DEVELOPMENT OF A CONTROLLER FOR PARTIAL STROKE TESTING: METSO NELES

By

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FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme
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:

Assoc. Prof. Dr. Nordin Bin Saad
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
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.

SITI NURSYAHIRAH BINTI JAMLUS

ABSTRACT

Partial Stroke Valve Testing (PST) which is related to the Emergency Valve Shutdown System is a method whereby the performance of a portion of a valve is tested at more frequent interval (accelerated proof test). PST can be a good complement to Full Stroke Testing (FST). The objective of this project is to develop a control for a PST that is based on a system called Programmable Logic Controller (PLC) as the main controller to do Full Stroke Testing and for the Partial Stroke Testing: it was conducted using software provide by the vendors. The problems that have been identified during the system familiarization and training session are needed to be solved in order to meet the project's objective. One of the problems is that first owing to the fact that the PST will be done using three different software from three different vendors, the valves are having problems to communicate with each other due to the connection architecture (point to point connection). Therefore a multiplexer is needed to be installed in between the connection. Scope of the study involved the detail explanations of the Metso's valves specifications. Furthermore, the device called ValvGuard that is attached to the valves and also the FieldCare Software (Metso' Valve Software) is discussed. The specification of the PLC device and the example of the ladder diagram developed and used in this project is presented. The software provided by Yokogawa called WideField2 is explained.

ACKNOWLEDGEMENT

This project would not have been possible without the assistance and guidance of certain individuals and organization whose contributions have helped in its completion.

First of all and most importantly, I would like to say thank you and utmost appreciation to the project supervisor, Associate Professor Dr. Nordin B. Saad for his valuable input and guidance throughout the course of this project and also for the trust that you put on me.

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Thirdly, I would like to thank Mr. Rashdan and Mr. Shah Rizal for their kindness and their help and not to forget the knowledge that both of them taught me during this project. I really appreciated it. Thank you!

Lastly, I would like to say thank you so much to my parents not only for their moral support but also financial support that both of them gave to me. Without them, life would become so difficult.

A word of sincere gratitude to the Final Year Project committee for arranging various seminars. The seminars were indeed very helpful and insightful. Special thanks to all lecturers from Universiti Teknologi Petronas who had provided untiring guidance throughout the period of the project.

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LIST OF ABBREVIATION

AIChE/CCPS	Center for Chemical Process Safety of the American Institute of Chemical Engineers
DTMs	Device Type Managers
DU	Dangerous Undetected
ESD	Emergency Shutdown Systems
FDT	Field Device Tool
FST	Full Stroke Testing
HART	Highway Addressable Remote Transducer
IEC	International Electrotechnical Commission
ISA	Industry Standard Architecture
IWG	Improvement Working Group
PLC	Programmable Logic Controller
PST	Partial Stroke Testing
RCI	Remote Communication Interface
SIL	Safety Integrity Level
SIS	Safety Instrumented Systems
UTP	Universiti Teknologi PETRONAS

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND STUDY

In a paper titled "Quantifying the Impart of Partial Stroke Valve Testing of Safety Instrumented Systems" Paul Gruhn, Joe Pittman, Susan Wiley and Tom LeBlanc, pointed out the overall performance of the safety instrumented system (SIS) can be determined from the sensor to the final control element such as valves [1]. The ISA S84 and IEC 1508/1511 standards, along with the AIChE/CCPS Guidelines on safety instrumented (interlock) systems concluded that the valves represent the "weak link" in today's systems where the most typical failure mode of the shutdown valves are the valves being stuck. Therefore, in order to test the performance of the shutdown valves, the only way is to stroke the valves. However, the valves cannot be completely closed because they will stop the production and can cause undesired situation to occur. Hence, if the valves can be partially stroke without stopping the production, it will contribute to a remarkable improvement in the safety instrumented system.

Partial Stroke Testing (PST) is a method whereby a portion of the valve assembly is tested at a more frequent interval than the full test rate. In simple words, an accelerated (partial) proof test. PST has been performed in different applications for many years where it can be used to improve safety instrumented system performance. Most of the operating companies agreed that the most difficult part to comply with the safety standards is the testing of final elements, especially emergency block valves. For the past thirty years, the turnarounds were every two to three years. Due to mechanical reliability and preventive maintenance program, the turnarounds have been extended to every five to six years whereby increased the production (great economic returns). Furthermore, by extending the turnarounds, the emergency shutdown valves are expected to go longer while maintaining best performance. This is not possible, thus other means of ensuring safety systems maintain the required risk reduction are needed for example partial stroke testing. The reliability that may be gained by conducting the PST is influenced by two factors: (i) the PST coverage, and (ii) the PST interval. The PST coverage is partly a design parameter (e.g. valve design, PST hardware and software) and partly an operational parameter (e.g. operational and environmental conditions) [2]. PST can be implemented in various ways such as illustrated in the Figure 1.1 and 1.2.

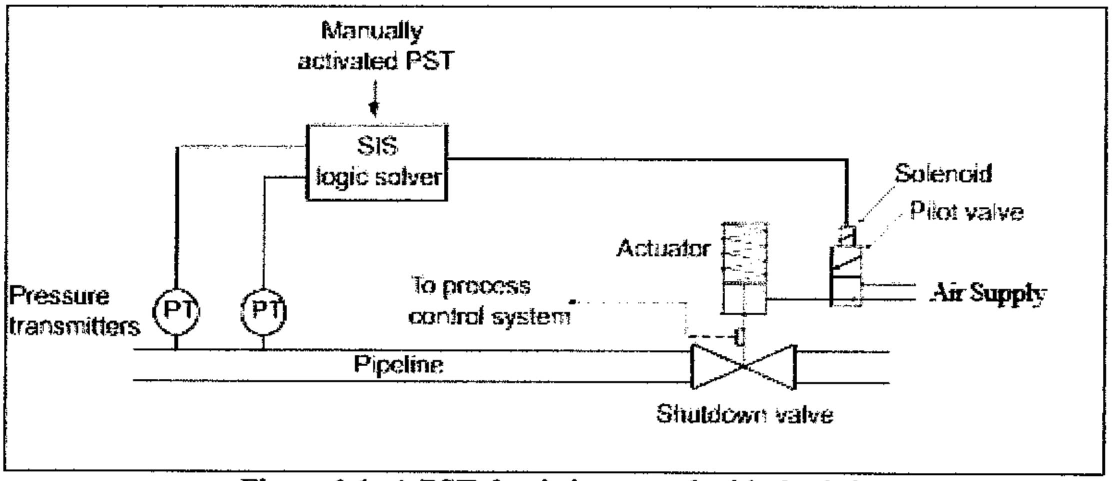


Figure 1.1: A PST that is integrated with the SIS

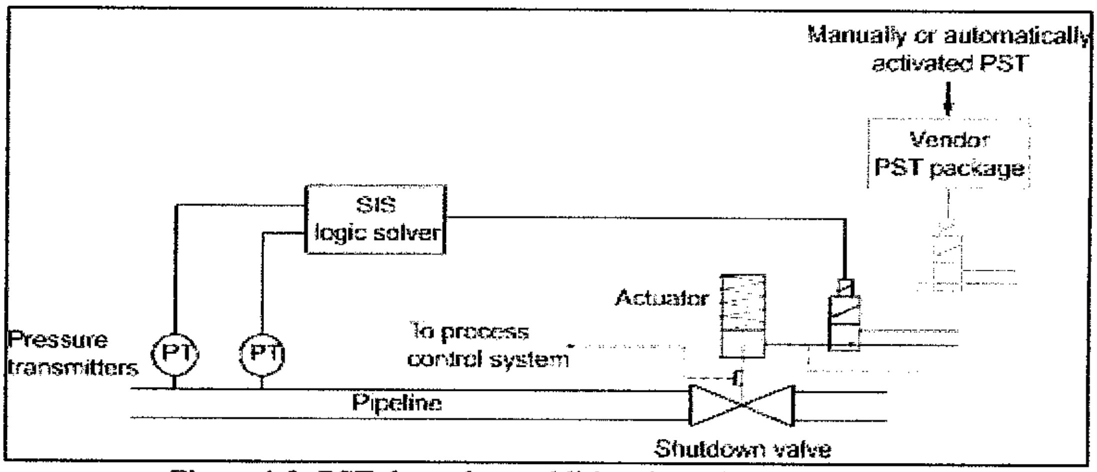


Figure 1.2: PST through an additional vendor PST package

1.2. Problem Statement

The PST project is collaboration between Universiti Teknologi PETRONAS (UTP) and the Improvement Working Group (IWG) SKG14 of PETRONAS. The team suggested that the FST to be controlled by a Programmable Logic Controller (PLC) and the PST using three different software; FieldCare Software (Metso's valves), Valve Link Software (Fisher's Valves) and Valvue ESD (Masoneilan). They will be used to execute various test operations in high frequency and repetitive mode. In the previous report, there are 3 connection methodologies that might be implemented in this project: Multi Drop Mode Connection Approach, Multiple Wiring/ Implementation Schemes Connection Approach and Point to Point Mode Connection Approach. However, after several discussions with the representatives from PETRONAS, the connection methodology that is going to be applied is the Point to Point Connection Method.

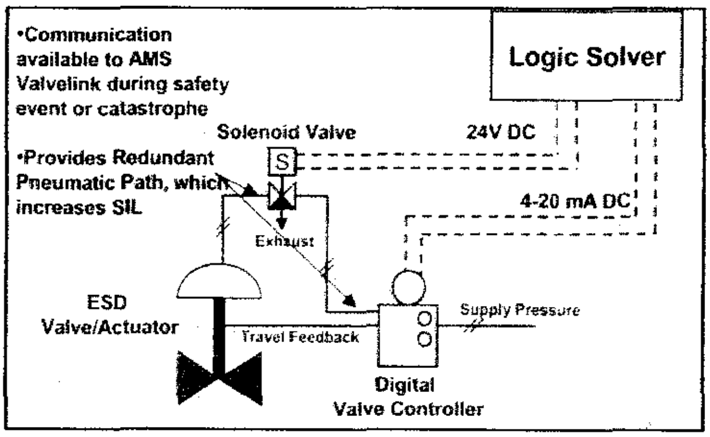


Figure 1.3: Point to Point Connection Method

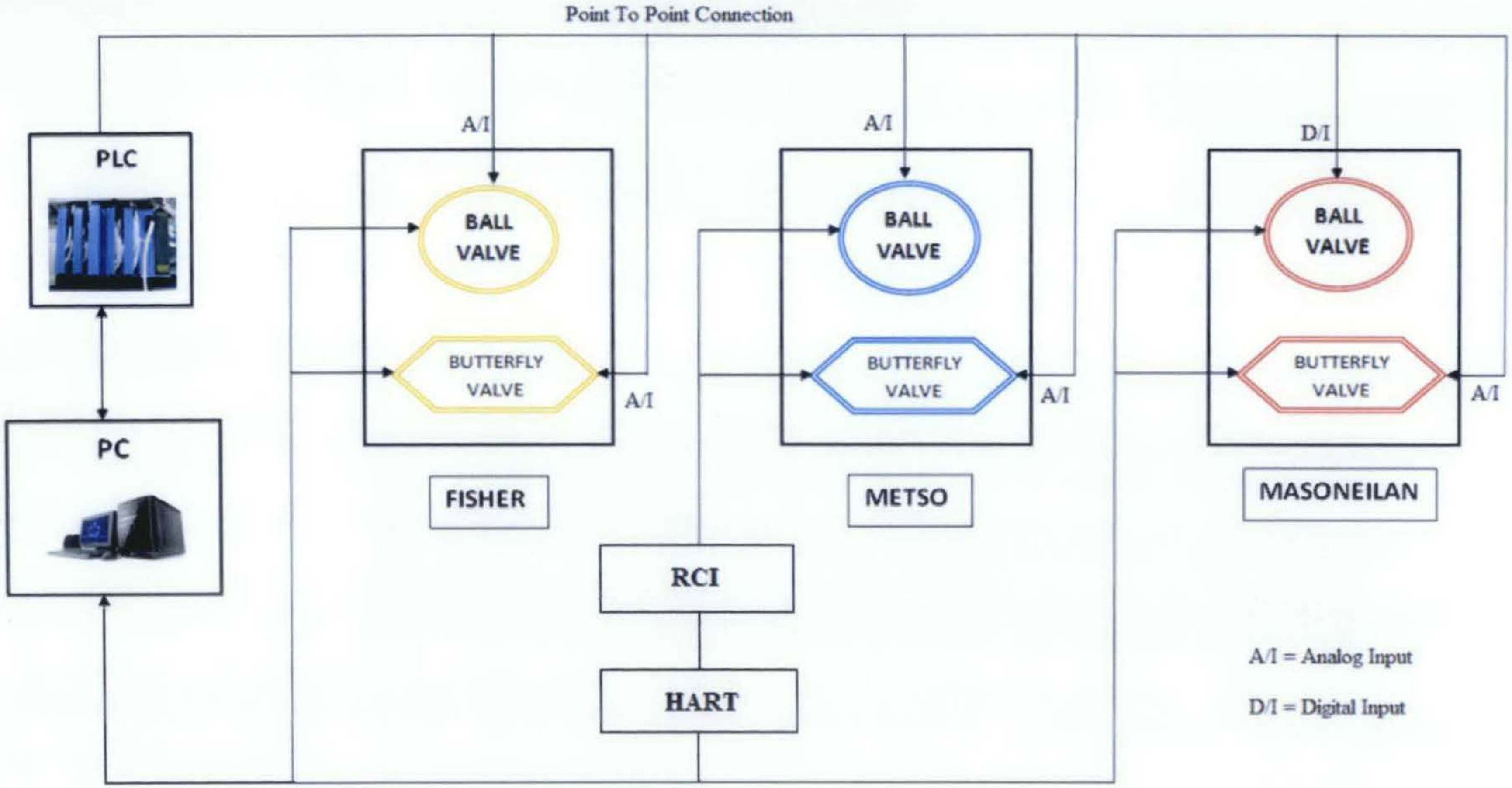


Figure 1.4: Project Layout

1.2.1. Problem Identification

The first problem that has been identified is the communication problem between valves from the different vendors. In order for the six valves to communicate with each other, a multi-point connection is needed. However the connection that has been made is a point to point connection. Therefore, the valves cannot communicate with each other which mean that the PST cannot be done simultaneously for all the valves as required in the earlier stage before.

Other than that, Fisher Rosemount Software (Valve Link Software) and Masoneilan Software (Valvue ESD Software) can only do stroke testing daily and not by hours as required by PETRONAS. Only Metso Neles Software (FieldCare Softcare) can do stroke testing by hours. Therefore, the PST must be done manually by the students.

Another problem is that, since the connection that is being used in this project is a point-to-point connection; therefore, a multiplexer needed to be installed in the connection as shown in Figure 1.4. A multiplexer is a device that performs multiplexing where it selects one of the many analog or digital input signals and outputs that into a single line.

1.3. Objective

According to the representatives from PETRONAS, this project is conducted to study the performance of partially stroked on six different valves from three different vendors where each valves has their own different specifications. This project is proposed due to the experienced that operation team had during conducting a shutdown process in the plant. The shutdown valves that were supposed to partially closed, have became fully stroked (fully closed) and therefore stopped the production. As a result, PETRONAS has lost millions of ringgit. Hence, a study on the PST and FST performance must be done in order to overcome this problem.

A lot of aspects in terms of failures of the valves operation that need to be taken consideration. However, all of the aspects will only be taken care after the Phase I of this project is succeeded. According to the plan, Phase I is about developing the coding for the testing and do PST and FST using the coding that has been developed and also the vendors' software. The testing need to be done based on the testing specification given by PETRONAS.

1.4. Scope of Study

Scope of study involved the detail explanations of the Metso's valves specifications. A discussion regarding the Metso's device called ValvGuard that is attached to the valves (ball and butterfly valves) will be discussed in the following chapter.

CHAPTER 2
LITERATURE REVIEW

2.1. METSO NELES VALVES SYSTEM (VG800X)

In order to have a better understanding about this project, supporting information and references about Metso's Valves System (VG800X) and FieldCare Software are needed. Both valves (Ball and Butterfly Valve) are using the Neles ValvGuard system where automated Emergency Shut Down (ESD) or Emergency Venting (ESV) valve testing is needed. By applying this system, the partial stroke testing can be done automatically where the ESD valve is closed partially and not affecting the flow in the pipe line. A standard 24VDC input is used by the VG800X which is usually used for solenoid valves. No internal links is needed between the VG800X and the modules that result in high resistant to wear and to the effects of vibration. The partial valve stroke tests are done at prefixed time intervals that match the Safety Integrity Level (SIL) requirements of the particular application.

The advantage of using the VG800X is that it is very economical and easy to use. Other than that, it is easy to do adjustment and parameter settings with local keypad and display, or by using HART (Highway Addressable Remote Transducer) connection and FieldCare software. The VG800X that allows predictive maintenance based trend analysis has a built-in diagnostic capabilities accessed via the HART communication connection. It also gives an excellent vibration resistance with means the contactless position feedback sensor and spool valve drive do not depend on mechanical links which can be affected by vibration. The position sensor which is immune to wear and unaffected by dirt, has a position signal that is free of electrical disturbance.

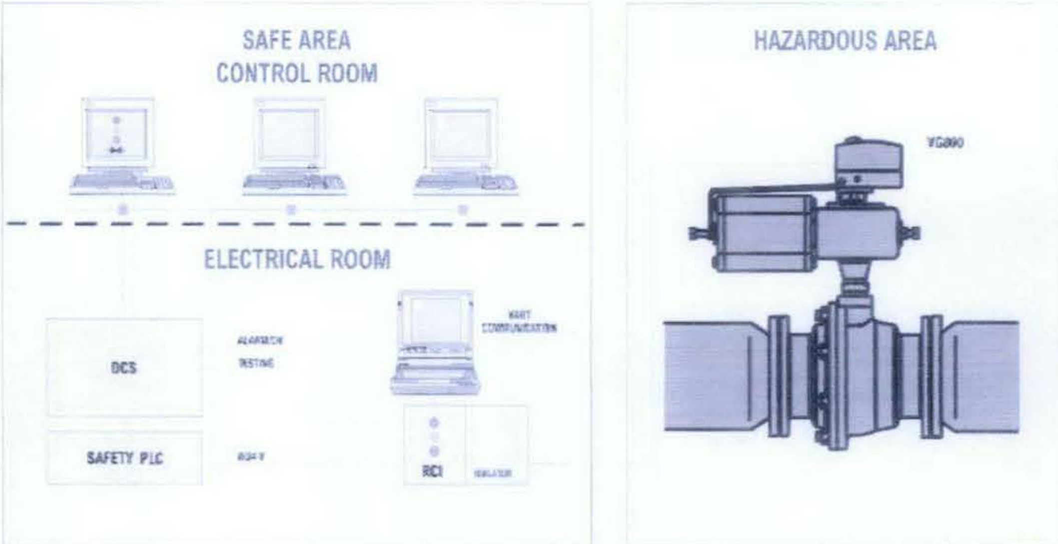


Figure 2.1: Principle of Operation of Metso's Valves (source taken from Metso Automation Catalogue)

Figures 2.2 (a, b, c, and d) show the example of overall connection system of Metso's Valve. The left picture shows the valve that has Neles ValvGuard on top of it where this valve is connected to the isolator. By having the Neles ValveGuard, the programmable functions and communication between the control room and the remote device fitted to the ESD valve in the field is enables by this smart technology. In order to provide continuous real time status information between the VG800X and the control room, a Remote Communication Interface (RCI) is used which provide three signal conditions: OK, Testing and Alarm. In addition, using HART communication protocol, the RCI is able to permits communication between a control room PC and the VG800X. Below are the technical specifications of the Neles VavlGuard.

Model	: VG8568B1S1A
Input	: 21 – 30VDC
Imax	: 100mA
Pmax	: 0.6 watt
Operational Temperature	: - 40 degC ....+75degC/ -40 degC....+ 80 degC
Supply Pressure	: 350 -750 kPa/3,5 – 7barg/ 51 -100 psig
ID	: SO577582002ASE

Figure 2.2a: Ball Valve (on top of it is the actuator(blue) and ValvGuard (red))

Figure 2.2b: Butterfly Valve

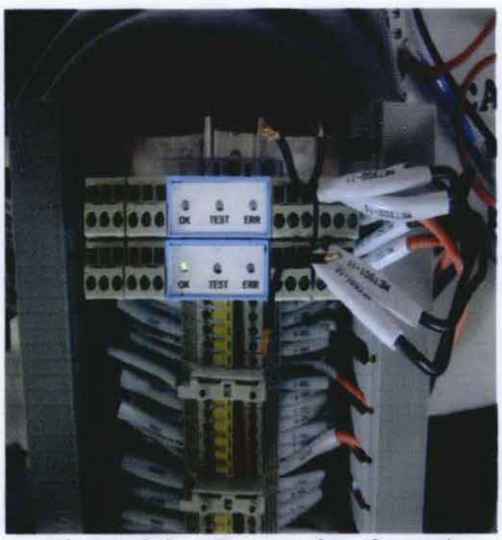


Figure 2.2c: Connection from the Metso's valve to RCI device

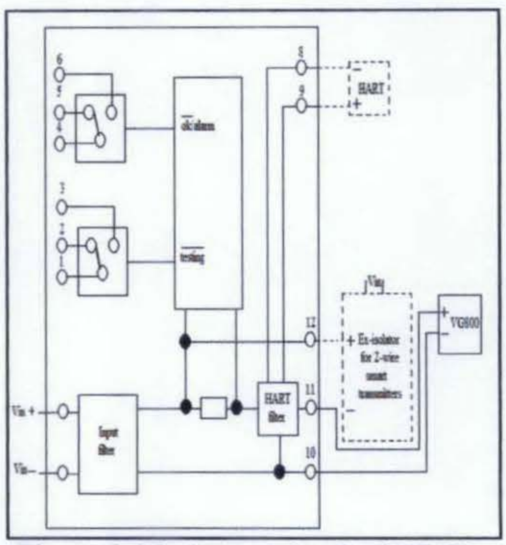


Figure 2.2d: Connection in the RCI

Figure 2.3 shows the picture of the inside of the actuator that will use in this project. The actuator is mounted on the valves. The actuator which is a mechanical device will take air supplied to it and converts it into some kind of motion or in other words, it response to a signal then move the valve to a desired position using the air pressure supplied to it. The actuator will create a linear motion, rotary motion of oscillatory motion but in this case, it will only create a rotary motion since the valves are in rotary motion.

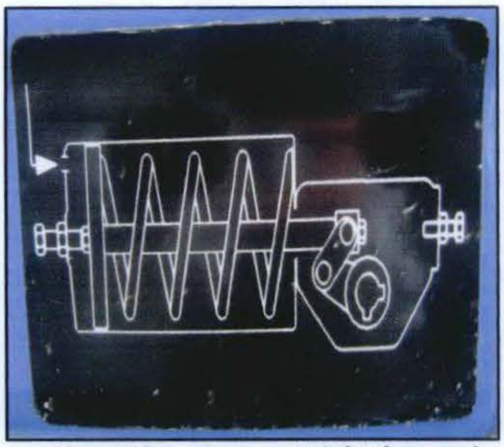


Figure 2.3: Actuator (the internal system)

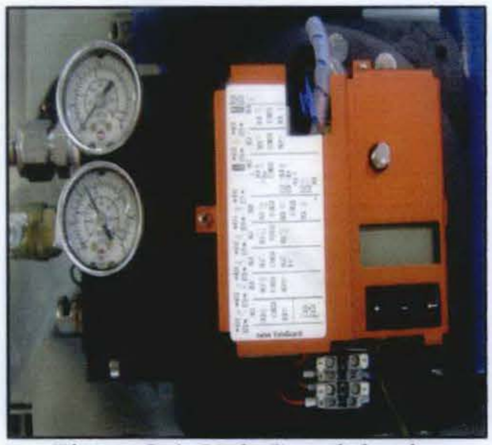


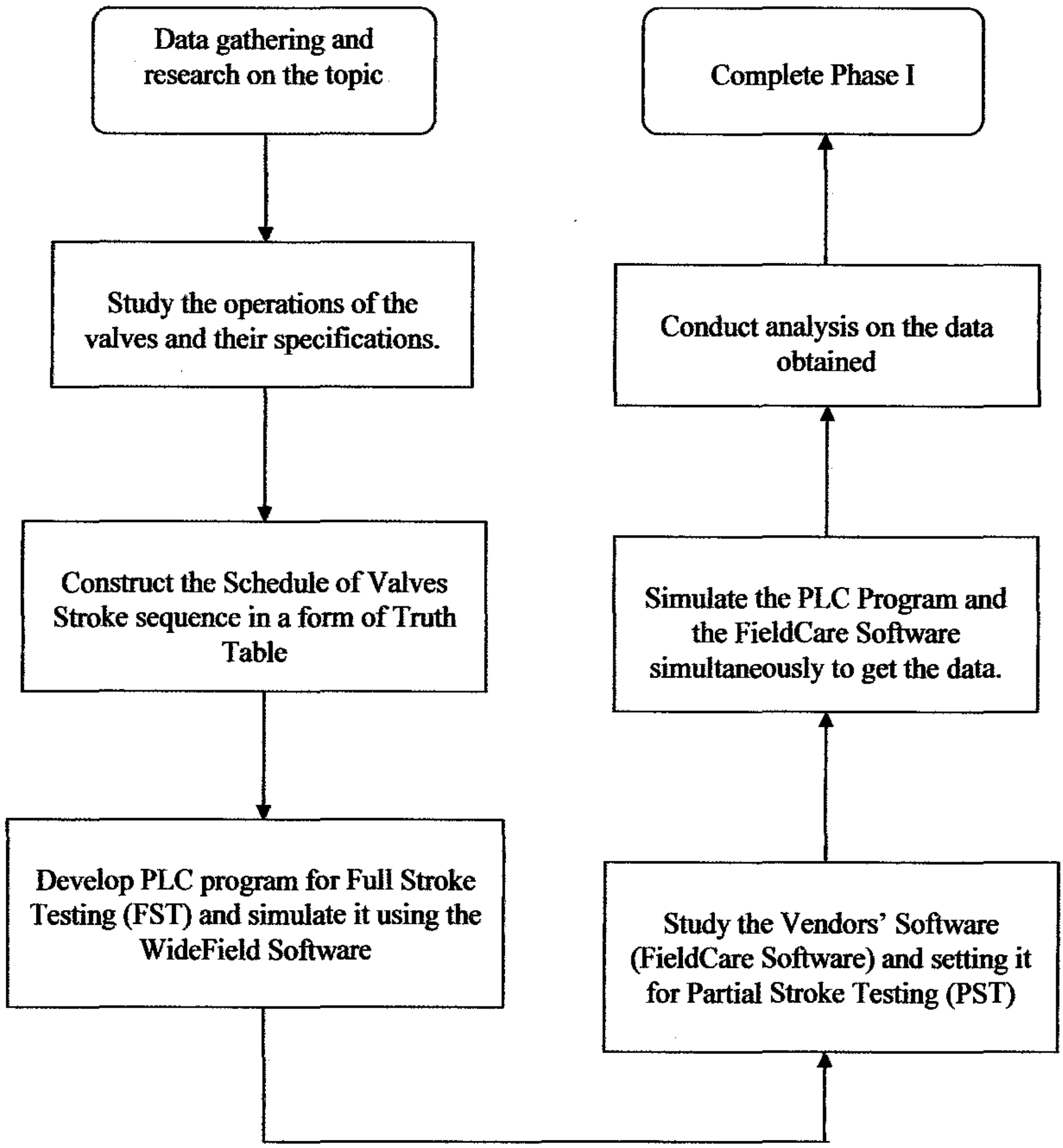
Figure 2.4: ValvGuard that is connected to the air pressure

Figure 2.5: Manual Setting

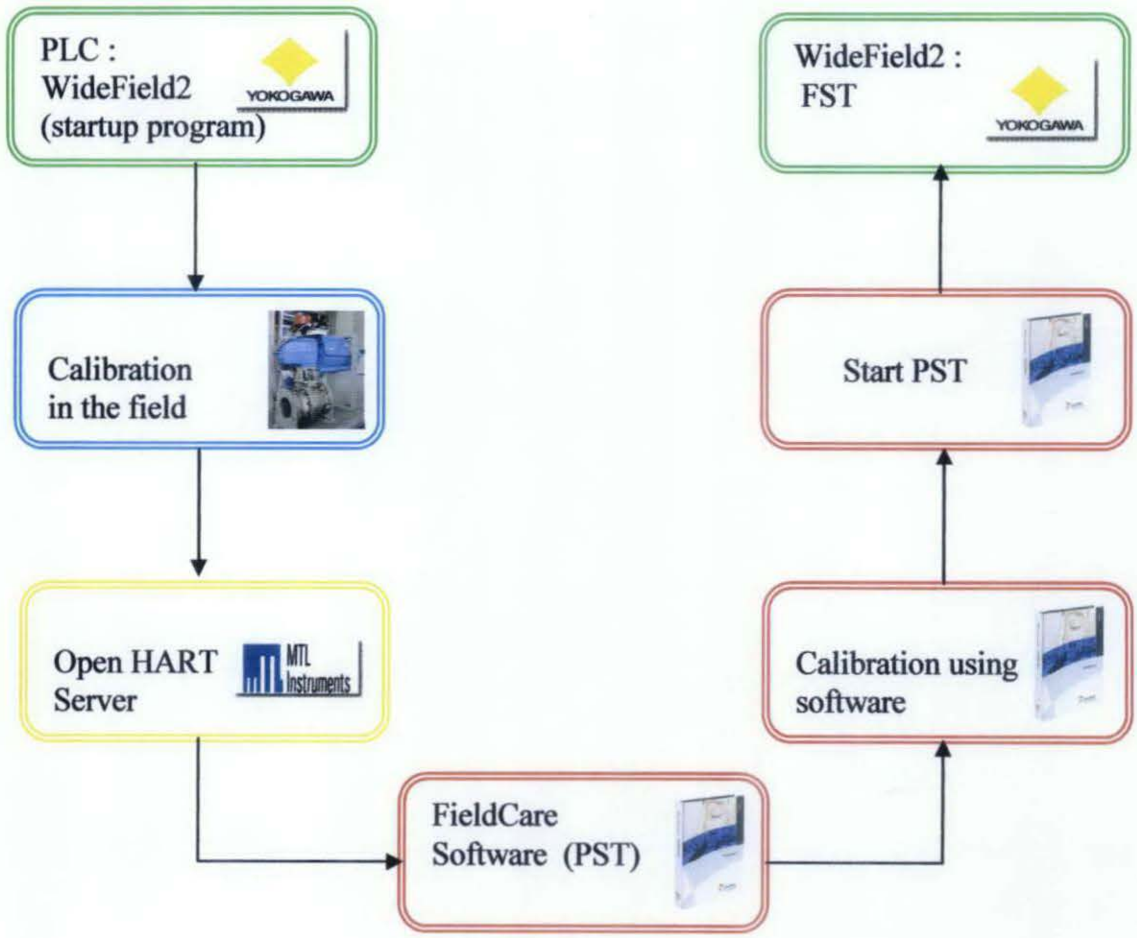
CHAPTER 3

METHODOLOGY

3.1. PROJECT WORK FLOW – PHASE I



3.2. TESTING PROCEDURE WORK FLOW



3.3. PROGRAMMABLE LOGIC CONTROLLER (PLC)

As has been mentioned in the abstract section, that controller to be used in this project is the Programmable Logic Controller or also known as PLC. PLC is a digitally operated electronic system, designed for use in an industrial environment, which uses a programmable memory for the internal storage of user-orientated instructions for implementing specific functions such as logic, sequencing, timing, counting, and arithmetic to control through digital or analog inputs and outputs, various types of machine or processes. The PLC is immune to electrical noise and resistance (vibration and impact). The reasons of why PLC is being used are because:

- Gain complete control of the manufacturing process
- Achieve consistency in manufacturing
- Improve quality and accuracy
- Work in difficult or hazardous environments
- Increase productivity
- Shorten the time to market
- Lower the cost of quality, scrap, and rework
- Offer greater product variety
- Quickly change over from one product to another
- Control inventory

In this project, the PLC specifications that going to be used is stated as below:

Company : YOKOGAWA (made in Japan)
Model : F3SP08
SUFFIX : -OP
STYLE : S1
REV : 15:02
SUPPLY : -
I/P : 100 -240 V_{AC}
O/P : -
DATE : 2007/07/04
NO : F7G041069

The function of PLC is to continual scanning of a program which means running through all conditions within a guaranteed period. The scanning process basically involved three steps:

1. Testing input Status:
   First of all, a PLC will check the inputs in order to check their initial status ON or OFF) or in other words, to check whether a sensor of switch etc is connected with an input is activated or not. The information obtained will be stored in the PLC memory which is needed to proceed to the next step.
2. Program execution:
   In this step, the PLC program will be executed instruction by instruction. Based on the program and the initial status of the input in the step 1, appropriate action will be taken. The action responses not only defined as activation of a certain output but also the obtained results can be kept and stored in the PLC memory to be used in the subsequent step.
3. Checkup and correction of output status:
   As a final step, PLC will check the output status to see if adjustment is needed where the change will be done based on the input status and the results from the program execution in the preceding steps. Then, following the execution of step 3 PLC returns to the beginning of this cycle and will continually repeats these steps.

3.3.1. PLC Function

After a few sets of PLC program have been developed, the best PLC program was chosen where it is a combination program for Start-up and Full Stroke testing. This program is used during the testing period. Compare to other vendors, Metso has the simplest PLC program because both the valves only need to used analog input as the start-up and FST signal. The function that has been applied in the program is the timer function.

3.3.1.1 Timer Function

A timer is an output instruction that waits a set amount of time before doing something in other words, it provides a delay between two actuations. For example it provides timed control to control a devices whether to activate it or de-activate it. A timer is activated by a change in the logic continuity of its rung. PLC timers can perform several of functions, such as:

- Delay an action
- Cause an operation to run a predetermined period of time
- Record the total accumulated time of continuous or immediate event

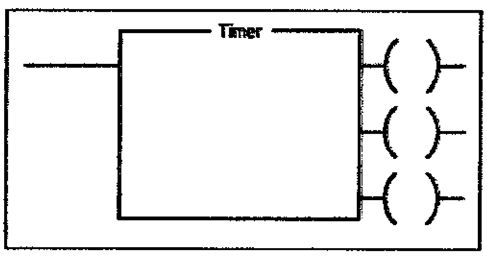


Figure 3.1: Basic timer ladder diagram

3.3.1.2. Tool

The equipment that will be used in this methodology is the PLC device itself. Figure 3.2 shows the PLC device that is being used in this project. The connection of the PLC can be referred to Figure 1.4. The PLC software that is used is the WideField2 software .

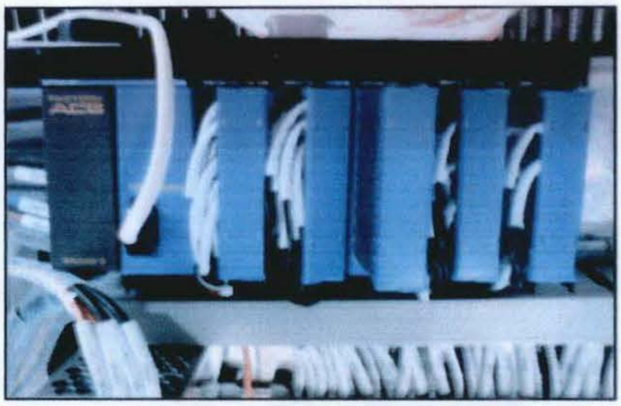


Figure 3.2: PLC Device

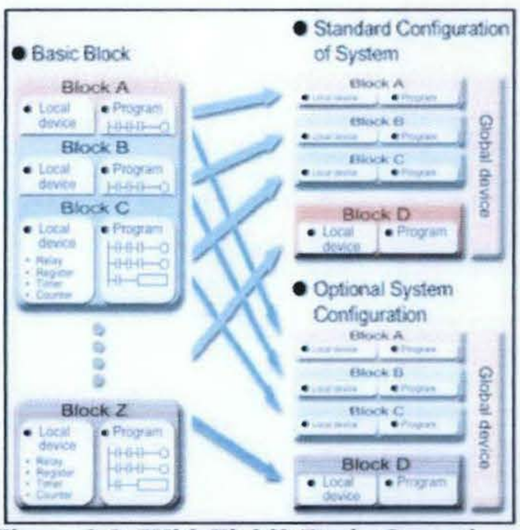


Figure 3.3: WideField2 Basic Operation

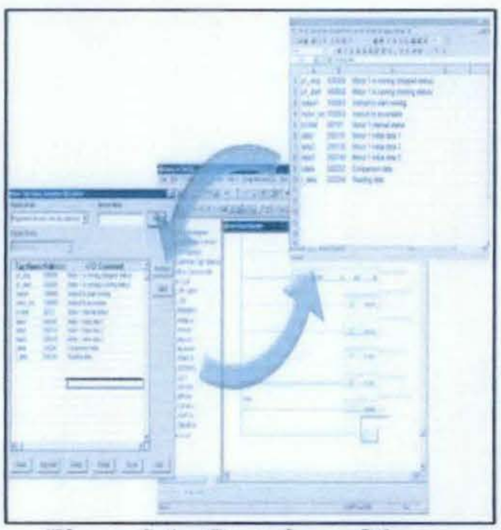


Figure 3.4 : Overview of the WideField2 Software

3.3.2. PLC Programming

Figure 3.5 shows the Start Up and Full Stroke Testing program that has been finalized and currently being used in the project.

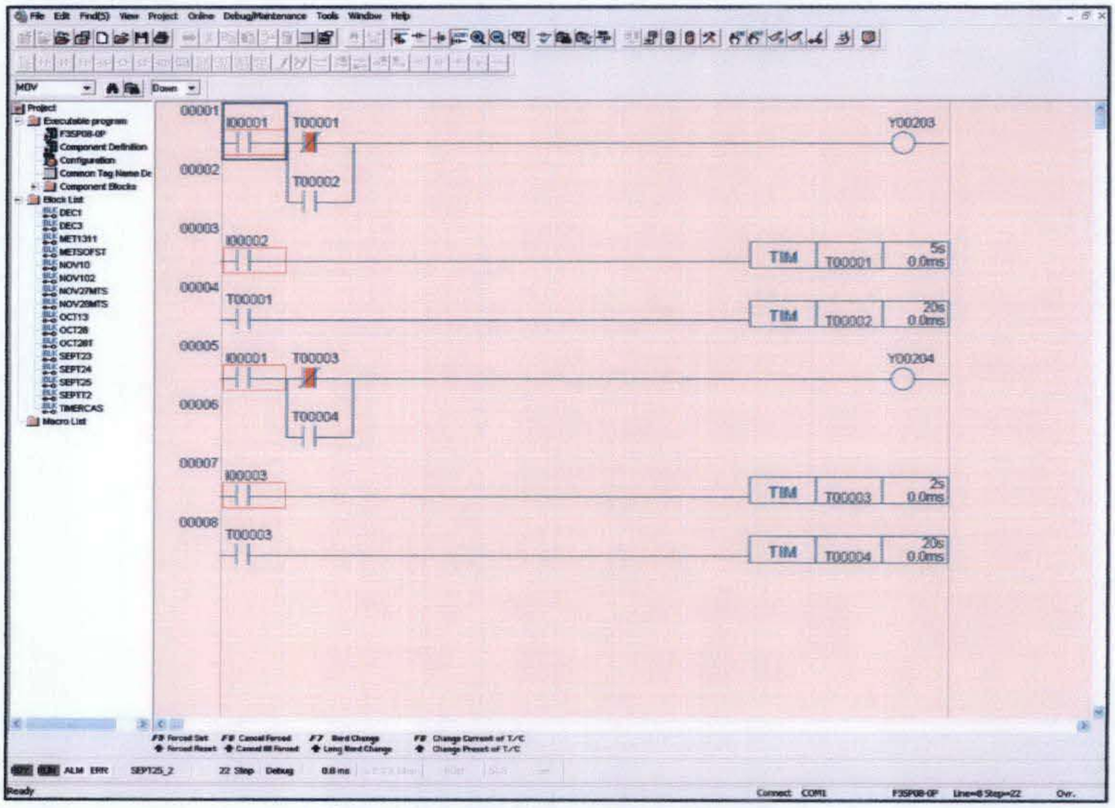


Figure 3.5: Start-up and FST Program

3.3.3. PLC Connection Steps : Start-Up and FST Program

In order to above the program shown in figure above, there are several steps needed. The steps are as follows:

Step 1: Open the WideField2 Software and go to Open Project and click on the "*SEPT25_2*" file as shown in the Figure 3.6. After open the SEPT25_2 folder click on the " SEPT25_5 " subfolder (refer to Figure 3.7). The contain of SEPT25_2 file will appear and the link of the finalized PLC program " **METSOFST** " can be seen on the left side of the window (Figure 3.8).

