power Up	Auto Reset
Action on Failed test	Ramp Back

Travel/Pressure Control	
Travel/Pressure Control	
Travel / Pressure Select	Travel
Travel / Pressure Cutoff Lo (%)	50
Travel / Pressure Cutoff Hi (%)	50
End Point Press. Control	
End Point Control Enable	Enabled
Control End	
Pressure Set Point	54.9 psi
Pressure Saturation Time (sec)	45
Dynamic Response	
Set Point Rate Limits	
SP Rate Open (%/sec)	0
SP Rate Close (%/sec)	0
Set Point Filter Lag Time (sec)	0

strument Configuration [BUTTERFLY VALVE] - Alerts

01 Feb 2009 13:16:04

Self Test Shut Down	
Flash ROM Fail Enable	No
No Free Time Enable	No
Reference Voltage Fail Enable	No
NVM Fail Enable	No
Temp Sensor Fail Enable	No
Travel Sensor Fail Enable	No
Drive Current Fail Enable	No
Travel History Alerts	
Cycle Count Alert Enable	No
de Count Deadband (%)	3
Cycle Count Alert Point	2147483647
Cycle Count	2147483647
Trav Acc Alert Enable	No
vl Accum Deadband (%)	3
Tvl Accum Alert Pt (%)	2147483647
Travel Accumulator (%)	2147483647

Deviation & Other Alerts	
Travel Dev Alert Enable	Yes
Travel Dev Alert Pt (%)	6.91
Travel Dev Time (sec)	9.99
Pressure Dev Alert Enable	Yes
Pressure Dev Alert Pt	2 psi
Pressure Dev Time (sec)	9.99
Drive Signal Alert Enable	Yes
Supply Pressure Alert Point	9 psi
Supply Pressure Alert Enable	Yes
Travel Alerts	
Tvl Alert Lo Enable	No
Tvl Alert Hi Enable	No
Tvl Alert Lo Lo Enable	No
Tvl Alert Hi Hi Enable	No
Lo Point (%)	2
Hi Point (%)	9
Lo Lo Point (%)	1
Hi Hi Point (%)	98.97
Deadband (%)	3
Tvl Limit/Cutoff Lo Enable	No
Tvl Limit/Cutoff Hi Enable	No

Alert Record and Commands	
Instrument Clock	01 FEB 2009 01:14
Valve Alerts Enable	Yes
Failure Alerts Enable	Yes
Misc Alerts Enable	Yes
Burst Mode Enable	No
Burst Command	3
Cmd #3 (Trending)	B
Pressure	
Alert Record Not Empty Enable	Yes
Alert Record Full Enable	Yes
Informational Status	
Inst Time Invalid Enable	Yes
Cal in Progress Enable	No
Autocal in Progress Enable	No
Diag in Progress Enable	Yes
Diag Data Avail Enable	Yes
Integrator Sat Hi Enable	Yes
Integrator Sat Lo Enable	Yes
Press Ctrl Active Enable	Yes
Multi-Drop Alert Enable	No
Electronic Alerts	
Shutdown Activated Alert Enable	Yes
Power Starvation Alert Enable	No
Non-Critical NVM Alert Enable	No

strument Configuration [BUTTERFLY VALVE] - Spec Sheet

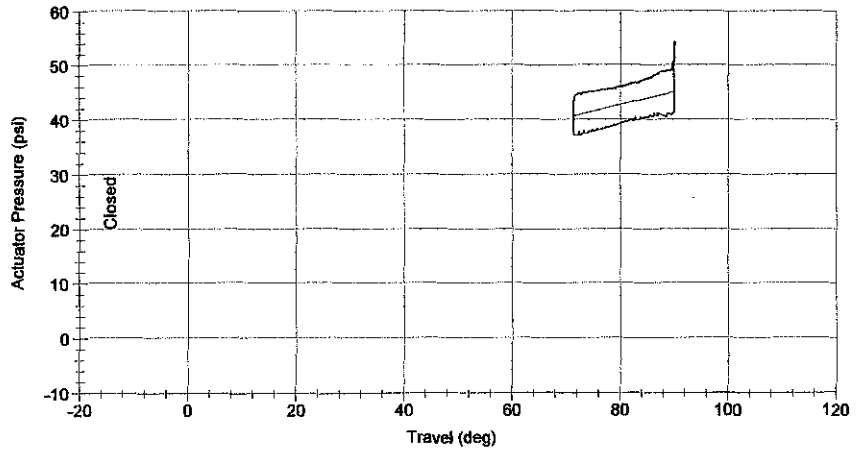
01 Feb 2009 13:16:04

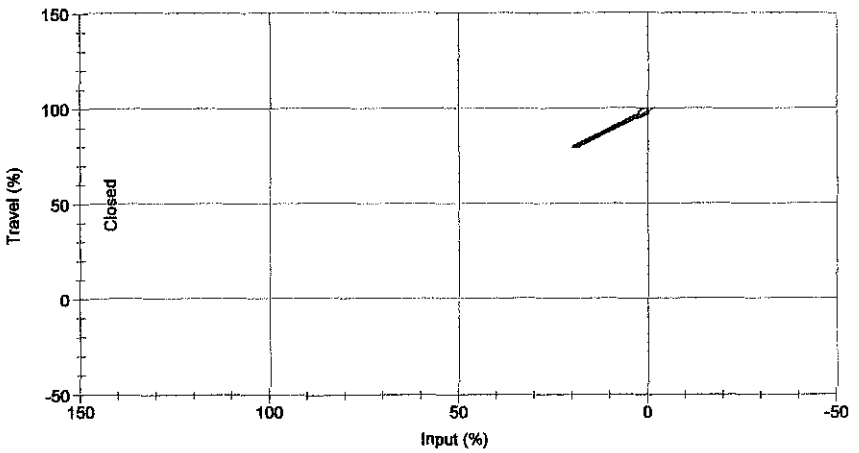
Spec Sheet Units	
Pressure Units	psi
Travel Units	deg
Length Units	in
Area Units	in2
Torque Units	lbf.in
Spring Rate Units	lbf/in
Valve	
Valve Mfg.	Fisher Controls
Valve Model	8560
Size	4 in
Class	300
Rated Travel	90.0 deg
Actual Travel	90.0 deg
Stem Diameter	2.0 in
Packing Type	TFE / Single
Inlet Pressure	100.0 psi
Outlet Pressure	0.0 psi

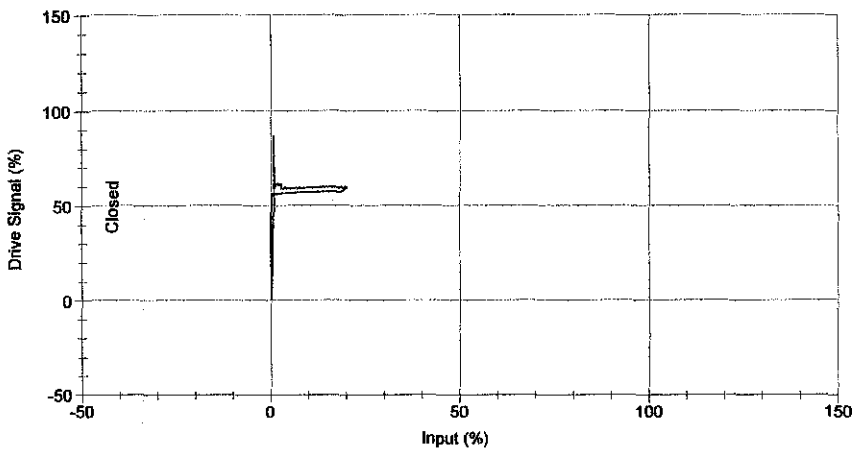
Trim	
Seat Type	
Leak Class	Unknown
Port Diameter	0.0 in
Actuator	
Actuator Mfg.	Fisher Controls
Actuator Model	1035
Actuator Size	20
Effective Area	0.0 in2
Air	Closes
Volume Booster/Quick Release	Unknown
Lower Bench Set	0.0 psi
Upper Bench Set	0.0 psi
Nominal Supply Pressure	0.0 psi
Spring Rate	0.0 lbf/in
Lever Style	Rack and Pinion
Moment Arm	0.0 in

Reference	
Trim Style 1	
Trim Style 2	
Stroking Time Open (sec)	0
Stroking Time Closed (sec)	0
Dynamic Torque	0.0 lbf.in
Breakout Torque	0.0 lbf.in

rtial Stroke [BUTTERFLY VALVE]







01 Feb 2009 13:16:15

Inputs

Input Start:	100.0 %
Input End:	80.0 %
Stroke Speed	0.5%/s
Test Pause Time:	10 sec
Collection Interval:	150.0 msec.

Analyzed Data

Avg. Dynamic Error:	1.62%
Min. Dynamic Error:	1.33%
Max. Dynamic Error:	1.98%
Dyn. Linearity (Ind.):	0.18%
Zero Ranged Travel at:	20.25 mA
Full Ranged Travel at:	3.70 mA
Average Torque:	NA
Minimum Torque:	NA
Maximum Torque:	NA
Spring Rate:	NA
Bench Set:	23.64 - 45.02 psi
Partial Stroke Test initiated by:	HART Command
Partial Stroke Test status:	Completed Successfully

Tuning Set

Tuning Set:	C
Gains	
Proportional:	4.40
Velocity:	3.00
MLF:	35.00
Integral Control:	Disabled
Integral Gain:	9.4

Notes

Valve

Manufacturer:	Fisher Controls
Type:	8560
Size:	4 in
Class:	300
Rated Travel:	90.00 deg
Actual Travel:	90.00 deg
Shaft Diameter:	2.0000 in
Packing Type:	TFE / Single
Inlet Pressure:	100.0000 psi
Outlet Pressure:	0.0000 psi

Trim

Seat Type:	
Leakage Class:	
Port Diameter:	0.0000 in

Actuator

Manufacturer:	Fisher Controls
Type:	1035
Size:	20
Effective Area:	0.00 in2
Air:	Closes
Bench Set:	0.0000 psi- 0.0000 psi
Nominal Supply Pressure:	0.0000 psi
Spring Rate:	0.0000 lbf/in
Style:	Rack and Pinion
Moment Arm:	0.0000 in

strument Configuration [BUTTERFLY VALVE] - Basic

01 Feb 2009 13:25:33

General	
HART Tag	DEMO-SIS
Message	
Descriptor	DEMO-SIS
Date	01/23/06
Valve Serial Number	16013812
strument Serial Number	16013812
Polling Address	0
Initial Setup	
Control Mode	Analog (RSP)
Restart Cont. Mode	Analog (RSP)
Zero Power Condition	Valve Open
avel / Pressure Cutoff Lo (%)	50
Valve Style	Rotary Shaft
Actuator Style	Piston - Sgl w/ Spring
Relay Type	Relay B - Special App.
Feedback Connection	Rotary-All/SS-Roller
Travel Sensor Motion	Counter-clockwise
Aux Terminal Mode	Push Button Partial Stroke Test
Partial Stroke Start Pt.	Valve Open
Inputs	
Analog Input Units	mA
Temperature Units	F
Input Characterization	
Input Characteristic	Linear

Pressure	
Max Supply Pressure	70 psi
Pressure Units	psi
Tuning	
Travel Control	
Travel Control Tuning Set	C
Proportional	4.4
Enable Integral Control	No
Integral Gain (reps/min)	9.4
Integral Settings	
Integral Dead Zone (%)	0.26
Integral Limit (%)	30
Pressure Control	
Pressure Control Tuning Set	C
Proportional	2.2
Enable Integral Control	Yes
Integral Gain (reps/sec)	0.1
SIS / Partial Stroke	
Partial Stroke Enable	Enabled
Test Start Point	
Partial Stroke Press Limit	17 psi
Max. Travel Movement (%)	20
Test Speed	0.5%/s
Test Pause Time	10 sec
Auto Test Interval (days)	0.00
SIS Options	
DVC Power Up	Auto Reset
Action on Failed test	Ramp Back

Travel/Pressure Control	
Travel/Pressure Control	
Travel / Pressure Select	Travel
Travel / Pressure Cutoff Lo (%)	50
Travel / Pressure Cutoff Hi (%)	50
End Point Press. Control	
End Point Control Enable	Enabled
Control End	
Pressure Set Point	54.9 psi
Pressure Saturation Time (sec)	45
Dynamic Response	
Set Point Rate Limits	
SP Rate Open (%/sec)	0
SP Rate Close (%/sec)	0
Set Point Filter Lag Time (sec)	0

strument Configuration [BUTTERFLY VALVE] - Alerts

01 Feb 2009 13:25:33

Self Test Shut Down	
Flash ROM Fail Enable	No
No Free Time Enable	No
Reference Voltage Fail Enable	No
NVM Fail Enable	No
Temp Sensor Fail Enable	No
Travel Sensor Fail Enable	No
Drive Current Fail Enable	No
Travel History Alerts	
Cycle Count Alert Enable	No
cle Count Deadband (%)	3
Cycle Count Alert Point	2147483647
Cycle Count	2147483647
Trav Acc Alert Enable	No
vl Accum Deadband (%)	3
Tvl Accum Alert Pt (%)	2147483647
Travel Accumulator (%)	2147483647