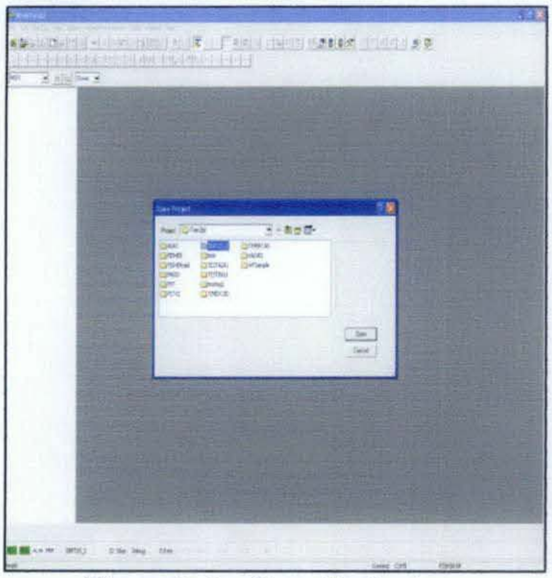


Figure 3.6 : Open Project

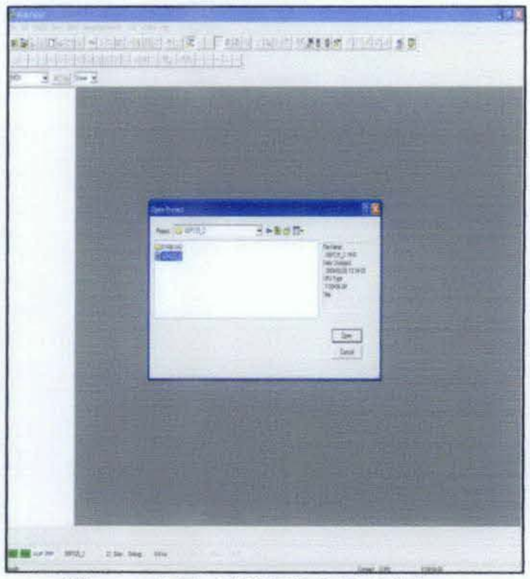


Figure 3.7 : SEPT25_2 folder

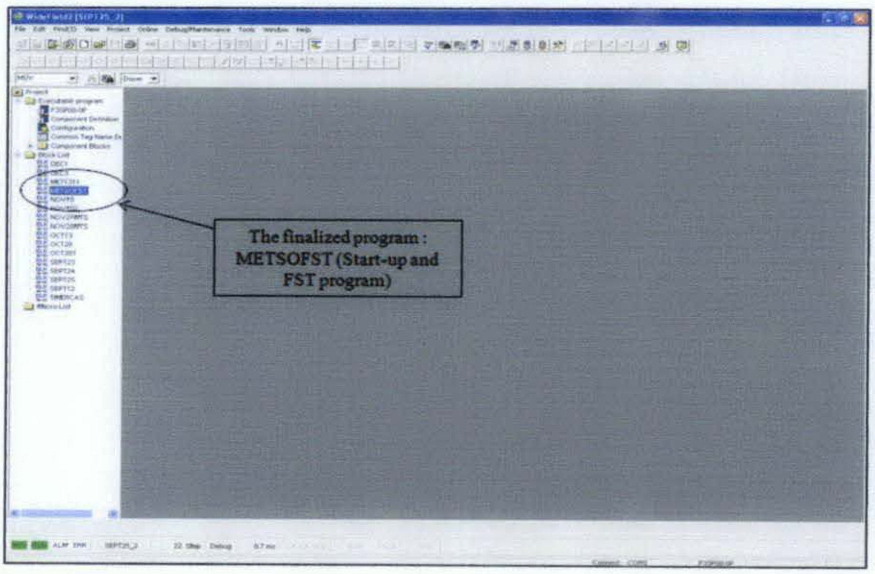


Figure 3.8 : The link of the finalized PLC Program " METSOFST"

Step 2: Click on the " *METSOFST* " link and the program will as shown in Figure 3.9.

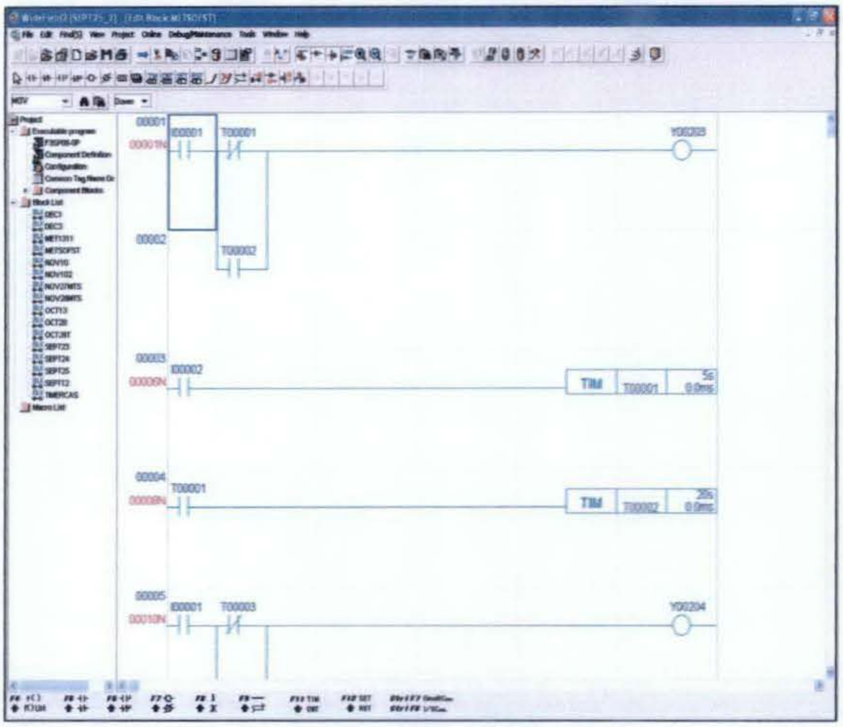


Figure 3.9 : The METSOFST Program

Step 3: Go to " *Online*" and click the " *Connect* " button as shown in Figure 3.10. This step is to connect the WideField2 Software to the PLC device.

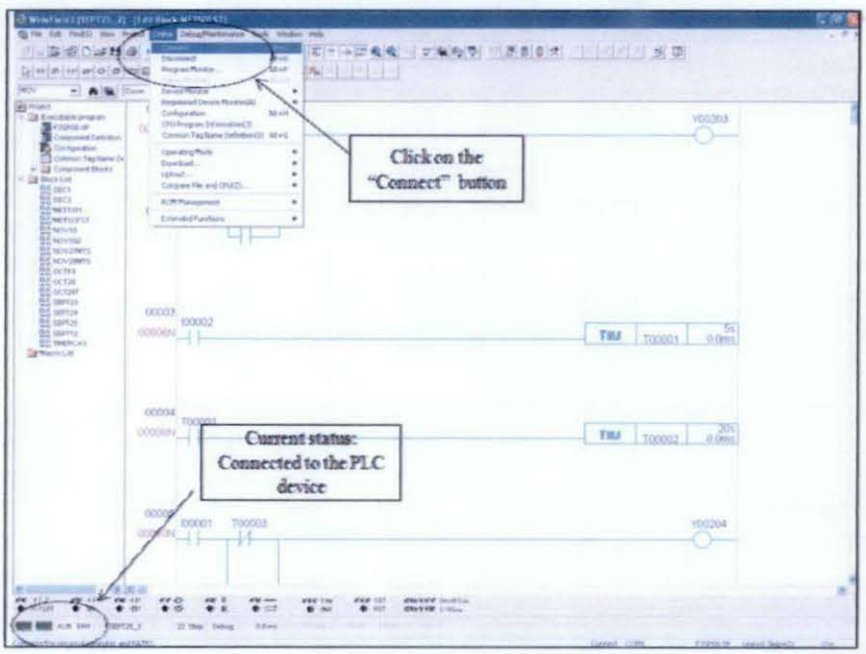


Figure 3.10 : Connecting to the PLC Device

Step 4: Download the " METSOFST " program to the device by clicking to the Download → Project, as shown in figure below.

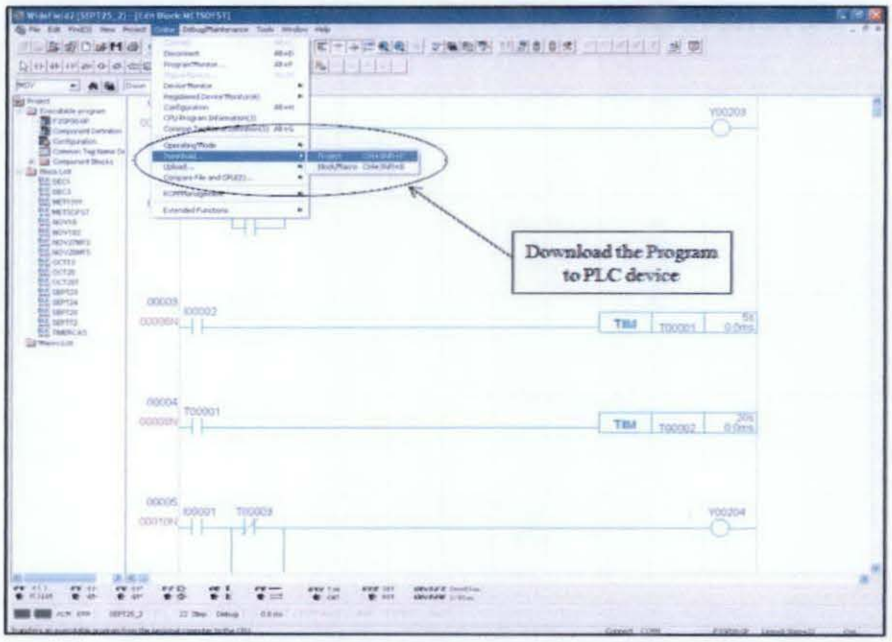


Figure 3.11: Downloading the program to the PLC Device

Step 5: Click on the " *Program Monitor*" where this step allow user to easily do changes, monitoring and controlling to the program while online.

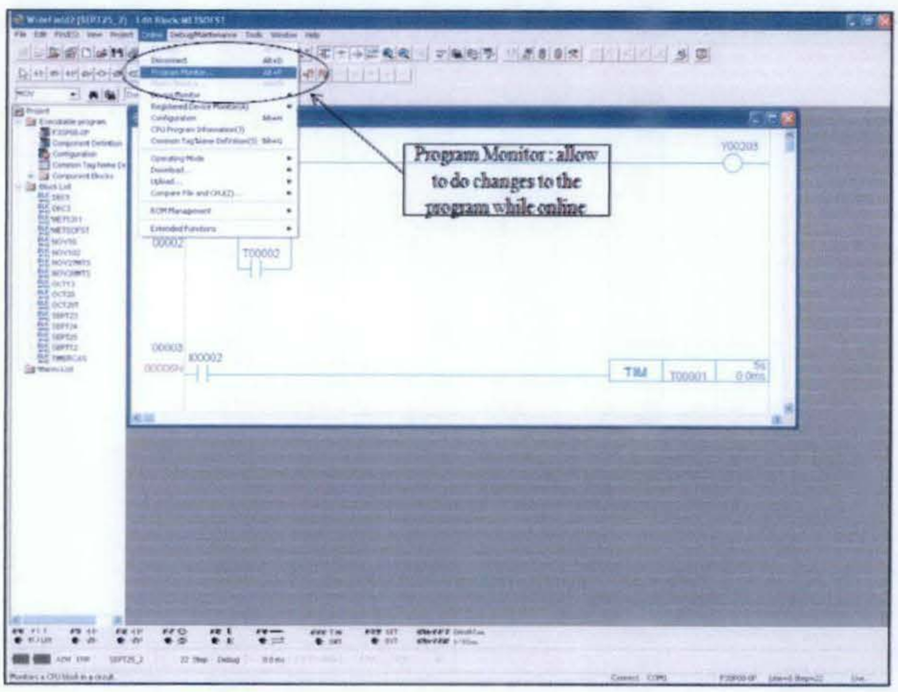


Figure 3.12 : Program Monitoring

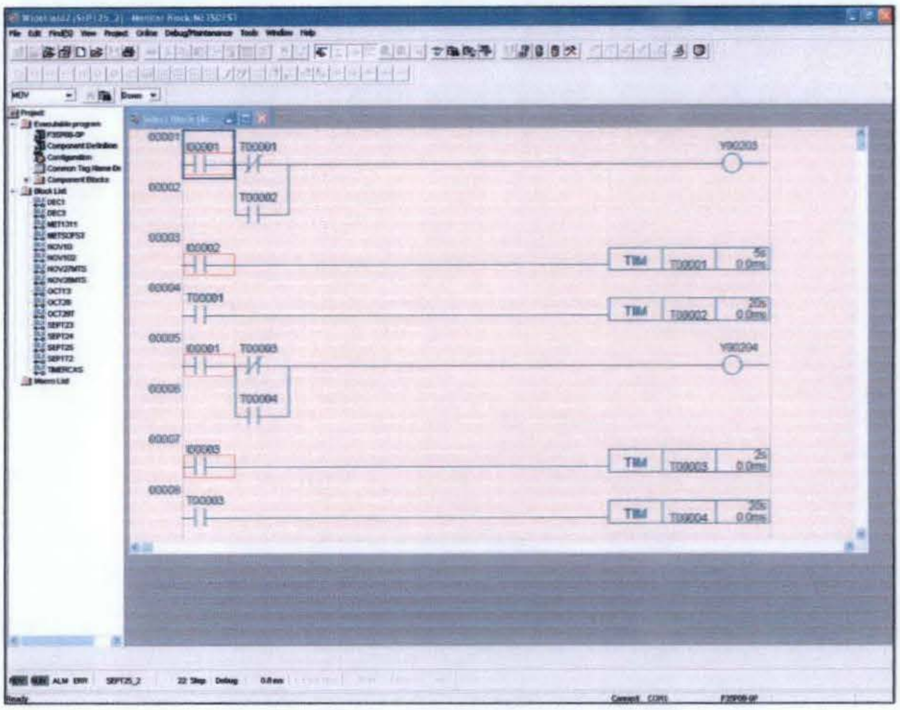


Figure 3.13 : Online Monitoring

Step 6 : Forced Set the Internal Relay, I00001 to start the Start-Up Program where the Ball and Butterfly Valves will move from fully closed to fully open. This step is important because the PST can only be done when the valves are fully opened.

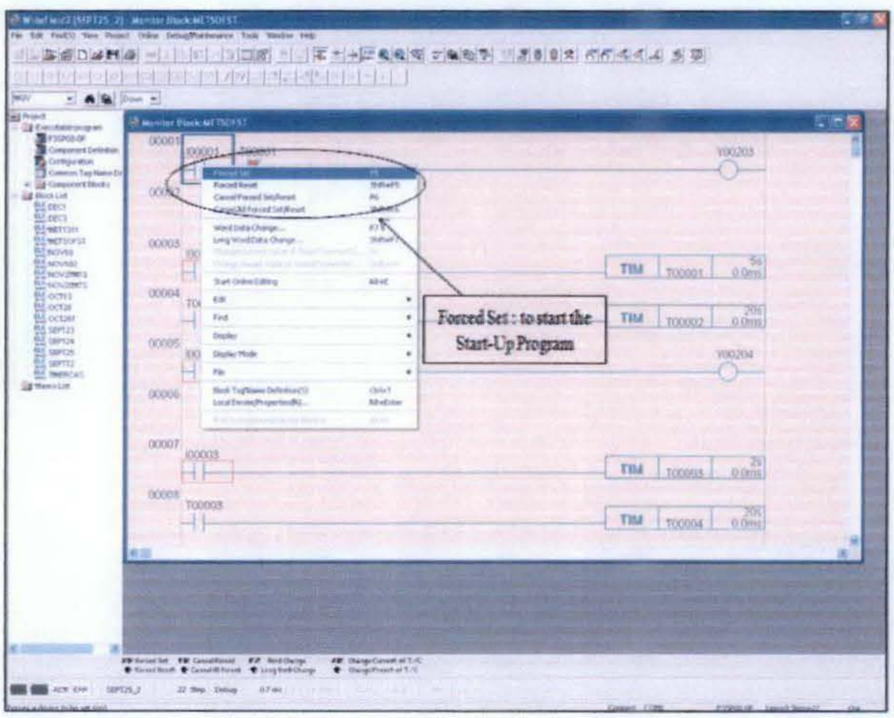


Figure 3.14: Forced Set I00001

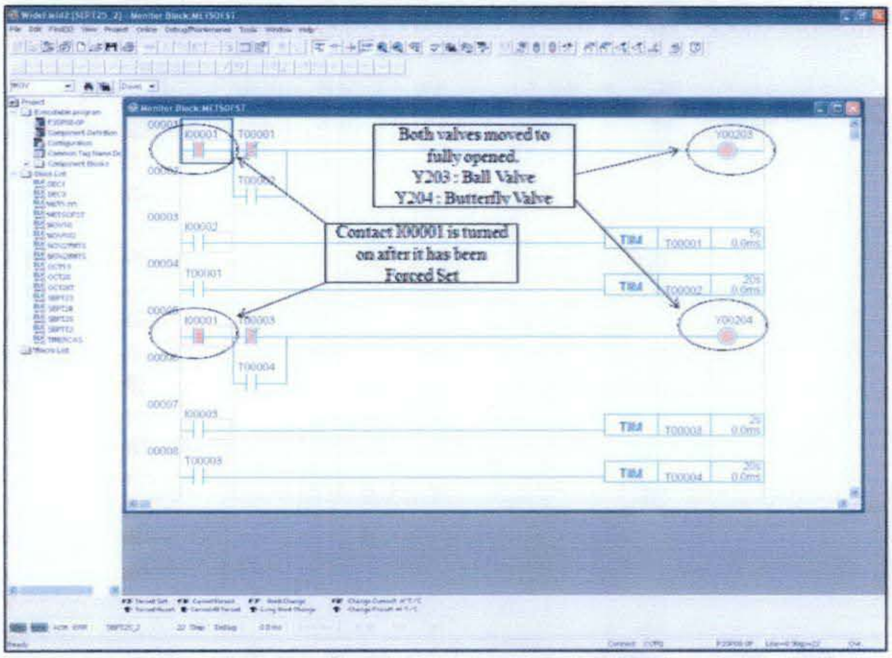


Figure 3.15: Ball and Butterfly Valves moved to fully opened position

Step 7 : Forced Set Internal Relay I00003 to do FST on the Butterfly Valve

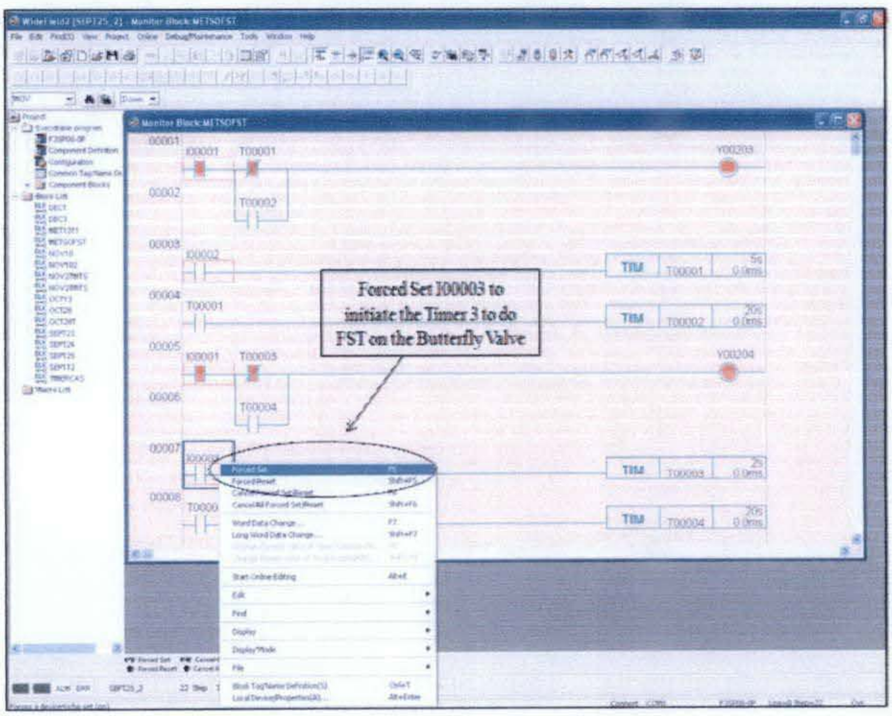


Figure 3.16: Forced Reset I00003

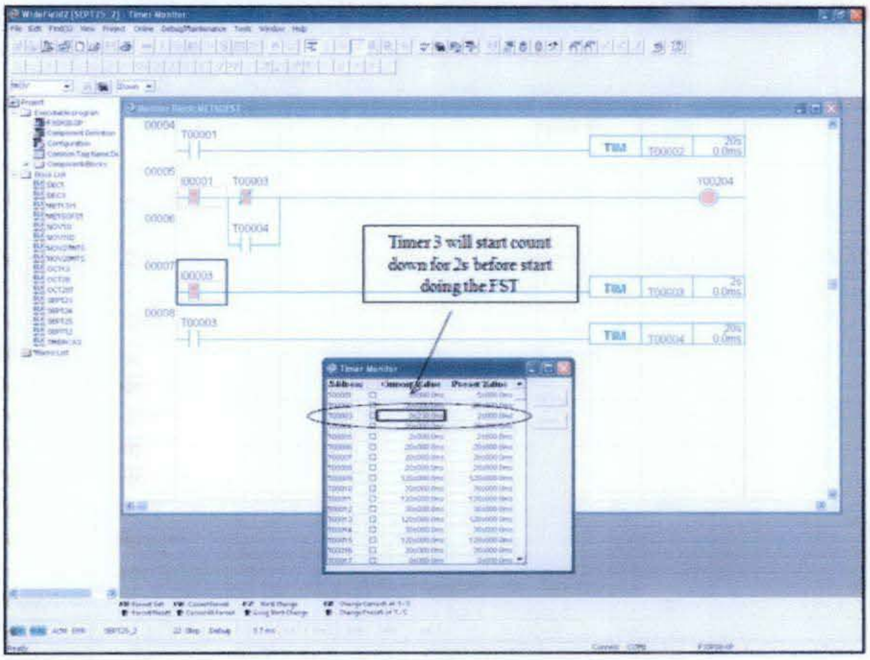


Figure 3.17: Timer 3 start to count down

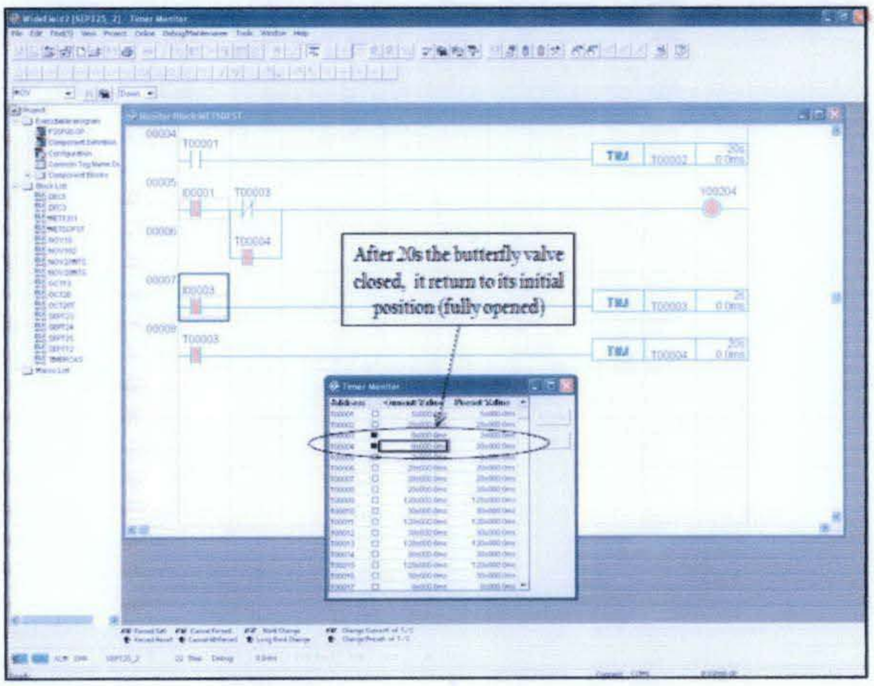


Figure 3.18: Timer 4 start to count down

Step 8: Forced Set Internal Relay I00002 to do FST on the Ball Valve

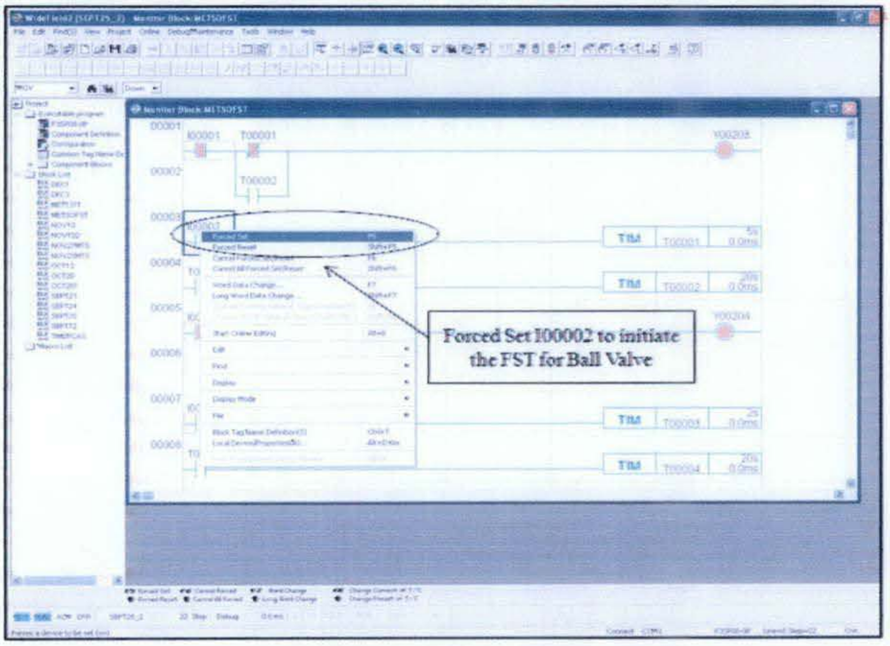


Figure 3.19: Forced Set I00002

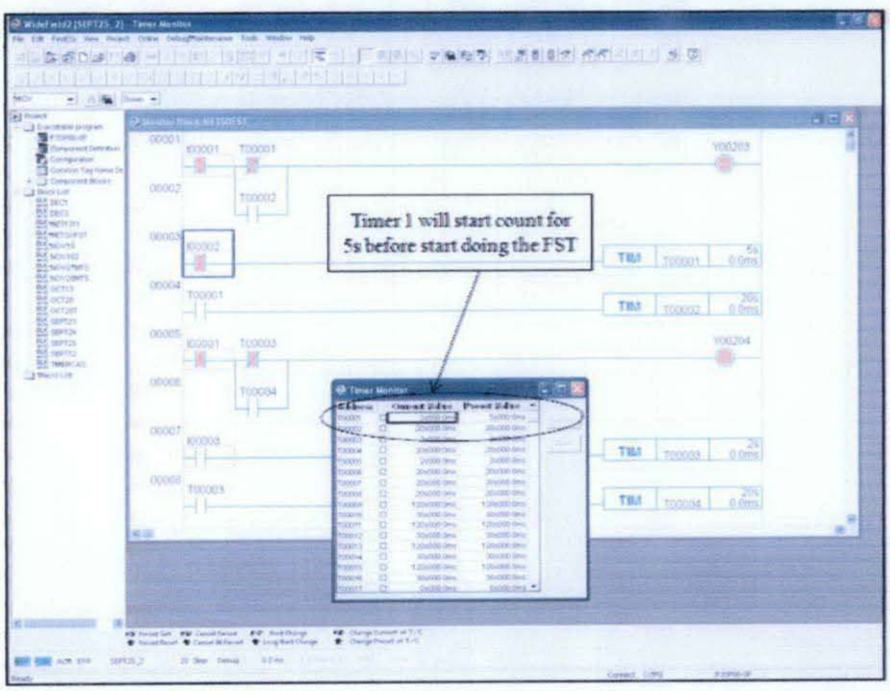


Figure 3.20: Timer 1 start to count down

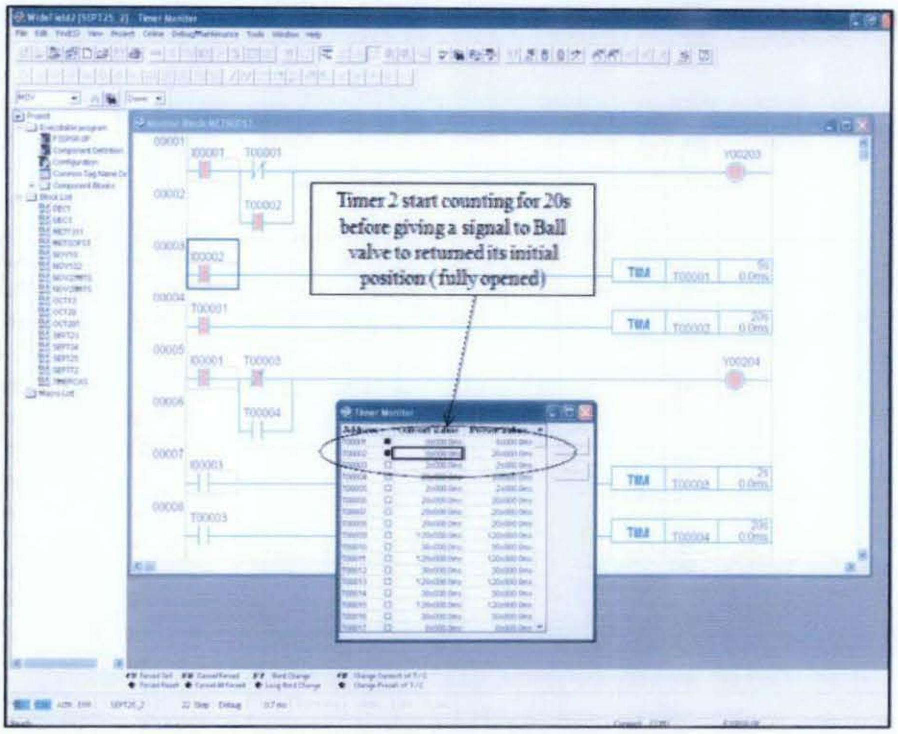


Figure 3.21: Timer 2 start to count down

3.3.4. Terminate Program

After done with the Full Stroke Testing and Partial Stroke Testing, the PLC program needs to move the valves to full closed position. Below are the steps to move the valves to full closed position and also terminate/disconnect the software from the devices.

Step 1: Forced Reset Internal Relay I00001 to move the valves (ball and butterfly valves) to fully closed.

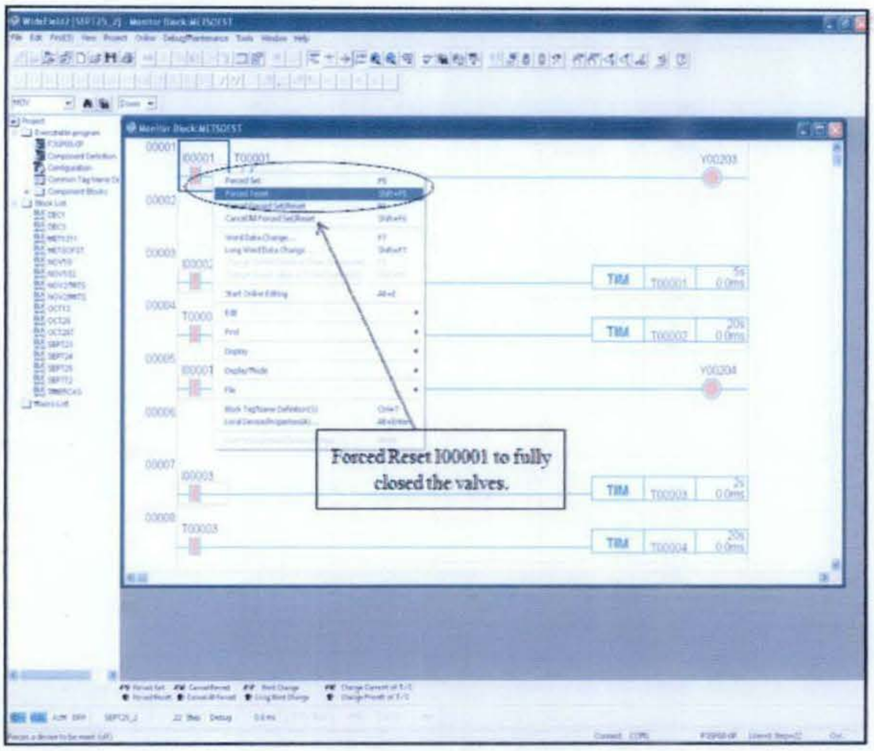


Figure 3.22: Forced Reset I00001

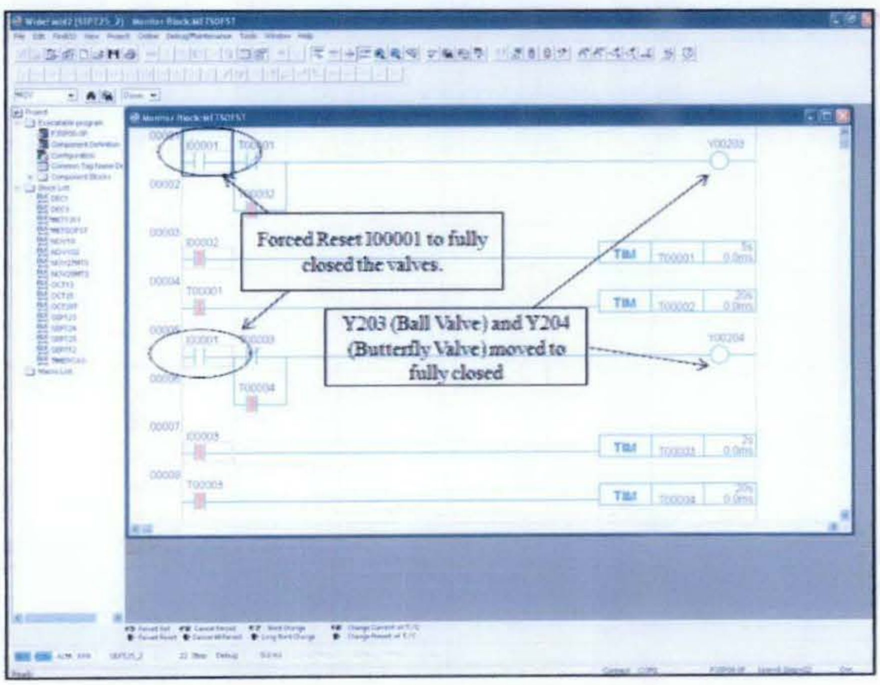


Figure 3.23: Y203 and Y204 moved to close position

Step 2: Go to " *Online* " and click on the " *Disconnect* " button. This step will disconnect the software from the devices.

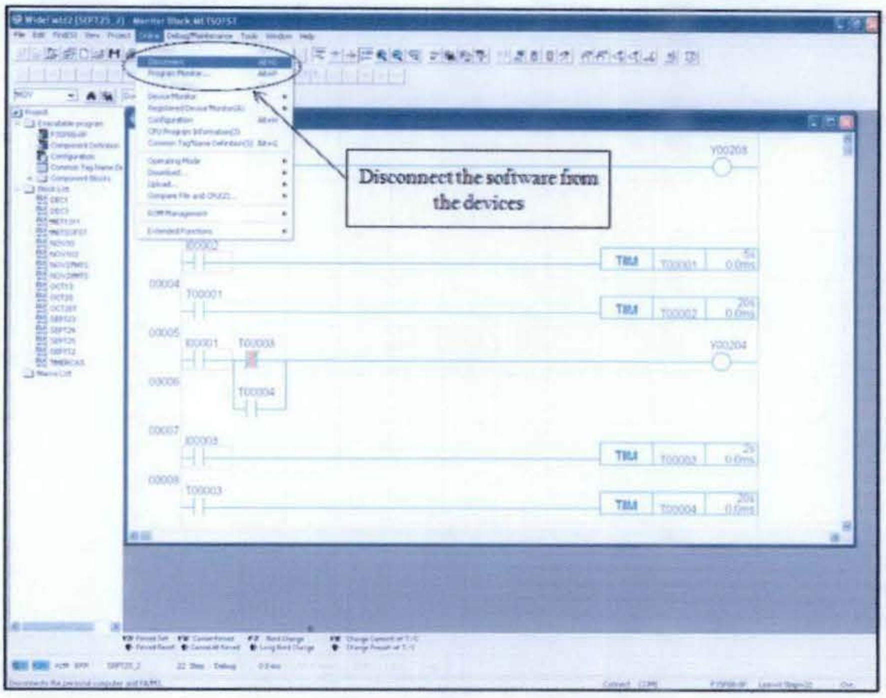


Figure 3.24: Disconnect the software

3.3.5. Summarization of the PLC Setup

• I00001	: 'I' stands for Internal Relay : Forced Set I00001 in order to change both valves from fully closed to fully opened : Used as a start-up signal for the valves
• I00002	: Internal Relay number 2 which is used for FST signal for ball valve : Forced Set I00002 to start the FST on ball valve
• I00003	: Internal Relay number 3 which is used for FST signal for butterfly valve
• Y203	: 'Y' stands for output : Y203 represent the ball valve
• Y204	: Y204 represent the butterfly valve

• T00001	: 'T' stands for Timer : T00001 is triggered by I00002 signal which will activate the timer for 5 seconds before start doing the FST (fully closed) to the ball valve
• T00002	: T00001 signal will forced set T00002 which will activate its timer for 20 seconds before sending a signal for the ball valve to move back from fully closed to fully opened condition.
• T00003	: T00003 is triggered by I00003 signal which will activate the timer for 2 seconds before start doing the FST (fully closed) to the butterfly valve
• T00004	: T00003 signal will forced set T00004 which will activate its timer for 20 seconds before sending a signal for the butterfly valve to move back from fully closed to fully opened condition

3.4. HART SERVER

In order to connect the Metso's valves with the FieldCare Software, HART server needs to be connected first. If HART server is unable to be connected, the FieldCare Software will not be able to detect any signal from the valves even though the valve is already in fully opened condition. The following is the steps to connect the HART server:

i. Open the HART server
ii. Right click the 'HART server' and click the Add Network
iii. A small window will appear and type the name as 'Metso'
iv. Right click the 'Metso' and click the 'LEARN'
v. Wait for a few seconds for the HART server to search for any available signal from the valves

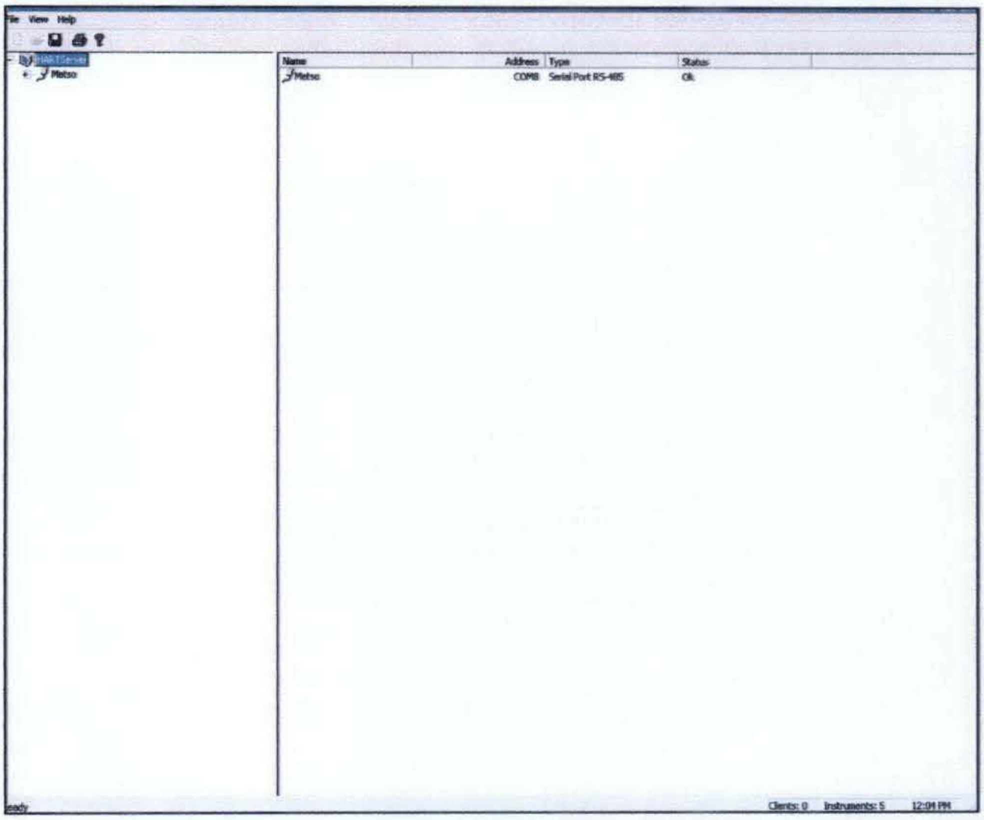


Figure 3.25: HART setting

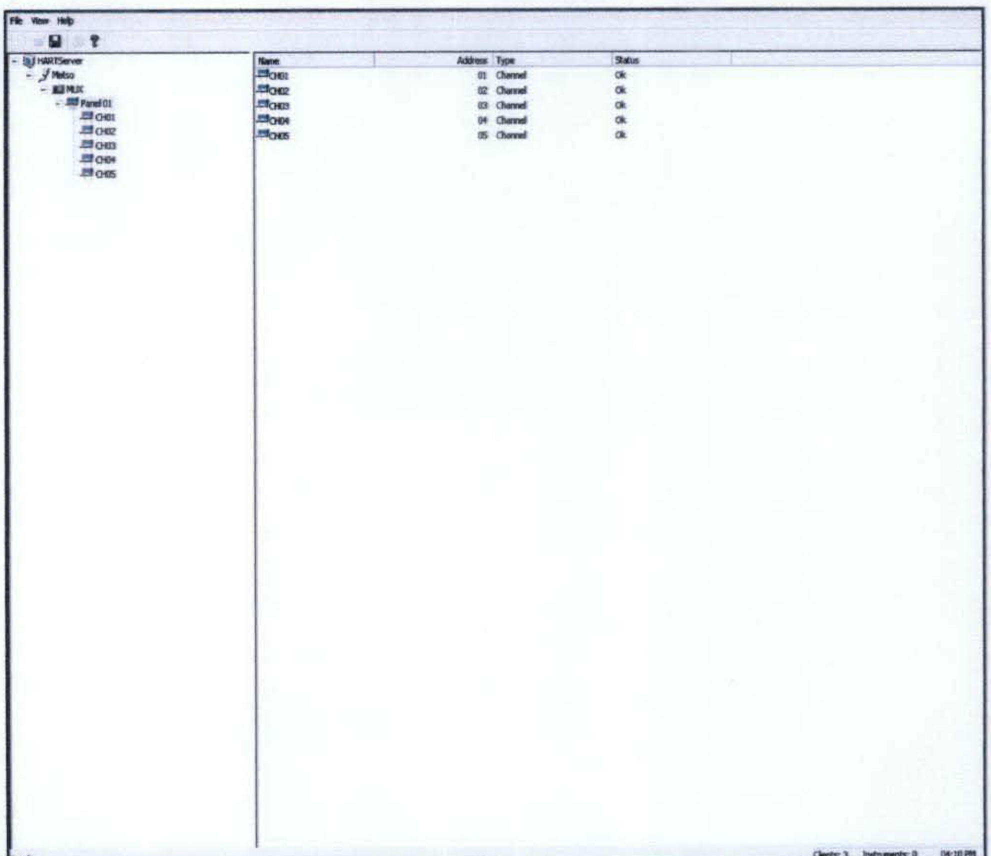


Figure 3.26: HART server detected the valves signal from the field

3.5. FIELDCARE SOFTWARE (METSO NELES'S VALVES)

Throughout this project, the Metso's software that was used for the PST operation is known as FieldCare Software. This software is a universal FDT (Field Device Tool) - based software for monitoring of intelligent field devices and is an independent of communication protocol. It can be used within a process control system or as a device management tool which consists of an FDT frame application and DTMs (Device Type Managers) and manage any device in any communication protocol as shown in Figure 3.5. Furthermore, its web-enabled interfaces allows for the information to be distributed anywhere across the user's network in real time. The software that is an embedded HART modem on the circuit board allows remote parameter settings and access to predictive maintenance system and has On-Line Monitoring to monitor the valve position, actuator cylinder pressure, circuit board temperature and valve leakage. FieldCare has the ability to browse and store data makes prediction of device condition extremely accurate and also provides real-time information under operational process conditions. The online data flow from all devices is visualized through an innovative colour-coded alert system and a series of selective alarms which provides a clear view of process performance and allows early, easy problem recognition as shown in Figure 3.27.

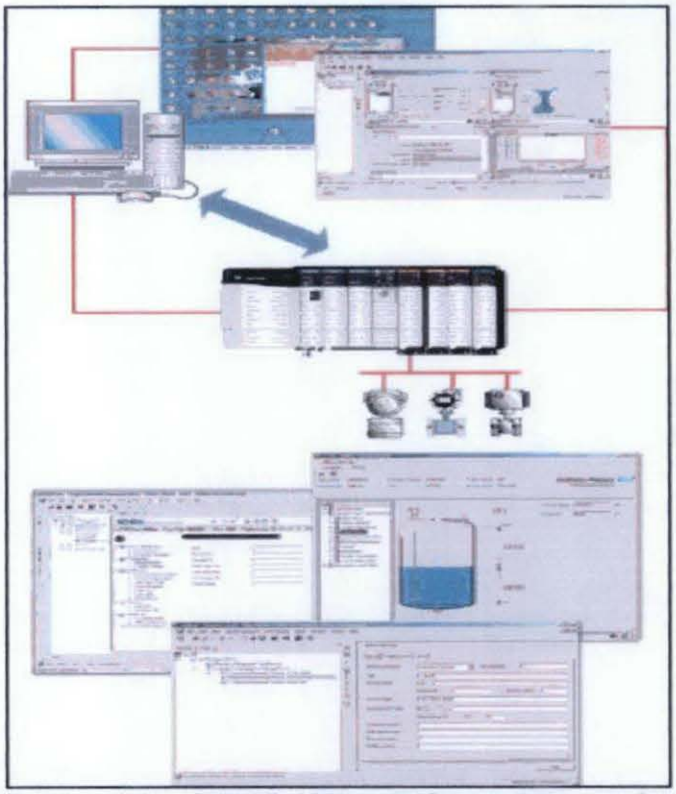


Figure 3.27: Overview of the FieldCare Software (source taken from SA Instrumentation & control – The official Journal of the SAIMC – issue date – June 2007)

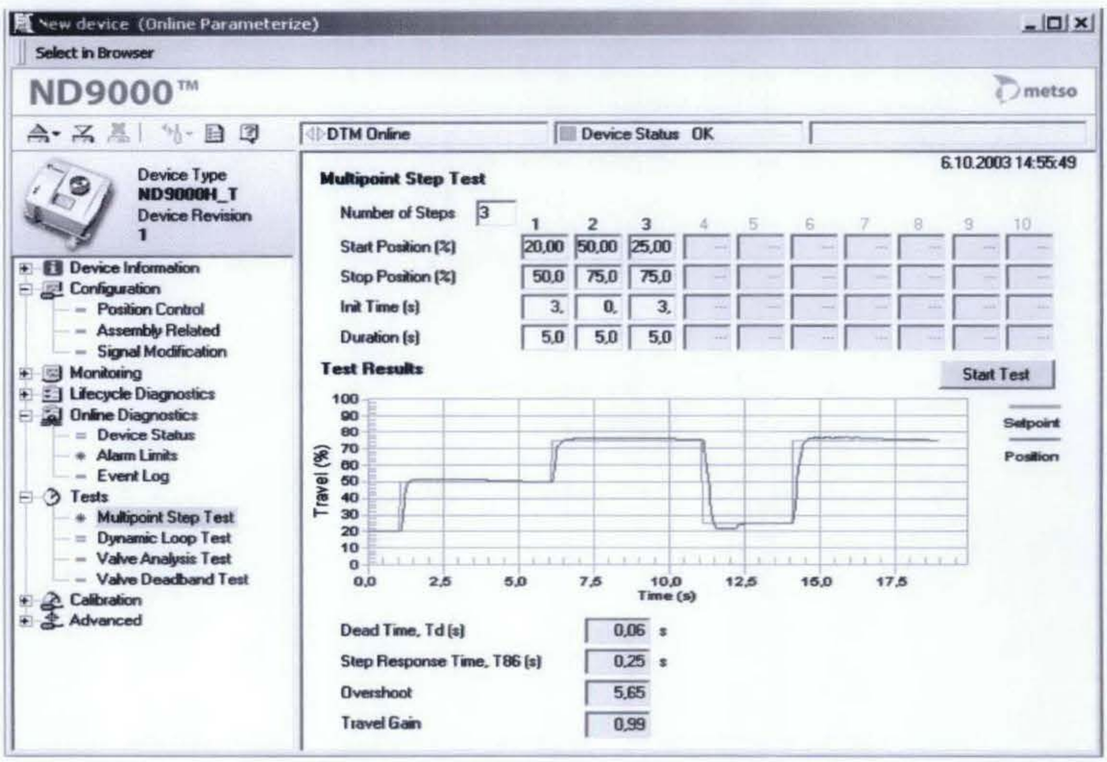


Figure 3.28: Online Data Flow

3.5.1. Condition Monitoring

FieldCare's Condition Monitoring will automatically polls device status information and immediately sends alerts to users when potential problem occurs before it disturb processes. Device status can be OK, alert, warning, or not known, and any of those can be shown in real time. The real-time data from real processes alert system, thus providing a clear view of performance. Condition Monitoring uses a web-enabled interface that allows the information to be shown anywhere for anybody across the user's network in real time. Alerts and warnings can also be e-mailed to other authorized persons.

3.5.2. FieldCare Connection

After the HART server has been connected, the FieldCare Software will be able to detect the valves and before doing the PST there are several setting need to be done. The setting is as follow:

i. Right click on the HART and click on the 'HART OPC Client'
ii. Right click on the HART OPC Client and click on the 'Add Network'
iii. All the devices that have been detected by HART Server will be connected to the FieldCare Software
iv. Right click on the 'VG800' device and select 'connect'. VG800 represent the Metso's Ball Valve. After it has been connected, double click VG800 and a window of VG800 will appear.
v. Right click on the 'VG800(1)' device and select 'connect'. VG800(1) represent the Metso's Butterfly Valve. After it has been connected, double click VG800(1) and a window of VG800(1) will appear.

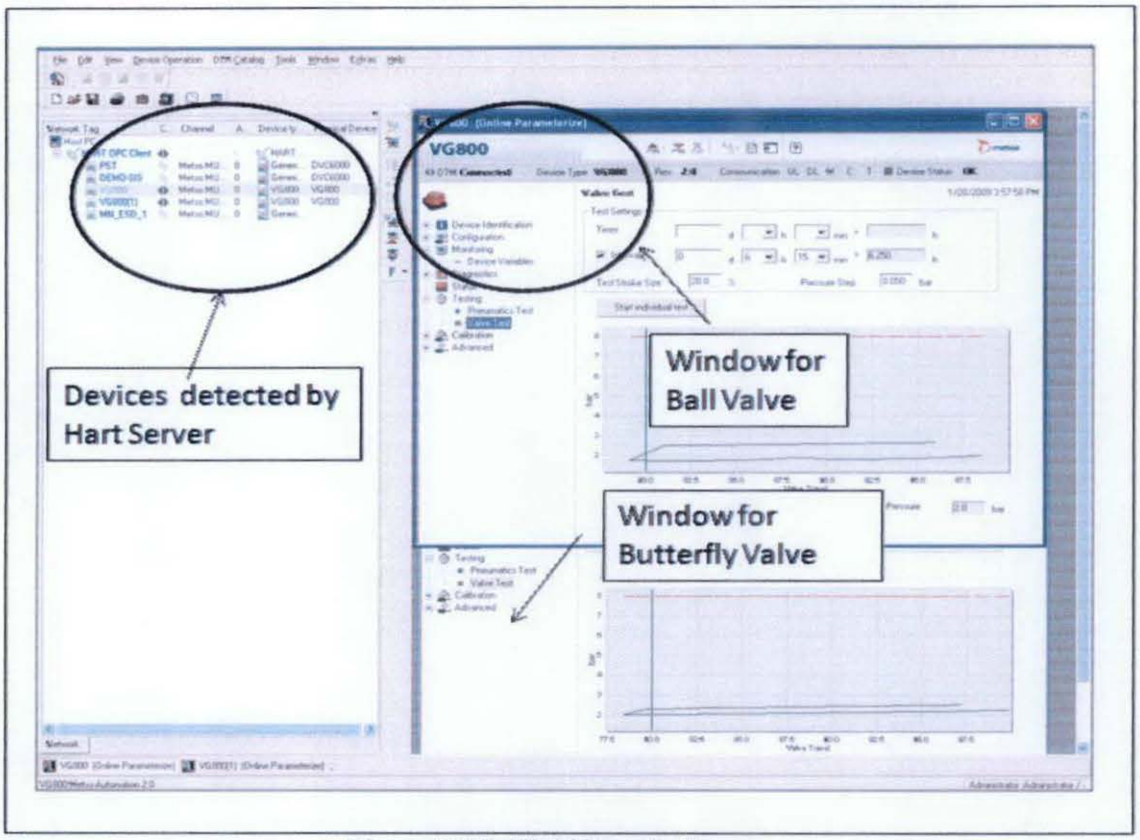


Figure 3.29: FieldCare Software

CHAPTER 4

RESULT & DISCUSSION

4.1. RESULT

During the early stage of the project, PETRONAS decided to do testing simultaneously for all valves by following the schedule that has been agreed before. However, after the HART Communication device has been installed as shown in Figure 1.4, the team is still having problem to communicate each valve from different vendors. Therefore, the Truth Table and the Schedule of the Valves Stroke in the previous report is inapplicable in this project. Moreover, the PETRONAS has asked the team to do separate testing for each vendor due to the matter arises. At this moment, the team has already started doing the testing on each valve. The criteria of the requirement are still the same which are as below:

- 6 times PST and 1 times FST daily, where the FST must be done simultaneously with any of the 6 times of PST
- Testing must be done at minimum of 90 days or 540 strokes

Up until now, Metso Neles valves have been tested for 42 days. However in this report, only the first fifth teen days will be included, the rest will be discussed in the next report. The interval time between the strokes has been set to 15 minutes as shown in Figure 4.1.

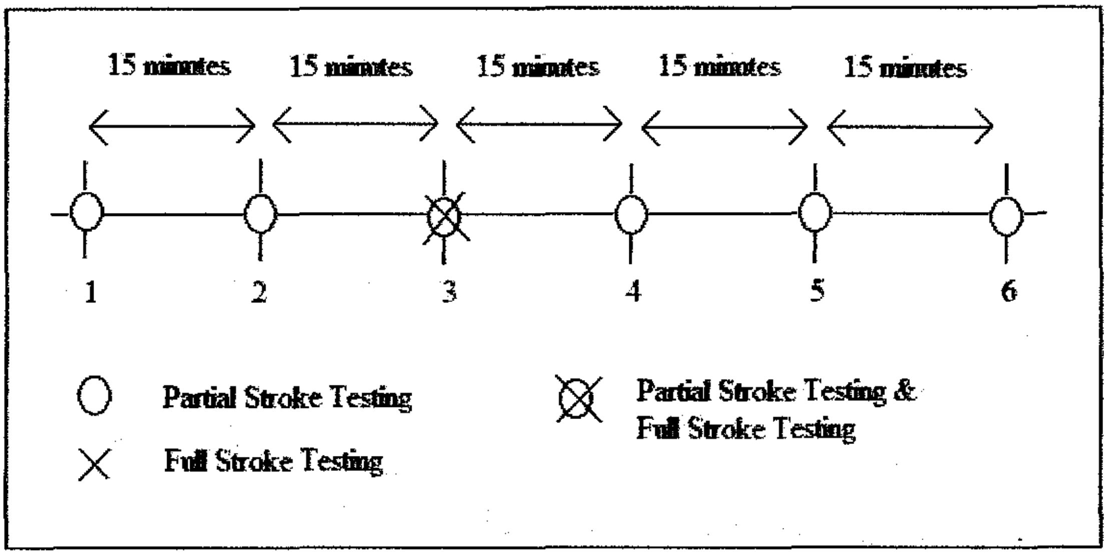


Figure 4.1: Interval time of 15 minutes between each stroke for both Ball and Butterfly valves

4.2. DEVICE CONFIGURATION

Table 4.1: Ball Valve Specification:

Positioner Information			
Device Type	VG800	Manufacturer	Metso Automation
Device ID	1410103	SW Revision	2
HW Revision	1	Final Assembly Number	0
Device Serial Number	2008-02-9300	Position Sensor Serial Number	834550
General			
Power-up Mode	Automatic		
Device Keyboard	Enabled		
Assembly Related			
Valve Acting Type	Rotary		
Rotation Direction to Fail Safe	Clockwise		
Fail Safe Action	Close		

Table 4.2: Butterfly Valve Specification:

Positioner Information			
Device Type	VG800	Manufacturer	Metso Automation
Device ID	1410066	SW Revision	2
HW Revision	1	Final Assembly Number	0
Device Serial Number	2007-50-9201	Position Sensor Serial Number	834561
General			
Power-up Mode	Automatic		
Device Keyboard	Enabled		
Assembly Related			
Valve Acting Type	Rotary		
Rotation Direction to Fail Safe	Clockwise		
Fail Safe Action	Close		

Table 4.3: Device Alert Settings

	Ball Valve	Butterfly Valve
Test Timeout (s)	90.0	90.0
Test Warning Time (s)	2.0	2.0
Position Error Tolerance (%)	10.0	10.0
Supply Pressure HIGH Alarm Limit	7.5 barG	7.5 barG
Supply Pressure LOW Alarm Limit	3 barG	3 barG
Pressure Peak	0 barG	0 barG
Pressure Peak Tolerance (%)	30.0	30.0
Pressure Recovery Time (s)	5.0	5.0
Valve Test Pressure Low Limit	0 barG	0 barG

Table 4.4: Statistical Alert Settings

	Ball Valve	Butterfly Valve
Load Factor Limit HIGH	100	100
Load Factor Limit LOW	0	0
Breakaway Pressure Limit HIGH	8 bar	8 bar
Breakaway Pressure Limit LOW	0 bar	0 bar
Leakage Alarm Limit (mV)	3200	3200
Valve Test No. Limit	1,000 000	1,000 000
Pneumatics Test No. Limit	1,000 000	1,000 000

Table 4.5: Valve Test

	Ball Valve	Butterfly Valve
Valve Test Interval	0.25	0.25
Test Stroke Size	20%	20%
Pressure Step	0.05 bar	0.05 bar

4.3. TESTING RESULTS

Based on the result obtained from the testing, there are five elements that need be emphasized. The five elements of results are based on two constants parameter which are:

- Valve Travel : 20 %
- Pressure Step: 0.05bar

The five elements are:

- Valve Testing Graph (PST)
- Partial Stroke Testing collide with Full Stroke Testing
- Pneumatic Test
- Breakaway Pressure
- Load Factor

4.3.1. Valve Test Result of Partial Stroke Testing

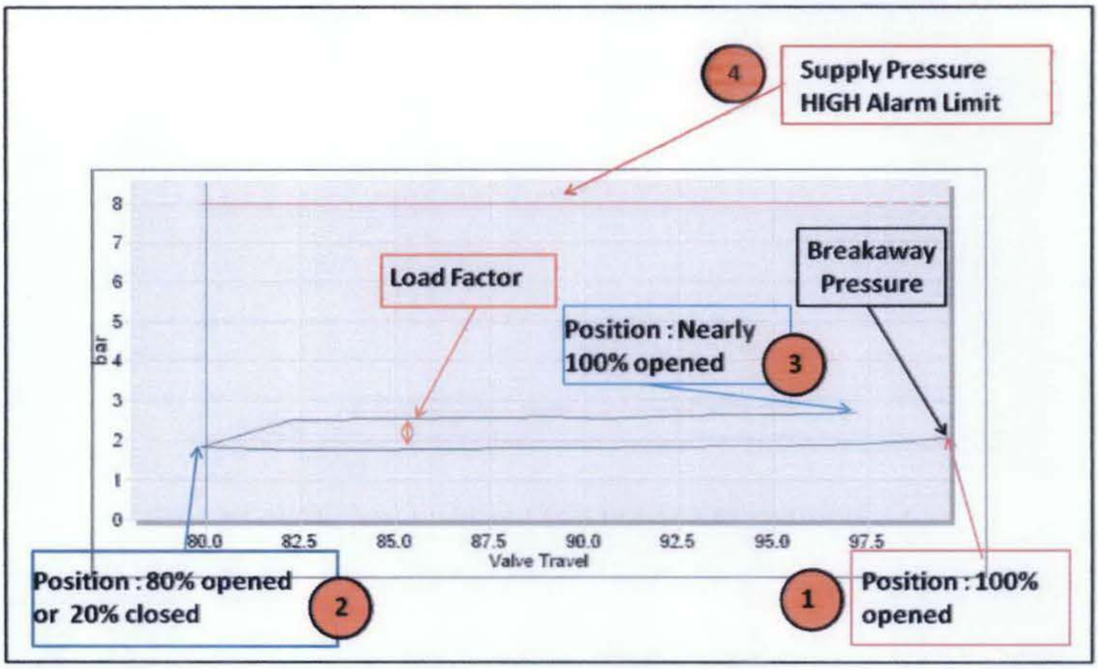


Figure 4.2 : Valve Test Result

1. Position where the valve start doing the PST, in other words, position where the valve moved from 100% opened to 80% opened (20% closed).
2. Position where the valve already reached 80% opened.
3. Position where the valve moved back to its initial position which is 100% opened.
4. Maximum air pressure that is allowable in the testing.

*Note: *Load Factor* and *Breakaway Pressure* will be discussed in the next part.

4.3.2. Partial Stroke Testing Collide With Full Stroke Testing

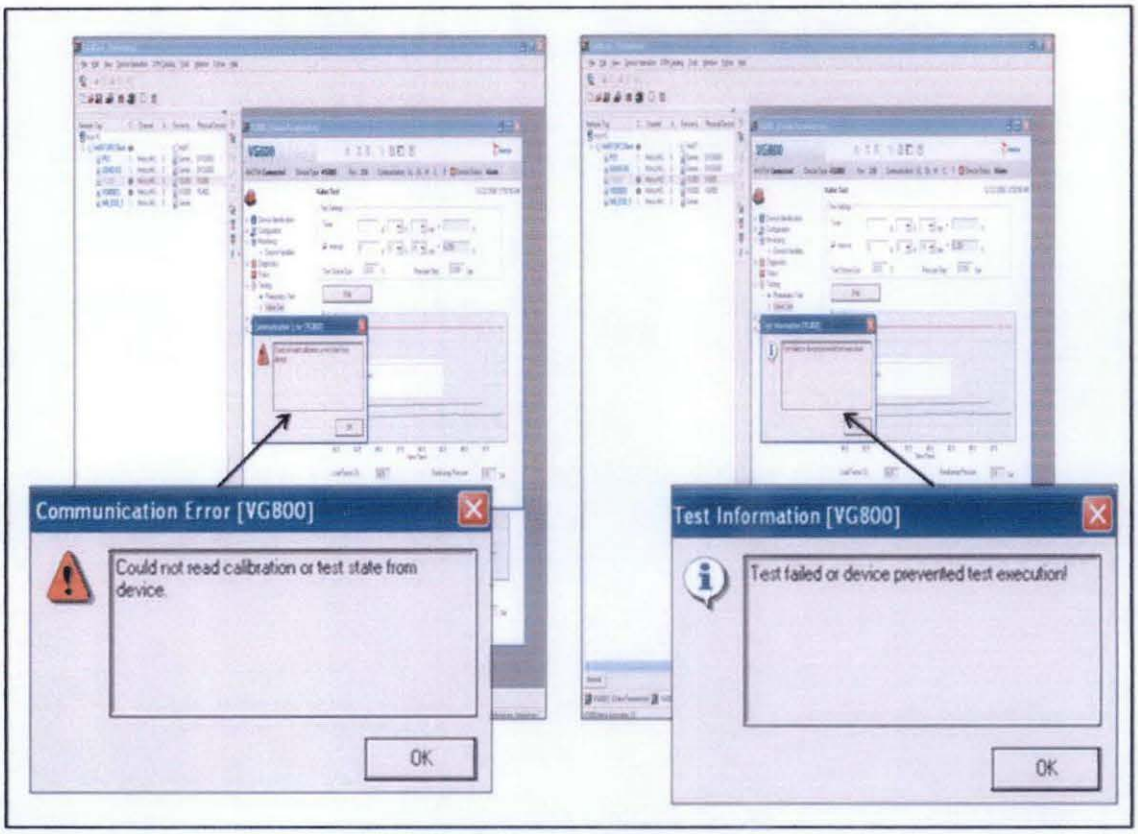


Figure 4.3: PST collide with FST errors

The result expected by PETRONAS for this testing is that the full stroke testing should override partial stroke testing command. Based on the result obtained from the testing, the ball valve and butterfly valve followed the FST command and ignored the PST command. This means that the valves that supposed to move to 80% opened position have moved to fully closed position right after they received the FST signal. The reason why the FST needs to override the PST command is because if the plant at that particular time is doing the PST and suddenly they received an emergency signal and need to shut down the plant, therefore they need to send a FST signal. If the ESD valves do not obey the FST command and still continue doing the PST, it means that the plant's operation cannot be stopped. Due to this matter, the plant will be having a very serious problem that may lead to the unwanted situation to occur.

4.3.3. Pneumatic Test

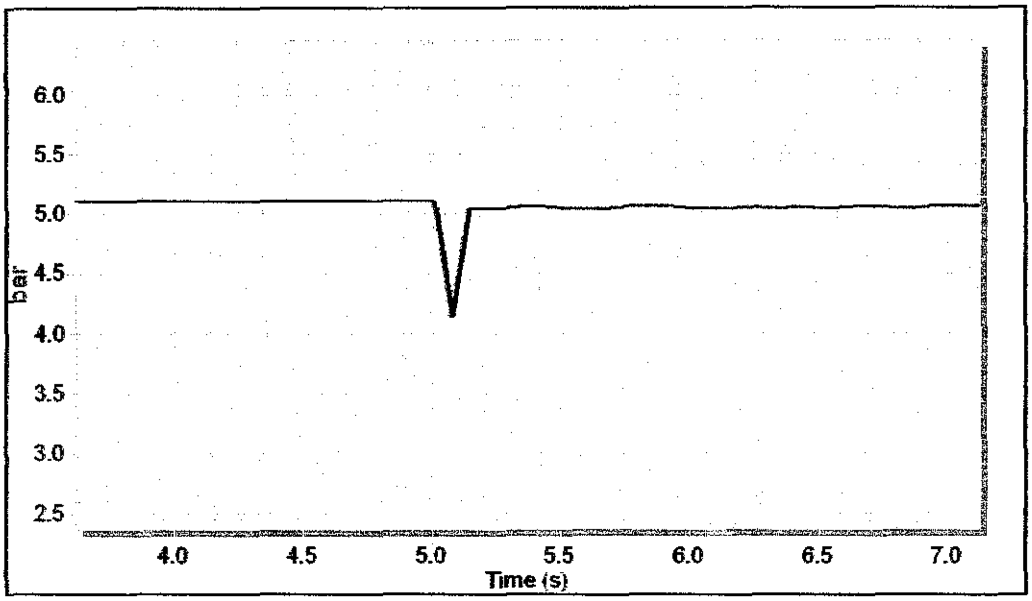


Figure 4.4: Pneumatic Test Result

Pneumatic test is conducted to test the valve sensitivity of the build in solenoid valve in the ValvGuard. In this test, only the spool valve is moved to test not only the pneumatics but also the electronics of the ValvGuard. This test can be run very frequently without affecting the process, where in this case, the pneumatic test was done right after the PST for every stroked.

4.3.4. Breakaway Pressure

Breakaway pressure shows the pressure level at which the valve starts to move in a valve test over total valve operation. The breakaway pressure value can be obtained using the valve test graph as shown in Figure 4.2. The information that is given by the breakaway pressure graph as shown in Figure 4.5 for the ball valve and Figure 4.6 for the butterfly valve are about the condition of the valves whether the valve is still good or need to be replaced. The breakaway pressure graphs is from Day 1 until Day 54.

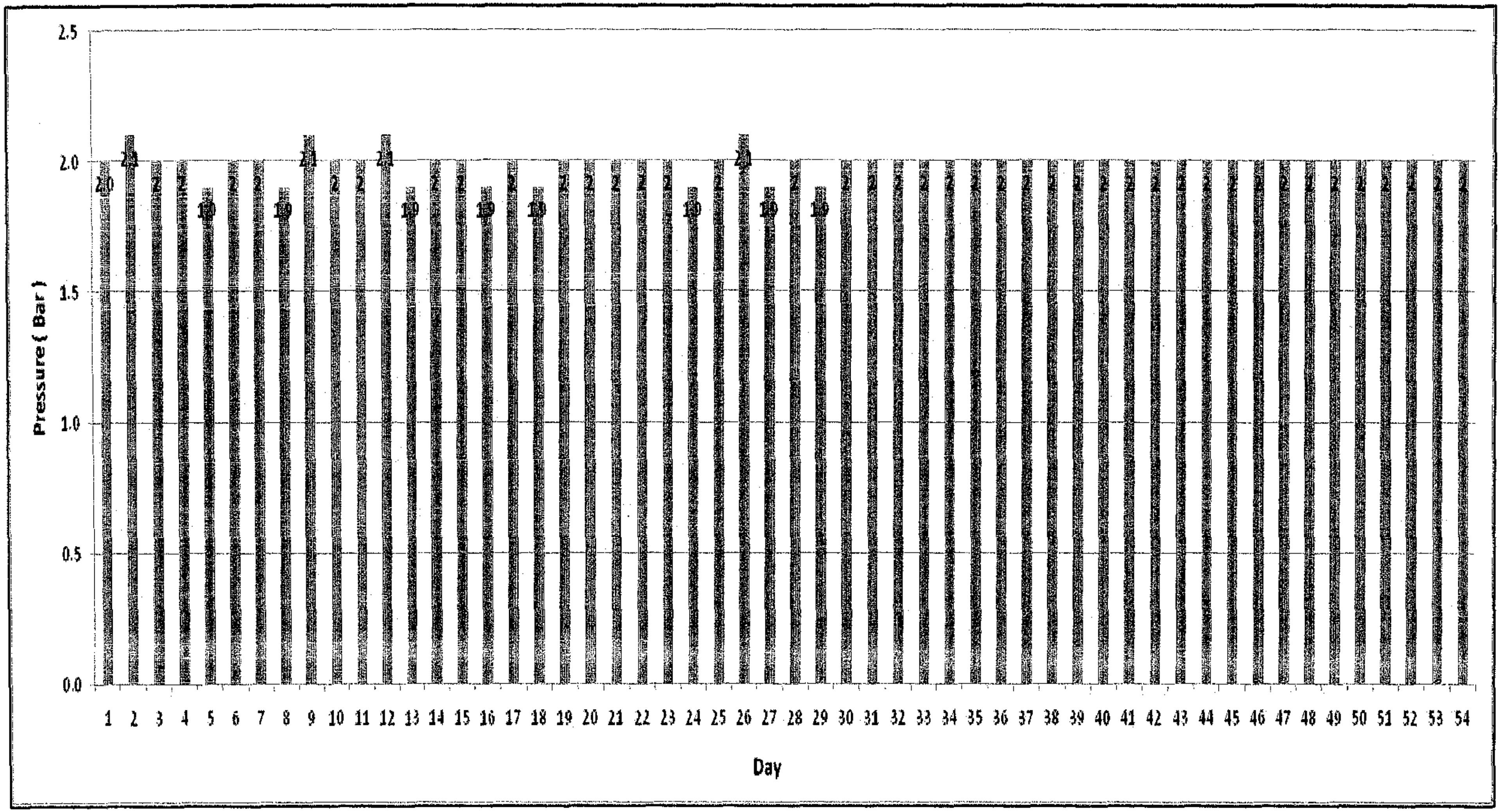


Figure 4.5: Breakaway Pressure for Ball Valve

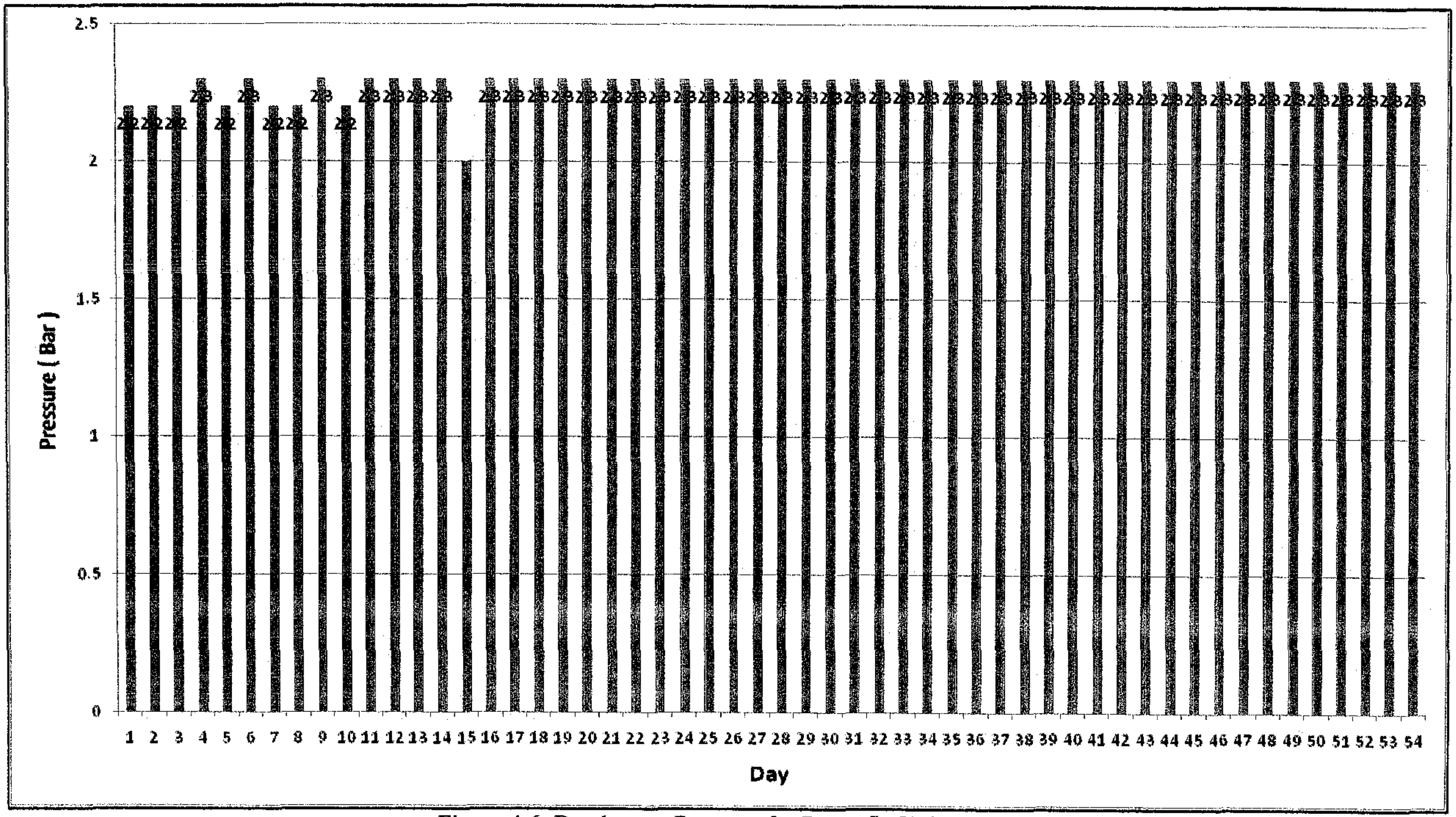


Figure 4.6: Breakaway Pressure for Butterfly Valve

4.3.5. Load Factor

The load factor indicates the changes in friction of the valve. A high load friction value means increased friction due to an undersized actuator.

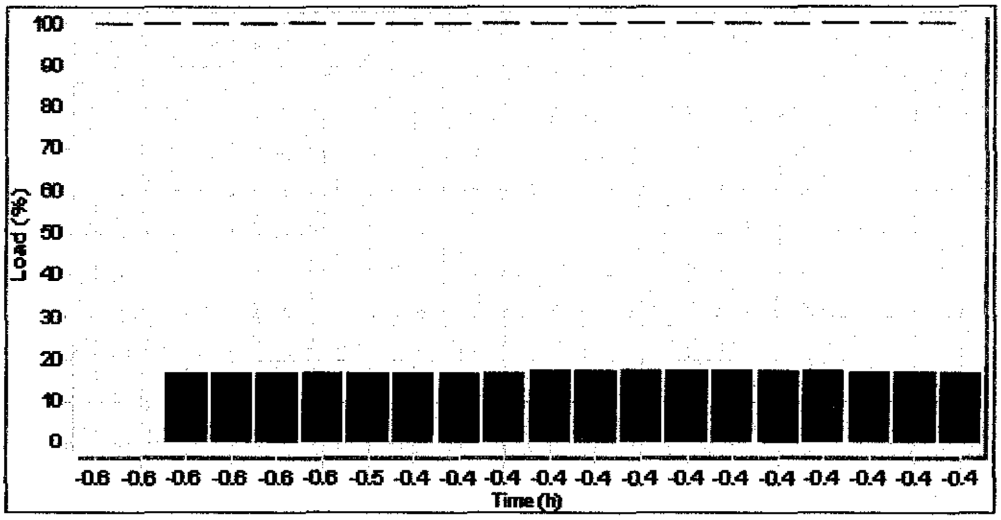


Figure 4.7: Load Factor for Ball Valve

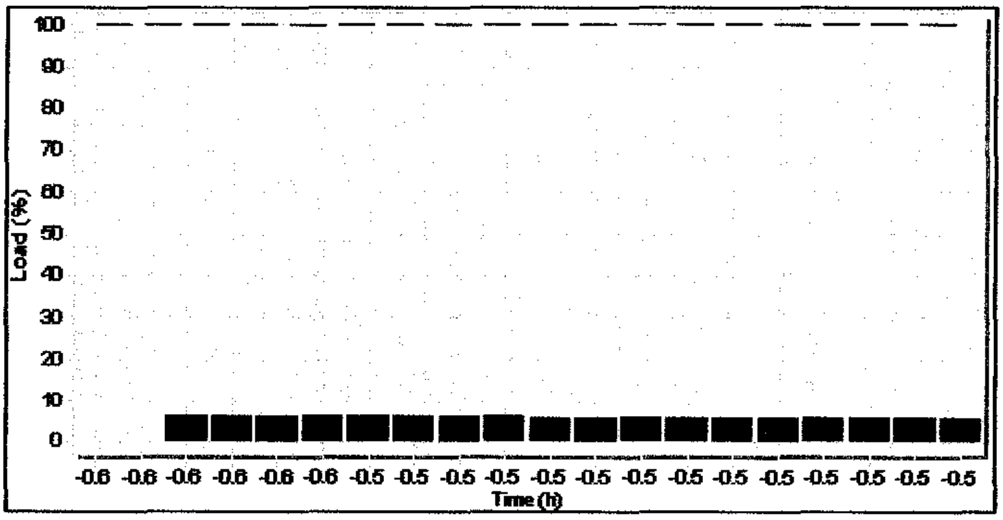


Figure 4.8: Load Factor for Butterfly Valve

TESTING DAY 1 **DATE: DEC 22nd , 2008**

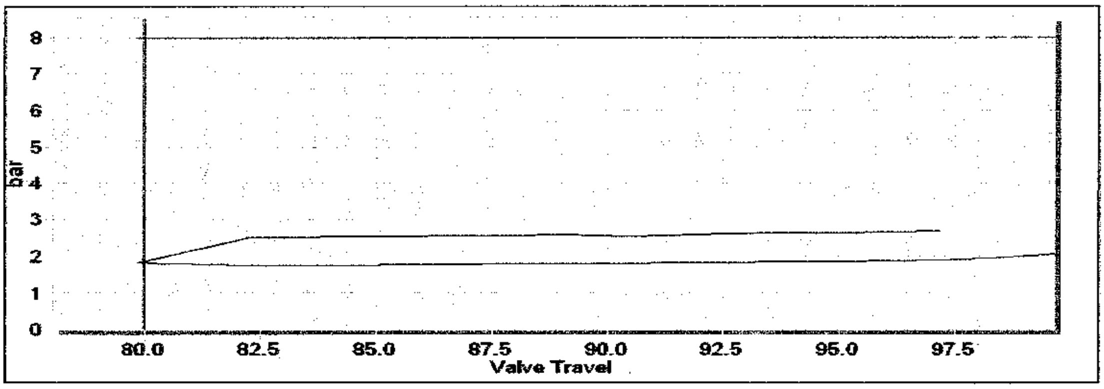
Valve : **Ball Valve**

Time: 10.20 – 11.35 am

Testing Criteria:

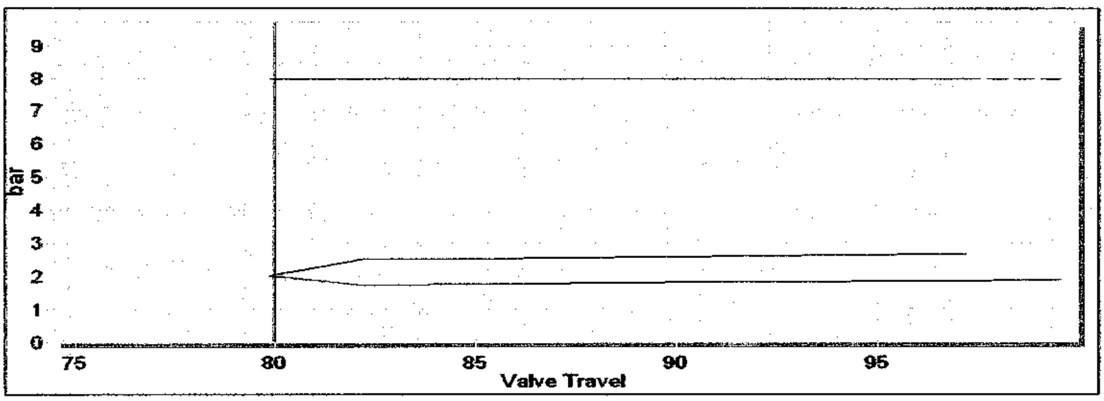
i) Valve Travel = **20%** ii) Pressure Step = **0.05bar**

1st Stroked:



The first PST was started at 10.20 am. The ball valve responded to the FieldCare Software instruction which the ball valve needs to be exactly stroked at 80% of its opening (which means 20% of valve opening is closed). The valve started to move when the pressure supplied to it dropped to 2.1 bars. This value also represents the breakaway value as explained earlier. After a few seconds the ball returned to its initial condition which is fully opened. During the first stroke testing, there is no error occur.