Deviation & Other Alerts	
Travel Dev Alert Enable	Yes
Travel Dev Alert Pt (%)	6.91
Travel Dev Time (sec)	9.99
Pressure Dev Alert Enable	Yes
Pressure Dev Alert Pt	2 psi
Pressure Dev Time (sec)	9.99
Drive Signal Alert Enable	Yes
Supply Pressure Alert Point	9 psi
Supply Pressure Alert Enable	Yes
Travel Alerts	
Tvl Alert Lo Enable	No
Tvl Alert Hi Enable	No
Tvl Alert Lo Lo Enable	No
Tvl Alert Hi Hi Enable	No
Lo Point (%)	2
Hi Point (%)	9
Lo Lo Point (%)	1
Hi Hi Point (%)	98.97
Deadband (%)	3
Tvl Limit/Cutoff Lo Enable	No
Tvl Limit/Cutoff Hi Enable	No

Alert Record and Commands	
Instrument Clock	01 FEB 2009 01:23
Valve Alerts Enable	Yes
Failure Alerts Enable	Yes
Misc Alerts Enable	Yes
Burst Mode Enable	No
Burst Command	3
Cmd #3 (Trending)	B Pressure
Alert Record Not Empty Enable	Yes
Alert Record Full Enable	Yes
Informational Status	
Inst Time Invalid Enable	Yes
Cal in Progress Enable	No
Autocal in Progress Enable	No
Diag in Progress Enable	Yes
Diag Data Avail Enable	Yes
Integrator Sat Hi Enable	Yes
Integrator Sat Lo Enable	Yes
Press Ctrl Active Enable	Yes
Multi-Drop Alert Enable	No
Electronic Alerts	
Shutdown Activated Alert Enable	Yes
Power Starvation Alert Enable	No
Non-Critical NVM Alert Enable	No

strument Configuration [BUTTERFLY VALVE] - Spec Sheet

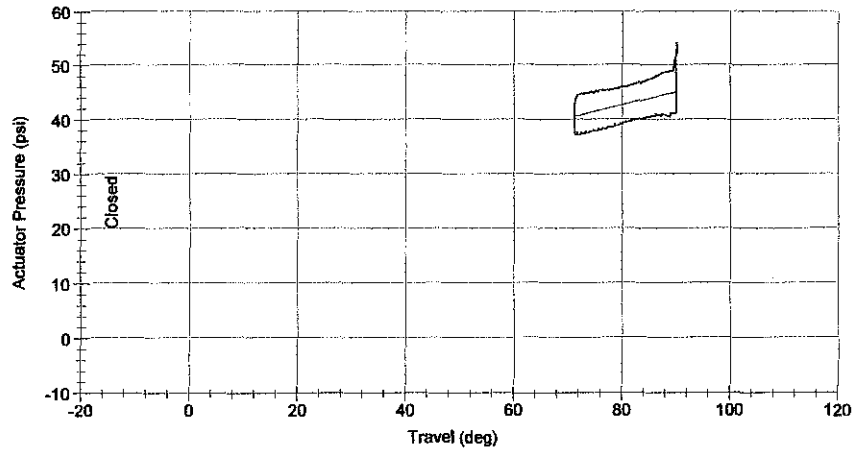
01 Feb 2009 13:25:33

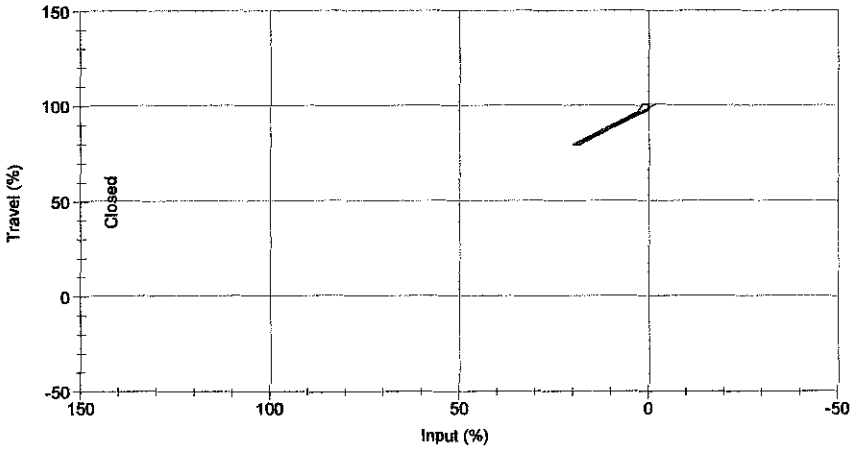
Spec Sheet Units	
Pressure Units	psi
Travel Units	deg
Length Units	in
Area Units	in2
Torque Units	lbf.in
Spring Rate Units	lbf/in
Valve	
Valve Mfg.	Fisher Controls
Valve Model	8560
Size	4 in
Class	300
Rated Travel	90.0 deg
Actual Travel	90.0 deg
Stem Diameter	2.0 in
Packing Type	TFE / Single
Inlet Pressure	100.0 psi
Outlet Pressure	0.0 psi

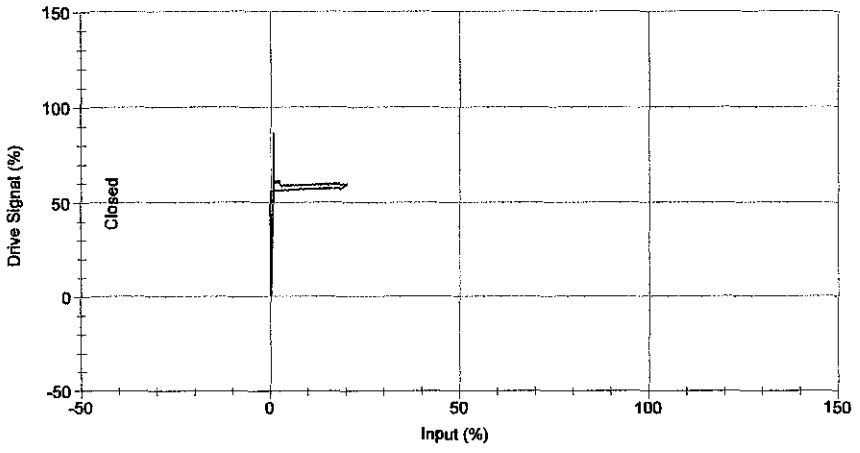
Trim	
Seat Type	
Leak Class	Unknown
Port Diameter	0.0 in
Actuator	
Actuator Mfg.	Fisher Controls
Actuator Model	1035
Actuator Size	20
Effective Area	0.0 in2
Air	Closes
Volume Booster/Quick Release	Unknown
Lower Bench Set	0.0 psi
Upper Bench Set	0.0 psi
Nominal Supply Pressure	0.0 psi
Spring Rate	0.0 lbf/in
Lever Style	Rack and Pinion
Moment Arm	0.0 in

Reference	
Trim Style 1	
Trim Style 2	
Stroking Time Open (sec)	0
Stroking Time Closed (sec)	0
Dynamic Torque	0.0 lbf.in
Breakout Torque	0.0 lbf.in

rtial Stroke [BUTTERFLY VALVE]







01 Feb 2009 13:25:43

Inputs

Input Start:	100.0 %
Input End:	80.0 %
Stroke Speed	0.5%/s
Test Pause Time:	10 sec
Collection Interval:	150.0 msec.

Analyzed Data

Avg. Dynamic Error:	1.45%
Min. Dynamic Error:	1.06%
Max. Dynamic Error:	1.86%
Dyn. Linearity (Ind.):	0.16%
Zero Ranged Travel at:	20.27 mA
Full Ranged Travel at:	3.68 mA
Average Torque:	NA
Minimum Torque:	NA
Maximum Torque:	NA
Spring Rate:	NA
Bench Set:	23.5 - 44.99 psi
Partial Stroke Test initiated by:	HART Command
Partial Stroke Test status:	Completed Successfully

Tuning Set

Tuning Set:	C
Gains	
Proportional:	4.40
Velocity:	3.00
MLF:	35.00
Integral Control:	Disabled
Integral Gain:	9.4

Notes

Valve

Manufacturer:	Fisher Controls
Type:	8560
Size:	4 in
Class:	300
Rated Travel:	90.00 deg
Actual Travel:	90.00 deg
Shaft Diameter:	2.0000 in
Packing Type:	TFE / Single
Inlet Pressure:	100.0000 psi
Outlet Pressure:	0.0000 psi

Trim

Seat Type:	
Leakage Class:	
Port Diameter:	0.0000 in

Actuator

Manufacturer:	Fisher Controls
Type:	1035
Size:	20
Effective Area:	0.00 in2
Air:	Closes
Bench Set:	0.0000 psi- 0.0000 psi
Nominal Supply Pressure:	0.0000 psi
Spring Rate:	0.0000 lbf/in
Style:	Rack and Pinion
Moment Arm:	0.0000 in

strument Configuration [BUTTERFLY VALVE] - Basic

01 Feb 2009 13:35:46

General	
HART Tag	DEMO-SIS
Message	
Descriptor	DEMO-SIS
Date	01/23/06
Valve Serial Number	16013812
ıstrument Serial Number	16013812
Polling Address	0
Initial Setup	
Control Mode	Analog (RSP)
Restart Cont. Mode	Analog (RSP)
Zero Power Condition	Valve Open
avel / Pressure Cutoff Lo (%)	50
Valve Style	Rotary Shaft
Actuator Style	Piston - Sgl w/ Spring
Relay Type	Relay B - Special App.
Feedback Connection	Rotary-All/SS-Roller
Travel Sensor Motion	Counter-clockwise
Aux Terminal Mode	Push Button Partial Stroke Test
Partial Stroke Start Pt.	Valve Open
Inputs	
Analog Input Units	mA
Temperature Units	F
Input Characterization	
Input Characteristic	Linear

Pressure	
Max Supply Pressure	70 psi
Pressure Units	psi
Tuning	
Travel Control	
Travel Control Tuning Set	C
Proportional	4.4
Enable Integral Control	No
Integral Gain (reps/min)	9.4
Integral Settings	
Integral Dead Zone (%)	0.26
Integral Limit (%)	30
Pressure Control	
Pressure Control Tuning Set	C
Proportional	2.2
Enable Integral Control	Yes
Integral Gain (reps/sec)	0.1
SIS / Partial Stroke	
Partial Stroke Enable	Enabled
Test Start Point	
Partial Stroke Press Limit	17 psi
Max. Travel Movement (%)	20
Test Speed	0.5%/s
Test Pause Time	10 sec
Auto Test Interval (days)	0.00
SIS Options	
DVC Power Up	Auto Reset
Action on Failed test	Ramp Back

Travel/Pressure Control	
Travel/Pressure Control	
Travel / Pressure Select	Travel
Travel / Pressure Cutoff Lo (%)	50
Travel / Pressure Cutoff Hi (%)	50
End Point Press. Control	
End Point Control Enable	Enabled
Control End	
Pressure Set Point	54.9 psi
Pressure Saturation Time (sec)	45
Dynamic Response	
Set Point Rate Limits	
SP Rate Open (%/sec)	0
SP Rate Close (%/sec)	0
Set Point Filter Lag Time (sec)	0

strument Configuration [BUTTERFLY VALVE] - Alerts

01 Feb 2009 13:35:46

Self Test Shut Down	
Flash ROM Fail Enable	No
No Free Time Enable	No
Reference Voltage Fail Enable	No
NVM Fail Enable	No
Temp Sensor Fail Enable	No
Travel Sensor Fail Enable	No
Drive Current Fail Enable	No
Travel History Alerts	
Cycle Count Alert Enable	No
cle Count Deadband (%)	3
Cycle Count Alert Point	2147483647
Cycle Count	2147483647
Trav Acc Alert Enable	No
vl Accum Deadband (%)	3
Tvl Accum Alert Pt (%)	2147483647
Travel Accumulator (%)	2147483647

Deviation & Other Alerts	
Travel Dev Alert Enable	Yes
Travel Dev Alert Pt (%)	6.91
Travel Dev Time (sec)	9.99
Pressure Dev Alert Enable	Yes
Pressure Dev Alert Pt	2 psi
Pressure Dev Time (sec)	9.99
Drive Signal Alert Enable	Yes
Supply Pressure Alert Point	9 psi
Supply Pressure Alert Enable	Yes
Travel Alerts	
Tvl Alert Lo Enable	No
Tvl Alert Hi Enable	No
Tvl Alert Lo Lo Enable	No
Tvl Alert Hi Hi Enable	No
Lo Point (%)	2
Hi Point (%)	9
Lo Lo Point (%)	1
Hi Hi Point (%)	98.97
Deadband (%)	3
Tvl Limit/Cutoff Lo Enable	No
Tvl Limit/Cutoff Hi Enable	No