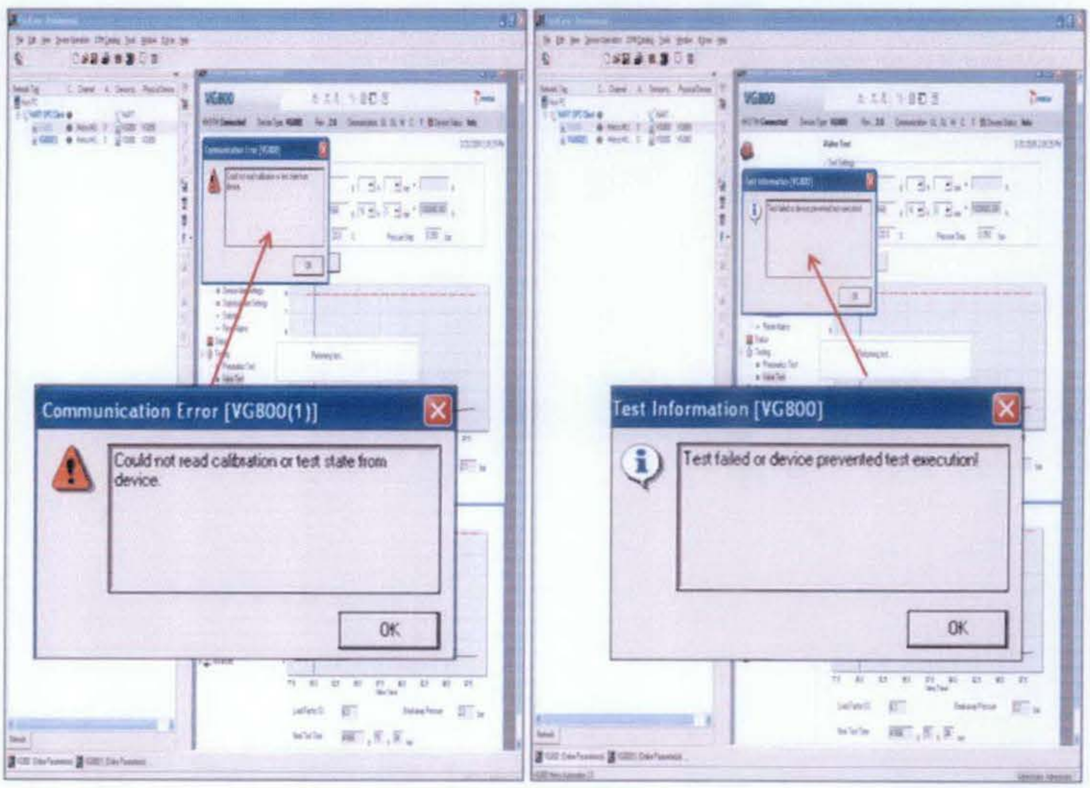
2nd Partial Stroke Testing :



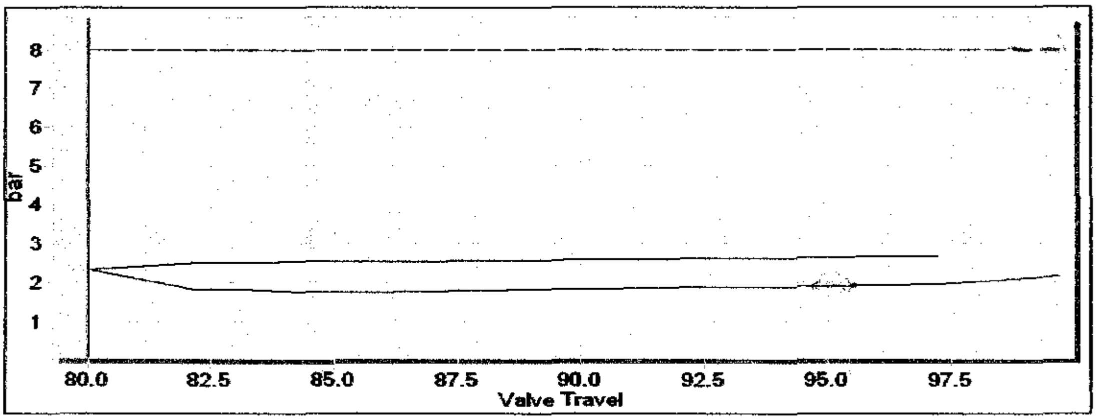
Since the setting in the FieldCare Software has been set to do PST with the interval period of 15 minutes, the second PST was done automatically 15 minutes later after the first stroked was done which is at 10.35 am. The respond was the same with the first PST. The breakaway pressure occurred at 1.9 bar and the valve started to do PST on its own. No error occurred during this stroked.

<u>3rd Partial Stroke Testing + Full Stroke Testing :</u>

At first, the ball valve received signal from the FieldCare Software and start doing the PST. In the middle of the PST execution, the valve received signal from PLC to do FST at that particular time. Based on the observation obtained, the valve followed the PLC command and started to do FST which means that it ignored the command given by the FieldCare Software. When the valve failed to respond to the FieldCare Software command, 2 windows error appeared. Below are the errors showed by the FieldCare Software at the moment the valve started to do FST.

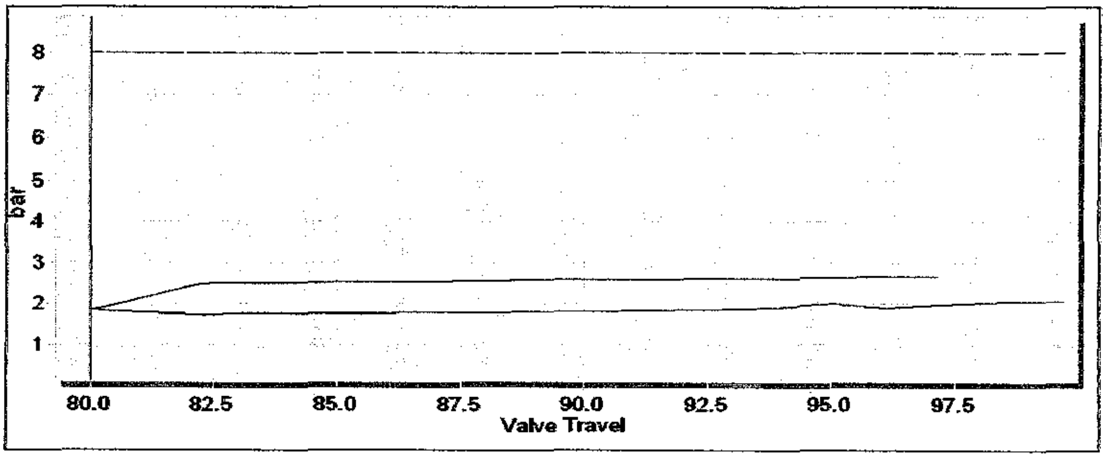


4th Partial Stroke Testing :



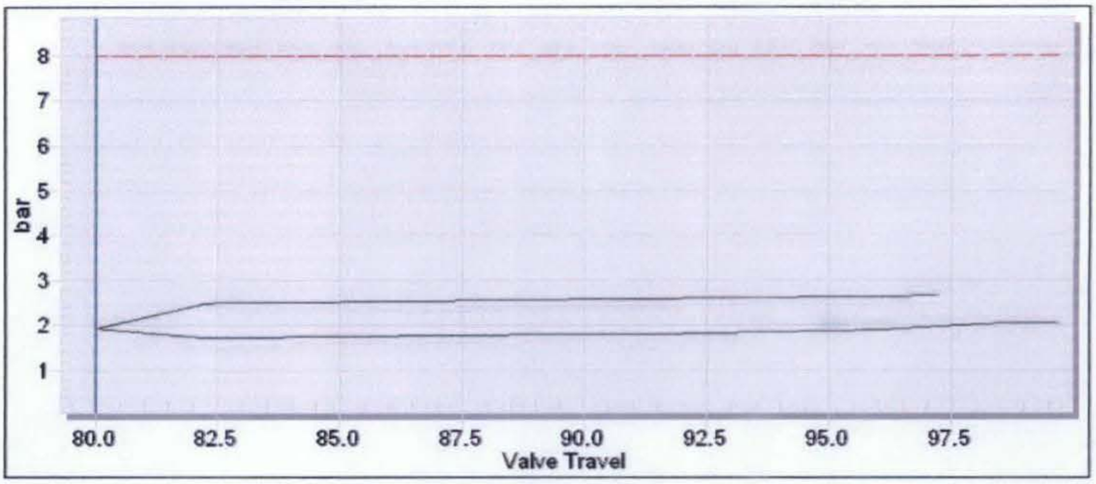
After the ball valve finished with the FST, the valve returned to its normal position which is fully opened. 15 minutes later, the valve began to do the 4th PST. The respond was the same with the first and second stroked of PST. No error occurs during the fourth stroke.

5th Partial Stroke Testing :



The fifth PST responded the same with the previous PST.

6th Partial Stroke Testing :



For the final PST, the valve also responded the same with the previous tests.

Since the results obtained from day 1 until day 55 are almost the same, therefore, the explanations are also the same as above. The results for day 1 until day 55 can be referred to Appendix I.

TESTING DAY 1 **DATE: DEC 22nd, 2008**

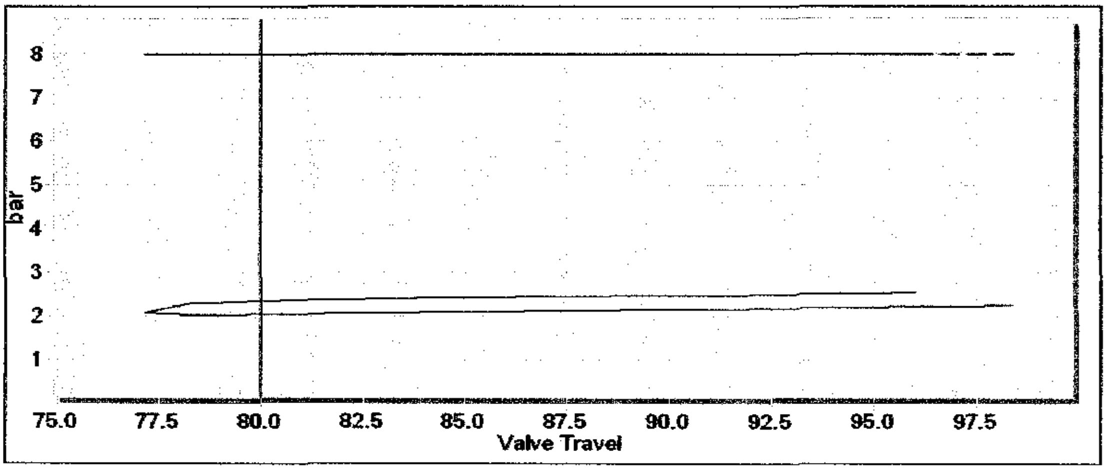
Valve: **Butterfly Valve**

Time : 10.20 – 11.35 a.m.

Testing Criteria:

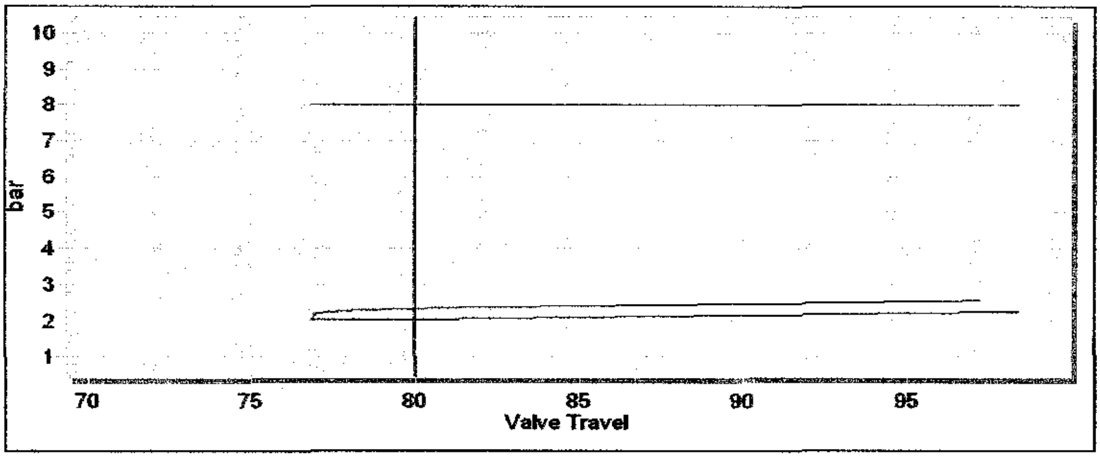
i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

1st Stroked:



The first PST started at 10.20 am. The butterfly valve responded to the FieldCare Software instruction which the butterfly valve needs to be exactly stroked at 80% of its opening. After a few seconds the butterfly valve returned to its initial position which is fully opened. No error occurs during the testing.

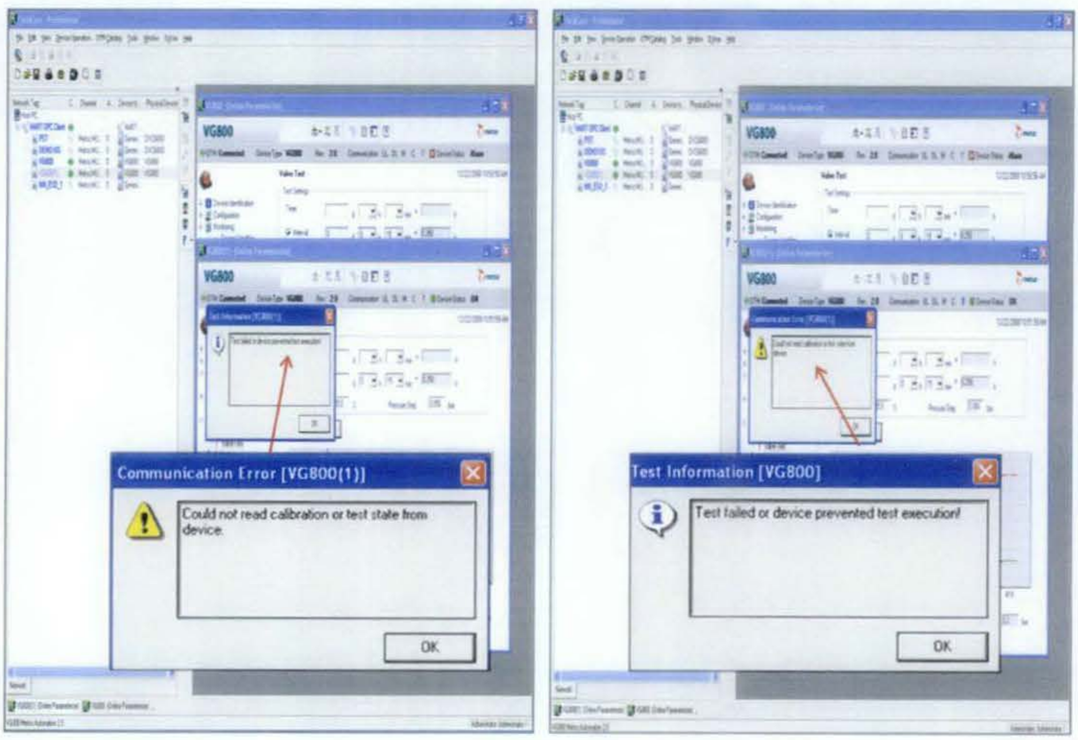
2nd Stroked:



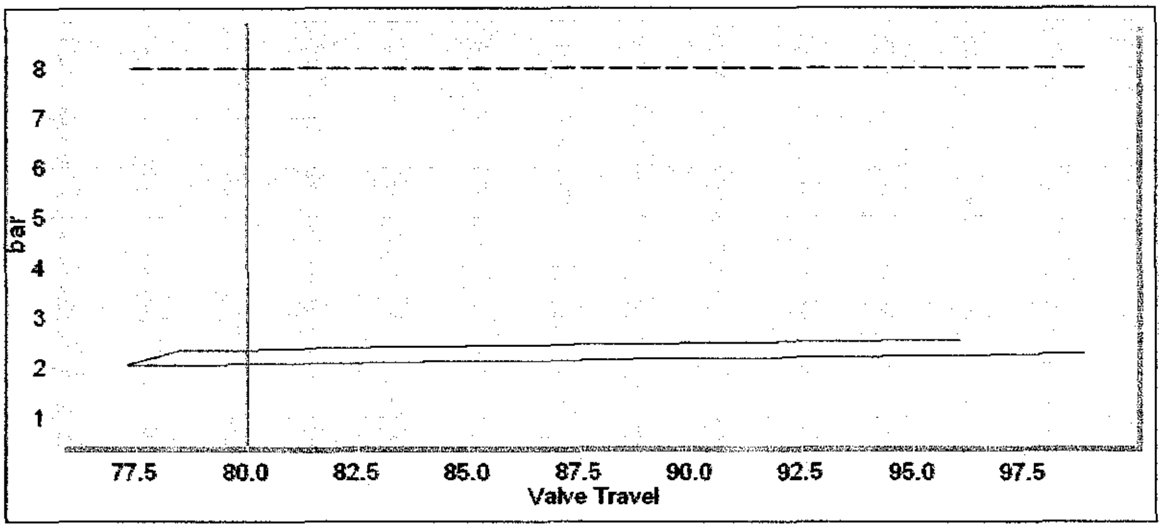
Since the setting at the FieldCare Software has been set to do PST with the interval time of 15 minutes, the second PST was done automatically after the next 15 minutes which is 10.35 am. The respond was the same with the first PST.

3^{rd} Partial Stroke Testing + Full Stroke Testing :

First, butterfly valve received command from FieldCare Software to do PST and after a few seconds the valve started to move, it receive another command from PLC to do FST. As a result, the butterfly valve followed the FST command and ignored the PST command, in other words, FST override PST command. The valve started to move to fully closed position for a few seconds before moving back to its initial position. The FieldCare Software then showed two error statuses which are the same error status as the ball valve. The errors are shown in the following figure.

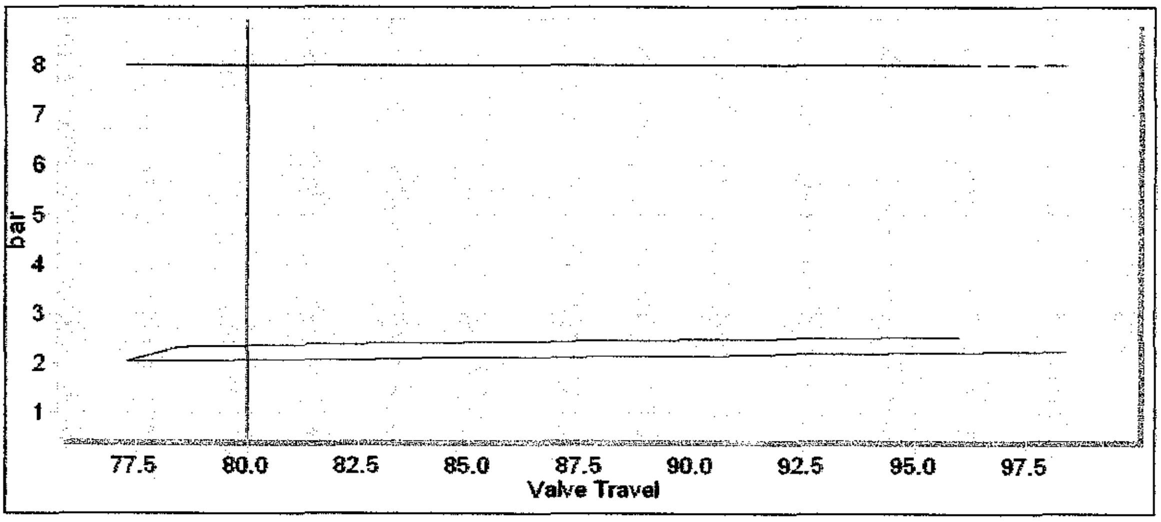


4th Stroked:



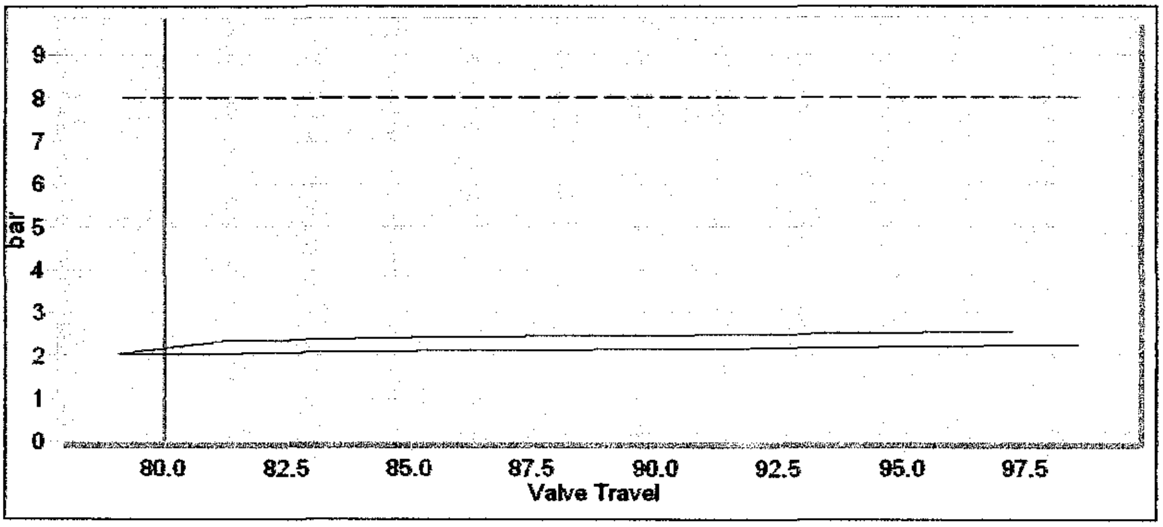
After the butterfly valve finished with the FST, the valve returned to its normal position which is fully opened. 15 minutes later, the valve began to do the 4th PST. The respond was the same as the previous PST.

5th Stroked:



The fifth PST responded the same with all the previous PST.

6th Stroked:



For the final PST, the valve also responded the same with the previous tests.

4.4. TESTING: PARAMETER CHANGE

This testing was conducted to study the effect of parameter change. During the testing, the parameter that has been changed was the pressure step. The pressure step was changed from 0.05bar to 0.005bar. The testing was conducted only for 10 days since the results obtained were similar during the 10 days period. The same five elements were recorded and analyzed. Below are the results for this testing:

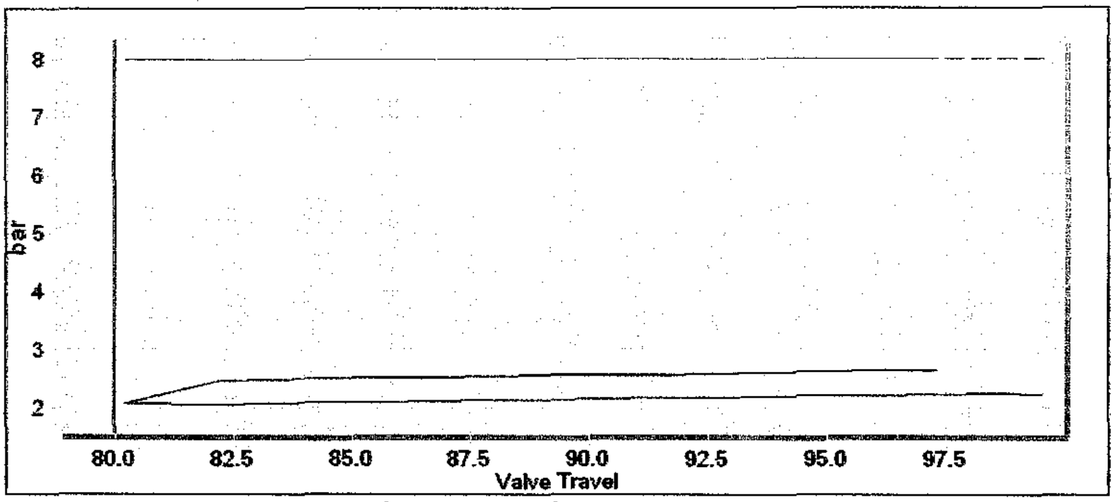


Figure 4.9: Valve Test Result

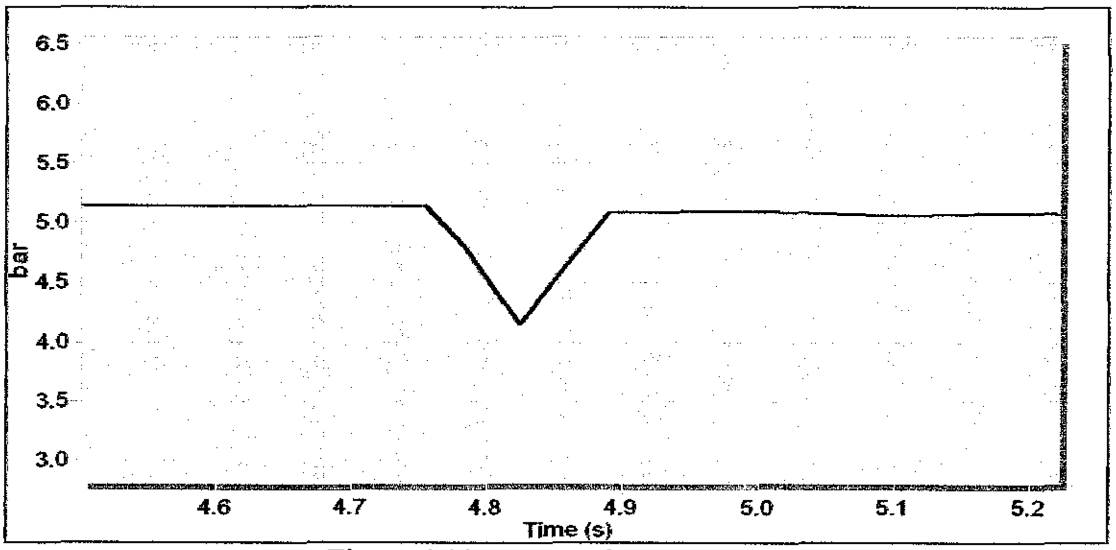


Figure 4.10: Pneumatic Test Result

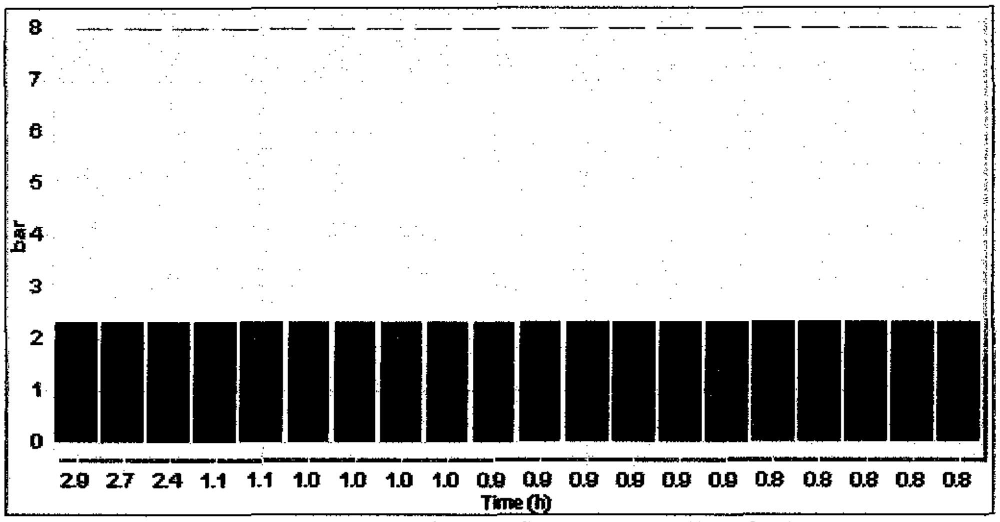


Figure 4.11: Breakaway Pressure (Ball Valve)

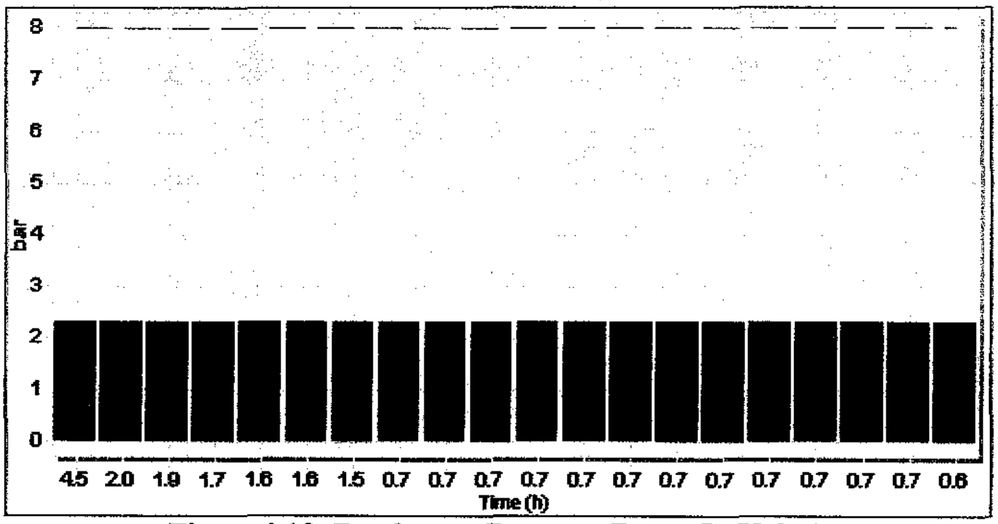


Figure 4.12: Breakaway Pressure (Butterfly Valve)

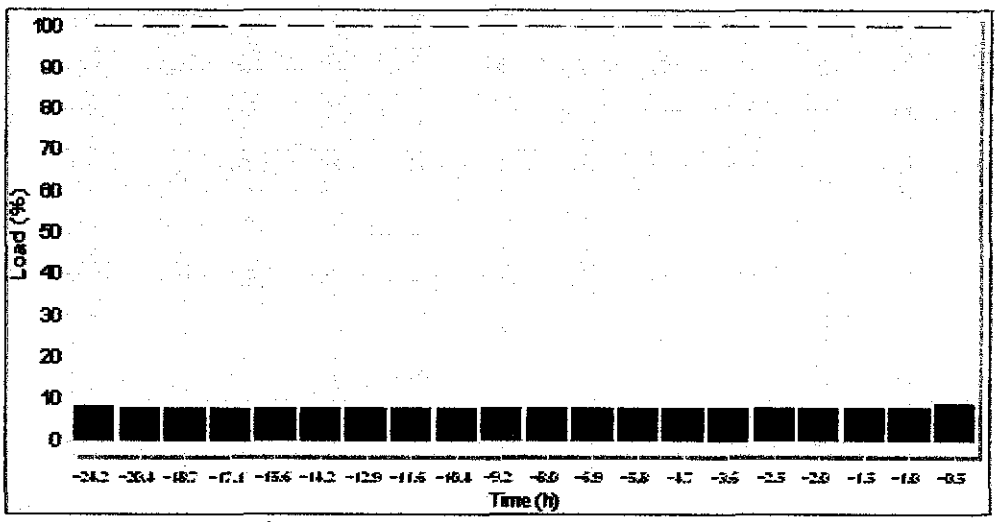


Figure 4.13: Load Factor (Ball Valve)

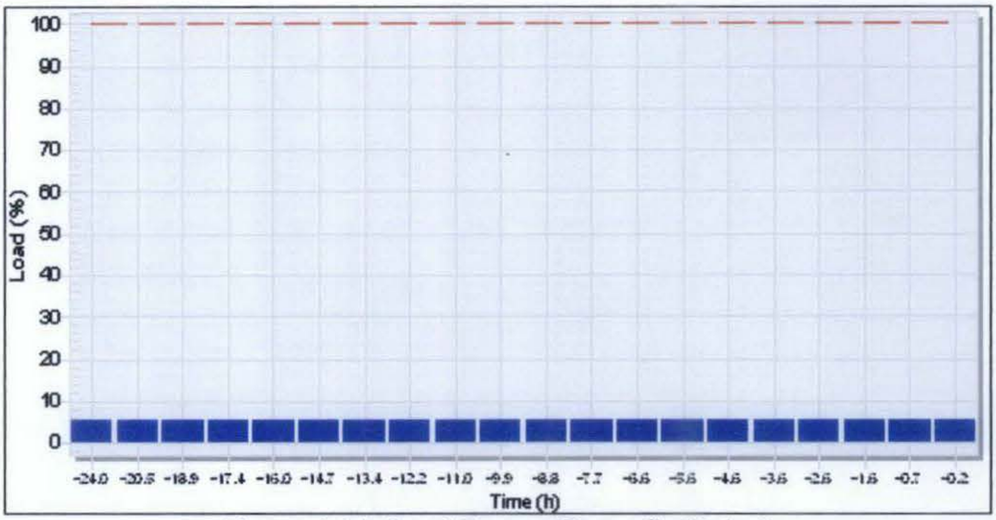


Figure 4.14: Load Factor (Butterfly Valve)

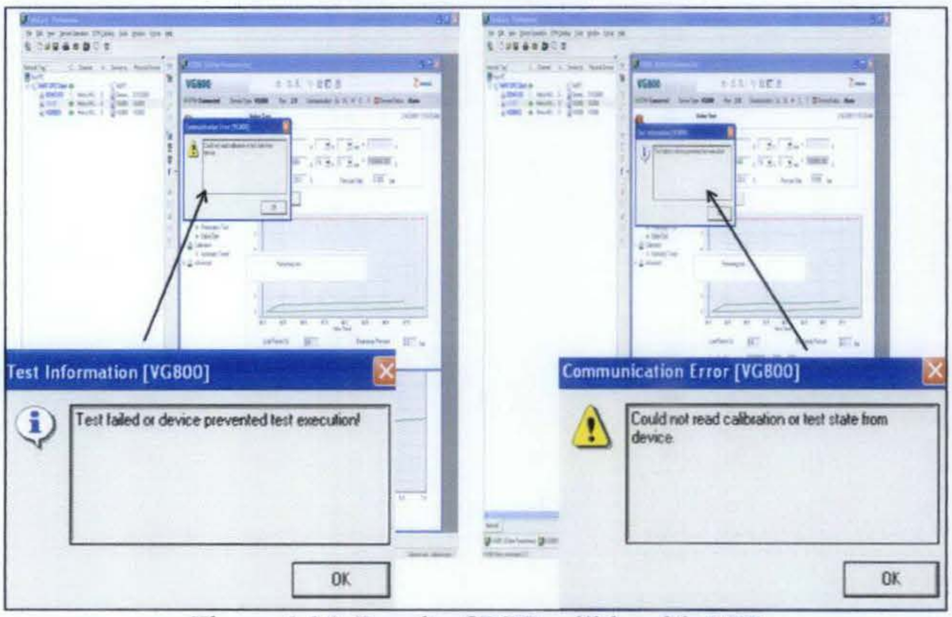


Figure 4.15: Result of PST collide with FST

Even though the pressure step has been changed to 0.005bar, the results for the valve test signature show almost the same as the result for 0.05bar of pressure step. However, since the pressure step has been lowered, the values of breakaway pressure (the pressure where the valves start to move) increase a bit from the average of 2.0 bar (0.05 bar pressure step) to 2.4bar. The results for Pneumatic test were the same but there were a little increased of the breakaway pressure and load factor values. Though the differences of these values were still within the range of acceptable values for a good valve conditions.

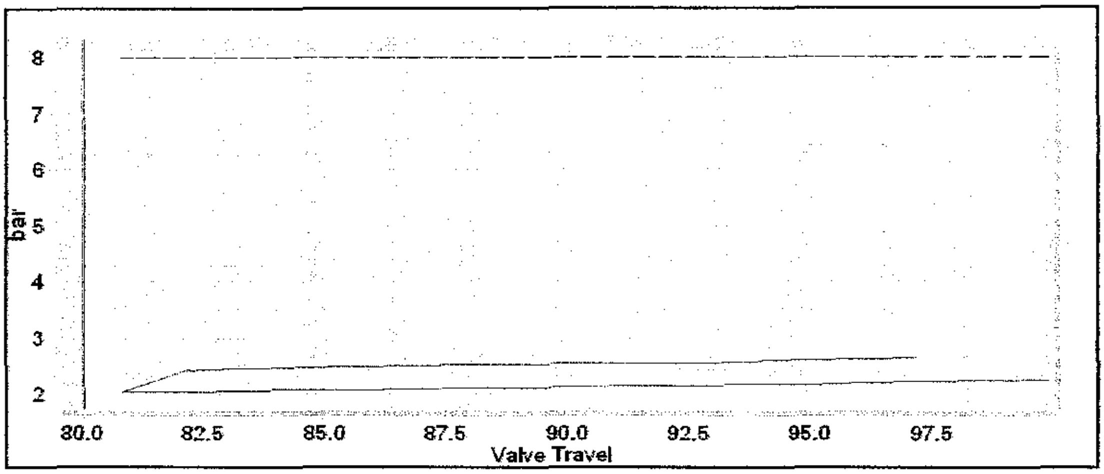
TESTING DAY 1 **DATE: April 2nd, 2008**

Valve : **Ball Valve**

Testing Criteria:

i) Valve Travel = 20% ii) Pressure Step = **0.005bar**

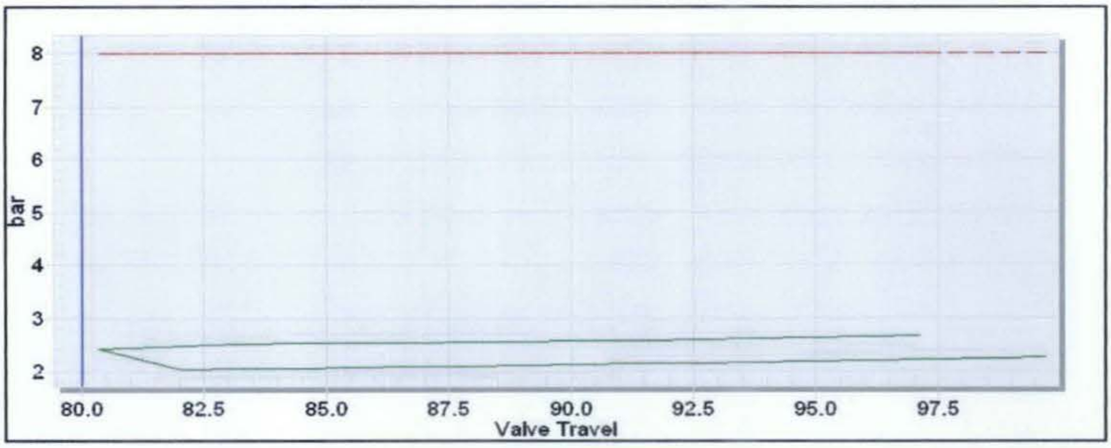
1st Stroked:



The ball valve responded to the FieldCare Software instruction which the ball valve needs to be exactly stroked at 80% of its opening (which means 20% of valve opening is closed). The valve started to move when the pressure supplied to it dropped to 2.4 bars. This value also represents the breakaway value as explained earlier. After a few seconds the ball returned to its initial condition which is fully opened. During the first stroke testing, there is no error occur.