Alert Record and Commands	
Instrument Clock	01 FEB 2009 01:34
Valve Alerts Enable	Yes
Failure Alerts Enable	Yes
Misc Alerts Enable	Yes
Burst Mode Enable	No
Burst Command	3
Cmd #3 (Trending)	B Pressure
Alert Record Not Empty Enable	Yes
Alert Record Full Enable	Yes
Informational Status	
Inst Time Invalid Enable	Yes
Cal in Progress Enable	No
Autocal in Progress Enable	No
Diag in Progress Enable	Yes
Diag Data Avail Enable	Yes
Integrator Sat Hi Enable	Yes
Integrator Sat Lo Enable	Yes
Press Ctrl Active Enable	Yes
Multi-Drop Alert Enable	No
Electronic Alerts	
Shutdown Activated Alert Enable	Yes
Power Starvation Alert Enable	No
Non-Critical NVM Alert Enable	No

strument Configuration [BUTTERFLY VALVE] - Spec Sheet

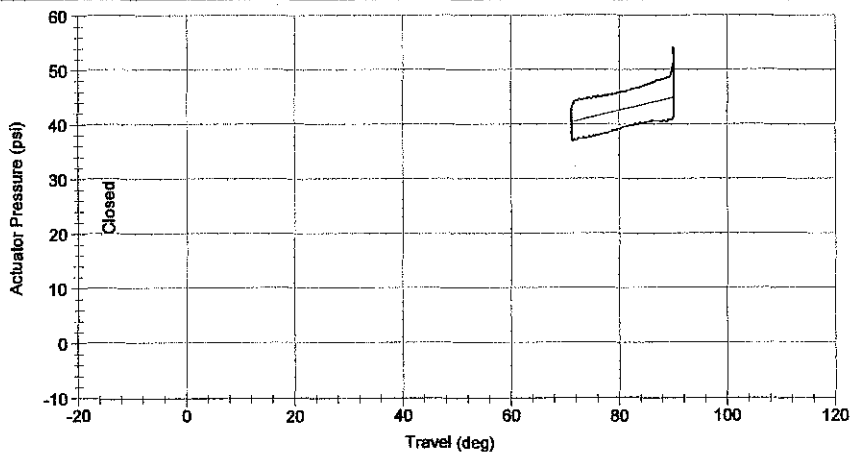
01 Feb 2009 13:35:46

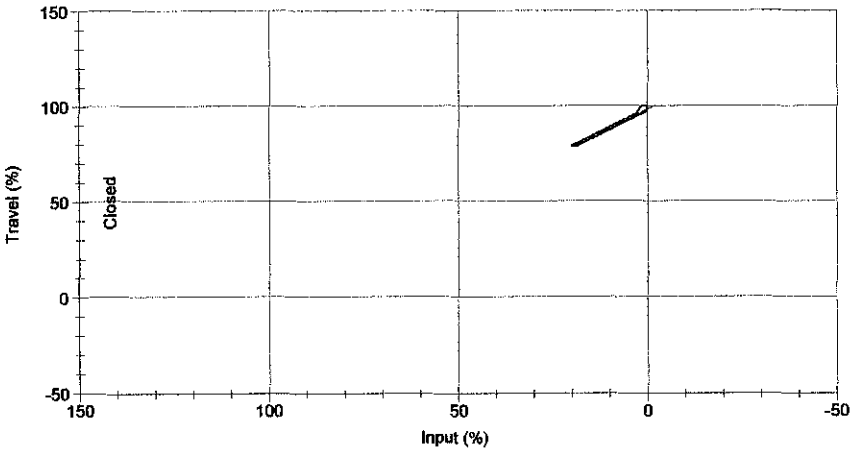
Spec Sheet Units	
Pressure Units	psi
Travel Units	deg
Length Units	in
Area Units	in2
Torque Units	lbf.in
Spring Rate Units	lbf/in
Valve	
Valve Mfg.	Fisher Controls
Valve Model	8560
Size	4 in
Class	300
Rated Travel	90.0 deg
Actual Travel	90.0 deg
Stem Diameter	2.0 in
Packing Type	TFE / Single
Inlet Pressure	100.0 psi
Outlet Pressure	0.0 psi

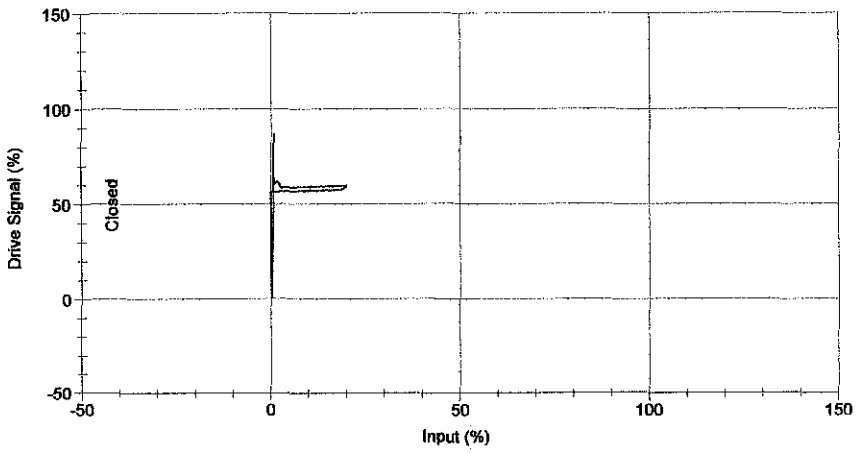
Trim	
Seat Type	
Leak Class	Unknown
Port Diameter	0.0 in
Actuator	
Actuator Mfg.	Fisher Controls
Actuator Model	1035
Actuator Size	20
Effective Area	0.0 in2
Air	Closes
Volume Booster/Quick Release	Unknown
Lower Bench Set	0.0 psi
Upper Bench Set	0.0 psi
Nominal Supply Pressure	0.0 psi
Spring Rate	0.0 lbf/in
Lever Style	Rack and Pinion
Moment Arm	0.0 in

Reference	
Trim Style 1	
Trim Style 2	
Stroking Time Open (sec)	0
Stroking Time Closed (sec)	0
Dynamic Torque	0.0 lbf.in
Breakout Torque	0.0 lbf.in

tial Stroke [BUTTERFLY VALVE]







01 Feb 2009 13:36:04

Inputs

Input Start:	100.0 %
Input End:	80.0 %
Stroke Speed	0.5%/s
Test Pause Time:	10 sec
Collection Interval:	150.0 msec.

Analyzed Data

Avg. Dynamic Error:	1.49%
Min. Dynamic Error:	1.06%
Max. Dynamic Error:	1.87%
Dyn. Linearity (Ind.):	0.17%
Zero Ranged Travel at:	20.18 mA
Full Ranged Travel at:	3.66 mA
Average Torque:	NA
Minimum Torque:	NA
Maximum Torque:	NA
Spring Rate:	NA
Bench Set:	24.13 - 44.89 psi
Partial Stroke Test initiated by:	HART Command
Partial Stroke Test status:	Completed Successfully

Tuning Set

Tuning Set:	C
Gains	
Proportional:	4.40
Velocity:	3.00
MLF:	35.00
Integral Control:	Disabled
Integral Gain:	9.4

Notes

Valve

Manufacturer:	Fisher Controls
Type:	8560
Size:	4 in
Class:	300
Rated Travel:	90.00 deg
Actual Travel:	90.00 deg
Shaft Diameter:	2.0000 in
Packing Type:	TFE / Single
Inlet Pressure:	100.0000 psi
Outlet Pressure:	0.0000 psi

Trim

Seat Type:	
Leakage Class:	
Port Diameter:	0.0000 in

Actuator

Manufacturer:	Fisher Controls
Type:	1035
Size:	20
Effective Area:	0.00 in2
Air:	Closes
Bench Set:	0.0000 psi- 0.0000 psi
Nominal Supply Pressure:	0.0000 psi
Spring Rate:	0.0000 lbf/in
Style:	Rack and Pinion
Moment Arm:	0.0000 in

strument Configuration [BUTTERFLY VALVE] - Basic

01 Feb 2009 13:45:21

General	
HART Tag	DEMO-SIS
Message	
Descriptor	DEMO-SIS
Date	01/23/06
Valve Serial Number	16013812
strument Serial Number	16013812
Polling Address	0
Initial Setup	
Control Mode	Analog (RSP)
Restart Cont. Mode	Analog (RSP)
Zero Power Condition	Valve Open
avel / Pressure Cutoff Lo (%)	50
Valve Style	Rotary Shaft
Actuator Style	Piston - Sgl w/ Spring
Relay Type	Relay B - Special App.
Feedback Connection	Rotary-All/SS-Roller
Travel Sensor Motion	Counter-clockwise
Aux Terminal Mode	Push Button Partial Stroke Test
Partial Stroke Start Pt.	Valve Open
Inputs	
Analog Input Units	mA
Temperature Units	F
Input Characterization	
Input Characteristic	Linear

Pressure	
Max Supply Pressure	70 psi
Pressure Units	psi
Tuning	
Travel Control	
Travel Control Tuning Set	C
Proportional	4.4
Enable Integral Control	No
Integral Gain (reps/min)	9.4
Integral Settings	
Integral Dead Zone (%)	0.26
Integral Limit (%)	30
Pressure Control	
Pressure Control Tuning Set	C
Proportional	2.2
Enable Integral Control	Yes
Integral Gain (reps/sec)	0.1
SIS / Partial Stroke	
Partial Stroke Enable	Enabled
Test Start Point	
Partial Stroke Press Limit	17 psi
Max. Travel Movement (%)	20
Test Speed	0.5%/s
Test Pause Time	10 sec
Auto Test Interval (days)	0.00
SIS Options	
DVC Power Up	Auto Reset
Action on Failed test	Ramp Back

Travel/Pressure Control	
Travel/Pressure Control	
Travel / Pressure Select	Travel
Travel / Pressure Cutoff Lo (%)	50
Travel / Pressure Cutoff Hi (%)	50
End Point Press. Control	
End Point Control Enable	Enabled
Control End	
Pressure Set Point	54.9 psi
Pressure Saturation Time (sec)	45
Dynamic Response	
Set Point Rate Limits	
SP Rate Open (%/sec)	0
SP Rate Close (%/sec)	0
Set Point Filter Lag Time (sec)	0

strument Configuration [BUTTERFLY VALVE] - Alerts

01 Feb 2009 13:45:21

Self Test Shut Down	
Flash ROM Fail Enable	No
No Free Time Enable	No
Reference Voltage Fail Enable	No
NVM Fail Enable	No
Temp Sensor Fail Enable	No
Travel Sensor Fail Enable	No
Drive Current Fail Enable	No
Travel History Alerts	
Cycle Count Alert Enable	No
dle Count Deadband (%)	3
Cycle Count Alert Point	2147483647
Cycle Count	2147483647
Trav Acc Alert Enable	No
vl Accum Deadband (%)	3
Tvl Accum Alert Pt (%)	2147483647
Travel Accumulator (%)	2147483647

Deviation & Other Alerts	
Travel Dev Alert Enable	Yes
Travel Dev Alert Pt (%)	6.91
Travel Dev Time (sec)	9.99
Pressure Dev Alert Enable	Yes
Pressure Dev Alert Pt	2 psi
Pressure Dev Time (sec)	9.99
Drive Signal Alert Enable	Yes
Supply Pressure Alert Point	9 psi
Supply Pressure Alert Enable	Yes
Travel Alerts	
Tvl Alert Lo Enable	No
Tvl Alert Hi Enable	No
Tvl Alert Lo Lo Enable	No
Tvl Alert Hi Hi Enable	No
Lo Point (%)	2
Hi Point (%)	9
Lo Lo Point (%)	1
Hi Hi Point (%)	98.97
Deadband (%)	3
Tvl Limit/Cutoff Lo Enable	No
Tvl Limit/Cutoff Hi Enable	No

Alert Record and Commands	
Instrument Clock	01 FEB 2009 01:44
Valve Alerts Enable	Yes
Failure Alerts Enable	Yes
Misc Alerts Enable	Yes
Burst Mode Enable	No
Burst Command	3
Cmd #3 (Trending)	B
Pressure	
Alert Record Not Empty Enable	Yes
Alert Record Full Enable	Yes
Informational Status	
Inst Time Invalid Enable	Yes
Cal in Progress Enable	No
Autocal in Progress Enable	No
Diag in Progress Enable	Yes
Diag Data Avail Enable	Yes
Integrator Sat Hi Enable	Yes
Integrator Sat Lo Enable	Yes
Press Ctrl Active Enable	Yes
Multi-Drop Alert Enable	No
Electronic Alerts	
Shutdown Activated Alert Enable	Yes
Power Starvation Alert Enable	No
Non-Critical NVM Alert Enable	No

strument Configuration [BUTTERFLY VALVE] - Spec Sheet

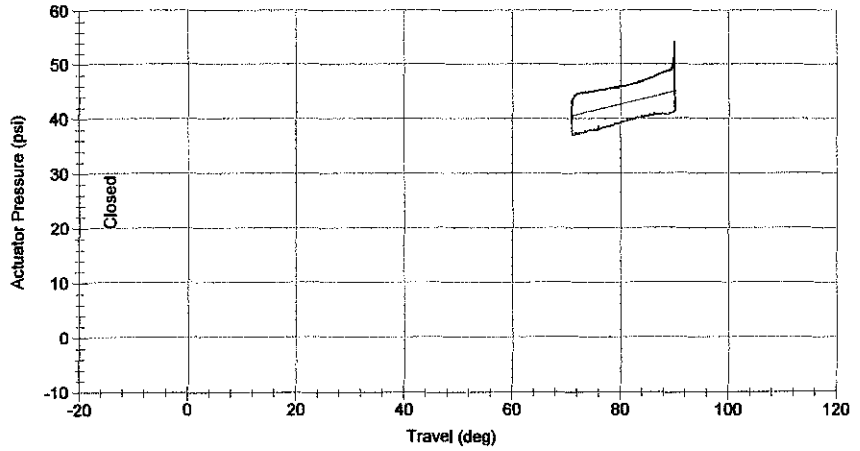
01 Feb 2009 13:45:21

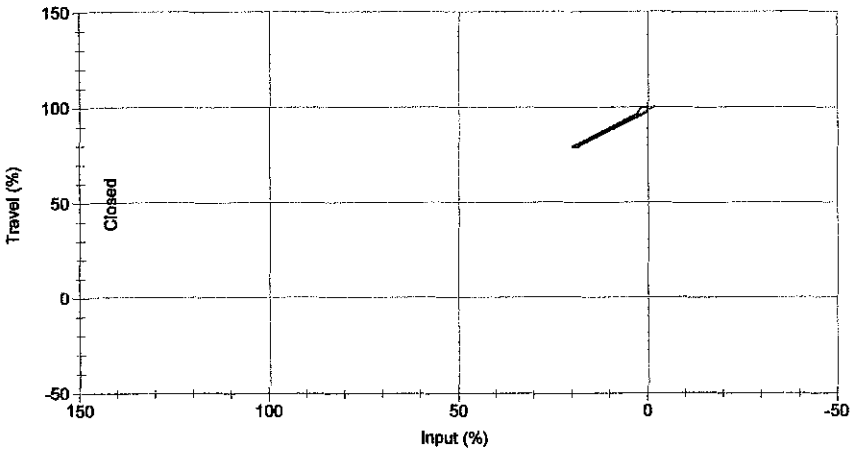
Spec Sheet Units	
Pressure Units	psi
Travel Units	deg
Length Units	in
Area Units	in2
Torque Units	lbf.in
Spring Rate Units	lbf/in
Valve	
Valve Mfg.	Fisher Controls
Valve Model	8560
Size	4 in
Class	300
Rated Travel	90.0 deg
Actual Travel	90.0 deg
Stem Diameter	2.0 in
Packing Type	TFE / Single
Inlet Pressure	100.0 psi
Outlet Pressure	0.0 psi

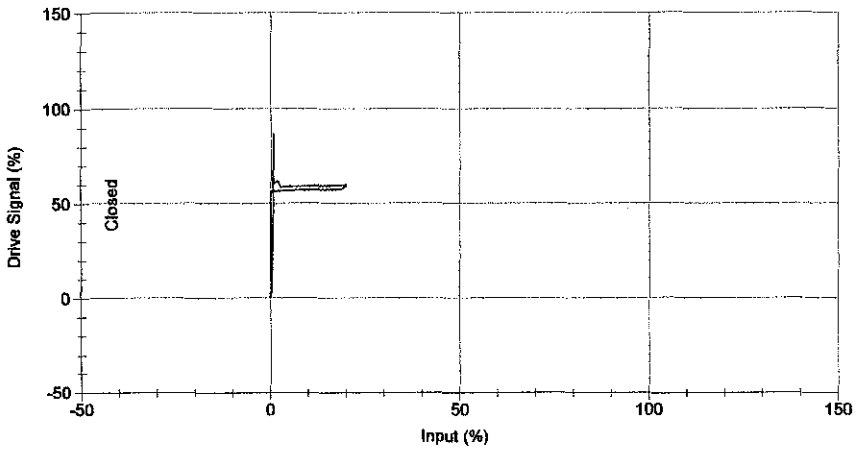
Trim	
Seat Type	
Leak Class	Unknown
Port Diameter	0.0 in
Actuator	
Actuator Mfg.	Fisher Controls
Actuator Model	1035
Actuator Size	20
Effective Area	0.0 in2
Air	Closes
Volume Booster/Quick Release	Unknown
Lower Bench Set	0.0 psi
Upper Bench Set	0.0 psi
Nominal Supply Pressure	0.0 psi
Spring Rate	0.0 lbf/in
Lever Style	Rack and Pinion
Moment Arm	0.0 in

Reference	
Trim Style 1	
Trim Style 2	
Stroking Time Open (sec)	0
Stroking Time Closed (sec)	0
Dynamic Torque	0.0 lbf.in
Breakout Torque	0.0 lbf.in

rtial Stroke [BUTTERFLY VALVE]







01 Feb 2009 13:45:33

Inputs

Input Start:	100.0 %
Input End:	80.0 %
Stroke Speed	0.5%/s
Test Pause Time:	10 sec
Collection Interval:	150.0 msec.

Analyzed Data

Avg. Dynamic Error:	1.47%
Min. Dynamic Error:	1.10%
Max. Dynamic Error:	1.82%
Dyn. Linearity (Ind.):	0.18%
Zero Ranged Travel at:	20.03 mA
Full Ranged Travel at:	3.69 mA
Average Torque:	NA
Minimum Torque:	NA
Maximum Torque:	NA
Spring Rate:	NA
Bench Set:	24.18 - 44.92 psi
Partial Stroke Test initiated by:	HART Command
Partial Stroke Test status:	Completed Successfully

Tuning Set

Tuning Set:	C
Gains	
Proportional:	4.40
Velocity:	3.00
MLF:	35.00
Integral Control:	Disabled
Integral Gain:	9.4

Notes

Valve

Manufacturer:	Fisher Controls
Type:	8560
Size:	4 in
Class:	300
Rated Travel:	90.00 deg
Actual Travel:	90.00 deg
Shaft Diameter:	2.0000 in
Packing Type:	TFE / Single
Inlet Pressure:	100.0000 psi
Outlet Pressure:	0.0000 psi

Trim

Seat Type:	
Leakage Class:	
Port Diameter:	0.0000 in

Actuator

Manufacturer:	Fisher Controls
Type:	1035
Size:	20
Effective Area:	0.00 in2
Air:	Closes
Bench Set:	0.0000 psi- 0.0000 psi
Nominal Supply Pressure:	0.0000 psi
Spring Rate:	0.0000 lbf/in
Style:	Rack and Pinion
Moment Arm:	0.0000 in

strument Configuration [BUTTERFLY VALVE] - Basic

01 Feb 2009 13:55:07

General	
HART Tag	DEMO-SIS
Message	
Descriptor	DEMO-SIS
Date	01/23/06
Valve Serial Number	16013812
strument Serial Number	16013812
Polling Address	0
Initial Setup	
Control Mode	Analog (RSP)
Restart Cont. Mode	Analog (RSP)
Zero Power Condition	Valve Open
avel / Pressure Cutoff Lo (%)	50
Valve Style	Rotary Shaft
Actuator Style	Piston - Sgl w/ Spring
Relay Type	Relay B - Special App.
Feedback Connection	Rotary-All/SS-Roller
Travel Sensor Motion	Counter-clockwise
Aux Terminal Mode	Push Button Partial Stroke Test
Partial Stroke Start Pt.	Valve Open
Inputs	
Analog Input Units	mA
Temperature Units	F
Input Characterization	
Input Characteristic	Linear

Pressure	
Max Supply Pressure	70 psi
Pressure Units	psi
Tuning	
Travel Control	
Travel Control Tuning Set	C
Proportional	4.4
Enable Integral Control	No
Integral Gain (reps/min)	9.4
Integral Settings	
Integral Dead Zone (%)	0.26
Integral Limit (%)	30
Pressure Control	
Pressure Control Tuning Set	C
Proportional	2.2
Enable Integral Control	Yes
Integral Gain (reps/sec)	0.1
SIS / Partial Stroke	
Partial Stroke Enable	Enabled
Test Start Point	
Partial Stroke Press Limit	17 psi
Max. Travel Movement (%)	20
Test Speed	0.5%/s
Test Pause Time	10 sec
Auto Test Interval (days)	0.00
SIS Options	
DVC Power Up	Auto Reset
Action on Failed test	Ramp Back

Travel/Pressure Control	
Travel/Pressure Control	
Travel / Pressure Select	Travel
Travel / Pressure Cutoff Lo (%)	50
Travel / Pressure Cutoff Hi (%)	50
End Point Press. Control	
End Point Control Enable	Enabled
Control End	
Pressure Set Point	54.9 psi
Pressure Saturation Time (sec)	45
Dynamic Response	
Set Point Rate Limits	
SP Rate Open (%/sec)	0
SP Rate Close (%/sec)	0
Set Point Filter Lag Time (sec)	0

strument Configuration [BUTTERFLY VALVE] - Alerts

01 Feb 2009 13:55:07

Self Test Shut Down	
Flash ROM Fail Enable	No
No Free Time Enable	No
Reference Voltage Fail Enable	No
NVM Fail Enable	No
Temp Sensor Fail Enable	No
Travel Sensor Fail Enable	No
Drive Current Fail Enable	No
Travel History Alerts	
Cycle Count Alert Enable	No
cle Count Deadband (%)	3
Cycle Count Alert Point	2147483647
Cycle Count	2147483647
Trav Acc Alert Enable	No
vl Accum Deadband (%)	3
Tvl Accum Alert Pt (%)	2147483647
Travel Accumulator (%)	2147483647

Deviation & Other Alerts	
Travel Dev Alert Enable	Yes
Travel Dev Alert Pt (%)	6.91
Travel Dev Time (sec)	9.99
Pressure Dev Alert Enable	Yes
Pressure Dev Alert Pt	2 psi
Pressure Dev Time (sec)	9.99
Drive Signal Alert Enable	Yes
Supply Pressure Alert Point	9 psi
Supply Pressure Alert Enable	Yes
Travel Alerts	
Tvl Alert Lo Enable	No
Tvl Alert Hi Enable	No
Tvl Alert Lo Lo Enable	No
Tvl Alert Hi Hi Enable	No
Lo Point (%)	2
Hi Point (%)	9
Lo Lo Point (%)	1
Hi Hi Point (%)	98.97
Deadband (%)	3
Tvl Limit/Cutoff Lo Enable	No
Tvl Limit/Cutoff Hi Enable	No

Alert Record and Commands	
Instrument Clock	01 FEB 2009 01:53
Valve Alerts Enable	Yes
Failure Alerts Enable	Yes
Misc Alerts Enable	Yes
Burst Mode Enable	No
Burst Command	3
Cmd #3 (Trending)	B Pressure
Alert Record Not Empty Enable	Yes
Alert Record Full Enable	Yes
Informational Status	
Inst Time Invalid Enable	Yes
Cal in Progress Enable	No
Autocal in Progress Enable	No
Diag in Progress Enable	Yes
Diag Data Avail Enable	Yes
Integrator Sat Hi Enable	Yes
Integrator Sat Lo Enable	Yes
Press Ctrl Active Enable	Yes
Multi-Drop Alert Enable	No
Electronic Alerts	
Shutdown Activated Alert Enable	Yes
Power Starvation Alert Enable	No
Non-Critical NVM Alert Enable	No

strument Configuration [BUTTERFLY VALVE] - Spec Sheet

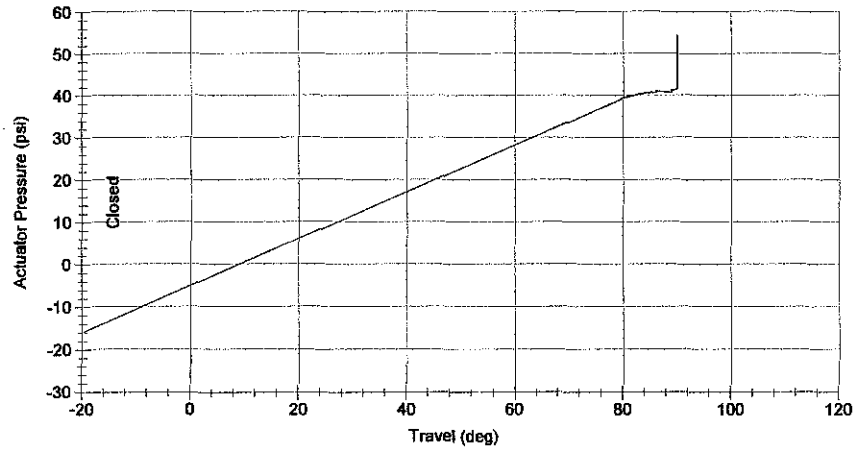
01 Feb 2009 13:55:07

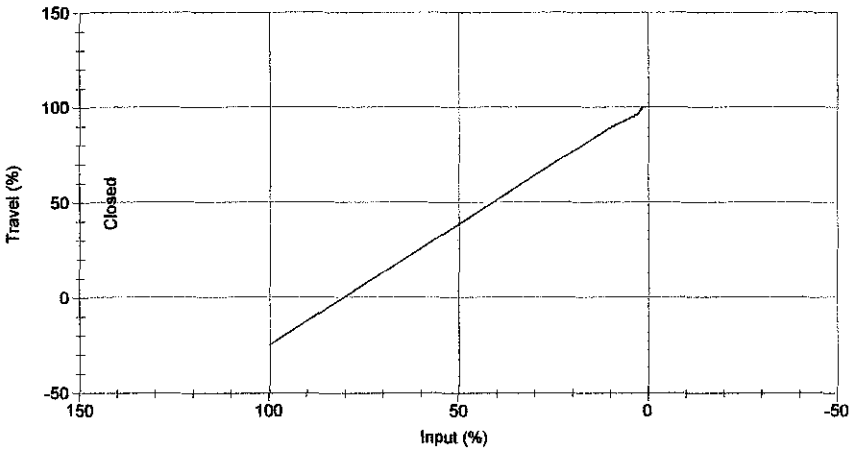
Spec Sheet Units	
Pressure Units	psi
Travel Units	deg
Length Units	in
Area Units	in2
Torque Units	lbf.in
Spring Rate Units	lbf/in
Valve	
Valve Mfg.	Fisher Controls
Valve Model	8560
Size	4 in
Class	300
Rated Travel	90.0 deg
Actual Travel	90.0 deg
Stem Diameter	2.0 in
Packing Type	TFE / Single
Inlet Pressure	100.0 psi
Outlet Pressure	0.0 psi