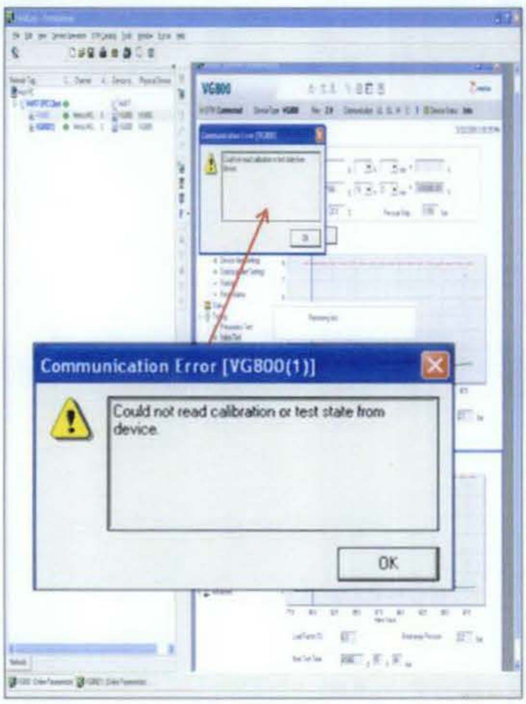
2nd Partial Stroke Testing :

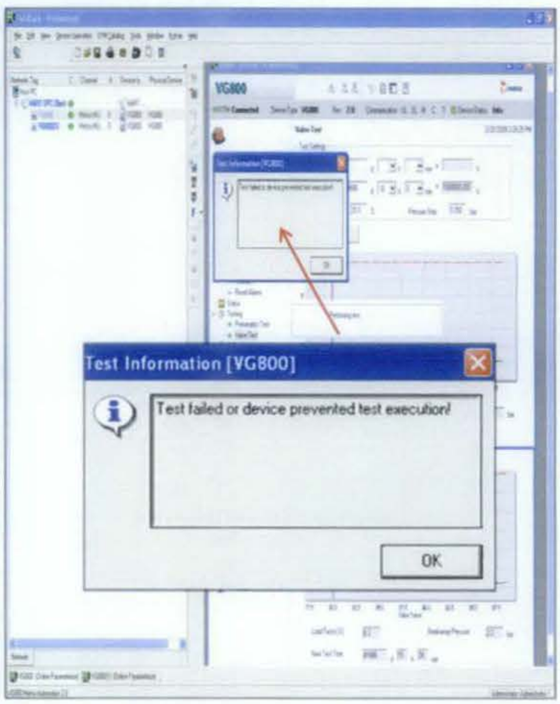
Since the setting in the FieldCare Software has been set to do PST with the interval period of 15 minutes, the second PST was done automatically 15 minutes later after the first stroked was done. The respond was the same with the first PST. The breakaway pressure occurred at 2.4 bar and the valve started to do PST on its own. No error occurred during this stroked.



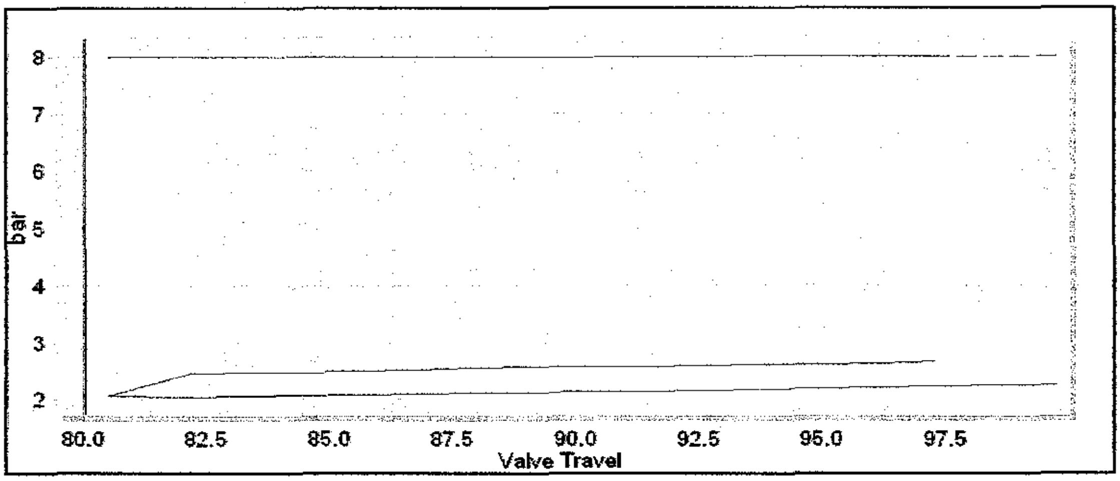
3[rd] Partial Stroke Testing + Full Stroke Testing :

At first, the ball valve received signal from the FieldCare Software and start doing the PST. In the middle of the PST execution, the valve received signal from PLC to do FST at that particular time. Based on the observation obtained, the valve followed the PLC command and started to do FST which means that it ignored the command given by the FieldCare Software. When the valve failed to respond to the FieldCare Software command, 2 windows error appeared. Below are the errors showed by the FieldCare Software at the moment the valve started to do FST.



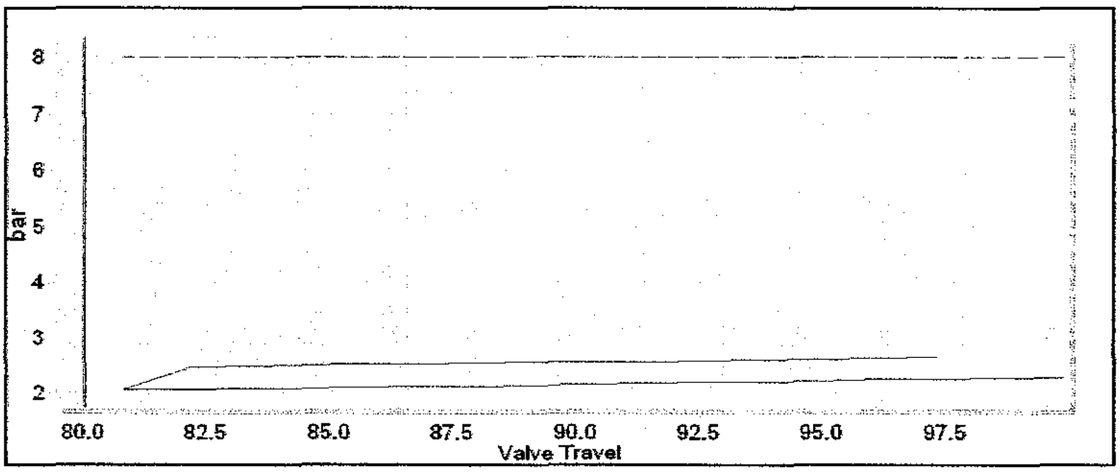


4th Partial Stroke Testing :



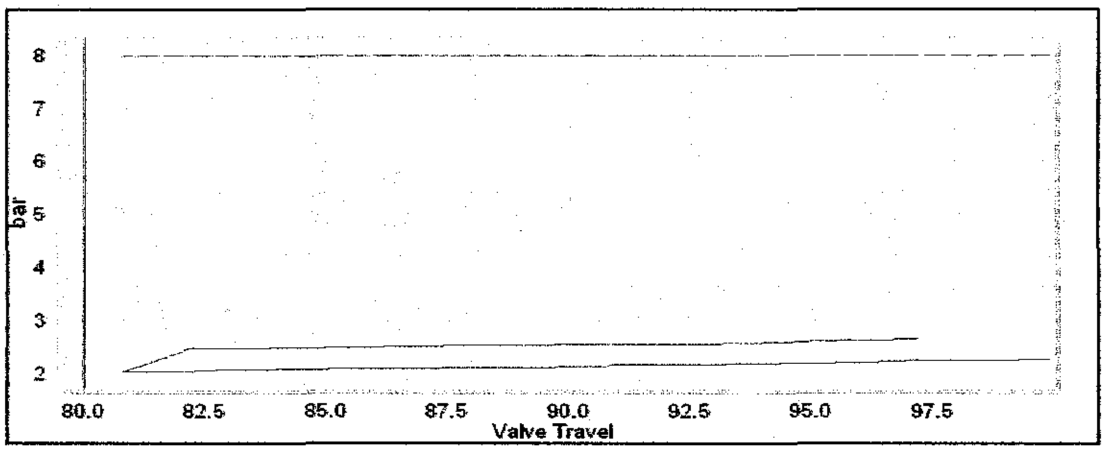
After the ball valve finished with the FST, the valve returned to its normal position which is fully opened. 15 minutes later, the valve began to do the 4th PST. The respond was the same with the first and second stroked of PST. No error occurs during the fourth stroke.

5th Partial Stroke Testing :



The fifth PST responded the same with the previous PST.

6^{th} Partial Stroke Testing :



For the final PST, the valve also responded the same with the previous tests.

Since the results obtained from day 1 until day 10 are almost the same, therefore, the explanations are also the same as above. The results for day 1 until day 10 can be referred to Appendix II.

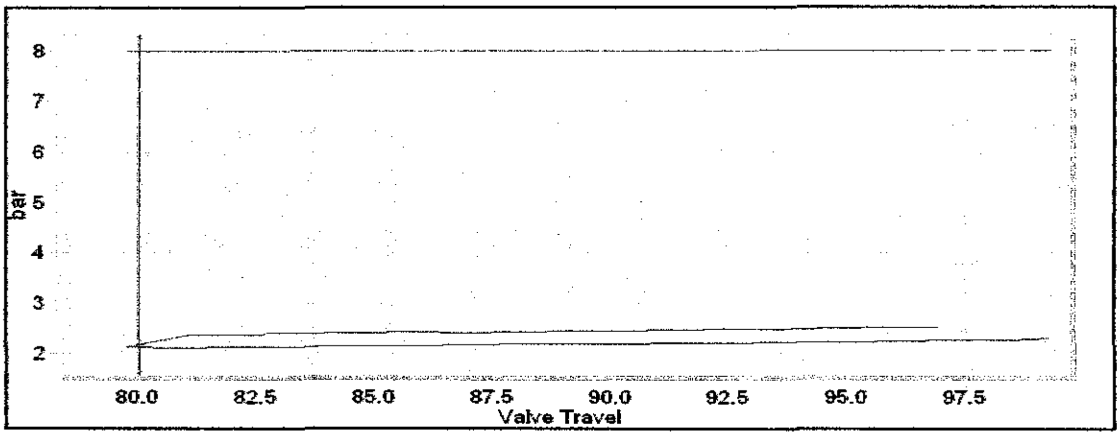
TESTING DAY 1 DATE: April 2nd, 2008

Valve: **Butterfly Valve**

Testing Criteria:

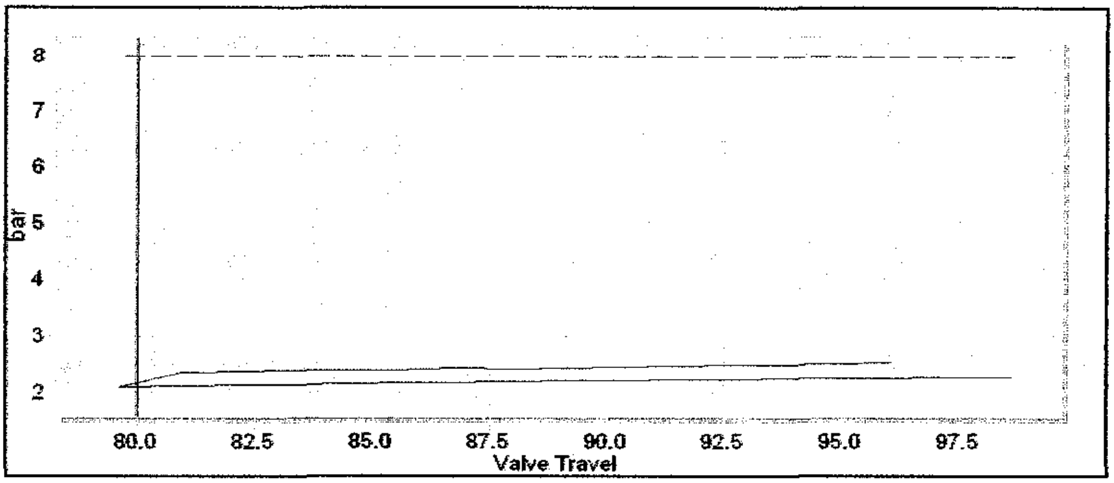
i) Valve Travel = 20% ii) Pressure Step = **0.005 bar**

1st Stroked:



The butterfly valve responded to the FieldCare Software instruction which the butterfly valve needs to be exactly stroked at 80% of its opening. After a few seconds the butterfly valve returned to its initial position which is fully opened. No error occurs during the testing.

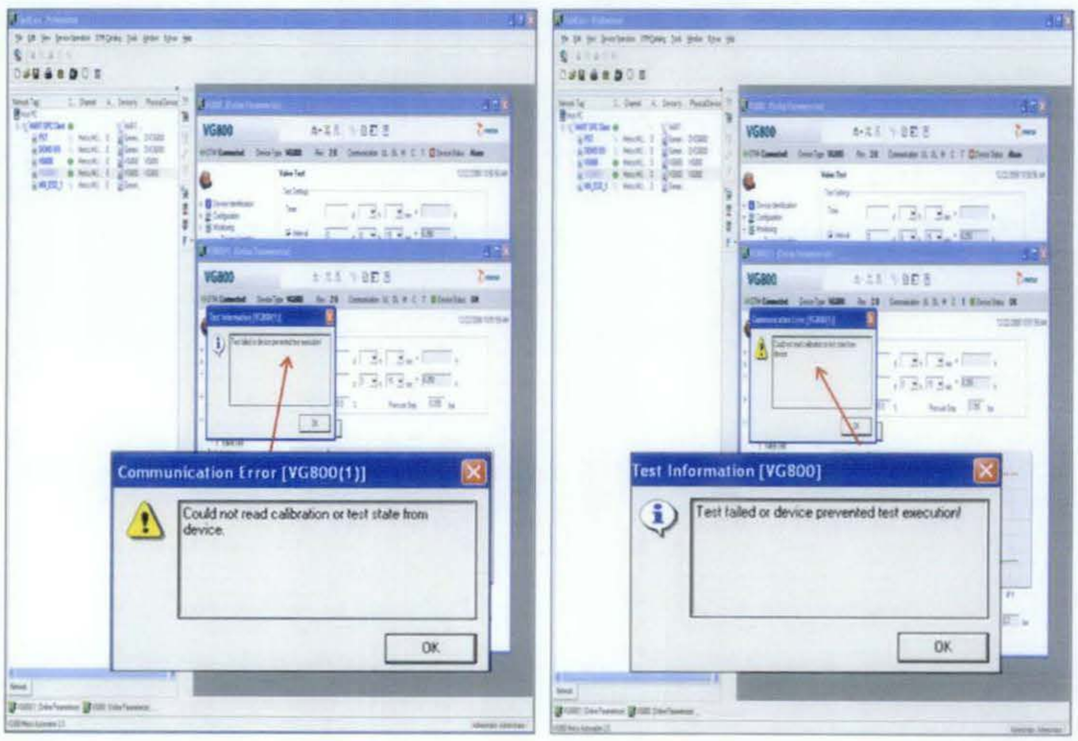
2nd Stroked:



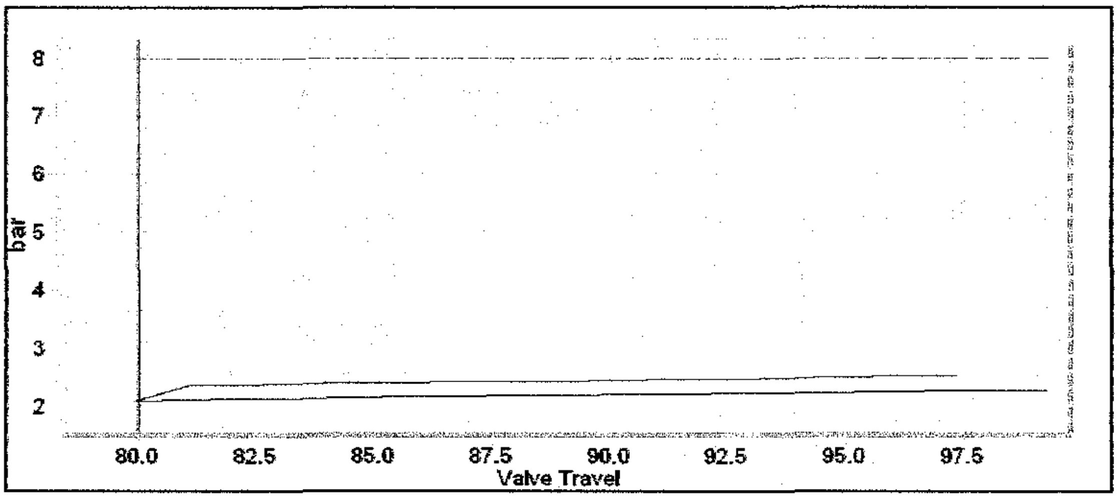
Since the setting at the FieldCare Software has been set to do PST with the interval time of 15 minutes, the second PST was done automatically after the next 15 minutes which is 10.35 am. The respond was the same with the first PST.

3rd Partial Stroke Testing + Full Stroke Testing :

First, butterfly valve received command from FieldCare Software to do PST and after a few seconds the valve started to move, it receive another command from PLC to do FST. As a result, the butterfly valve followed the FST command and ignored the PST command, in other words, FST override PST command. The valve started to move to fully closed position for a few seconds before moving back to its initial position. The FieldCare Software then showed two error statuses which are the same error status as the ball valve. The errors are shown in the following figure.

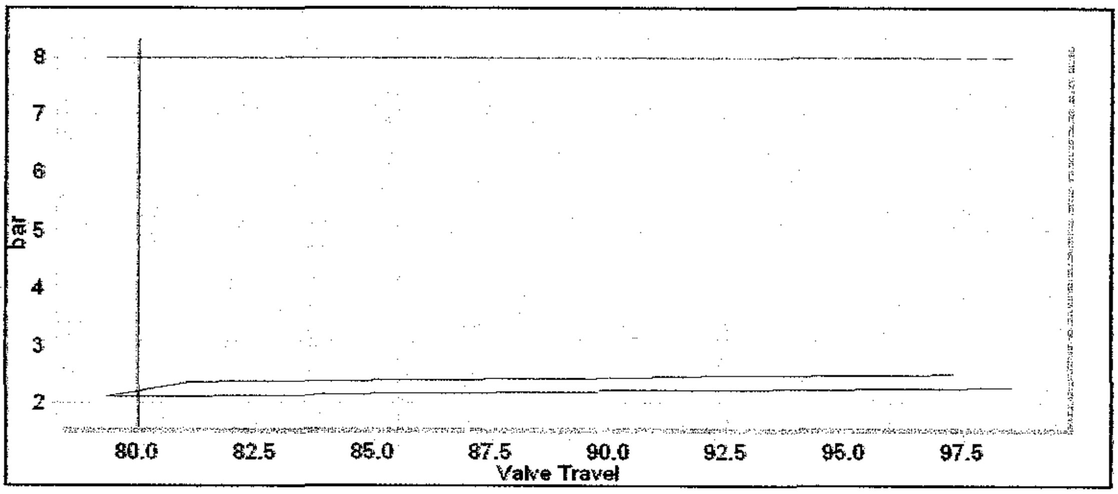


4^{th} Stroked:



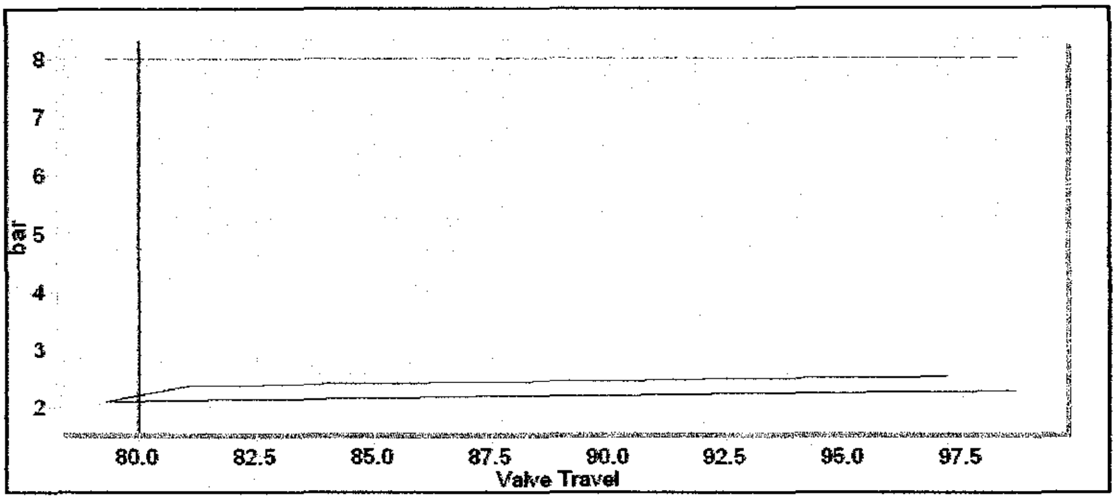
After the butterfly valve finished with the FST, the valve returned to its normal position which is fully opened. 15 minutes later, the valve began to do the 4^{th} PST. The respond was the same as the previous PST.

5^{th} Stroked:



The fifth PST responded the same with all the previous PST.

6th Stroked:



For the final PST, the valve also responded the same with the previous tests.

4.5. DISCUSSION

During the test, the Metso's Valves performed accordingly to the instruction given to them. There is no major problem arise during the testing. Based on the valve test results, the result for each stroke shows similar patterns and consistency. The results obtained for the breakaway pressure, load factor and pneumatic test show that the valve is still in good condition. One of the advantages of the Metso's software is that the test for the ball valve and butterfly valve can be done at the same time which means ease on the monitoring and speed up the testing time. However, there are some limitations using the FieldCare software. One of it is the valve speed of Metso's valves cannot be changed. The other software, Fisher and Masoneilan have the option of changing the valve speed. For FieldCare Software, the parameter that can only be changed are the valve travel and the pressure step. The results obtained for the 0.005bar pressure step were almost the same with the results for 0.05 bar.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1. CONCLUSION

Partial Stroke Valve Testing is basically a means to partially close a valve at a certain degrees, say 20 degree and then return to the initial position. The movement of the valve is very small in that the impact on the process flow or pressure can be ignored. However, the small valve movement can help to recognize several types of failure possibility. The probability of a valve failing to perform its designed function increases with the increase of the valve age. Failures may occur while in open position and may cause the valve to "fail to close" or to "leak in closed position" in any demand situation. Such failures may remain for a long period of time and are called the dangerous undetected (DU) failures (IEC 61508, 1998). As mentioned in the earlier section, Programmable Logic Controller (PLC) and FieldCare Software are the methodologies use to control and observe the performance of the FST and PST throughout the project period. The PST device,ValvGuard800X provide by Metso Automation Company measured five elements of results that need to be highlighted and there are: valve test, PST collide with FST, pneumatic test, breakaway pressure and load factor. After analyzing these elements, it shows that the valves' conditions are still good throughout the testing period.

5.2. RECOMMENDATION

As the Phase I project is expected to be completed at the end of April 2009, there are lots results to be analyzed to get the accurate final information regarding the testing. However, the students are having problem to do comparison between valves from different vendors since there are some limitation with the vendors' software. Therefore, it would be great if PETRONAS team provide the students with the criteria of performance that they really want. By doing this, the Phase II testing activity would be easier to be conducted.

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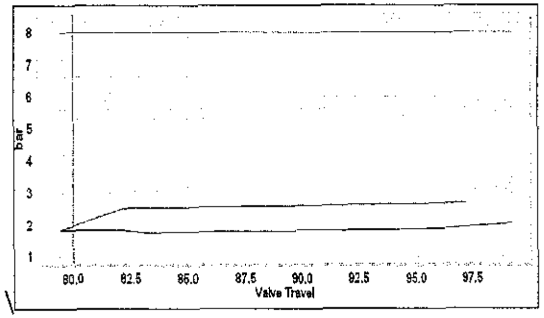
APPENDICES

APPENDIX I : TESTING RESULTS

TESTING DAY 3: Ball Valve **DATE: DEC 23rd , 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

1st Stroked:



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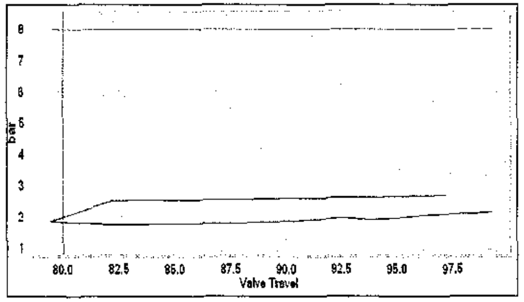
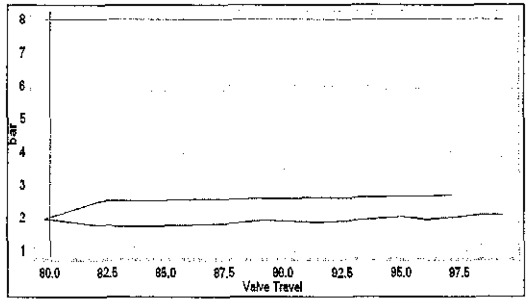
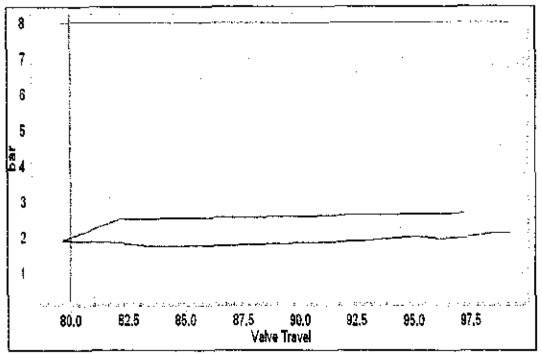


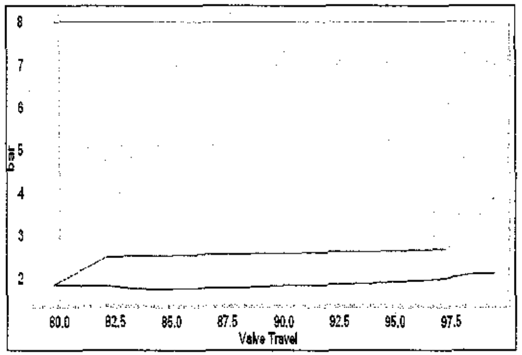
4th Stroked:



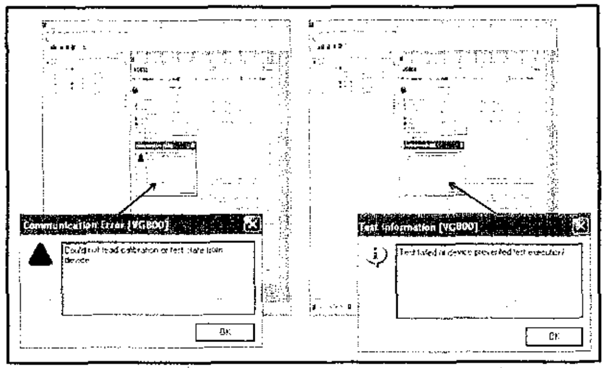
5th Stroked:



6th Stroked:



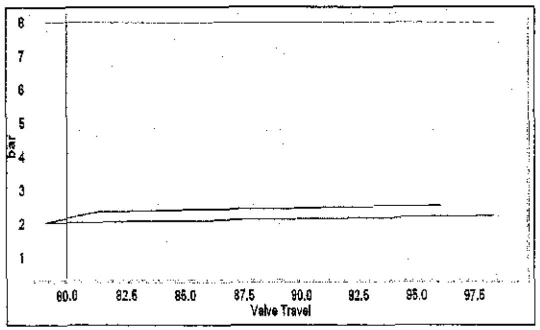
PST + FST



TESTING DAY 3: Butterfly Valve **DATE: DEC 23rd, 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

1st Stroked:



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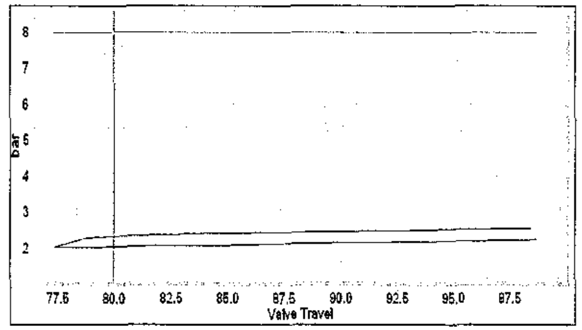

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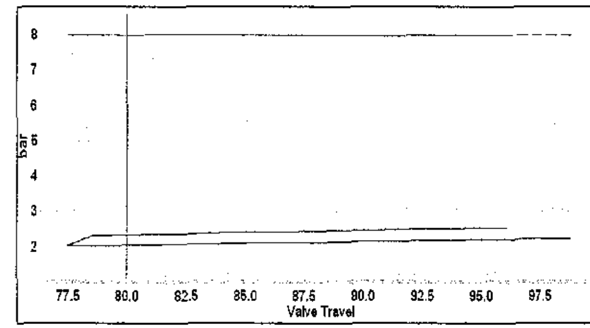

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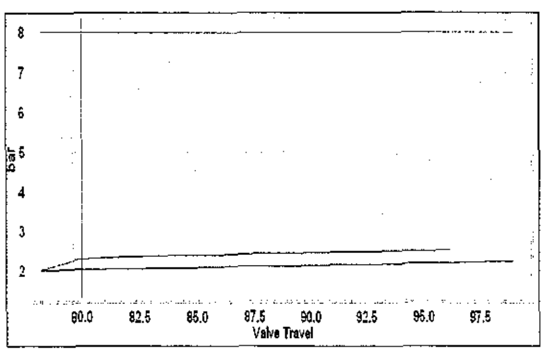

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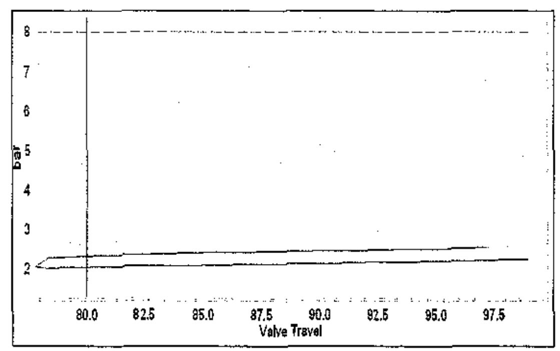
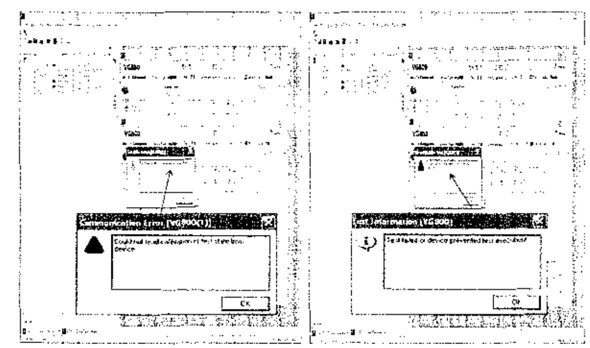


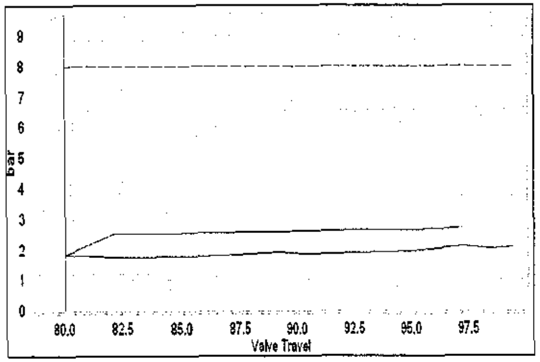
PST + FST:



TESTING DAY 5: Ball Valve **DATE: Jan 5th, 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

1st Stroked:



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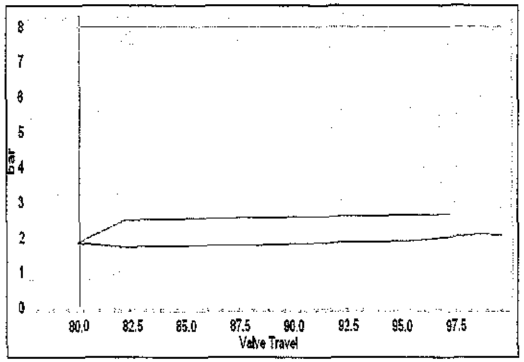

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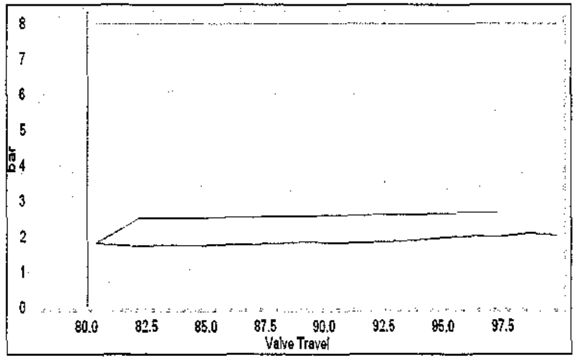

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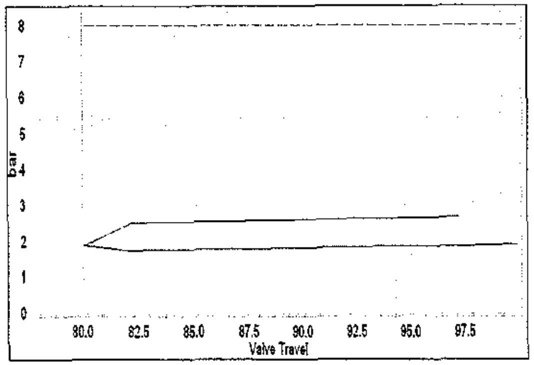

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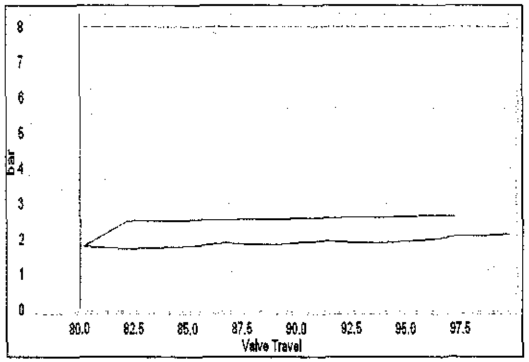
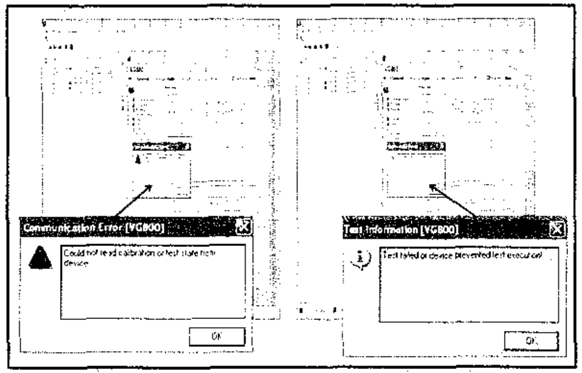


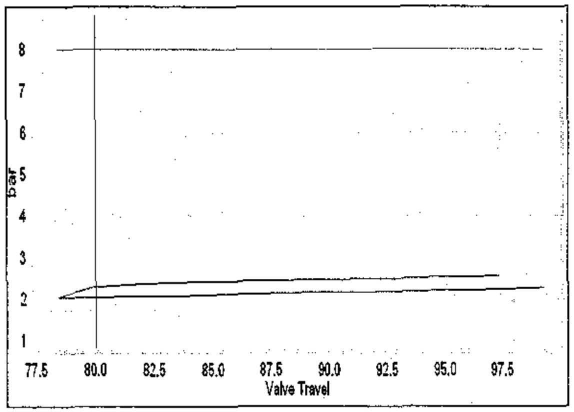
PST + FST:



TESTING DAY 5: Butterfly Valve **DATE: JAN 5th , 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

1st Stroked:



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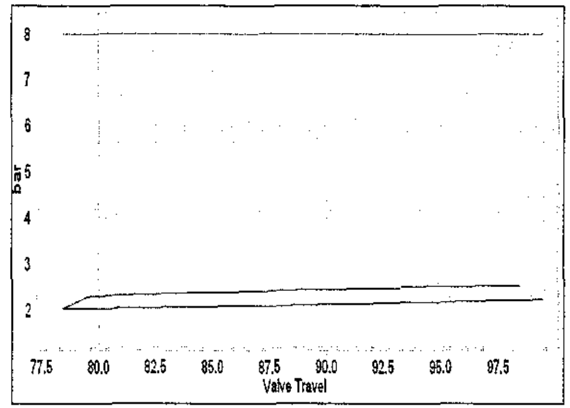

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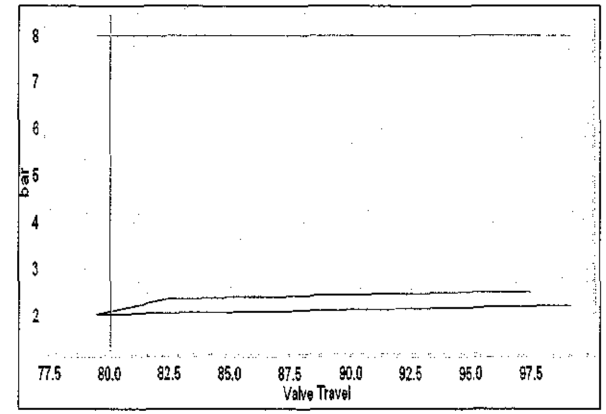

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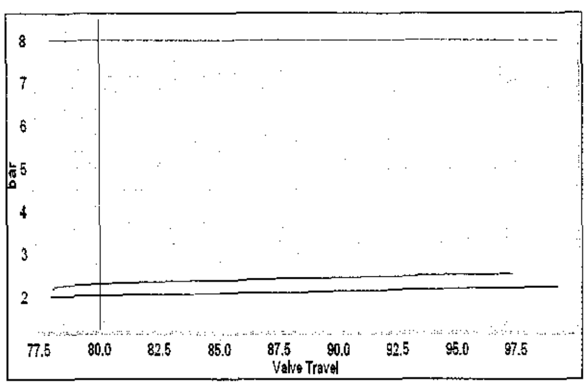

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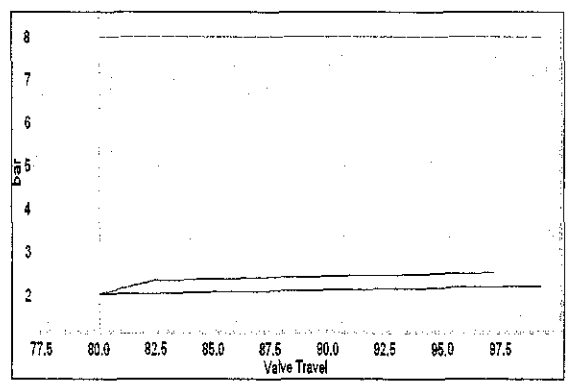

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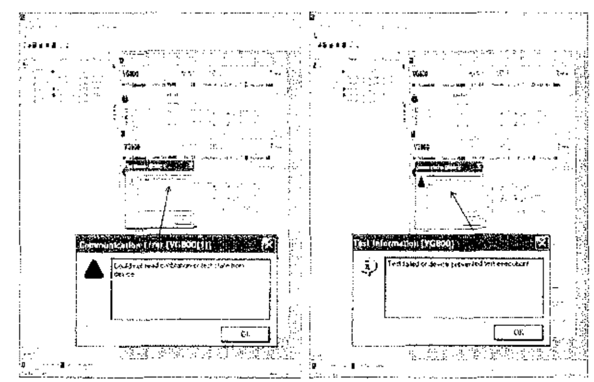
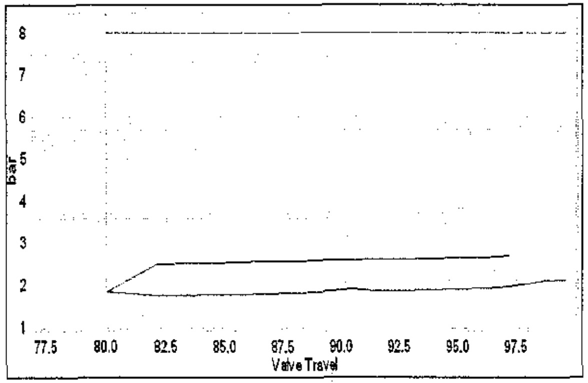