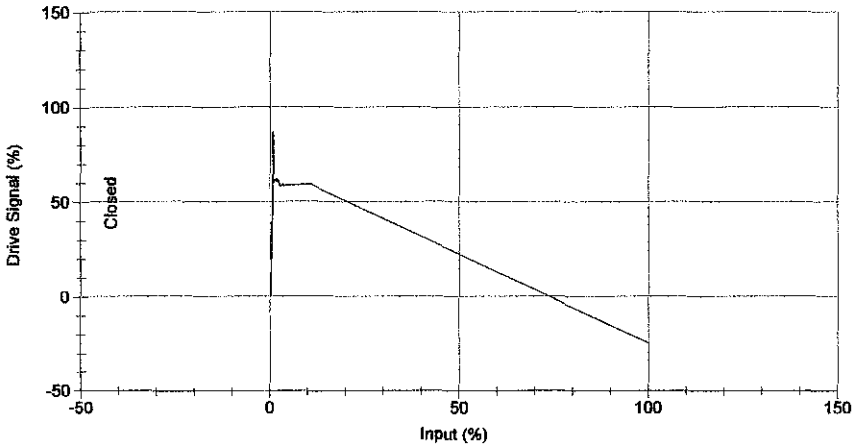
Trim	
Seat Type	
Leak Class	Unknown
Port Diameter	0.0 in
Actuator	
Actuator Mfg.	Fisher Controls
Actuator Model	1035
Actuator Size	20
Effective Area	0.0 in2
Air	Closes
Volume Booster/Quick Release	Unknown
Lower Bench Set	0.0 psi
Upper Bench Set	0.0 psi
Nominal Supply Pressure	0.0 psi
Spring Rate	0.0 lbf/in
Lever Style	Rack and Pinion
Moment Arm	0.0 in

Reference	
Trim Style 1	
Trim Style 2	
Stroking Time Open (sec)	0
Stroking Time Closed (sec)	0
Dynamic Torque	0.0 lbf.in
Breakout Torque	0.0 lbf.in

rtial Stroke [BUTTERFLY VALVE]







01 Feb 2009 13:55:19

Inputs

Input Start:	100.0 %
Input End:	80.0 %
Stroke Speed	0.5%/s
Test Pause Time:	10 sec
Collection Interval:	150.0 msec.

Analyzed Data

Avg. Dynamic Error:	-10000.00%
Min. Dynamic Error:	-10000.00%
Max. Dynamic Error:	-10000.00%
Dyn. Linearity (Ind.):	-10000.00%
Zero Ranged Travel at:	-10000.00 mA
Full Ranged Travel at:	-10000.00 mA
Average Torque:	NA
Minimum Torque:	NA
Maximum Torque:	NA
Spring Rate:	NA
Bench Set:	NA
Partial Stroke Test initiated by:	HART Command
Partial Stroke Test status:	Failed - Emergency Occurred

Tuning Set

Tuning Set:	C
Gains	
Proportional:	4.40
Velocity:	3.00
MLF:	35.00
Integral Control:	Disabled
Integral Gain:	9.4

Notes

Valve

Manufacturer:	Fisher Controls
Type:	8560
Size:	4 in
Class:	300
Rated Travel:	90.00 deg
Actual Travel:	90.00 deg
Shaft Diameter:	2.0000 in
Packing Type:	TFE / Single
Inlet Pressure:	100.0000 psi
Outlet Pressure:	0.0000 psi

Trim

Seat Type:	
Leakage Class:	
Port Diameter:	0.0000 in

Actuator

Manufacturer:	Fisher Controls
Type:	1035
Size:	20
Effective Area:	0.00 in2
Air:	Closes
Bench Set:	0.0000 psi- 0.0000 psi
Nominal Supply Pressure:	0.0000 psi
Spring Rate:	0.0000 lbf/in
Style:	Rack and Pinion
Moment Arm:	0.0000 in

APPENDIX V

Summary of Analyzed Data for Ball Valve

Day1

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.70	2.75	2.75	2.77	2.74
2	Minimum Dynamic Error (%)	2.09	1.79	1.85	1.93	1.94
3	Maximum Dynamic Error (%)	3.53	3.63	3.45	3.80	3.70
4	Dynamic Linearity (Ind.) (%)	0.42	0.47	0.57	0.64	0.61
5	Zero Ranged Travel at (mA)	19.95	19.90	19.84	19.86	19.90
6	Full Ranged Travel at (mA)	4.02	4.03	4.05	4.05	4.04
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.56	26.72	26.35	26.53	26.16
12	Bench Set Upper (psi)	44.92	44.92	44.66	44.69	44.6

Day 2

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.71	2.71	2.75	2.72	2.74
2	Minimum Dynamic Error (%)	1.99	1.81	1.67	1.81	1.76
3	Maximum Dynamic Error (%)	3.47	3.22	3.71	3.43	3.51
4	Dynamic Linearity (Ind.) (%)	0.48	0.44	0.59	0.45	0.50
5	Zero Ranged Travel at (mA)	20.00	19.94	19.93	20.00	19.98
6	Full Ranged Travel at (mA)	4.05	4.05	4.06	4.05	4.05
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.9	25.48	26.16	27.06	26.66
12	Bench Set Upper (psi)	44.89	44.92	44.69	44.65	44.65

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.69	2.76	2.71	2.79	2.78
2	Minimum Dynamic Error (%)	1.89	1.72	2.01	1.63	1.73
3	Maximum Dynamic Error (%)	3.53	3.61	3.45	3.72	3.68
4	Dynamic Linearity (Ind.) (%)	0.50	0.48	0.47	0.47	0.47
5	Zero Ranged Travel at (mA)	19.90	19.89	19.97	19.95	19.81
6	Full Ranged Travel at (mA)	4.03	4.04	4.03	4.03	4.04
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.79	26.14	26.59	26.58	26.24
12	Bench Set Upper (psi)	44.76	44.62	44.65	44.7	44.66

Day 4

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.71	2.74	2.76	2.76	2.74
2	Minimum Dynamic Error (%)	2.04	2.15	1.90	1.78	1.87
3	Maximum Dynamic Error (%)	3.23	3.38	3.71	3.49	3.43
4	Dynamic Linearity (Ind.) (%)	0.35	0.40	0.42	0.49	0.42
5	Zero Ranged Travel at (mA)	19.95	19.92	19.84	19.91	19.96
6	Full Ranged Travel at (mA)	4.01	4.02	4.04	4.04	4.04
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.59	26.16	26.49	26.52	26.09
12	Bench Set Upper (psi)	44.93	44.71	44.65	44.62	44.73

Day 5

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.63	2.78	2.78	2.79	2.74
2	Minimum Dynamic Error (%)	1.54	1.56	1.93	1.99	1.91
3	Maximum Dynamic Error (%)	3.60	3.73	3.70	3.81	3.51
4	Dynamic Linearity (Ind.) (%)	0.37	0.50	0.40	0.45	0.43
5	Zero Ranged Travel at (mA)	19.95	19.95	19.94	19.96	19.93
6	Full Ranged Travel at (mA)	3.97	4.04	4.05	4.04	4.05
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.85	26.26	25.9	26.82	26.63
12	Bench Set Upper (psi)	44.75	44.62	44.6	44.54	44.59

Day 6

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.68	2.71	2.71	2.72	2.78
2	Minimum Dynamic Error (%)	1.73	2.04	1.96	1.76	1.91
3	Maximum Dynamic Error (%)	3.23	3.44	3.52	3.42	3.55
4	Dynamic Linearity (Ind.) (%)	0.41	0.49	0.53	0.60	0.51
5	Zero Ranged Travel at (mA)	20.01	19.96	19.95	19.92	19.94
6	Full Ranged Travel at (mA)	4.02	4.02	4.04	4.05	4.05
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.94	25.98	26.14	26.22	26.74
12	Bench Set Upper (psi)	44.76	44.77	44.77	44.65	44.68

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.70	2.74	2.74	2.72	2.79
2	Minimum Dynamic Error (%)	2.08	1.73	2.04	1.66	2.09
3	Maximum Dynamic Error (%)	3.44	3.48	3.61	3.51	3.58
4	Dynamic Linearity (Ind.) (%)	0.37	0.59	0.48	0.54	0.57
5	Zero Ranged Travel at (mA)	19.96	19.97	19.96	19.98	19.89
6	Full Ranged Travel at (mA)	4.03	4.03	4.03	4.05	4.06
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.23	26.43	26.27	26.0	26.42
12	Bench Set Upper (psi)	44.91	44.73	44.71	44.71	44.61

Day 8

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.71	2.71	2.75	2.78	2.78
2	Minimum Dynamic Error (%)	2.03	1.72	1.80	2.10	1.86
3	Maximum Dynamic Error (%)	3.41	3.39	3.65	3.47	3.52
4	Dynamic Linearity (Ind.) (%)	0.51	0.43	0.47	0.51	0.52
5	Zero Ranged Travel at (mA)	19.96	20.04	19.95	19.97	19.89
6	Full Ranged Travel at (mA)	4.02	4.03	4.04	4.05	4.04
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.61	26.39	25.77	26.16	26.14
12	Bench Set Upper (psi)	44.86	44.68	44.7	44.72	44.7

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.71	2.72	2.80	2.78	2.80
2	Minimum Dynamic Error (%)	2.03	2.09	2.09	1.99	2.14
3	Maximum Dynamic Error (%)	3.27	3.56	3.44	3.60	3.54
4	Dynamic Linearity (Ind.) (%)	0.57	0.46	0.52	0.57	0.53
5	Zero Ranged Travel at (mA)	19.86	19.97	19.94	19.96	19.92
6	Full Ranged Travel at (mA)	4.03	4.02	4.04	4.04	4.05
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.67	26.5	26.93	26.4	26.27
12	Bench Set Upper (psi)	44.89	44.7	44.62	44.71	44.6

Day 10

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.65	2.71	2.79	2.73	2.72
2	Minimum Dynamic Error (%)	1.90	1.94	1.94	2.07	1.87
3	Maximum Dynamic Error (%)	3.34	3.49	3.61	3.57	3.53
4	Dynamic Linearity (Ind.) (%)	0.42	0.46	0.59	0.61	0.38
5	Zero Ranged Travel at (mA)	19.95	19.96	19.87	19.90	19.99
6	Full Ranged Travel at (mA)	4.00	3.99	4.01	4.03	4.02
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.78	26.1	26.19	26.3	25.84
12	Bench Set Upper (psi)	44.84	44.56	44.56	44.58	44.59

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.71	2.74	2.77	2.76	2.73
2	Minimum Dynamic Error (%)	1.78	1.97	1.77	1.53	1.84
3	Maximum Dynamic Error (%)	3.56	3.74	3.63	3.77	3.80
4	Dynamic Linearity (Ind.) (%)	0.43	0.69	0.69	0.68	0.55
5	Zero Ranged Travel at (mA)	20.02	19.94	19.95	19.93	20.08
6	Full Ranged Travel at (mA)	4.01	4.02	4.04	4.05	4.02
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.48	26.8	26.81	26.28	26.02
12	Bench Set Upper (psi)	44.86	44.55	44.54	44.55	44.61

Day 12

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.77	2.74	2.71	2.75	2.84
2	Minimum Dynamic Error (%)	2.22	2.01	1.98	1.86	2.11
3	Maximum Dynamic Error (%)	3.52	3.67	3.52	3.69	3.77
4	Dynamic Linearity (Ind.) (%)	0.59	0.40	0.51	0.44	0.50
5	Zero Ranged Travel at (mA)	19.91	19.95	19.94	19.96	19.87
6	Full Ranged Travel at (mA)	4.03	4.02	4.02	4.02	4.06
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.22	26.24	26.64	26.42	26.21
12	Bench Set Upper (psi)	44.92	44.68	44.59	44.6	44.54

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.74	2.74	2.78	2.73	2.78
2	Minimum Dynamic Error (%)	1.92	1.76	1.79	1.85	1.64
3	Maximum Dynamic Error (%)	3.40	3.79	3.78	3.55	3.64
4	Dynamic Linearity (Ind.) (%)	0.39	0.62	0.53	0.60	0.51
5	Zero Ranged Travel at (mA)	19.91	19.93	19.96	19.97	19.89
6	Full Ranged Travel at (mA)	4.03	4.05	4.05	4.04	4.06
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.15	26.29	26.3	26.52	26.43
12	Bench Set Upper (psi)	44.8	44.61	44.61	44.59	44.61

Day 14

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.69	2.71	2.76	2.75	2.77
2	Minimum Dynamic Error (%)	2.17	1.95	1.95	1.99	2.12
3	Maximum Dynamic Error (%)	3.47	3.55	3.84	3.64	3.74
4	Dynamic Linearity (Ind.) (%)	0.54	0.44	0.51	0.40	0.54
5	Zero Ranged Travel at (mA)	19.98	20.03	19.91	19.98	19.95
6	Full Ranged Travel at (mA)	4.06	4.04	4.06	4.05	4.05
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.14	26.14	25.8	26.14	26.39
12	Bench Set Upper (psi)	44.89	44.64	44.71	44.6	44.59

Day 15

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.73	2.73	2.74	2.80	2.80
2	Minimum Dynamic Error (%)	2.04	1.95	1.98	1.89	1.88
3	Maximum Dynamic Error (%)	3.56	3.38	3.53	3.63	3.57
4	Dynamic Linearity (Ind.) (%)	0.62	0.39	0.39	0.40	0.41
5	Zero Ranged Travel at (mA)	19.89	19.94	19.94	19.86	19.85
6	Full Ranged Travel at (mA)	4.03	4.05	4.05	4.06	4.06
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.46	26.23	25.75	26.27	26.63
12	Bench Set Upper (psi)	44.82	44.72	44.68	44.64	44.6

Day 16

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.74	2.72	2.80	2.78	2.84
2	Minimum Dynamic Error (%)	2.01	1.93	1.92	1.98	1.92
3	Maximum Dynamic Error (%)	3.67	3.36	3.78	3.76	3.94
4	Dynamic Linearity (Ind.) (%)	0.55	0.44	0.47	0.48	0.50
5	Zero Ranged Travel at (mA)	19.89	19.93	19.87	19.96	19.83
6	Full Ranged Travel at (mA)	4.03	4.03	4.04	4.03	4.04
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.45	26.41	26.08	26.05	26.33
12	Bench Set Upper (psi)	44.88	44.67	44.63	44.67	44.56

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.71	2.79	2.78	2.81	2.77
2	Minimum Dynamic Error (%)	1.78	1.78	1.75	1.54	2.11
3	Maximum Dynamic Error (%)	3.32	3.71	3.53	3.74	3.74
4	Dynamic Linearity (Ind.) (%)	0.45	0.63	0.50	0.47	0.59
5	Zero Ranged Travel at (mA)	19.95	19.84	19.89	19.93	20.01
6	Full Ranged Travel at (mA)	4.02	4.04	4.03	4.02	4.04
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.69	26.69	26.67	26.03	26.18
12	Bench Set Upper (psi)	44.79	44.6	44.53	44.62	44.56

Day 18

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.69	2.77	2.76	2.75	2.81
2	Minimum Dynamic Error (%)	1.94	2.08	1.60	1.84	1.97
3	Maximum Dynamic Error (%)	3.65	3.58	3.69	3.89	4.05
4	Dynamic Linearity (Ind.) (%)	0.62	0.55	0.49	0.51	0.60
5	Zero Ranged Travel at (mA)	19.84	19.87	19.92	19.99	19.88
6	Full Ranged Travel at (mA)	4.03	4.05	4.04	4.05	4.06
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.16	26.74	26.82	26.24	26.01
12	Bench Set Upper (psi)	44.93	44.61	44.64	44.64	44.57

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.71	2.74	2.73	2.79	2.82
2	Minimum Dynamic Error (%)	2.01	2.11	1.91	2.06	1.78
3	Maximum Dynamic Error (%)	3.43	3.64	3.57	3.74	4.08
4	Dynamic Linearity (Ind.) (%)	0.33	0.50	0.52	0.52	0.47
5	Zero Ranged Travel at (mA)	19.98	19.98	20.00	19.98	19.86
6	Full Ranged Travel at (mA)	4.02	4.02	4.04	4.05	4.05
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.26	26.53	26.39	26.53	26.03
12	Bench Set Upper (psi)	44.86	44.73	44.74	44.65	44.63

Day 20 (analog to digital)

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.18	2.20	2.18	2.16	2.17
2	Minimum Dynamic Error (%)	1.53	1.46	1.51	1.20	1.50
3	Maximum Dynamic Error (%)	2.85	3.02	3.00	2.89	3.11
4	Dynamic Linearity (Ind.) (%)	0.34	0.44	0.46	0.38	0.38
5	Zero Ranged Travel at (mA)	4.21	4.25	4.24	4.21	4.26
6	Full Ranged Travel at (mA)	20.03	20.03	20.03	20.03	20.02
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.77	25.46	24.97	25.31	25.23
12	Bench Set Upper (psi)	44.21	44.08	44.11	44.02	44.02

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.17	2.15	2.19	2.21	2.21
2	Minimum Dynamic Error (%)	1.39	1.34	1.25	1.48	1.21
3	Maximum Dynamic Error (%)	3.11	2.98	2.97	2.92	3.09
4	Dynamic Linearity (Ind.) (%)	0.46	0.43	0.47	0.42	0.43
5	Zero Ranged Travel at (mA)	4.18	4.17	4.23	4.24	4.18
6	Full Ranged Travel at (mA)	20.05	20.05	20.04	20.04	20.05
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.86	26.0	25.14	25.32	24.79
12	Bench Set Upper (psi)	44.12	44.02	44.12	44.04	44.04

Day 22

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.17	2.18	2.23	2.22	2.18
2	Minimum Dynamic Error (%)	1.48	1.43	1.53	1.45	1.23
3	Maximum Dynamic Error (%)	2.80	2.94	3.09	3.06	2.98
4	Dynamic Linearity (Ind.) (%)	0.43	0.41	0.42	0.52	0.49
5	Zero Ranged Travel at (mA)	4.19	4.22	4.24	4.23	4.22
6	Full Ranged Travel at (mA)	20.03	20.03	20.03	20.03	20.04
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.29	25.19	25.31	25.04	24.79
12	Bench Set Upper (psi)	44.06	43.86	43.86	43.88	43.81

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.18	2.19	2.17	2.17	2.17
2	Minimum Dynamic Error (%)	1.43	1.40	1.25	1.35	1.32
3	Maximum Dynamic Error (%)	2.85	2.98	3.02	3.11	2.98
4	Dynamic Linearity (Ind.) (%)	0.45	0.46	0.45	0.45	0.47
5	Zero Ranged Travel at (mA)	4.19	4.22	4.12	4.21	4.15
6	Full Ranged Travel at (mA)	20.04	20.03	20.04	20.04	20.04
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.57	25.21	25.35	25.1	24.79
12	Bench Set Upper (psi)	44.19	43.99	43.96	43.9	43.95

Day 24

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.17	2.18	2.14	2.19	2.22
2	Minimum Dynamic Error (%)	1.53	1.27	1.12	1.21	1.17
3	Maximum Dynamic Error (%)	2.84	3.00	2.94	2.87	2.95
4	Dynamic Linearity (Ind.) (%)	0.38	0.42	0.50	0.47	0.48
5	Zero Ranged Travel at (mA)	4.20	4.18	4.15	4.20	4.26
6	Full Ranged Travel at (mA)	20.03	20.05	20.04	20.05	20.03
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.6	24.78	24.91	25.22	25.17
12	Bench Set Upper (psi)	44.16	43.99	44.04	44.02	43.96

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.17	2.12	2.18	2.16	2.22
2	Minimum Dynamic Error (%)	1.36	1.27	1.41	1.31	1.29
3	Maximum Dynamic Error (%)	2.82	2.97	2.98	3.06	3.13
4	Dynamic Linearity (Ind.) (%)	0.42	0.43	0.51	0.54	0.41
5	Zero Ranged Travel at (mA)	4.13	4.12	4.14	4.14	4.17
6	Full Ranged Travel at (mA)	20.05	20.06	20.05	20.05	20.05
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.37	24.75	25.49	25.28	25.1
12	Bench Set Upper (psi)	44.15	44.03	43.9	43.9	43.98

Day 26

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.16	2.18	2.12	2.15	2.16
2	Minimum Dynamic Error (%)	1.29	1.18	1.18	1.55	1.13
3	Maximum Dynamic Error (%)	2.91	2.97	2.96	2.91	2.98
4	Dynamic Linearity (Ind.) (%)	0.29	0.52	0.48	0.49	0.45
5	Zero Ranged Travel at (mA)	4.16	4.23	4.19	4.17	4.14
6	Full Ranged Travel at (mA)	20.05	20.05	20.04	20.04	20.04
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.27	25.05	24.9	24.77	24.84
12	Bench Set Upper (psi)	44.32	44.01	43.95	43.97	44.02

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.14	2.18	2.20	2.18	2.22
2	Minimum Dynamic Error (%)	1.47	1.35	1.45	1.23	1.33
3	Maximum Dynamic Error (%)	2.76	2.97	3.09	2.99	3.19
4	Dynamic Linearity (Ind.) (%)	0.39	0.47	0.47	0.46	0.42
5	Zero Ranged Travel at (mA)	4.20	4.14	4.24	4.25	4.27
6	Full Ranged Travel at (mA)	20.04	20.05	20.04	20.04	20.04
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.68	25.42	25.42	25.38	25.38
12	Bench Set Upper (psi)	44.2	44.05	44.06	44.06	44.0

Day 28

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.22	2.20	2.19	2.23	2.22
2	Minimum Dynamic Error (%)	1.64	1.56	1.39	1.53	1.51
3	Maximum Dynamic Error (%)	2.87	2.90	2.86	3.00	3.02
4	Dynamic Linearity (Ind.) (%)	0.40	0.45	0.41	0.42	0.46
5	Zero Ranged Travel at (mA)	4.28	4.20	4.23	4.24	4.27
6	Full Ranged Travel at (mA)	20.03	20.04	20.05	20.05	20.04
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.99	25.33	24.94	25.16	24.8
12	Bench Set Upper (psi)	44.08	44.03	44.12	44.05	44.11

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.17	2.14	2.19	2.14	2.23
2	Minimum Dynamic Error (%)	1.31	1.00	1.35	1.22	1.31
3	Maximum Dynamic Error (%)	3.05	3.06	2.97	3.02	2.92
4	Dynamic Linearity (Ind.) (%)	0.47	0.45	0.47	0.42	0.42
5	Zero Ranged Travel at (mA)	4.16	4.22	4.16	4.13	4.20
6	Full Ranged Travel at (mA)	20.04	20.05	20.05	20.05	20.03
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.86	25.28	24.43	25.2	24.83
12	Bench Set Upper (psi)	43.98	43.94	43.93	43.83	43.78

Day 30

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.18	2.20	2.21	2.19	2.25
2	Minimum Dynamic Error (%)	1.46	1.54	1.51	1.31	1.67
3	Maximum Dynamic Error (%)	2.88	2.91	3.00	2.87	3.03
4	Dynamic Linearity (Ind.) (%)	0.38	0.42	0.36	0.39	0.37
5	Zero Ranged Travel at (mA)	4.20	4.25	4.23	4.24	4.25
6	Full Ranged Travel at (mA)	20.05	20.04	20.04	20.04	20.04
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.69	24.85	25.12	24.95	25.3
12	Bench Set Upper (psi)	44.22	44.09	44.0	44.03	43.99

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.19	2.13	2.15	2.18	2.20
2	Minimum Dynamic Error (%)	1.48	1.43	1.24	1.45	1.31
3	Maximum Dynamic Error (%)	2.91	2.94	2.93	2.87	2.98
4	Dynamic Linearity (Ind.) (%)	0.47	0.44	0.47	0.44	0.43
5	Zero Ranged Travel at (mA)	4.25	4.22	4.17	4.23	4.28
6	Full Ranged Travel at (mA)	20.02	20.05	20.05	20.04	20.03
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.78	25.13	24.68	25.14	24.96
12	Bench Set Upper (psi)	43.98	44.01	44.02	44.04	43.97

Day 32

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.16	2.17	2.17	2.16	2.20
2	Minimum Dynamic Error (%)	1.28	1.25	1.35	1.33	1.37
3	Maximum Dynamic Error (%)	3.03	3.02	3.05	3.08	2.98
4	Dynamic Linearity (Ind.) (%)	0.43	0.50	0.54	0.45	0.45
5	Zero Ranged Travel at (mA)	4.21	4.15	4.17	4.13	4.15
6	Full Ranged Travel at (mA)	20.06	20.06	20.05	20.05	20.05
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	25.05	24.72	24.91	25.28	24.8
12	Bench Set Upper (psi)	44.02	44.06	44.06	43.98	43.97

Day 33

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.16	2.23	2.19	2.17	2.16
2	Minimum Dynamic Error (%)	1.43	1.42	1.51	1.26	1.25
3	Maximum Dynamic Error (%)	2.80	3.00	2.98	2.95	2.96
4	Dynamic Linearity (Ind.) (%)	0.32	0.36	0.38	0.42	0.40
5	Zero Ranged Travel at (mA)	4.19	4.27	4.19	4.28	4.11
6	Full Ranged Travel at (mA)	20.04	20.04	20.05	20.03	20.05
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.2	24.95	24.84	25.04	25.0
12	Bench Set Upper (psi)	44.16	44.11	44.05	44.04	43.98

Day 34

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.14	2.17	2.12	2.19	2.17
2	Minimum Dynamic Error (%)	1.36	1.20	1.21	1.25	1.36
3	Maximum Dynamic Error (%)	2.75	2.91	2.97	3.05	3.06
4	Dynamic Linearity (Ind.) (%)	0.36	0.45	0.45	0.39	0.41
5	Zero Ranged Travel at (mA)	4.12	4.17	4.17	4.20	4.20
6	Full Ranged Travel at (mA)	20.04	20.05	20.05	20.05	20.04
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.55	24.96	24.92	24.74	25.17
12	Bench Set Upper (psi)	44.1	44.0	44.03	43.98	43.95

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	2.17	2.14	2.19	2.14	2.23
2	Minimum Dynamic Error (%)	1.31	1.00	1.35	1.22	1.31
3	Maximum Dynamic Error (%)	3.05	3.06	2.97	3.02	2.92
4	Dynamic Linearity (Ind.) (%)	0.47	0.45	0.47	0.42	0.42
5	Zero Ranged Travel at (mA)	4.16	4.22	4.16	4.13	4.20
6	Full Ranged Travel at (mA)	20.04	20.05	20.05	20.05	20.03
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set Lower (psi)	24.86	25.28	24.43	25.2	24.83
12	Bench Set Upper (psi)	43.98	43.94	43.93	43.83	43.78

APPENDIX VI

Summary of Analyzed Data for Butterfly Valve

Day1

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.47	1.25	1.45	1.38	1.31
2	Minimum Dynamic Error (%)	1.20	0.94	1.05	1.09	1.08
3	Maximum Dynamic Error (%)	1.84	1.56	1.78	1.65	1.64
4	Dynamic Linearity (Ind.) (%)	0.19	0.21	0.22	0.15	0.22
5	Zero Ranged Travel at (mA)	20.21	20.39	20.21	20.32	20.13
6	Full Ranged Travel at (mA)	3.64	3.61	3.64	3.63	3.63
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	22.83 – 45.12	22.82 – 45.09	22.57 – 45.11	23.09 – 45.04	23.23 – 45.09

Day 2

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.63	1.62	1.45	1.49	1.47
2	Minimum Dynamic Error (%)	1.24	1.33	1.06	1.06	1.10
3	Maximum Dynamic Error (%)	1.98	1.98	1.86	1.87	1.82
4	Dynamic Linearity (Ind.) (%)	0.22	0.18	0.16	0.17	0.18
5	Zero Ranged Travel at (mA)	20.39	20.25	20.27	20.18	20.03
6	Full Ranged Travel at (mA)	3.64	3.70	3.68	3.66	3.69
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.37 – 45.01	23.64 – 45.02	23.5 – 44.99	24.13 – 44.89	24.18 – 44.92

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.62	1.52	1.39	1.47	1.49
2	Minimum Dynamic Error (%)	1.24	1.14	0.95	1.03	1.18
3	Maximum Dynamic Error (%)	1.98	1.96	1.82	1.82	1.85
4	Dynamic Linearity (Ind.) (%)	0.18	0.19	0.19	0.21	0.16
5	Zero Ranged Travel at (mA)	20.23	20.10	20.34	20.25	20.38
6	Full Ranged Travel at (mA)	3.66	3.70	3.67	3.69	3.68
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.82 – 45.01	23.49 – 44.94	23.68 – 44.99	23.16 – 44.93	23.49 – 44.97

Day 4

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.60	1.56	1.50	1.55	1.53
2	Minimum Dynamic Error (%)	1.29	1.27	1.21	1.28	1.18
3	Maximum Dynamic Error (%)	1.96	2.01	1.76	1.82	1.90
4	Dynamic Linearity (Ind.) (%)	0.17	0.20	0.19	0.21	0.21
5	Zero Ranged Travel at (mA)	20.26	20.14	20.07	20.24	20.14
6	Full Ranged Travel at (mA)	3.62	3.64	3.65	3.65	3.67
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.79 – 45.05	24.42 – 44.85	23.76 – 44.97	24.08 – 45.02	23.81 – 44.86

Day 3

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.69	1.61	1.59	1.59	1.53
2	Minimum Dynamic Error (%)	0.73	1.24	1.26	1.20	1.21
3	Maximum Dynamic Error (%)	2.59	2.15	2.23	1.95	1.82
4	Dynamic Linearity (Ind.) (%)	0.59	0.20	0.24	0.14	0.20
5	Zero Ranged Travel at (mA)	20.49	20.27	20.32	20.20	20.27
6	Full Ranged Travel at (mA)	3.64	3.58	3.65	3.62	3.63
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	18.79 – 45.79	23.1 – 45.1	22.95 – 45.35	23.24 – 45.08	23.53 – 45.08

Day 6

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.55	1.50	1.51	1.52	1.56
2	Minimum Dynamic Error (%)	1.24	1.19	1.11	1.12	1.25
3	Maximum Dynamic Error (%)	1.87	1.89	1.86	2.01	1.90
4	Dynamic Linearity (Ind.) (%)	0.15	0.15	0.15	0.22	0.20
5	Zero Ranged Travel at (mA)	20.31	20.31	20.31	20.24	20.27
6	Full Ranged Travel at (mA)	3.63	3.64	3.64	3.68	3.66
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.32 – 45.03	23.56 – 45.19	22.63 – 45.14	22.97 – 45.06	22.87 – 45.03

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.50	1.58	1.60	1.41	1.49
2	Minimum Dynamic Error (%)	1.25	1.18	1.14	1.10	1.06
3	Maximum Dynamic Error (%)	1.77	1.88	1.97	1.82	1.91
4	Dynamic Linearity (Ind.) (%)	0.18	0.14	0.18	0.18	0.18
5	Zero Ranged Travel at (mA)	20.21	20.20	20.26	20.28	20.28
6	Full Ranged Travel at (mA)	3.64	3.67	3.65	3.64	3.64
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.2 – 45.02	24.32 – 45.01	24.07 – 45.01	23.24 – 45.09	23.72 – 44.99

Day 8

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.58	1.47	1.64	1.57	1.51
2	Minimum Dynamic Error (%)	1.31	1.14	1.35	1.18	1.09
3	Maximum Dynamic Error (%)	1.95	1.79	1.95	1.95	1.95
4	Dynamic Linearity (Ind.) (%)	0.17	0.18	0.17	0.19	0.14
5	Zero Ranged Travel at (mA)	20.23	20.16	20.31	20.18	20.22
6	Full Ranged Travel at (mA)	3.66	3.67	3.67	3.66	3.66
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.54 – 45.03	23.77 – 45.01	23.79 – 45.05	23.67 – 45.04	23.87 – 44.91

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.57	1.49	1.52	1.45	1.42
2	Minimum Dynamic Error (%)	1.17	1.15	1.26	1.09	1.13
3	Maximum Dynamic Error (%)	2.09	1.94	1.82	1.85	1.91
4	Dynamic Linearity (Ind.) (%)	0.20	0.15	0.15	0.20	0.14
5	Zero Ranged Travel at (mA)	20.16	20.24	20.24	20.19	20.25
6	Full Ranged Travel at (mA)	3.64	3.64	3.66	3.66	3.66
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	24.73 – 44.84	24.66 – 45.01	23.92 – 45.05	24.05 – 44.76	24.46 – 44.80

Day 10

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.55	1.60	1.47	1.56	1.49
2	Minimum Dynamic Error (%)	1.10	1.23	1.20	1.09	1.07
3	Maximum Dynamic Error (%)	1.97	2.00	1.89	1.93	1.80
4	Dynamic Linearity (Ind.) (%)	0.18	0.22	0.16	0.23	0.19
5	Zero Ranged Travel at (mA)	20.18	20.12	20.17	20.05	20.16
6	Full Ranged Travel at (mA)	3.58	3.60	3.60	3.64	3.60
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	24.46 – 45.16	24.32 – 45.09	23.40 – 45.07	24.02 – 45.03	23.97 – 45.02

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.60	1.46	1.46	1.46	1.56
2	Minimum Dynamic Error (%)	1.29	1.12	1.15	1.14	1.26
3	Maximum Dynamic Error (%)	1.99	1.73	1.82	1.82	1.81
4	Dynamic Linearity (Ind.) (%)	0.16	0.17	0.15	0.16	0.19
5	Zero Ranged Travel at (mA)	20.20	20.17	20.29	20.26	20.21
6	Full Ranged Travel at (mA)	3.58	3.62	3.61	3.67	3.67
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	24.49 – 45.07	24.13 – 44.96	23.07 – 45.04	23.98 – 45.06	23.48 – 45.05

Day 12

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.40	1.40	1.56	1.54	1.49
2	Minimum Dynamic Error (%)	1.11	1.06	1.22	1.25	1.18
3	Maximum Dynamic Error (%)	1.79	1.74	1.91	1.94	1.89
4	Dynamic Linearity (Ind.) (%)	0.23	0.20	0.23	0.19	0.24
5	Zero Ranged Travel at (mA)	20.06	20.19	20.21	20.18	20.26
6	Full Ranged Travel at (mA)	3.61	3.62	3.64	3.62	3.63
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.94 – 44.98	23.83 – 45.05	24.23 – 44.99	23.22 – 45.20	24.04 – 44.99

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.60	1.50	1.44	1.53	1.43
2	Minimum Dynamic Error (%)	1.25	1.17	0.87	1.18	1.14
3	Maximum Dynamic Error (%)	1.91	1.89	1.81	1.92	1.84
4	Dynamic Linearity (Ind.) (%)	0.23	0.20	0.19	0.18	0.15
5	Zero Ranged Travel at (mA)	20.19	20.14	20.14	20.29	20.22
6	Full Ranged Travel at (mA)	3.67	3.65	3.67	3.66	3.67
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.76 – 44.88	23.93 – 44.88	23.56 – 44.80	23.45 – 44.89	23.71 – 44.98

Day 14

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.46	1.50	1.48	1.57	1.42
2	Minimum Dynamic Error (%)	1.13	1.14	1.17	1.21	1.14
3	Maximum Dynamic Error (%)	1.93	1.84	2.01	1.97	1.74
4	Dynamic Linearity (Ind.) (%)	0.18	0.23	0.17	0.16	0.21
5	Zero Ranged Travel at (mA)	20.29	20.13	20.24	20.21	20.27
6	Full Ranged Travel at (mA)	3.65	3.64	3.65	3.67	3.69
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.28 – 45.12	23.20 – 45.07	23.43 – 45.02	22.88 – 45.14	23.47 – 44.99

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.56	1.40	1.50	1.49	1.55
2	Minimum Dynamic Error (%)	1.14	1.03	1.22	1.14	1.25
3	Maximum Dynamic Error (%)	1.82	1.87	1.87	1.86	1.98
4	Dynamic Linearity (Ind.) (%)	0.19	0.16	0.21	0.21	0.20
5	Zero Ranged Travel at (mA)	20.14	20.26	20.31	20.31	20.42
6	Full Ranged Travel at (mA)	3.65	3.64	3.64	3.65	3.67
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.48 – 45.05	23.13 – 45.03	22.96 – 45.00	22.72 – 45.03	22.96 – 45.01

Day 16

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.39	1.34	1.50	1.52	1.52
2	Minimum Dynamic Error (%)	1.08	0.95	1.18	1.21	1.18
3	Maximum Dynamic Error (%)	1.75	1.75	1.90	1.93	1.87
4	Dynamic Linearity (Ind.) (%)	0.16	0.16	0.18	0.17	0.16
5	Zero Ranged Travel at (mA)	20.20	20.27	20.18	20.21	20.31
6	Full Ranged Travel at (mA)	3.64	3.62	3.62	3.64	3.65
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.57 – 45.12	22.95 – 45.01	22.77 – 45.05	23.78 – 44.99	23.21 – 44.91

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.46	1.42	1.56	1.60	1.46
2	Minimum Dynamic Error (%)	1.04	1.03	1.17	1.25	1.16
3	Maximum Dynamic Error (%)	1.86	1.83	1.91	1.91	1.82
4	Dynamic Linearity (Ind.) (%)	0.21	0.19	0.17	0.27	0.16
5	Zero Ranged Travel at (mA)	20.21	20.27	20.25	20.24	20.34
6	Full Ranged Travel at (mA)	3.54	3.68	3.65	3.68	3.62
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.41 – 45.01	23.65 – 45.02	23.68 – 44.96	23.88 – 45.03	23.76 – 44.91

Day 18

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.53	1.61	1.49	1.50	1.55
2	Minimum Dynamic Error (%)	1.16	1.35	1.06	1.11	1.12
3	Maximum Dynamic Error (%)	1.99	1.87	1.85	1.86	1.91
4	Dynamic Linearity (Ind.) (%)	0.14	0.23	0.17	0.16	0.21
5	Zero Ranged Travel at (mA)	20.18	20.14	20.31	20.14	20.09
6	Full Ranged Travel at (mA)	3.67	3.67	3.62	3.67	3.68
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	24.27 – 44.88	23.79 – 44.94	23.79 – 44.94	24.48 – 44.76	23.84 – 44.97

Day 19

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.42	1.62	1.51	1.47	1.52
2	Minimum Dynamic Error (%)	1.15	1.28	1.14	1.07	1.28
3	Maximum Dynamic Error (%)	1.97	1.93	1.80	1.86	1.76
4	Dynamic Linearity (Ind.) (%)	0.17	0.14	0.17	0.16	0.19
5	Zero Ranged Travel at (mA)	20.12	20.23	20.12	20.06	20.21
6	Full Ranged Travel at (mA)	3.67	3.67	3.68	3.67	3.67
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	24.71 – 44.83	24.02 – 44.91	23.55 – 45.01	23.52 – 44.82	24.62 – 44.74

Day 20

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.71	1.50	1.47	1.43	1.45
2	Minimum Dynamic Error (%)	1.31	1.10	1.11	1.12	1.17
3	Maximum Dynamic Error (%)	2.14	1.87	1.92	1.78	1.76
4	Dynamic Linearity (Ind.) (%)	0.28	0.20	0.20	0.20	0.18
5	Zero Ranged Travel at (mA)	20.30	20.24	20.20	20.12	20.17
6	Full Ranged Travel at (mA)	3.63	3.64	3.68	3.67	3.67
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.01 – 45.08	23.50 – 45.10	23.40 – 45.06	23.10 – 44.97	23.41 – 44.90

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.68	1.74	1.56	1.55	1.51
2	Minimum Dynamic Error (%)	1.33	1.43	1.30	1.12	1.08
3	Maximum Dynamic Error (%)	2.03	2.11	1.90	2.02	1.90
4	Dynamic Linearity (Ind.) (%)	0.25	0.18	0.18	0.17	0.16
5	Zero Ranged Travel at (mA)	20.17	20.17	20.24	20.15	20.30
6	Full Ranged Travel at (mA)	3.65	3.65	3.63	3.65	3.65
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.23 – 44.98	24.30 – 44.85	23.75 – 45.04	23.52 – 44.90	22.79 – 45.12

Day 22

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.50	1.57	1.55	1.40	1.54
2	Minimum Dynamic Error (%)	1.17	1.10	1.14	0.90	1.20
3	Maximum Dynamic Error (%)	1.83	1.92	1.92	1.82	1.89
4	Dynamic Linearity (Ind.) (%)	0.16	0.16	0.19	0.19	0.19
5	Zero Ranged Travel at (mA)	20.12	20.20	20.18	20.26	20.11
6	Full Ranged Travel at (mA)	3.65	3.66	3.65	3.65	3.68
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.92 – 44.98	23.76 – 44.92	23.31 – 44.99	23.94 – 44.85	24.62 – 44.87

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.43	1.49	1.56	1.55	1.51
2	Minimum Dynamic Error (%)	1.12	1.17	1.30	1.12	1.08
3	Maximum Dynamic Error (%)	1.94	1.81	1.90	2.02	1.90
4	Dynamic Linearity (Ind.) (%)	0.15	0.21	0.18	0.17	0.16
5	Zero Ranged Travel at (mA)	20.14	20.19	20.24	20.15	20.30
6	Full Ranged Travel at (mA)	3.63	3.63	3.63	3.65	3.65
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	24.63 – 44.75	24.30 – 44.85	23.75 – 45.04	23.52 – 44.90	22.79 – 45.12

Day 24

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.71	1.66	1.53	1.46	1.45
2	Minimum Dynamic Error (%)	1.40	1.33	1.20	1.17	1.09
3	Maximum Dynamic Error (%)	2.03	2.13	1.85	1.78	1.84
4	Dynamic Linearity (Ind.) (%)	0.17	0.22	0.19	0.20	0.17
5	Zero Ranged Travel at (mA)	20.24	20.16	20.16	20.18	20.22
6	Full Ranged Travel at (mA)	3.66	3.69	3.66	3.65	3.63
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.51 – 44.97	23.45 – 45.18	23.79 – 45.06	24.04 – 45.00	24.48 – 45.04

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.51	1.44	1.54	1.55	1.38
2	Minimum Dynamic Error (%)	1.12	1.06	1.17	1.21	0.94
3	Maximum Dynamic Error (%)	1.92	1.87	1.86	1.88	1.82
4	Dynamic Linearity (Ind.) (%)	0.19	0.19	0.21	0.18	0.19
5	Zero Ranged Travel at (mA)	20.22	20.15	20.21	20.38	20.22
6	Full Ranged Travel at (mA)	3.60	3.67	3.66	3.65	3.67
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.75 – 44.91	23.40 – 45.01	23.61 – 44.97	23.05 – 45.15	23.22 – 45.09

Day 26

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.58	1.54	1.59	1.52	1.50
2	Minimum Dynamic Error (%)	1.15	1.20	1.21	1.17	1.20
3	Maximum Dynamic Error (%)	1.93	1.95	1.94	1.95	1.84
4	Dynamic Linearity (Ind.) (%)	0.20	0.23	0.17	0.21	0.16
5	Zero Ranged Travel at (mA)	20.23	20.28	20.22	20.22	20.23
6	Full Ranged Travel at (mA)	3.63	3.64	3.66	3.65	3.63
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.4 – 44.97	22.44 – 45.17	22.86 – 45.09	23.62 – 45.03	23.02 – 45.00

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.50	1.51	1.48	1.47	1.42
2	Minimum Dynamic Error (%)	1.12	1.20	1.16	1.15	1.04
3	Maximum Dynamic Error (%)	1.92	1.87	1.77	1.81	1.75
4	Dynamic Linearity (Ind.) (%)	0.19	0.20	0.19	0.16	0.18
5	Zero Ranged Travel at (mA)	20.22	20.23	20.16	20.17	20.19
6	Full Ranged Travel at (mA)	3.65	3.66	3.67	3.67	3.66
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	23.91 – 45.00	23.06 – 45.04	24.1 – 44.88	23.74 – 44.93	23.7 – 44.85

Day 28

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.50	1.45	1.52	1.41	1.50
2	Minimum Dynamic Error (%)	1.10	1.12	1.25	1.14	1.18
3	Maximum Dynamic Error (%)	1.92	1.90	1.80	1.86	1.92
4	Dynamic Linearity (Ind.) (%)	0.17	0.15	0.15	0.16	0.15
5	Zero Ranged Travel at (mA)	20.11	20.34	20.28	20.21	20.09
6	Full Ranged Travel at (mA)	3.65	3.63	3.66	3.66	3.66
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	24.08 – 44.84	23.84 – 44.97	24.02 – 45.05	23.72 – 45.02	24.37 – 44.94

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.50	1.45	1.52	1.41	1.50
2	Minimum Dynamic Error (%)	1.10	1.12	1.25	1.14	1.18
3	Maximum Dynamic Error (%)	1.92	1.90	1.80	1.86	1.92
4	Dynamic Linearity (Ind.) (%)	0.17	0.15	0.15	0.16	0.15
5	Zero Ranged Travel at (mA)	20.11	20.34	20.28	20.21	20.09
6	Full Ranged Travel at (mA)	3.65	3.63	3.66	3.66	3.66
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	24.08 – 44.84	23.84 – 44.97	24.02 – 45.05	23.72 – 45.02	24.37 – 44.94

Day 30

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.64	1.59	1.59	1.61	1.45
2	Minimum Dynamic Error (%)	1.26	1.26	1.26	1.29	1.12
3	Maximum Dynamic Error (%)	2.02	1.97	1.97	1.97	1.68
4	Dynamic Linearity (Ind.) (%)	0.19	0.21	0.21	0.20	0.17
5	Zero Ranged Travel at (mA)	20.13	20.08	20.08	20.14	20.16
6	Full Ranged Travel at (mA)	3.57	3.61	3.61	3.61	3.60
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	24.15 – 44.87	23.89 – 45.01	23.89 – 45.01	23.98 – 44.94	24.12 – 44.97

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.64	1.59	1.59	1.61	1.45
2	Minimum Dynamic Error (%)	1.26	1.26	1.26	1.29	1.12
3	Maximum Dynamic Error (%)	2.02	1.97	1.97	1.97	1.68
4	Dynamic Linearity (Ind.) (%)	0.19	0.21	0.21	0.20	0.17
5	Zero Ranged Travel at (mA)	20.13	20.08	20.08	20.14	20.16
6	Full Ranged Travel at (mA)	3.57	3.61	3.61	3.61	3.60
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	24.15 – 44.87	23.89 – 45.01	23.89 – 45.01	23.98 – 44.94	24.12 – 44.97

Day 32

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.64	1.59	1.59	1.61	1.45
2	Minimum Dynamic Error (%)	1.26	1.26	1.26	1.29	1.12
3	Maximum Dynamic Error (%)	2.02	1.97	1.97	1.97	1.68
4	Dynamic Linearity (Ind.) (%)	0.19	0.21	0.21	0.20	0.17
5	Zero Ranged Travel at (mA)	20.13	20.08	20.08	20.14	20.16
6	Full Ranged Travel at (mA)	3.57	3.61	3.61	3.61	3.60
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	24.15 – 44.87	23.89 – 45.01	23.89 – 45.01	23.98 – 44.94	24.12 – 44.97

Day 33

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.54	1.55	1.62	1.45	1.50
2	Minimum Dynamic Error (%)	1.09	1.22	1.26	1.12	1.20
3	Maximum Dynamic Error (%)	1.87	2.01	2.06	1.81	2.12
4	Dynamic Linearity (Ind.) (%)	0.24	0.20	0.18	0.17	0.19
5	Zero Ranged Travel at (mA)	20.11	20.05	20.04	20.21	20.21
6	Full Ranged Travel at (mA)	3.46	3.55	3.57	3.55	3.55
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	24.07 – 44.92	24.18 – 44.87	23.42 – 45.03	23.45 – 45.04	23.53 – 44.94

Day 34

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.58	1.65	1.58	1.65	1.65
2	Minimum Dynamic Error (%)	1.16	1.31	1.28	1.33	1.25
3	Maximum Dynamic Error (%)	1.97	2.04	1.92	1.92	1.92
4	Dynamic Linearity (Ind.) (%)	0.21	0.18	0.15	0.19	0.17
5	Zero Ranged Travel at (mA)	20.13	20.10	20.12	20.12	20.16
6	Full Ranged Travel at (mA)	3.56	3.58	3.58	3.58	3.59
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	24.4 – 44.7	24.08 – 45.8	24.71 – 44.83	24.3 – 44.79	24.63 – 44.79

	Parameter	PST 1	PST 2	PST 3	PST 4	PST 5
1	Average Dynamic Error (%)	1.64	1.59	1.59	1.61	1.45
2	Minimum Dynamic Error (%)	1.26	1.26	1.26	1.29	1.12
3	Maximum Dynamic Error (%)	2.02	1.97	1.97	1.97	1.68
4	Dynamic Linearity (Ind.) (%)	0.19	0.21	0.21	0.20	0.17
5	Zero Ranged Travel at (mA)	20.13	20.08	20.08	20.14	20.16
6	Full Ranged Travel at (mA)	3.57	3.61	3.61	3.61	3.60
7	Average Torque	NA	NA	NA	NA	NA
8	Maximum Torque	NA	NA	NA	NA	NA
9	Minimum Torque	NA	NA	NA	NA	NA
10	Spring Rate	NA	NA	NA	NA	NA
11	Bench Set (psi)	24.15 – 44.87	23.89 – 45.01	23.89 – 45.01	23.98 – 44.94	24.12 – 44.97