TESTING DAY 7:Ball Valve **DATE: JAN 7th , 2008**

Testing Criteria; i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

1st Stroked:



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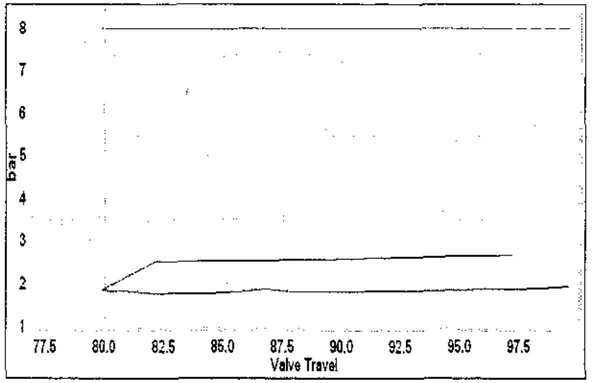

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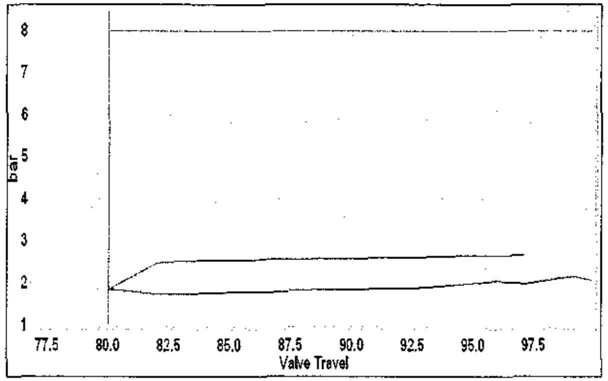

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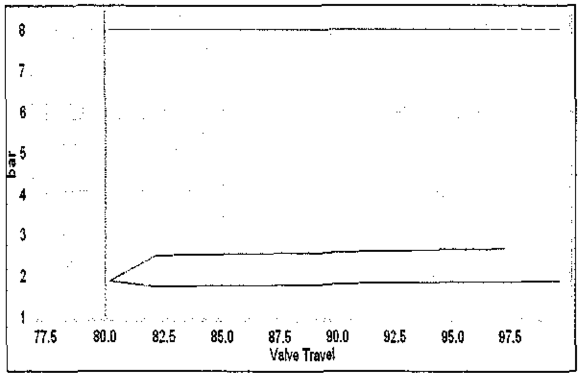

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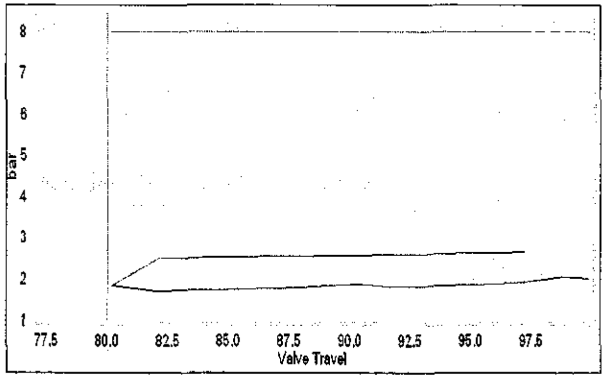
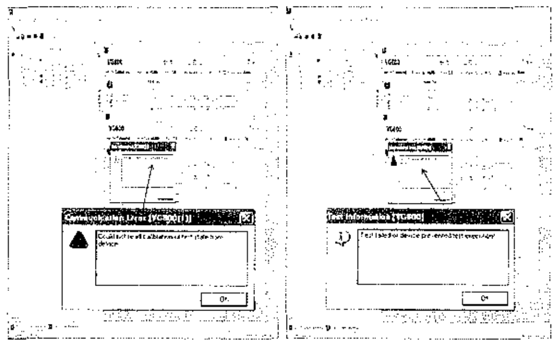


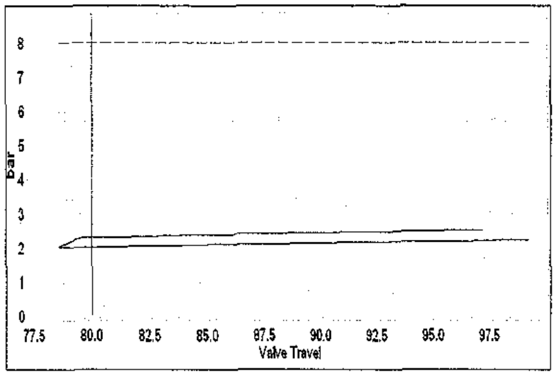
PST + FST:



TESTING DAY 7: Butterfly Valve **DATE: Jan 7th, 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

1st Stroked:



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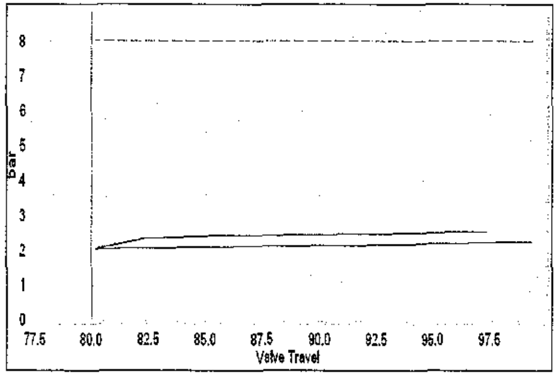

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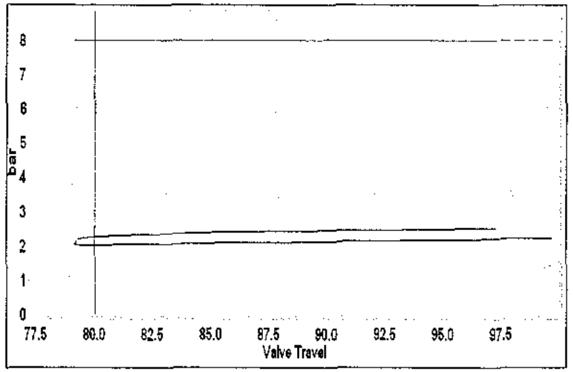

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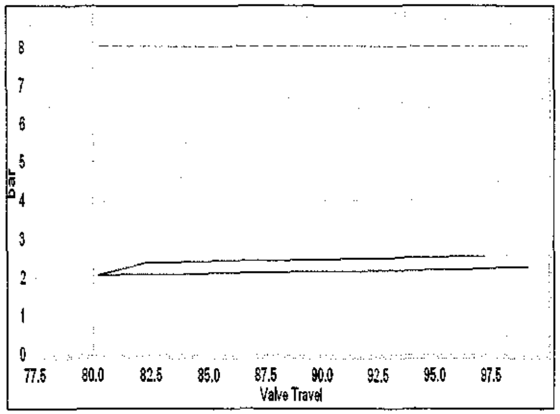
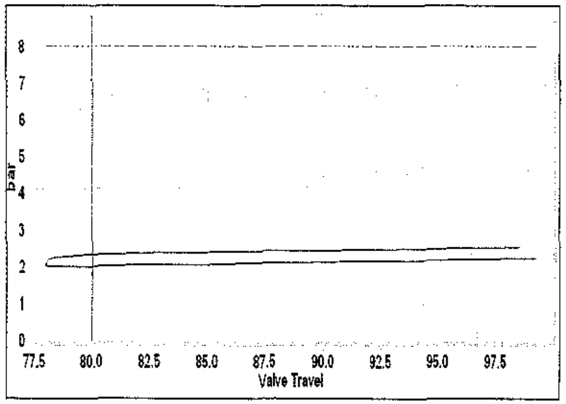
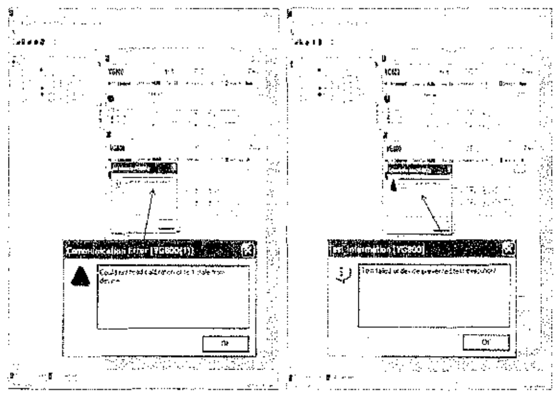


6th Stroked:



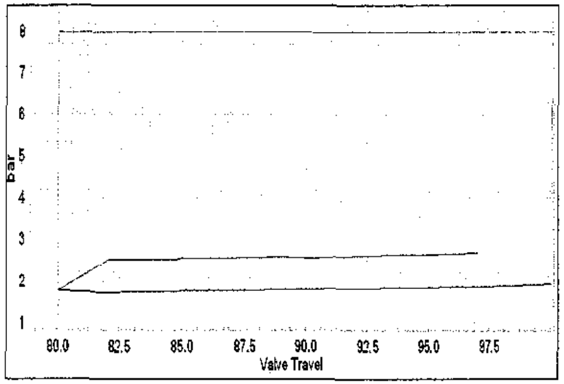
PST + FST:



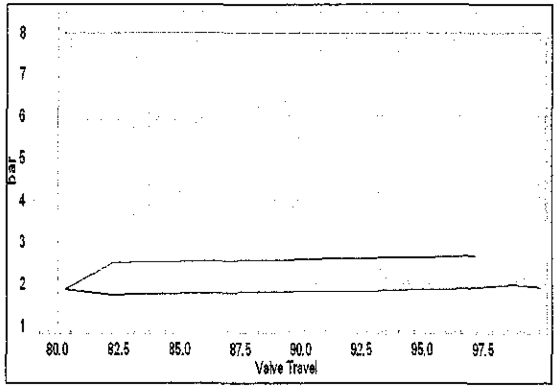
TESTING DAY 9: Ball Valve **DATE: JAN 9th , 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

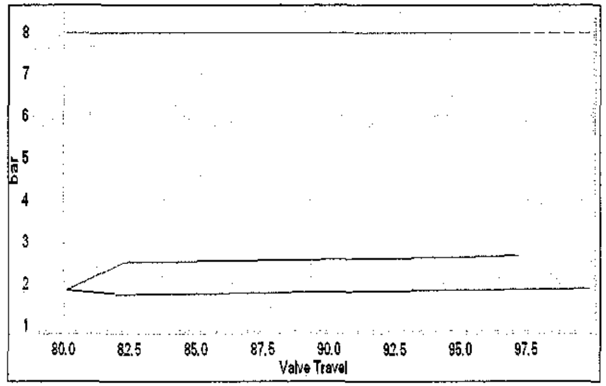
1st Stroked:



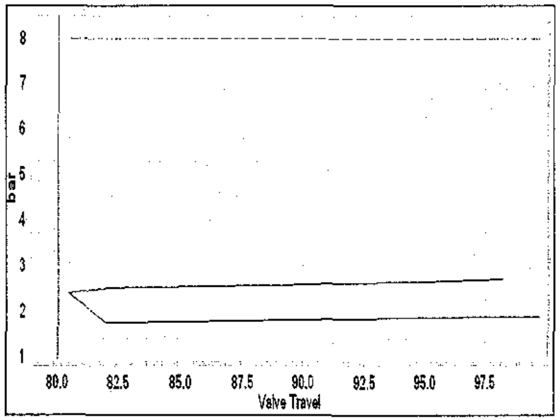
2nd Stroked :



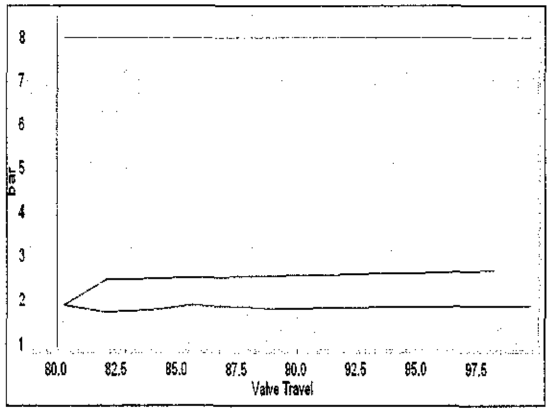
4th Stroked:



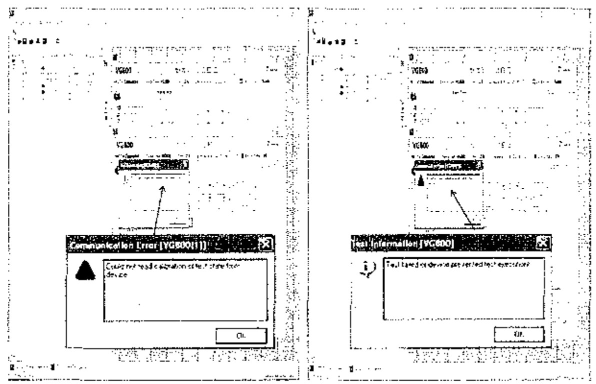
5th Stroked:



6th Stroked:



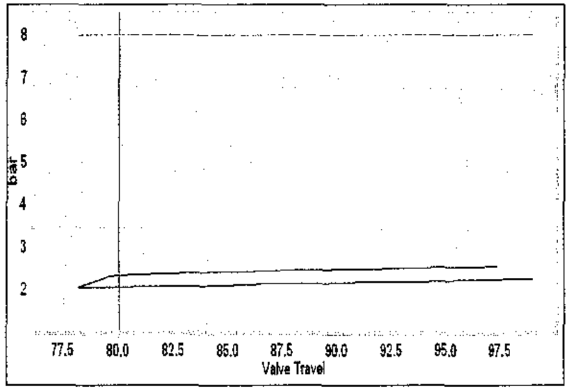
PST + FST:



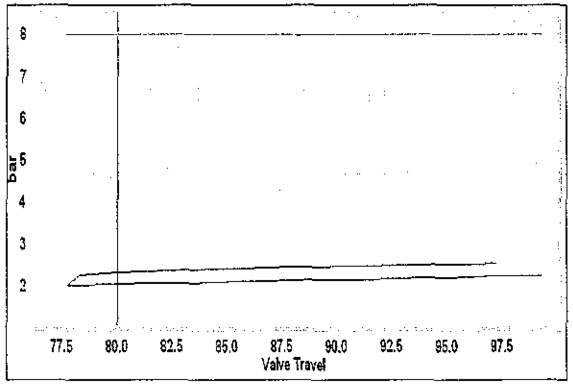
TESTING DAY 9: Butterfly Valve **DATE: Jan 9th, 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

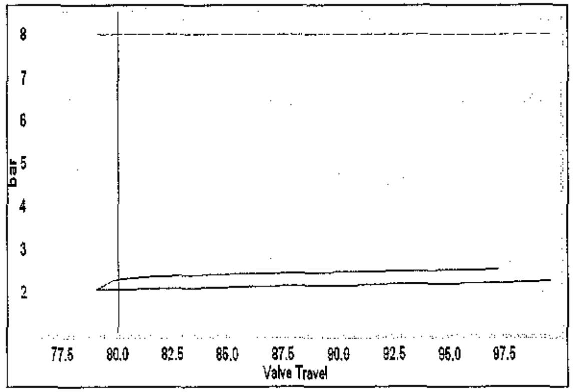
1st Stroked:



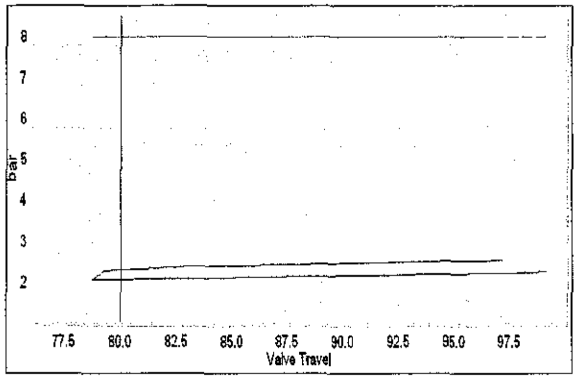
2nd Stroked :



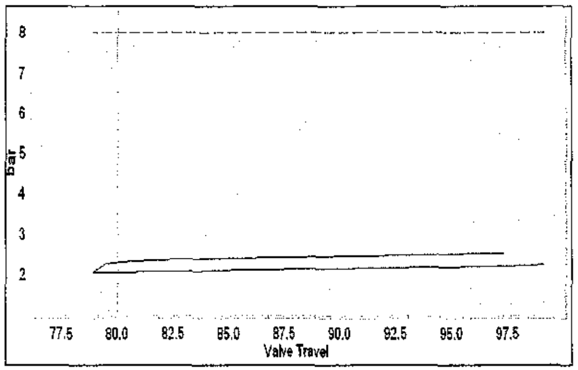
4th Stroked:



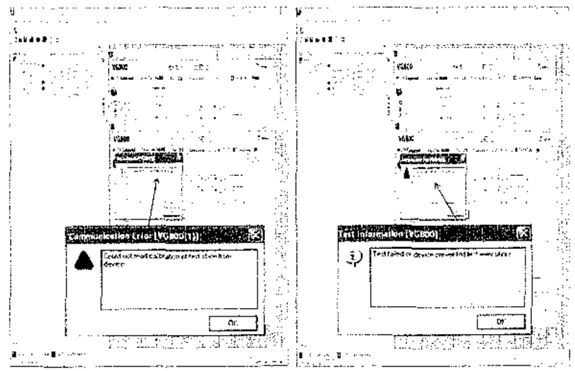
5th Stroked:



6th Stroked:



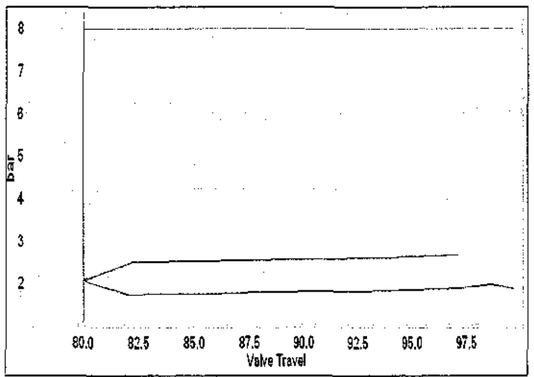
PST + FST:



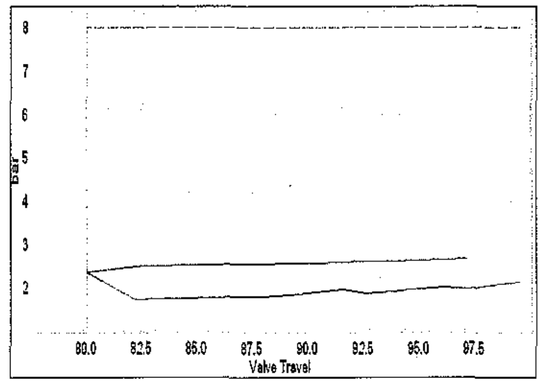
TESTING DAY 11: Ball Valve **DATE: JAN 11th, 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

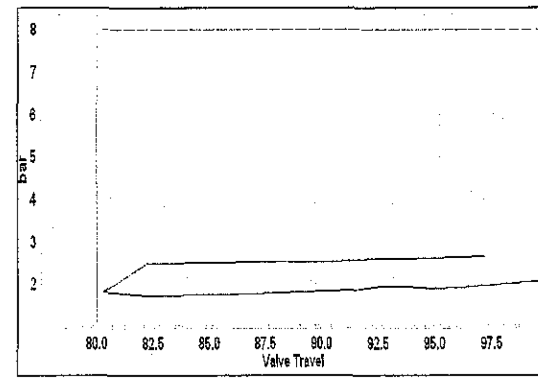
1st Stroked:



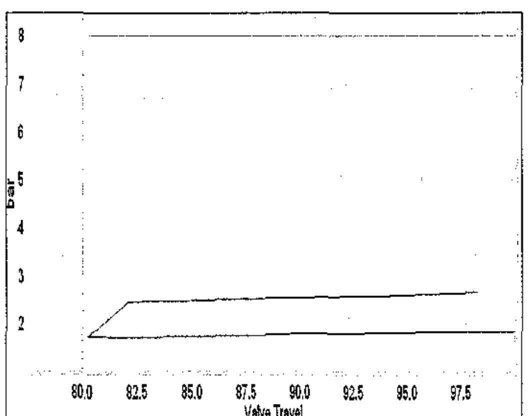
2nd Stroked :



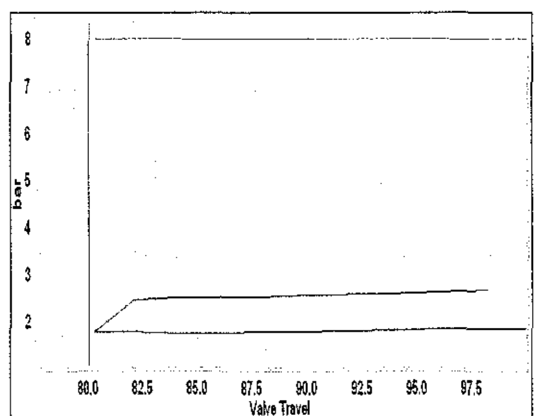
4th Stroked:



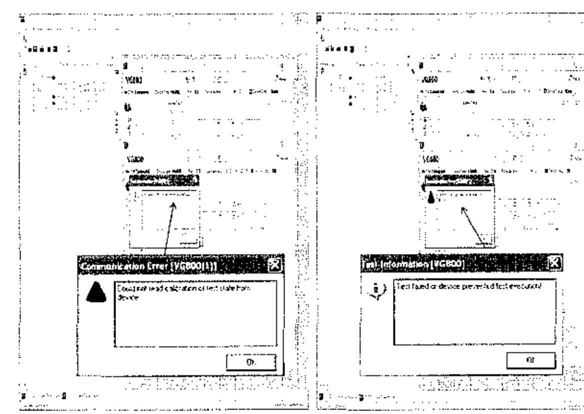
5th Stroked:



6th Stroked:



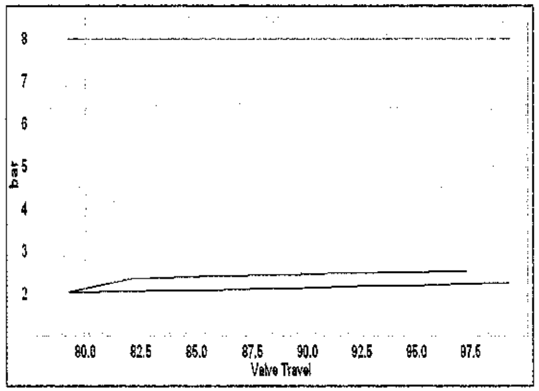
PST + FST:



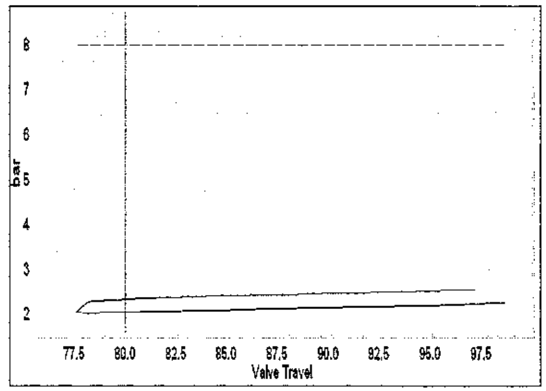
TESTING DAY 11: Butterfly Valve **DATE: Jan 11th, 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

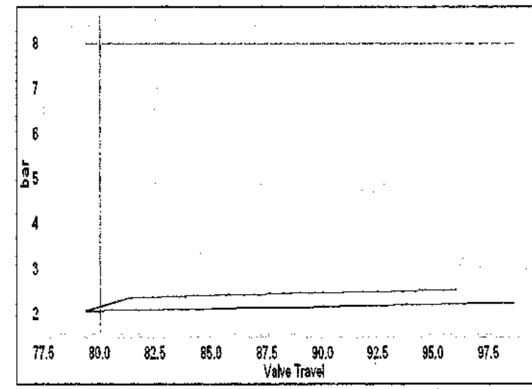
1st Stroked:



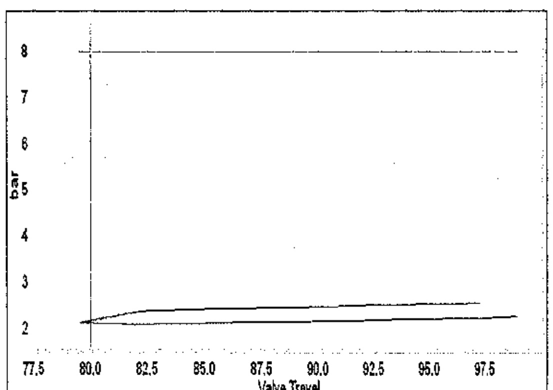
2nd Stroked :



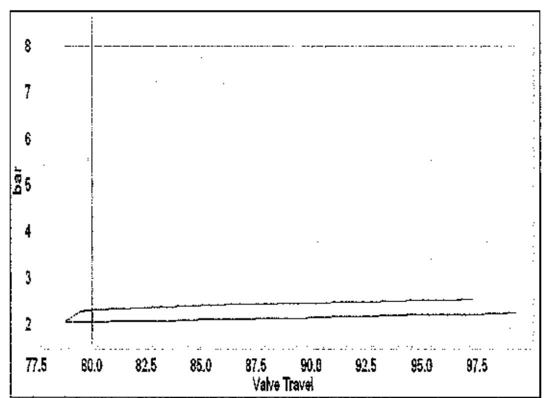
4th Stroked:



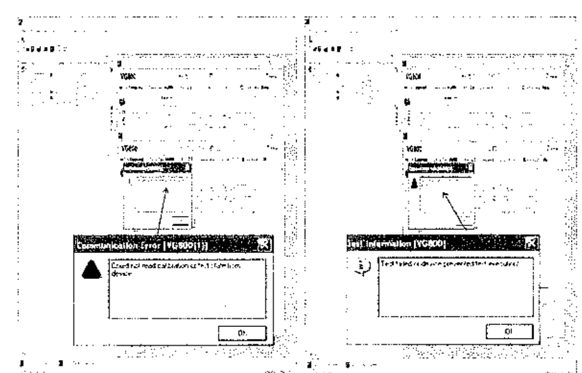
5th Stroked:



6th Stroked:



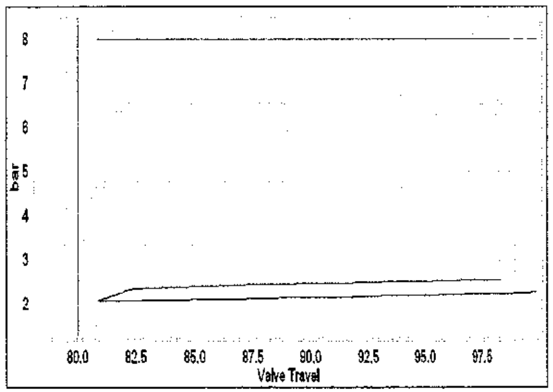
PST + FST:



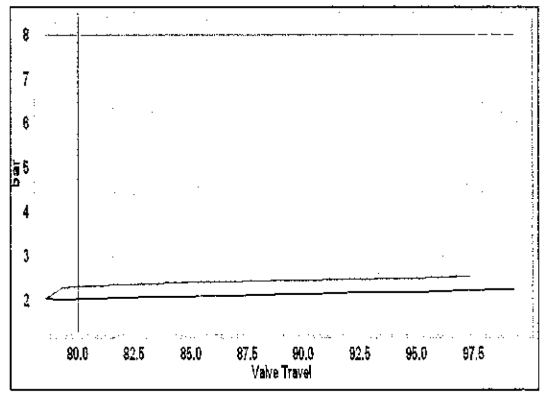
TESTING DAY 13: Butterfly Valve **DATE: Jan 13th, 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

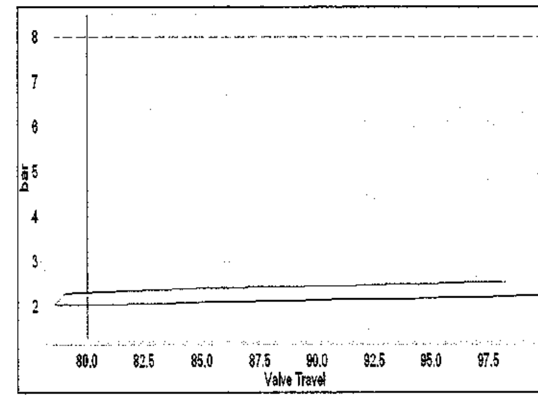
1st Stroked:



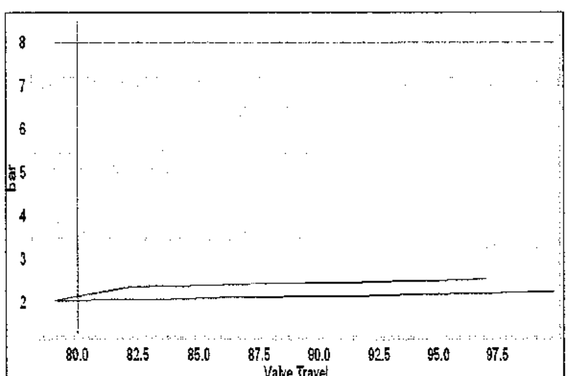
2nd Stroked :



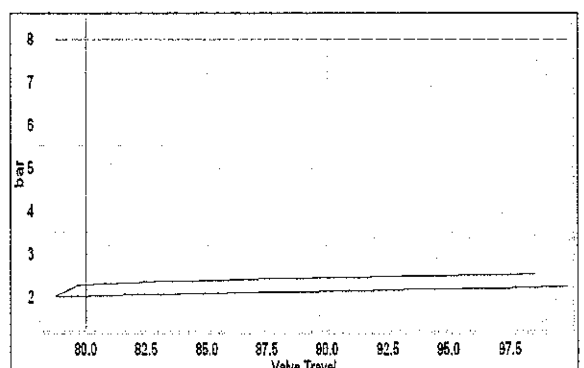
4th Stroked:



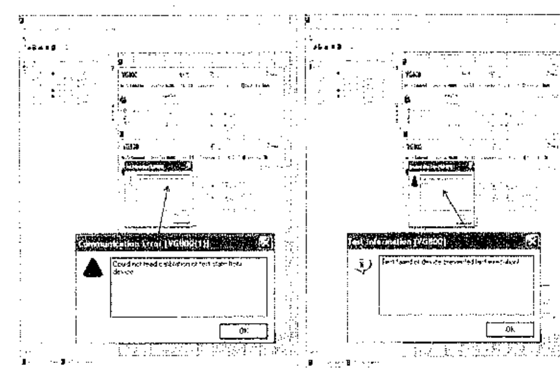
5th Stroked:



6th Stroked:



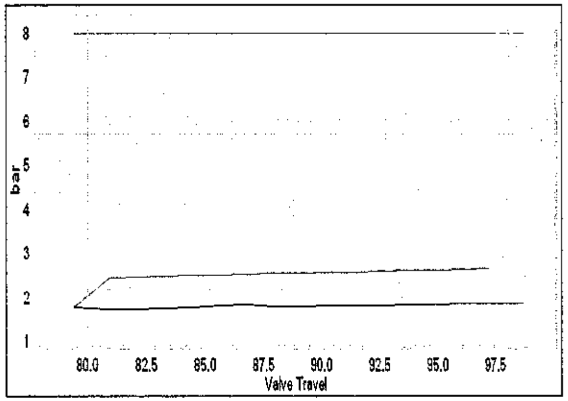
PST + FST:



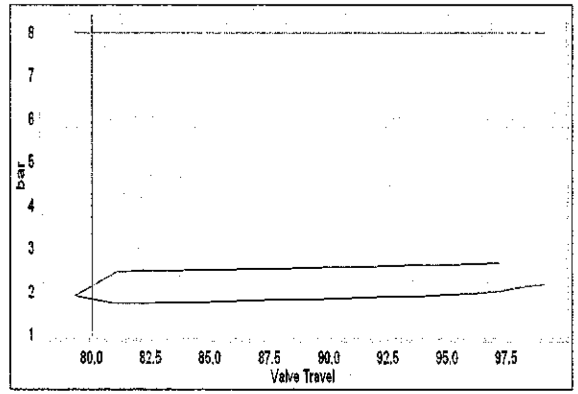
TESTING DAY 13: Ball Valve **DATE: JAN 13th, 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

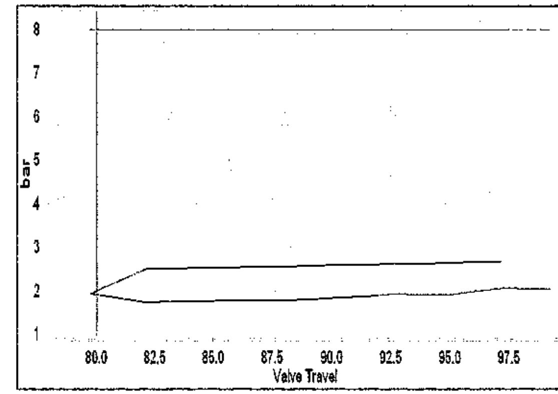
1st Stroked:



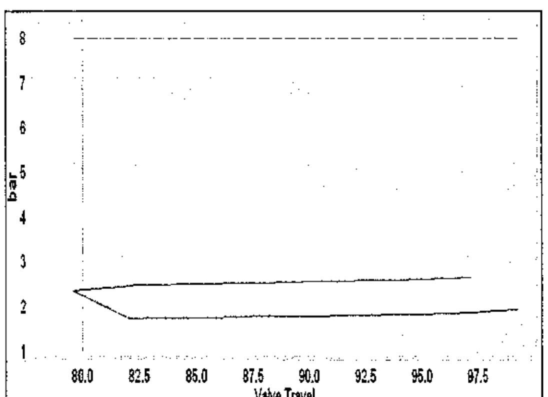
2nd Stroked :



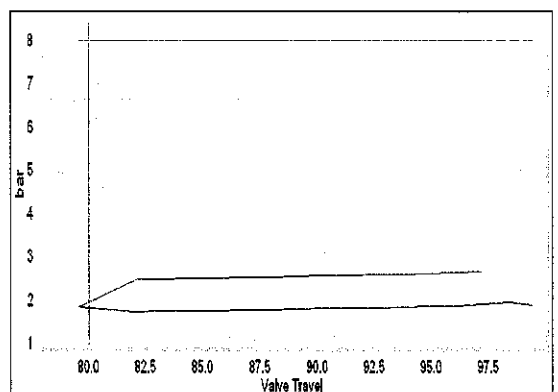
4th Stroked:



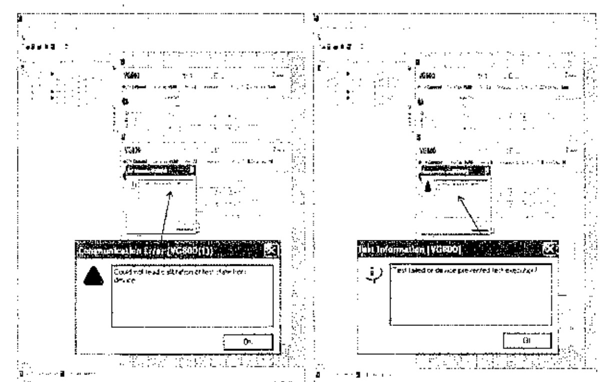
5th Stroked:



6th Stroked:



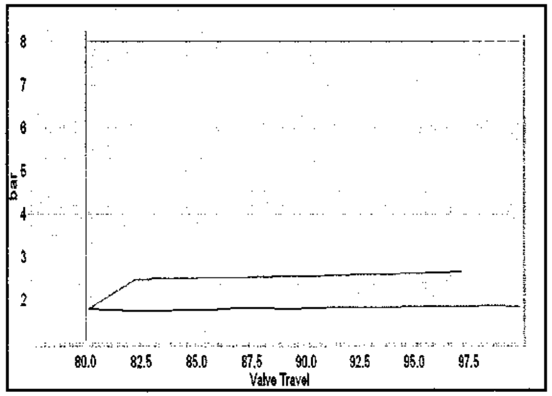
PST + FST:



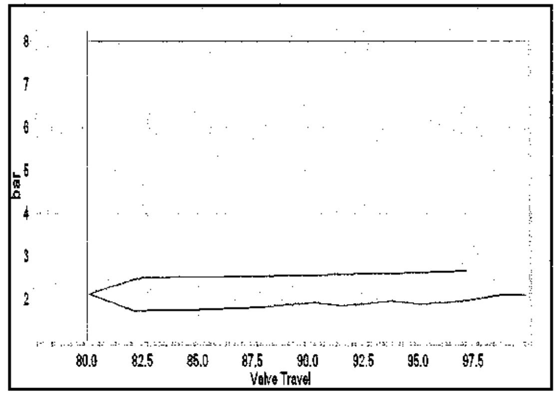
TESTING DAY 15: Ball Valve **DATE: JAN 15th, 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

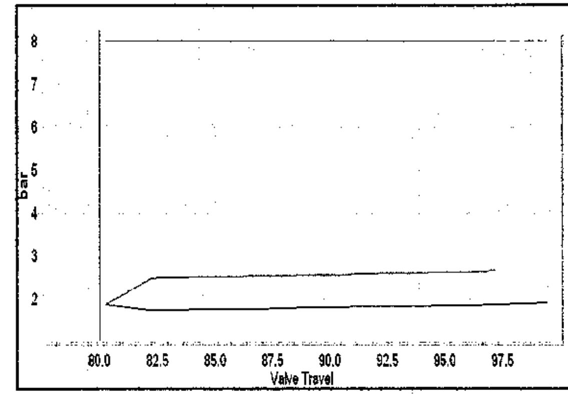
1st Stroked:



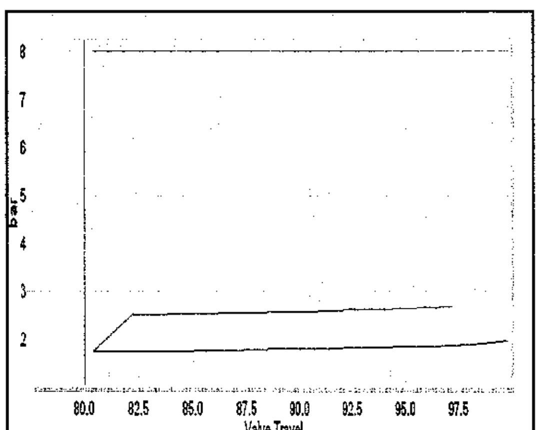
2nd Stroked :



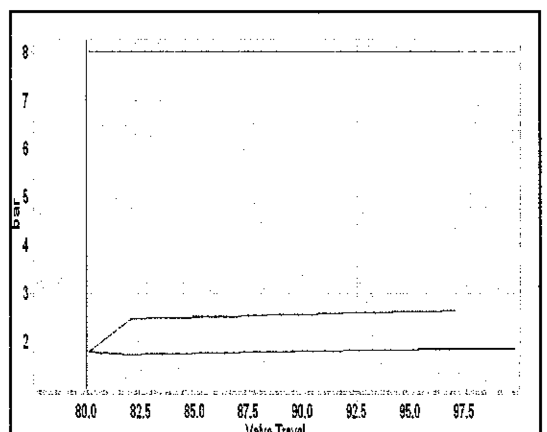
4th Stroked:



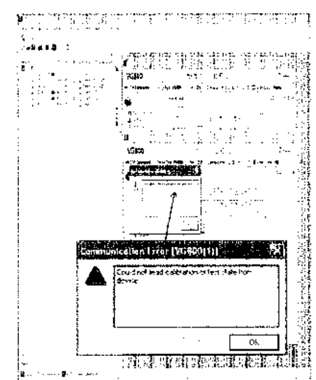
5th Stroked:

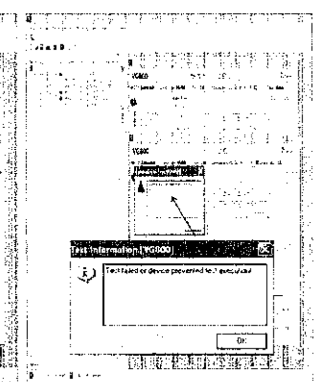


6th Stroked:



PST + FST:

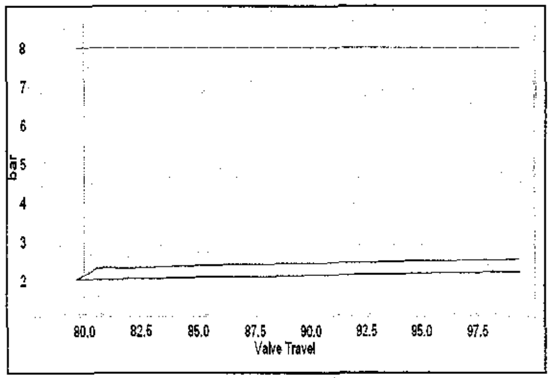




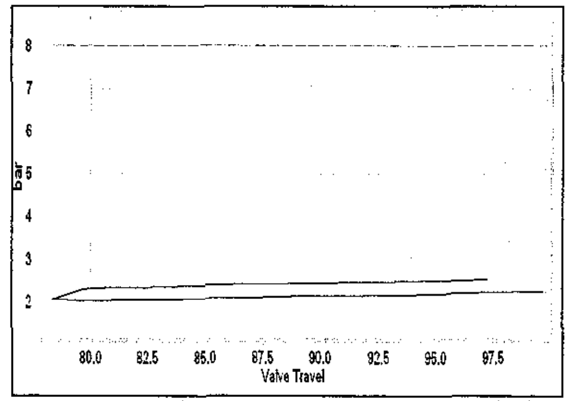
TESTING DAY 15: Butterfly Valve **DATE: Jan 15th, 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

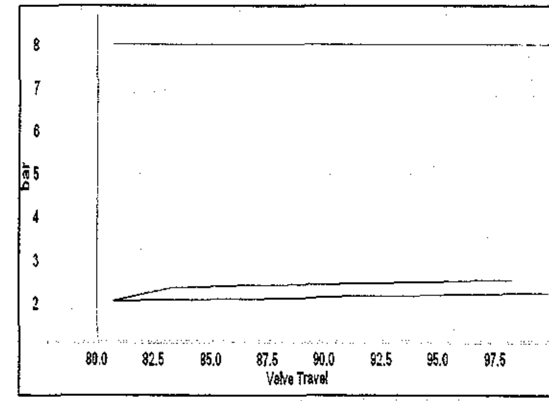
1st Stroked:



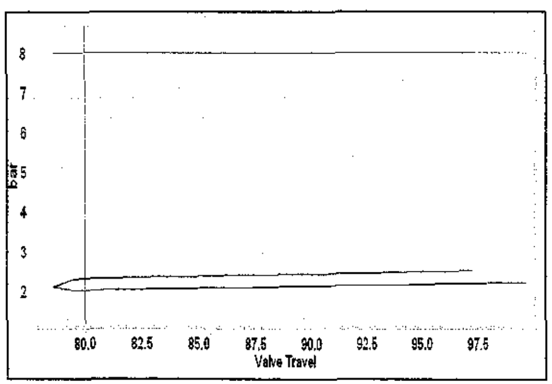
2nd Stroked :



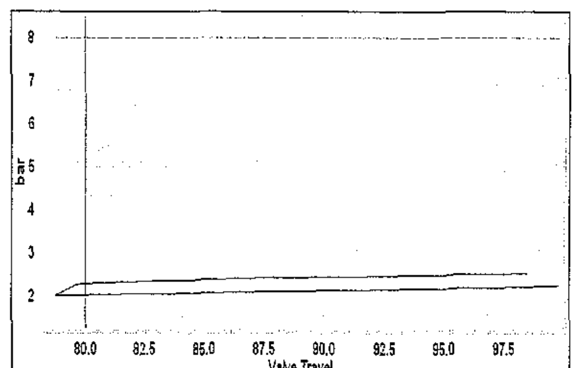
4th Stroked:



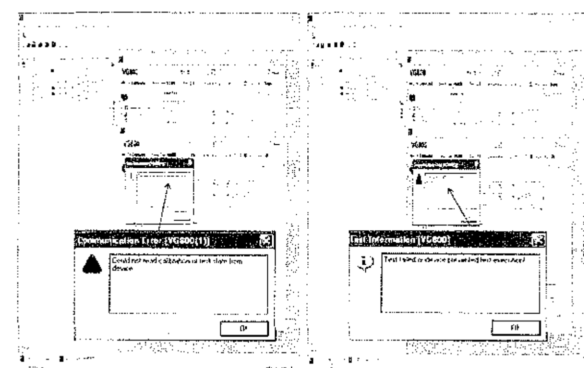
5th Stroked:



6th Stroked:



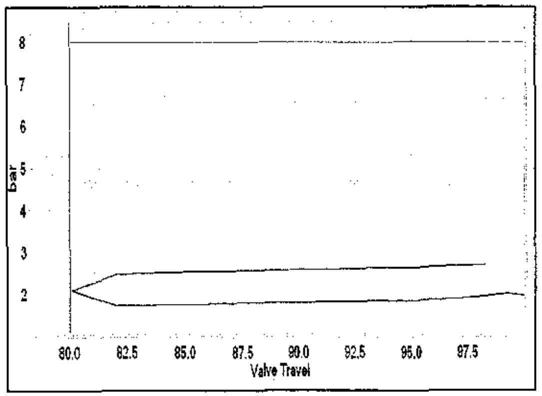
PST + FST:



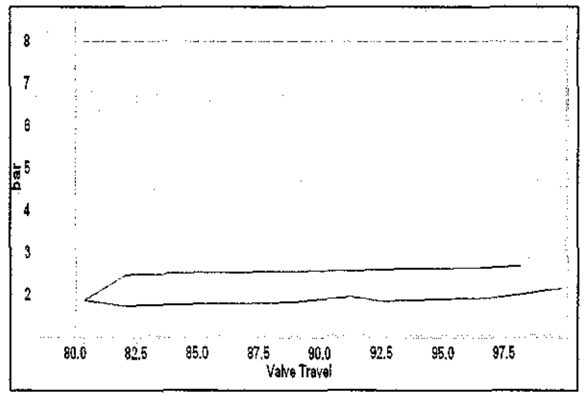
TESTING DAY 17: Ball Valve **DATE: JAN 17th, 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

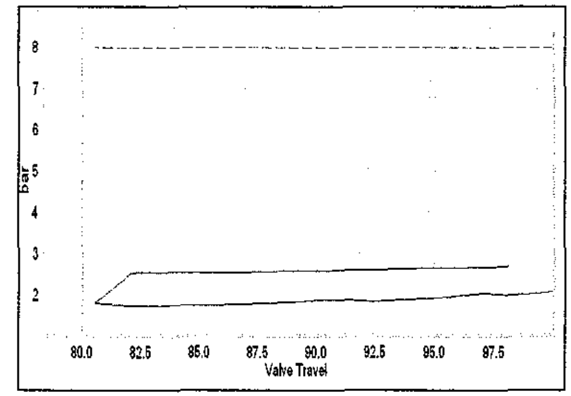
1st Stroked:



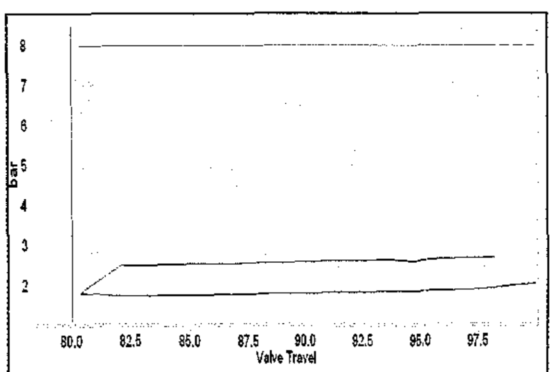
2nd Stroked :



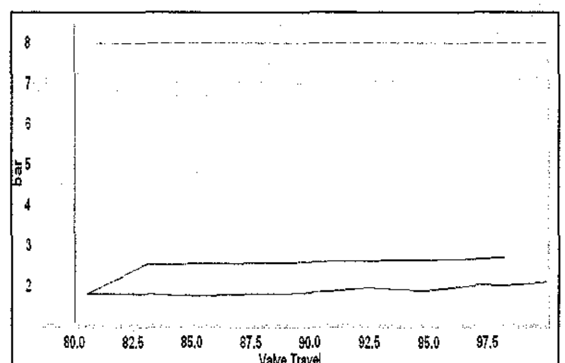
4th Stroked:



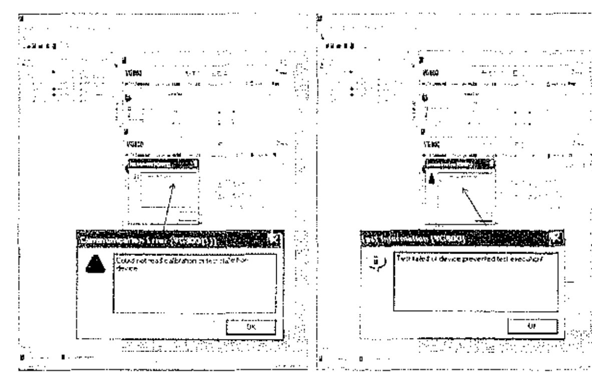
5th Stroked:



6th Stroked:

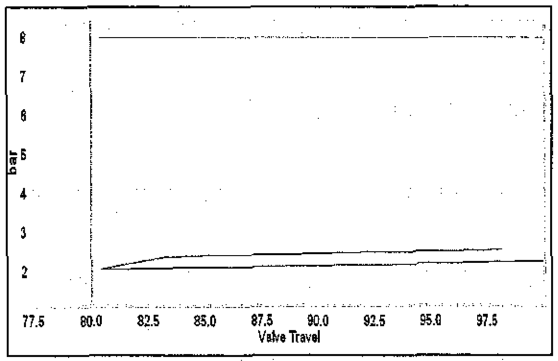


PST + FST:

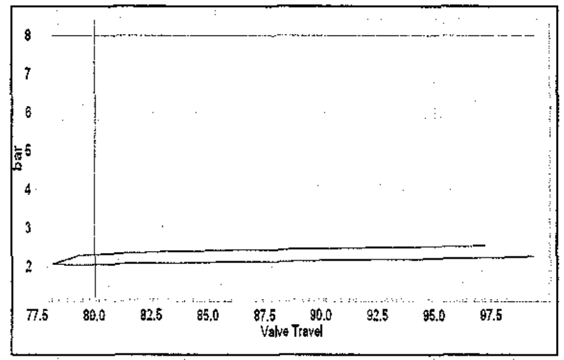


Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

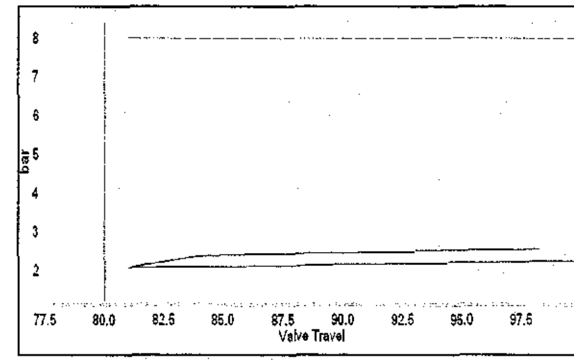
1st Stroked:



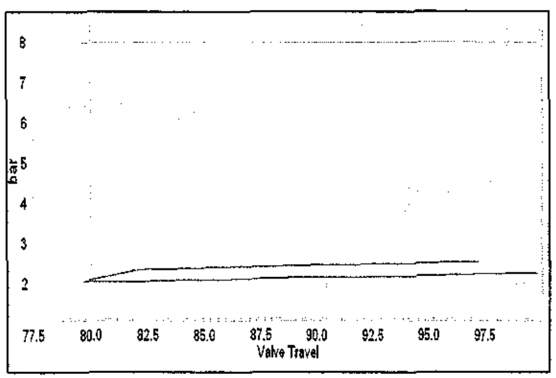
2nd Stroked :



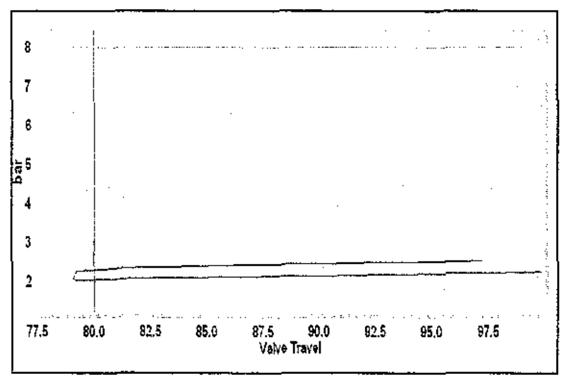
4th Stroked:



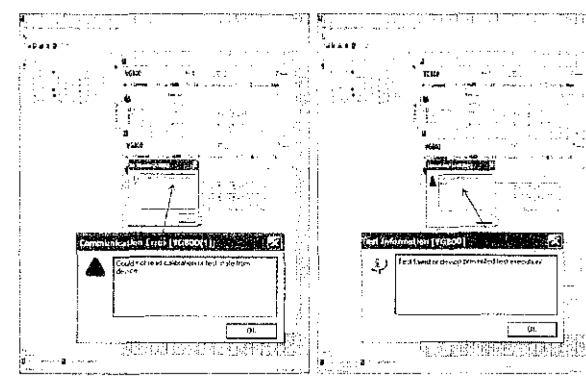
5th Stroked:



6th Stroked:



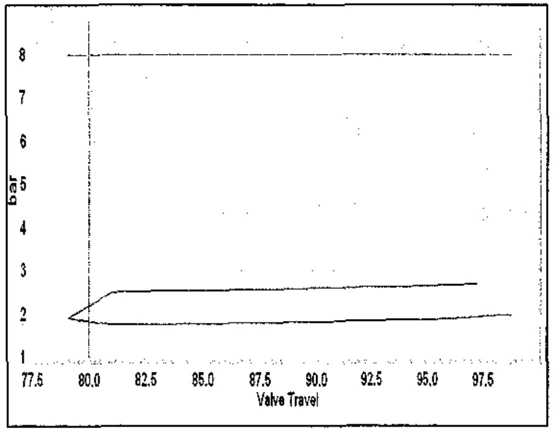
PST + FST:



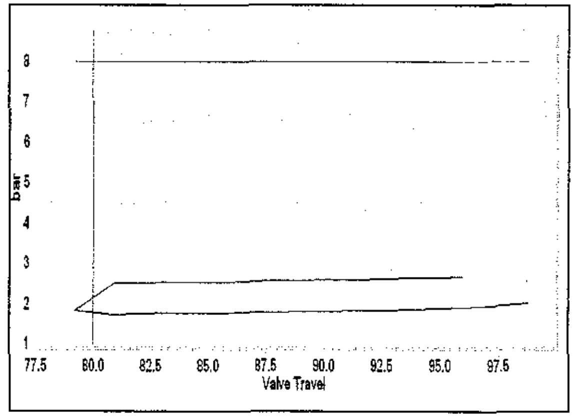
TESTING DAY 19: Ball Valve **DATE: JAN 19th, 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

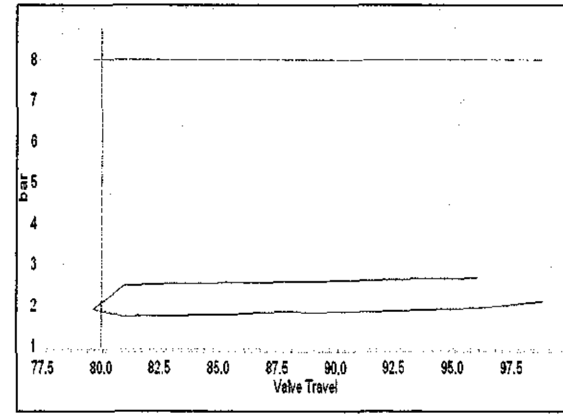
1st Stroked:



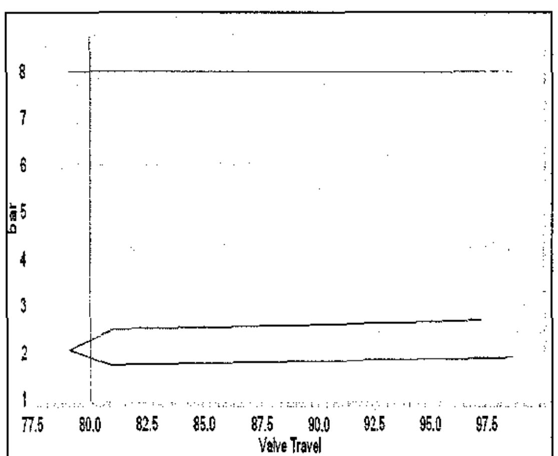
2nd Stroked :



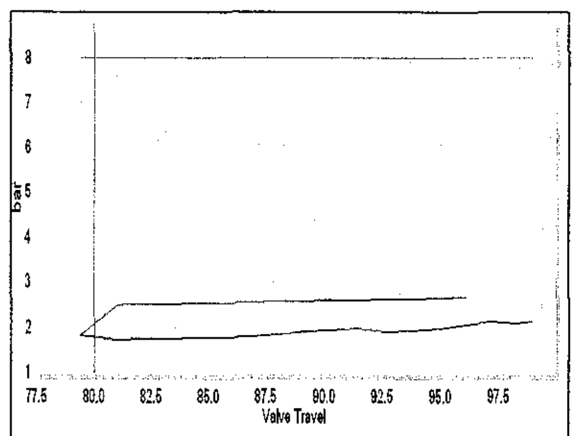
4th Stroked:



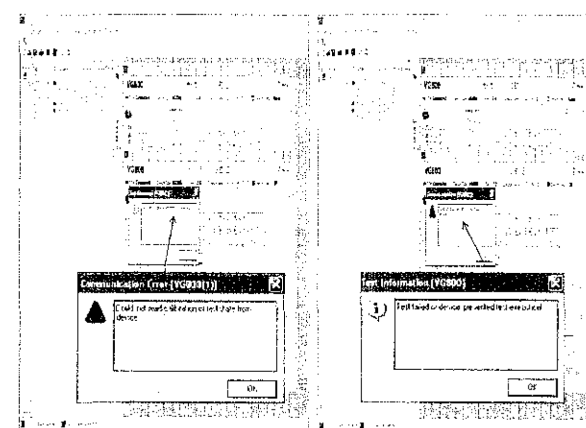
5th Stroked:



6th Stroked:



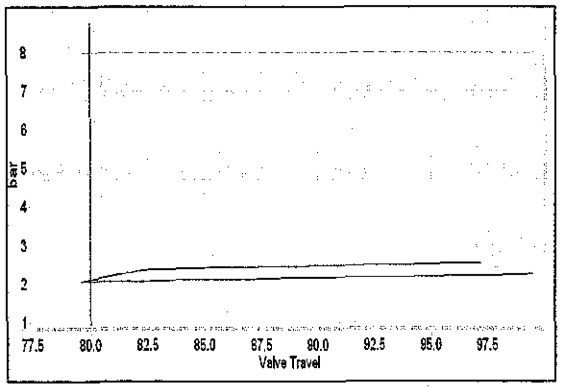
PST + FST:



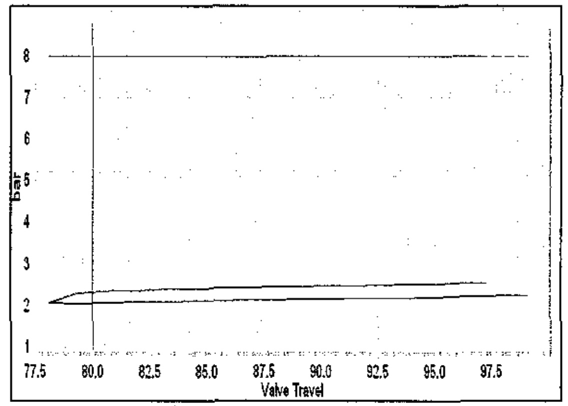
TESTING DAY 19: Butterfly Valve **DATE: Jan 19th, 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

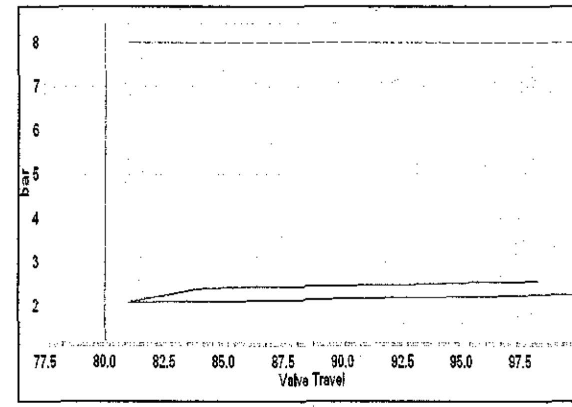
<u>1st Stroked:</u>



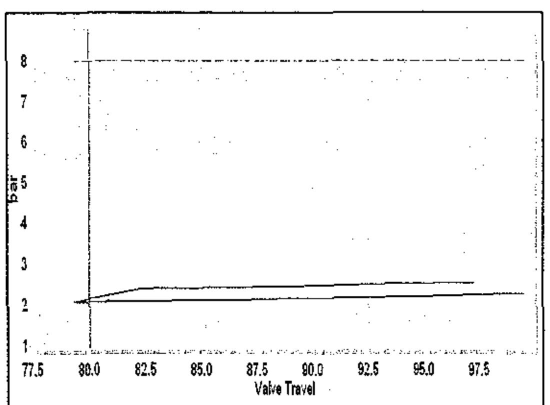
<u>2nd Stroked :</u>



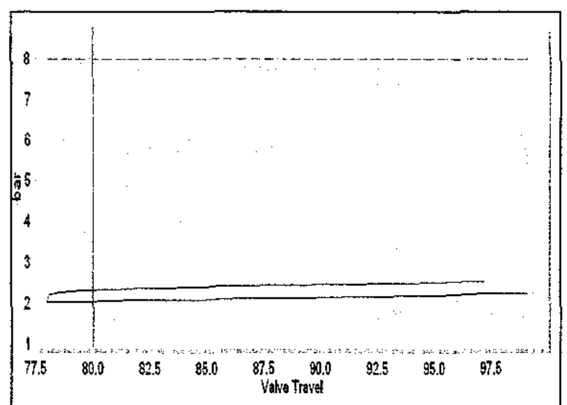
<u>4th Stroked:</u>



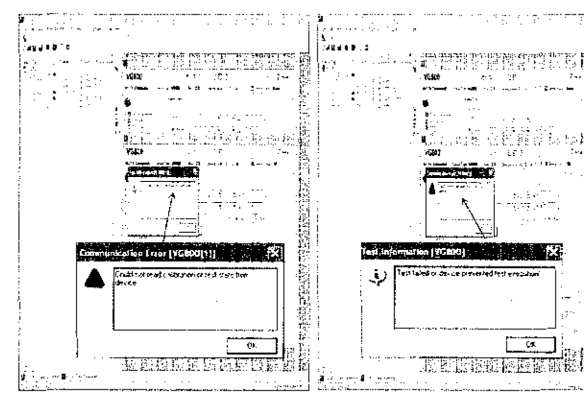
<u>5th Stroked:</u>



<u>6th Stroked:</u>



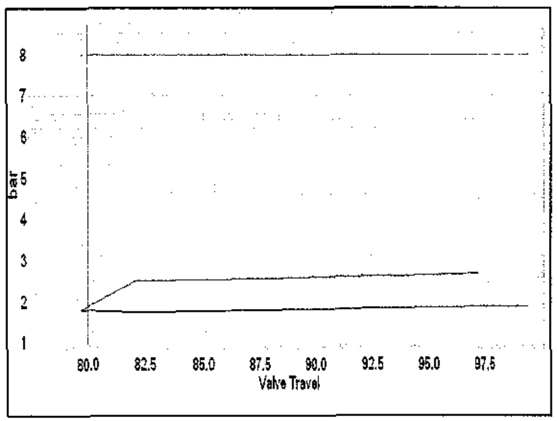
<u>PST + FST:</u>



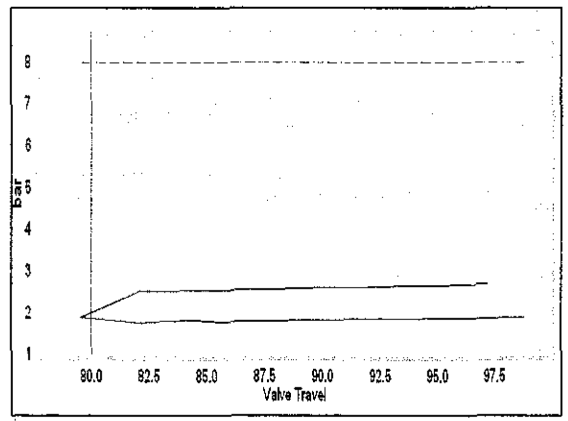
TESTING DAY 21: Ball Valve **DATE: JAN 21st, 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

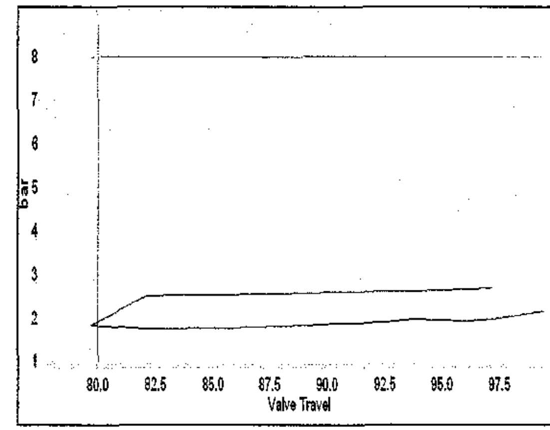
1st Stroked:



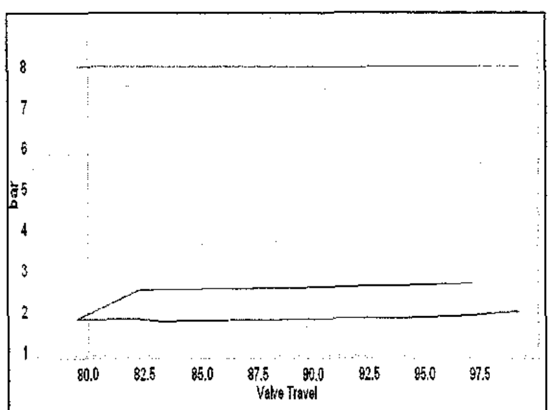
2nd Stroked :



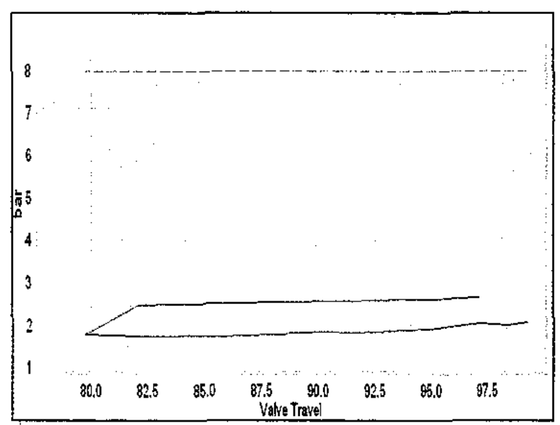
4th Stroked:



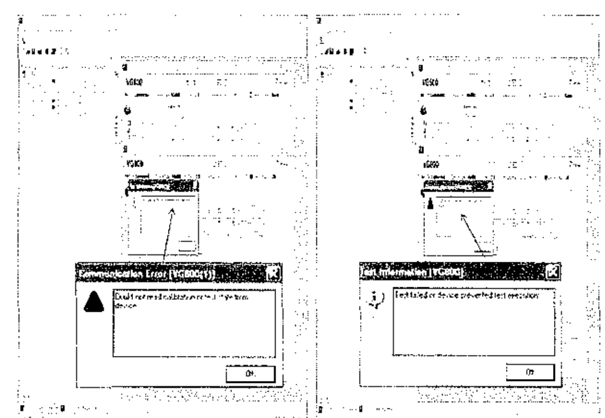
5th Stroked:



6th Stroked:



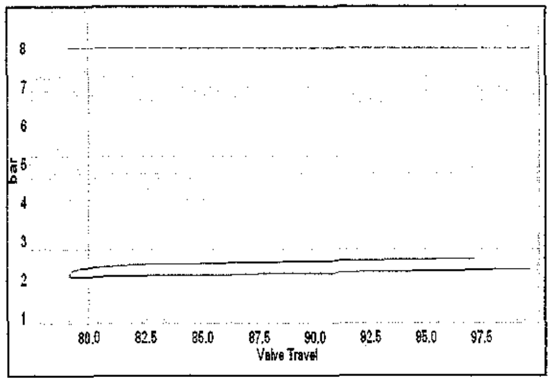
PST + FST:



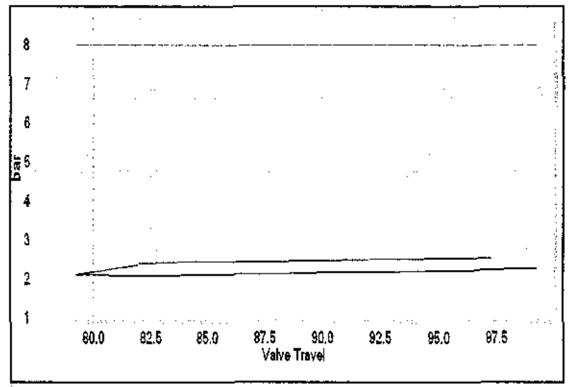
TESTING DAY 21: Butterfly Valve **DATE: Jan 21st , 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

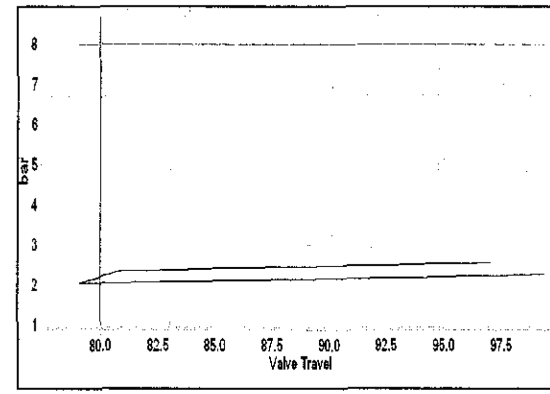
1st Stroked:



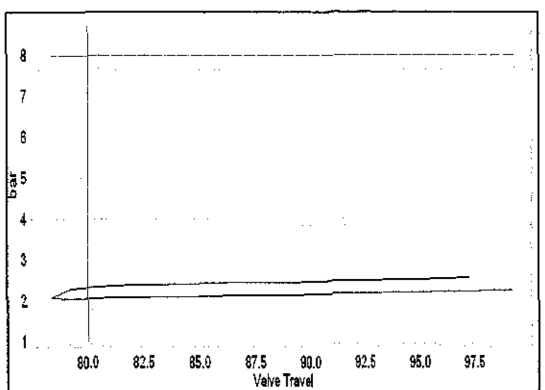
2nd Stroked :



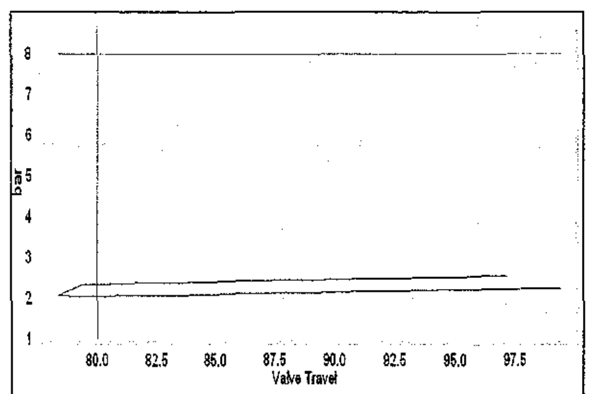
4th Stroked:



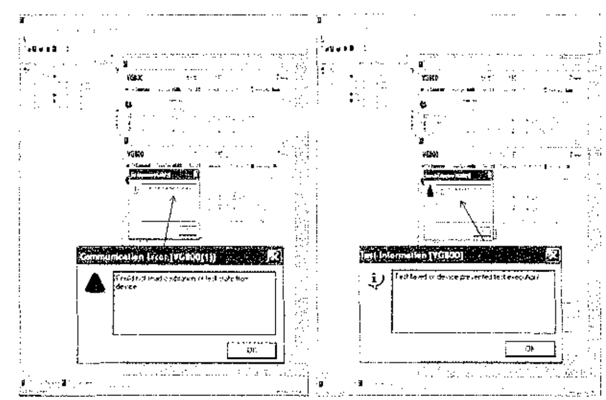
5th Stroked:



6th Stroked:



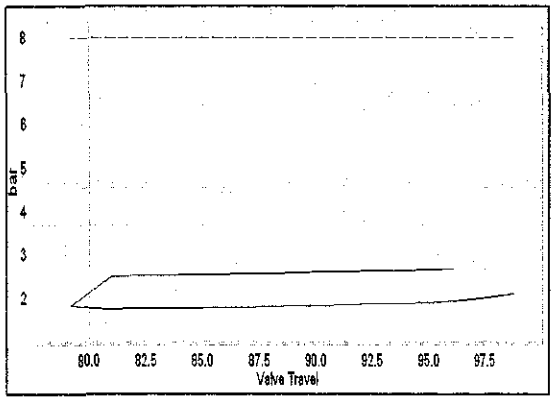
PST + FST:



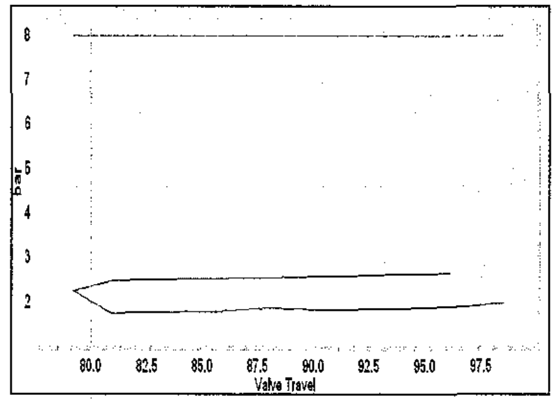
TESTING DAY 23: Ball Valve **DATE: JAN 23rd, 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

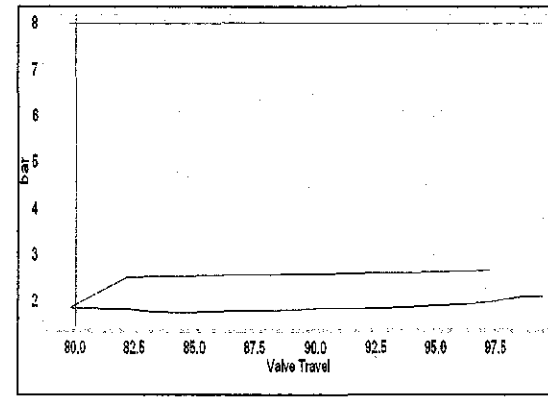
<u>1st Stroked:</u>



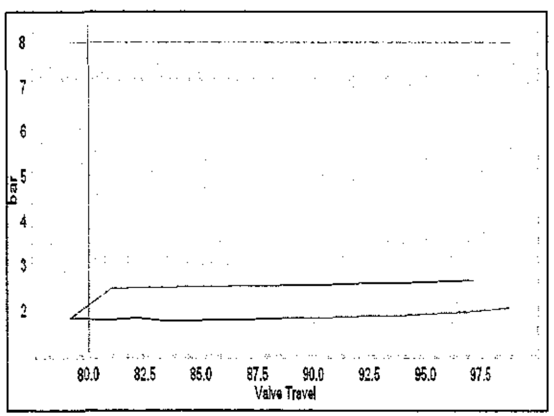
<u>2nd Stroked :</u>



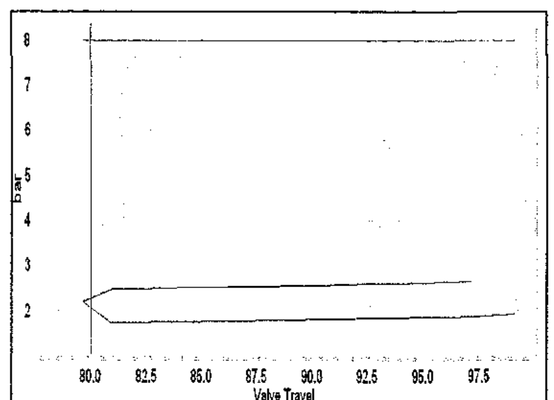
<u>4th Stroked:</u>



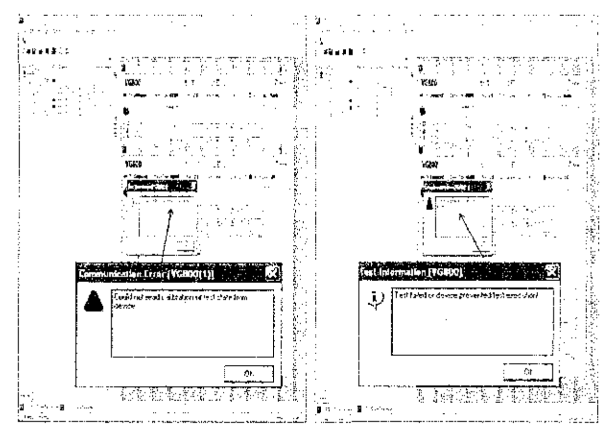
<u>5th Stroked:</u>



<u>6th Stroked:</u>



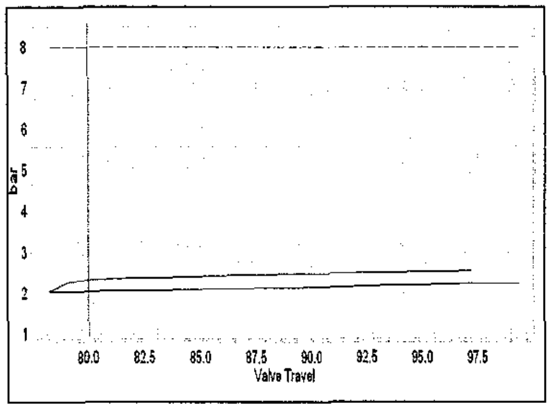
<u>PST + FST:</u>



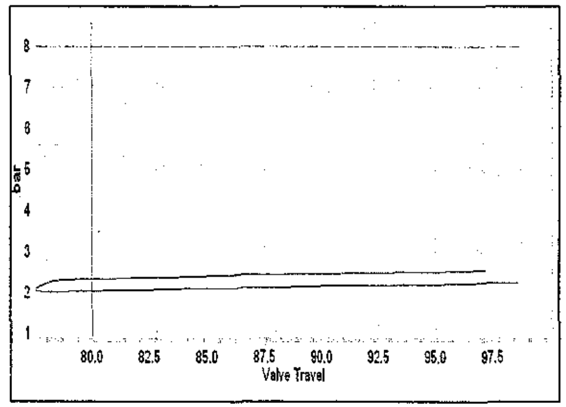
TESTING DAY 23: Butterfly Valve **DATE: Jan 23rd , 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

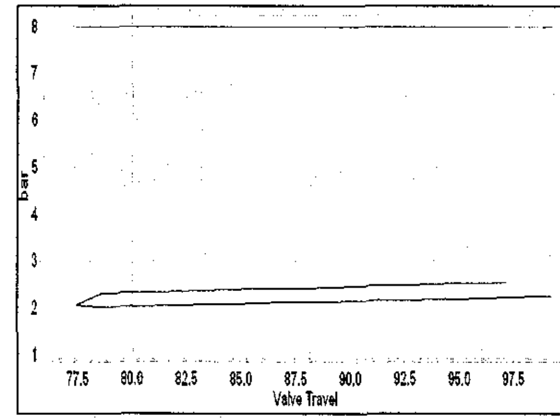
1st Stroked:



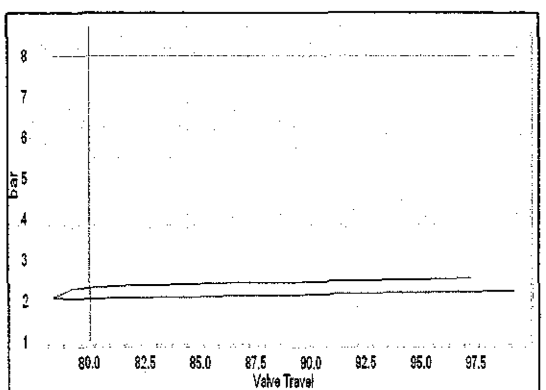
2nd Stroked :



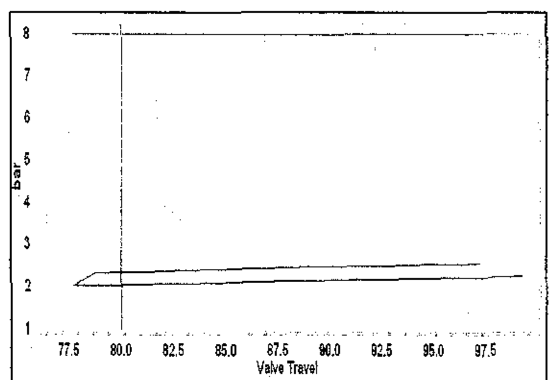
4th Stroked:



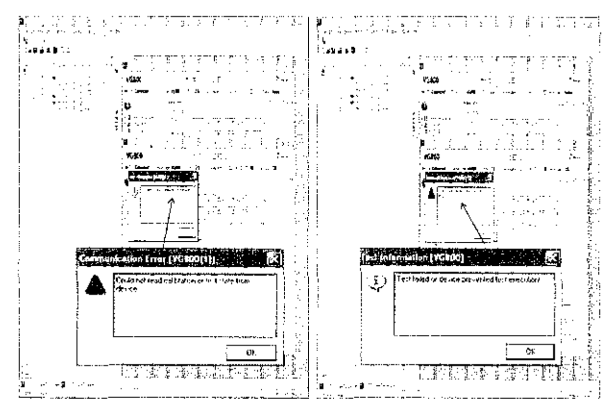
5th Stroked:



6th Stroked:



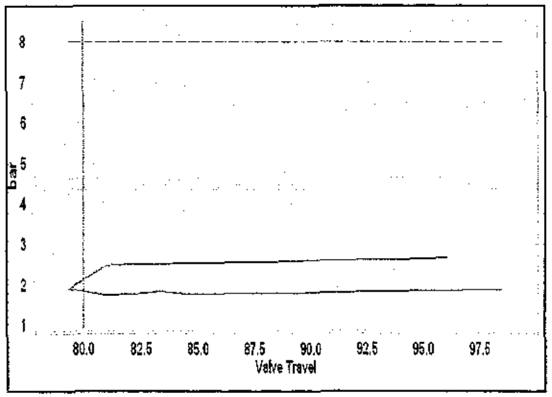
PST + FST:



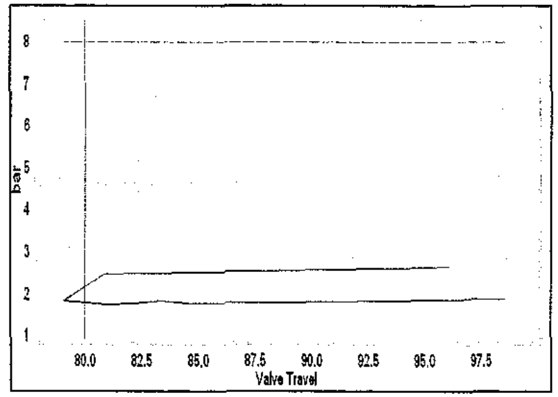
TESTING DAY 25: Ball Valve **DATE: JAN 25th, 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

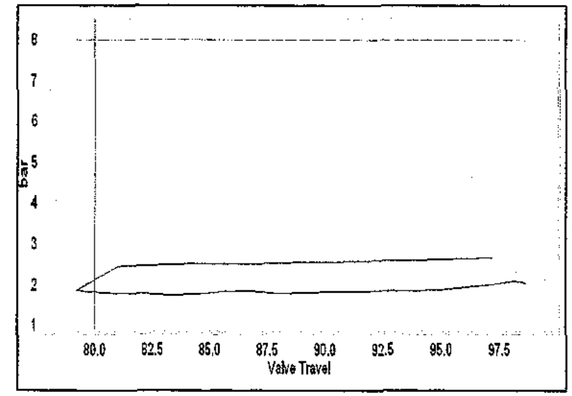
1st Stroked:



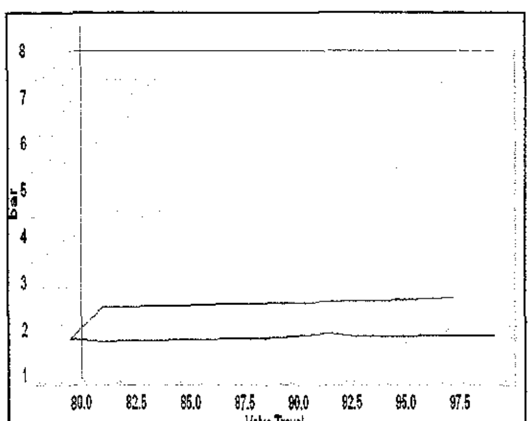
2nd Stroked :



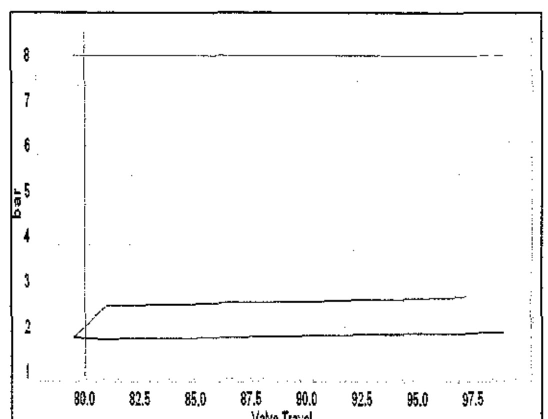
4th Stroked:



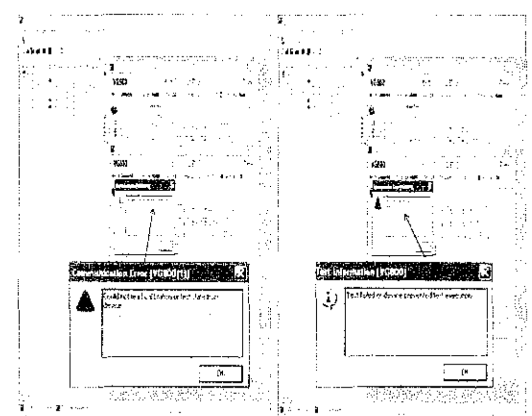
5th Stroked:



6th Stroked:



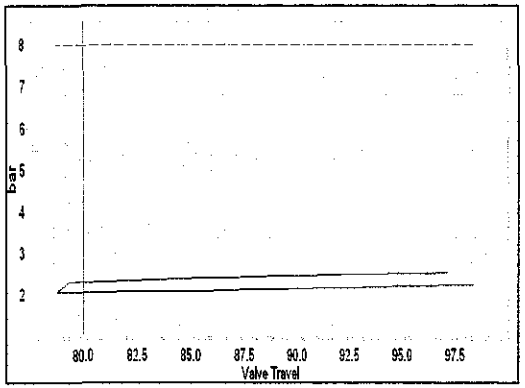
PST + FST:



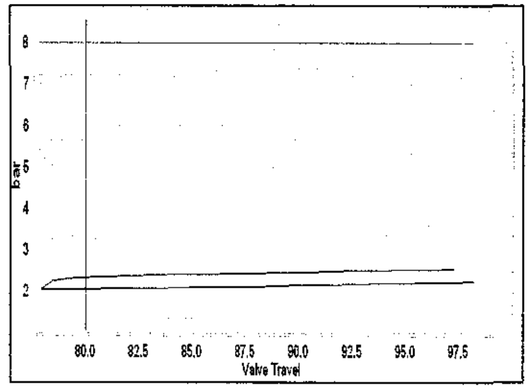
TESTING DAY 25: Butterfly Valve **DATE: Jan 25th , 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

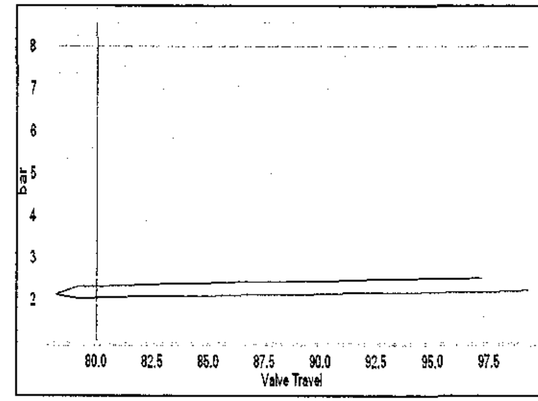
1st Stroked:



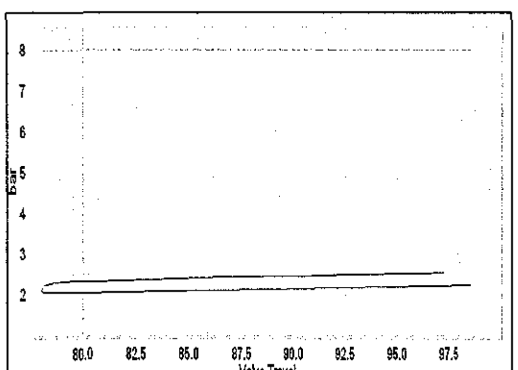
2nd Stroked :



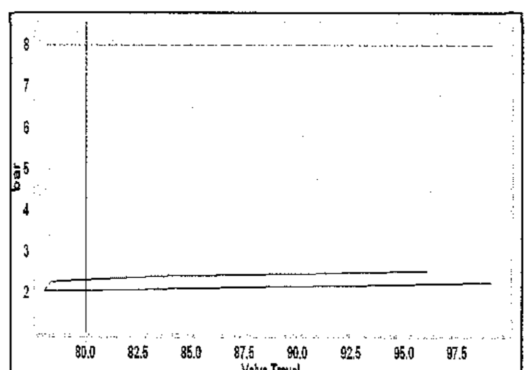
4th Stroked:



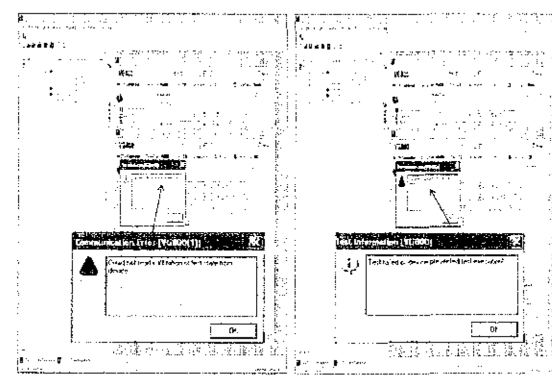
5th Stroked:



6th Stroked:

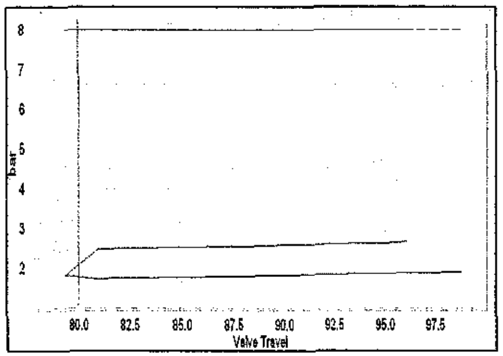


PST + FST:

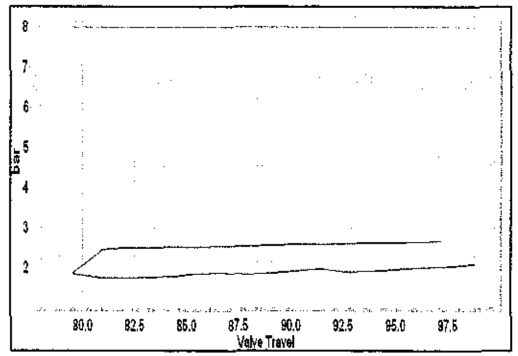


Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

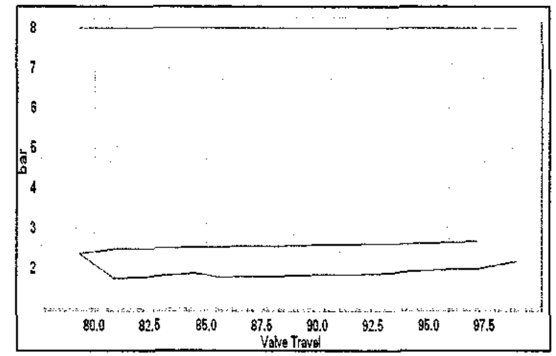
1st Stroked:



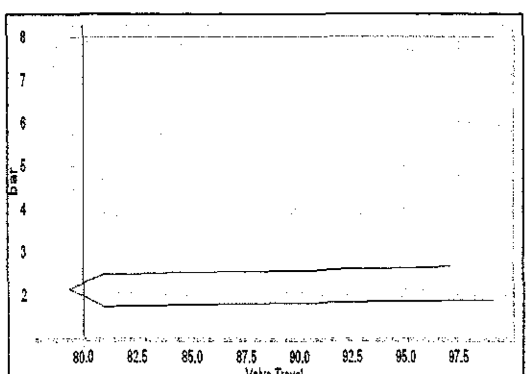
2nd Stroked :



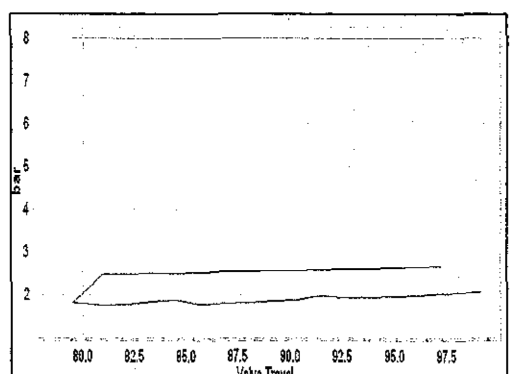
4th Stroked:



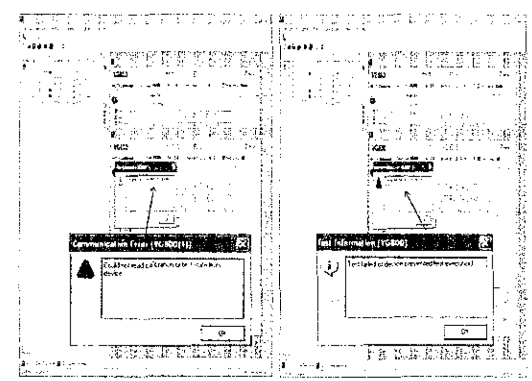
5th Stroked:



6th Stroked:

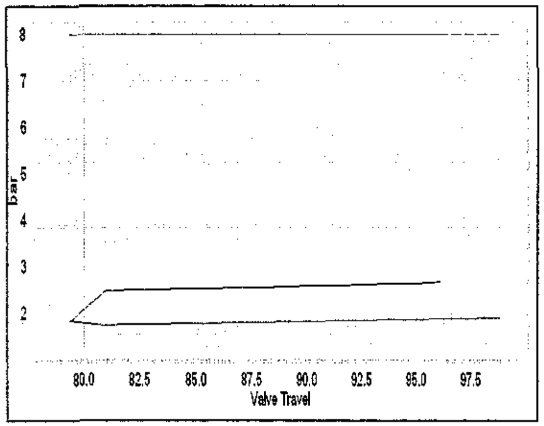


PST + FST:

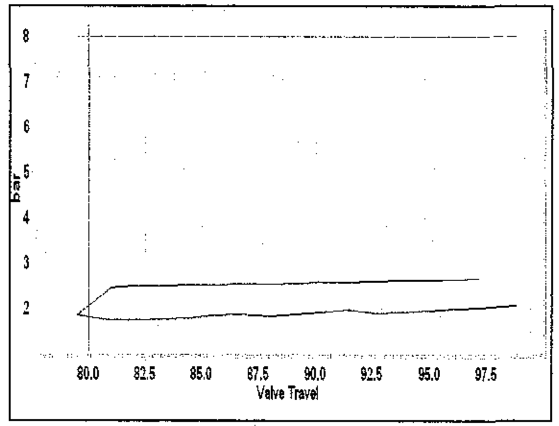


Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

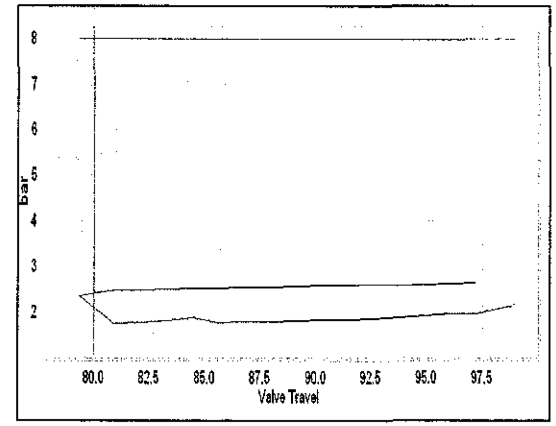
1st Stroked:



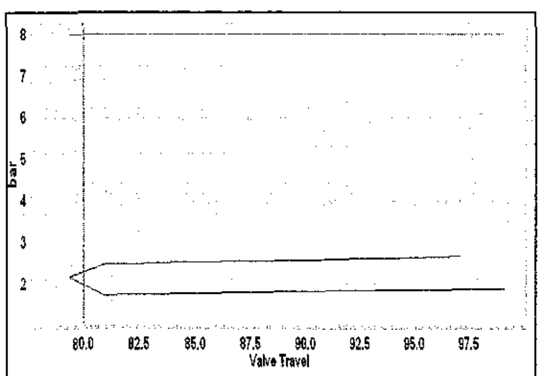
2nd Stroked :



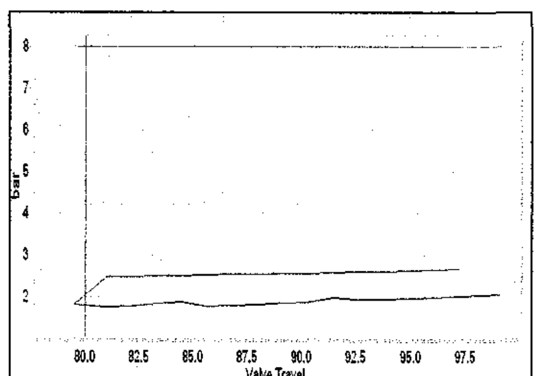
4th Stroked:



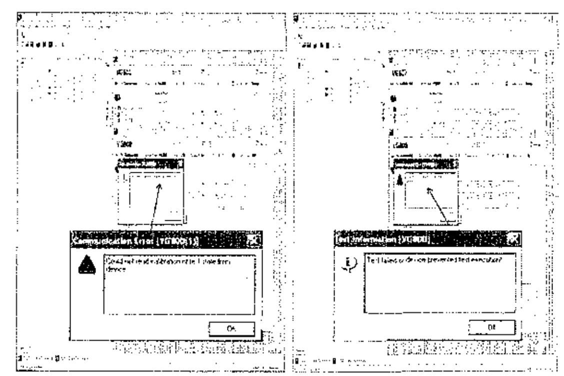
5th Stroked:



6th Stroked:



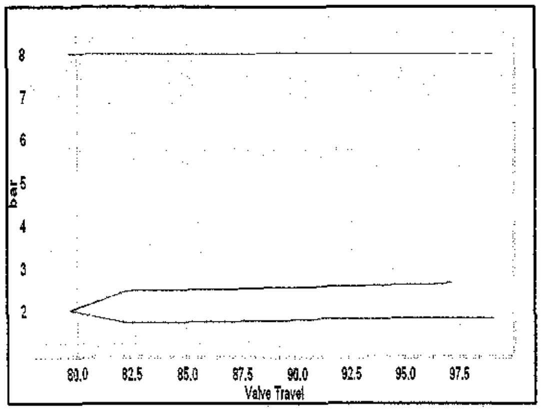
PST + FST:



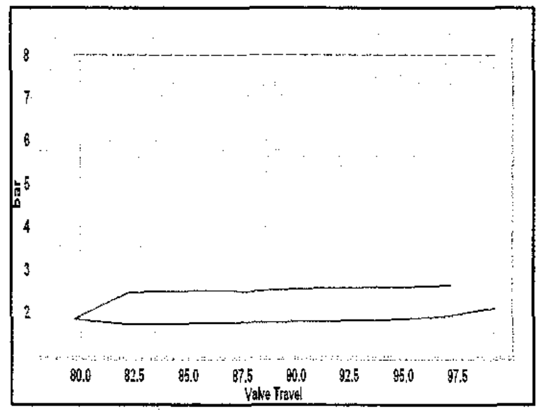
TESTING DAY 29: Ball Valve **DATE: Feb 3rd , 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

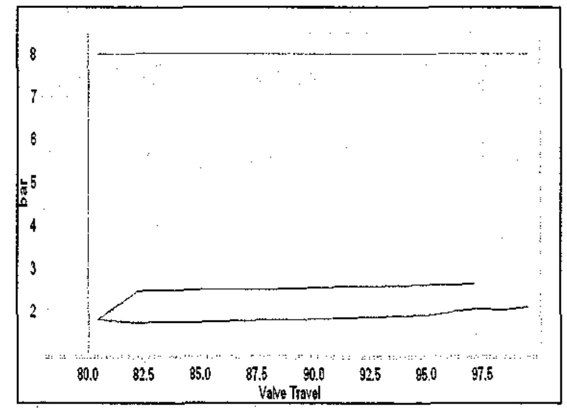
1st Stroked:



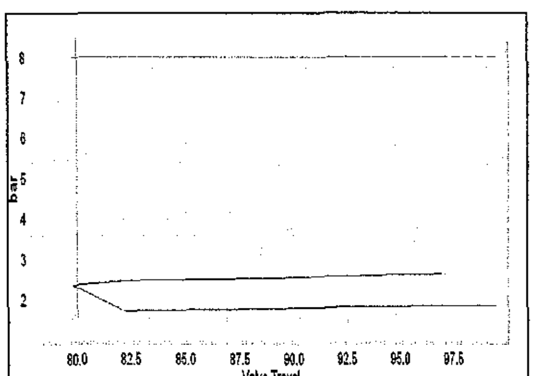
2nd Stroked :



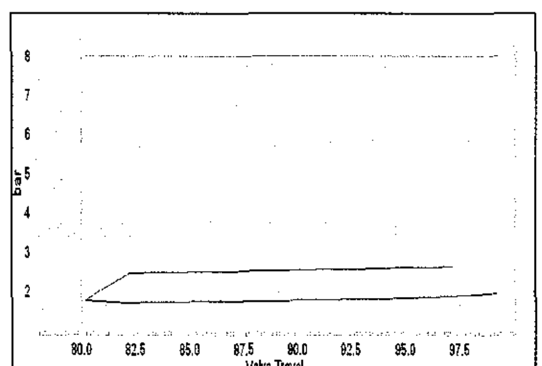
4th Stroked:



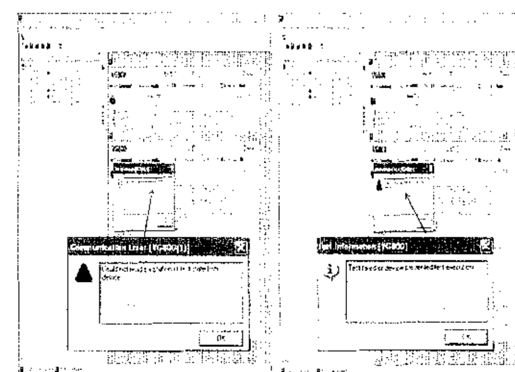
5th Stroked:



6th Stroked:



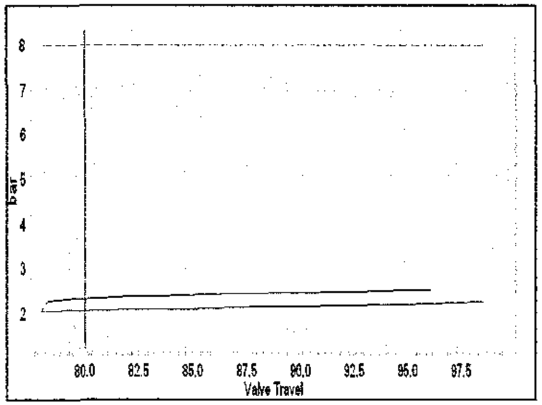
PST + FST:



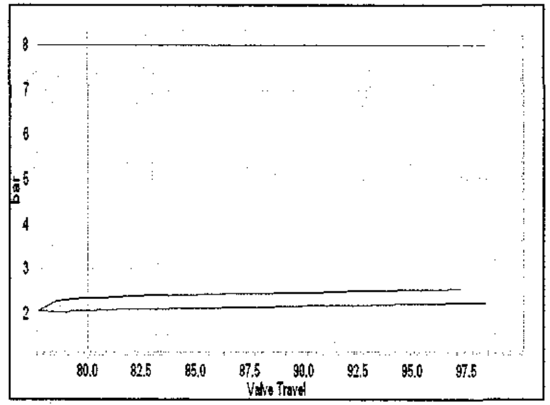
TESTING DAY 29: Butterfly Valve **DATE: Feb 3rd, 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

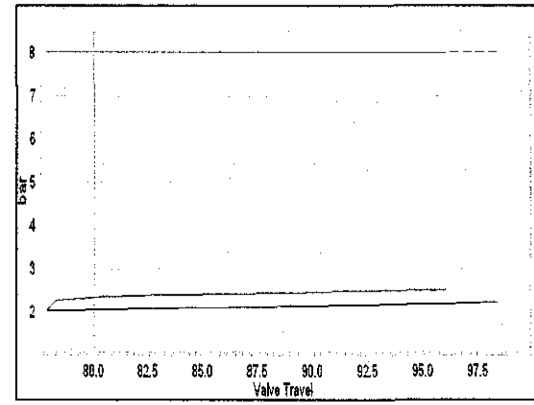
1st Stroked:



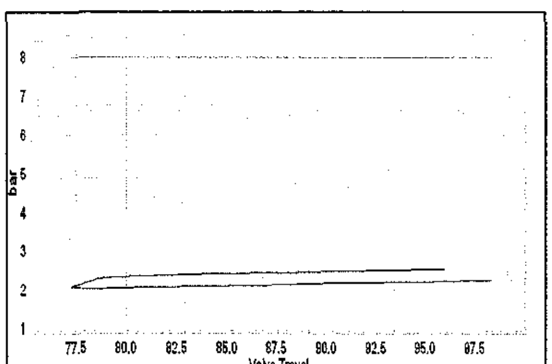
2nd Stroked :



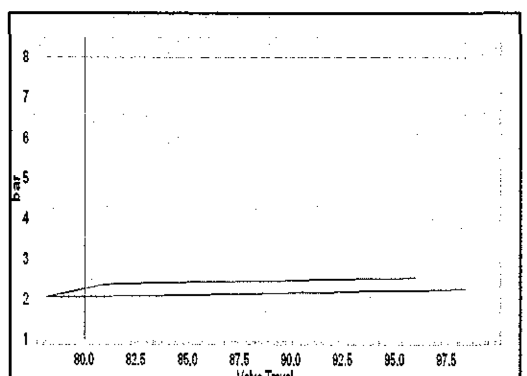
4th Stroked:



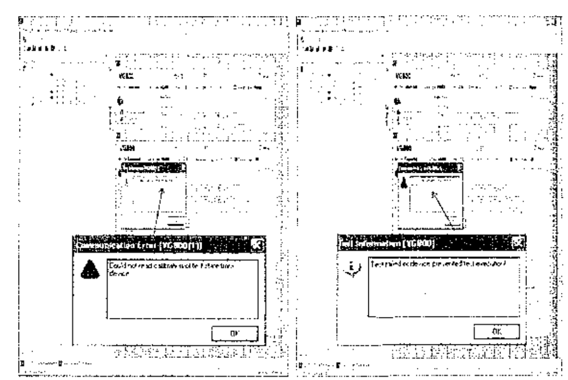
5th Stroked:



6th Stroked:



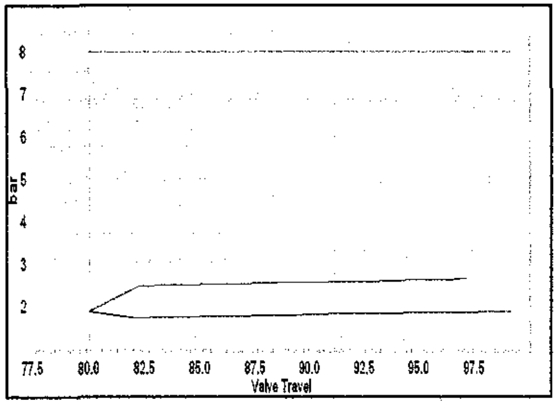
PST + FST:



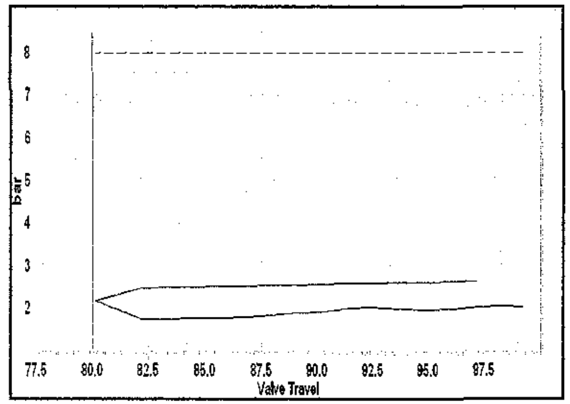
TESTING DAY 31: Ball Valve **DATE: Feb 5th , 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

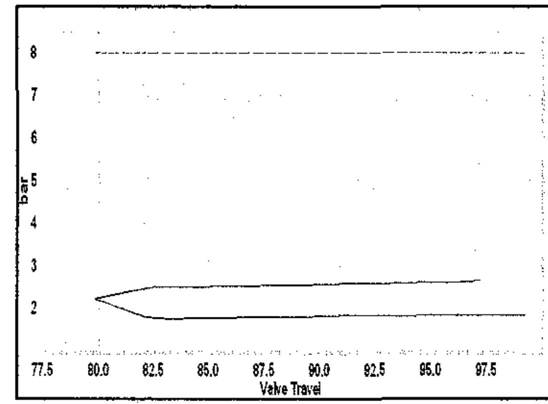
1st Stroked:



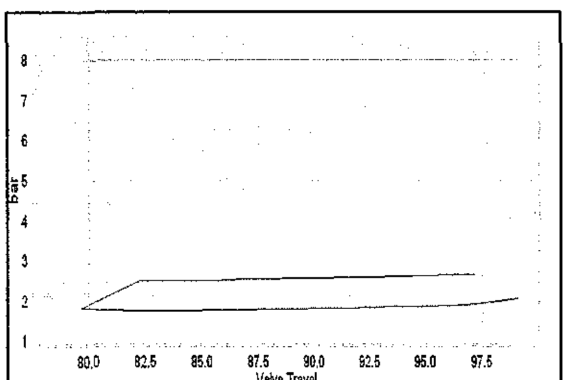
2nd Stroked :



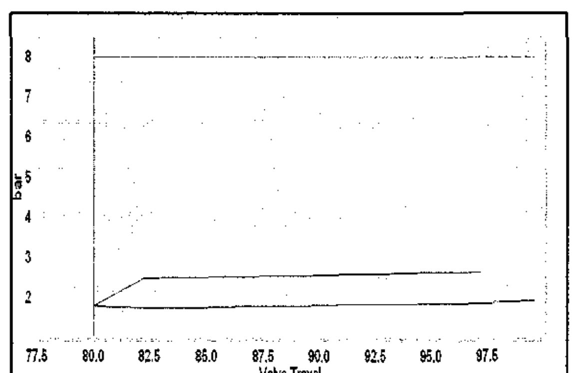
4th Stroked:



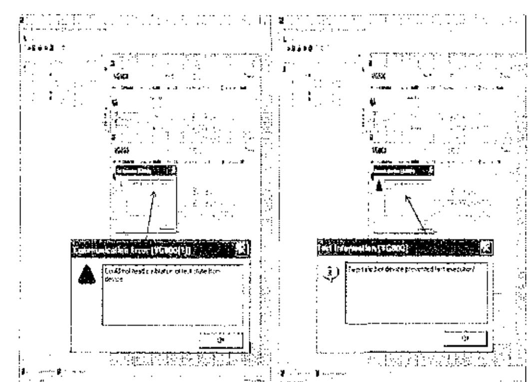
5th Stroked:



6th Stroked:



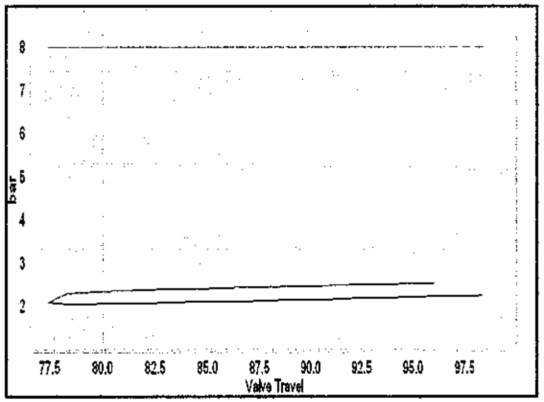
PST + FST:



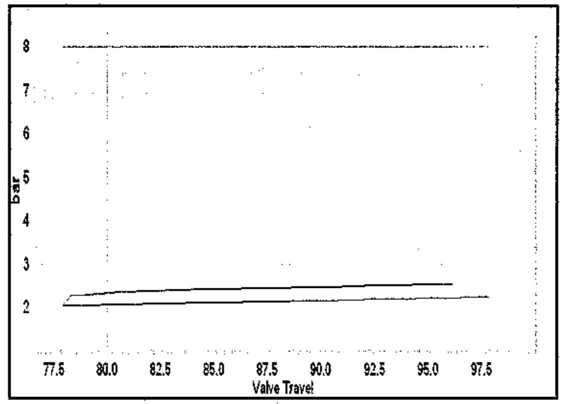
TESTING DAY 31: Butterfly Valve **DATE: Feb 5th , 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

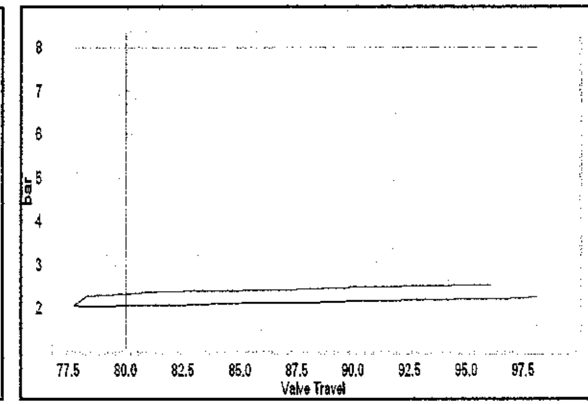
1st Stroked:



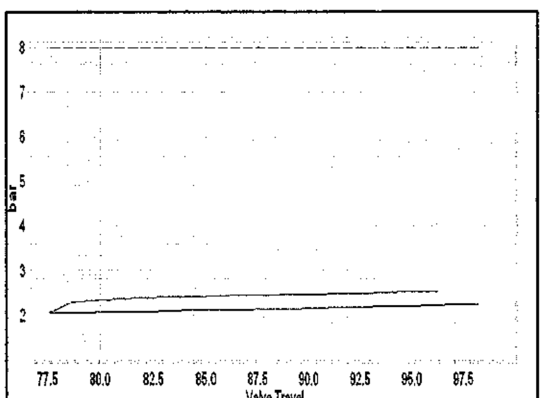
2nd Stroked :



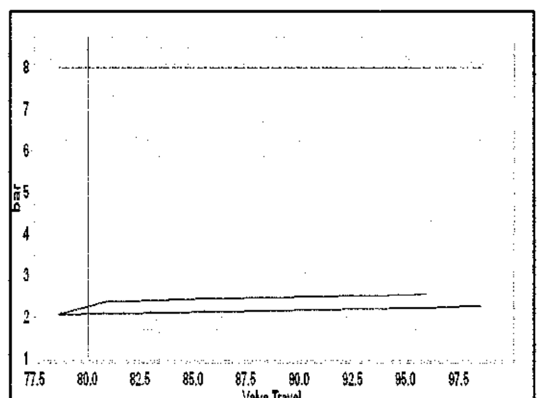
4th Stroked:



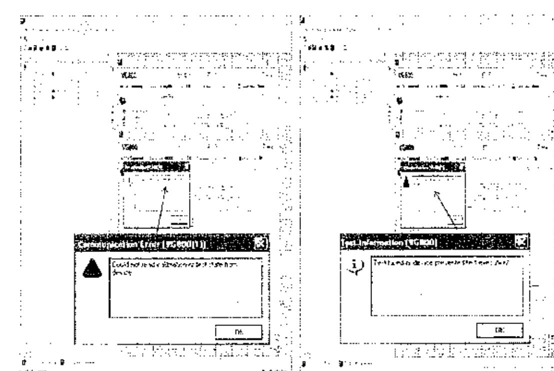
5th Stroked:



6th Stroked:



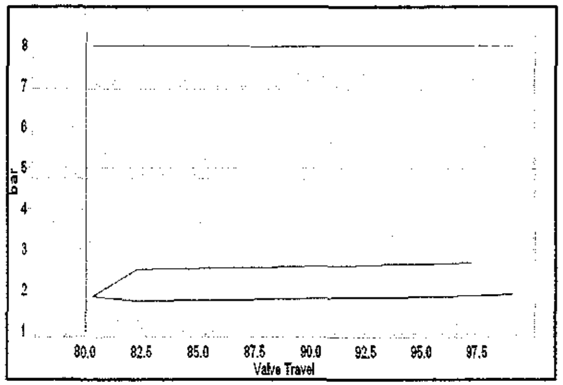
PST + FST:



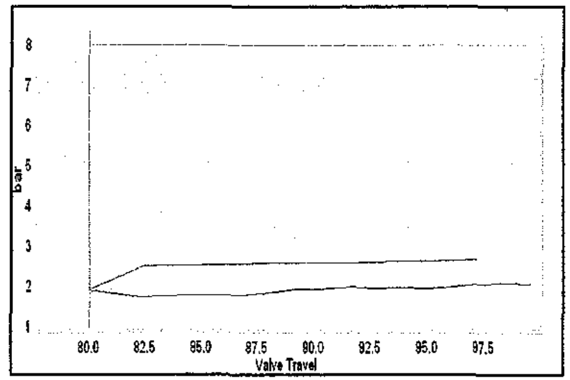
TESTING DAY 33: Ball Valve **DATE: Feb 7th , 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

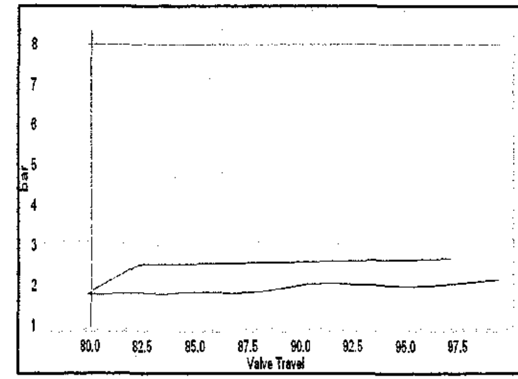
1st Stroked:



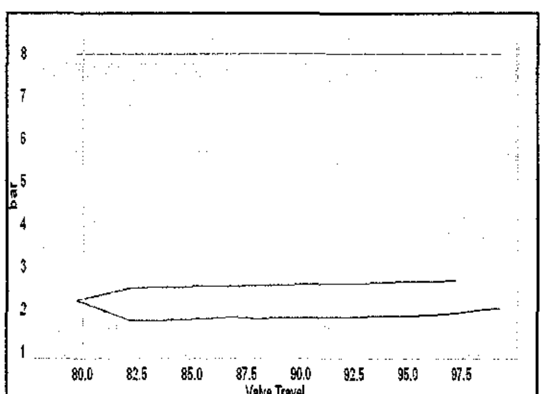
2nd Stroked :



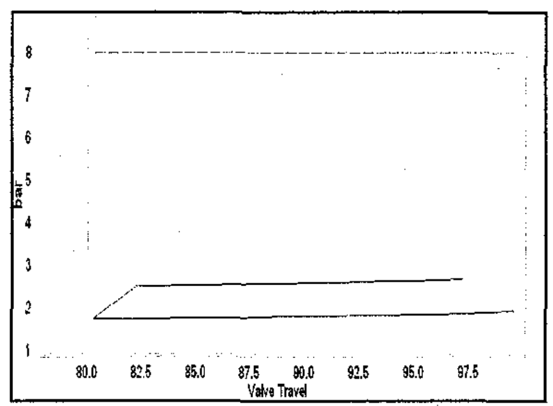
4th Stroked:



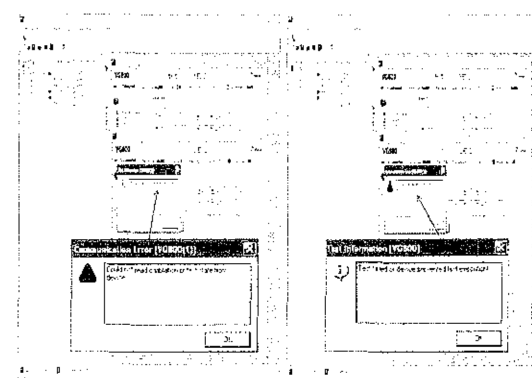
5th Stroked:



6th Stroked:



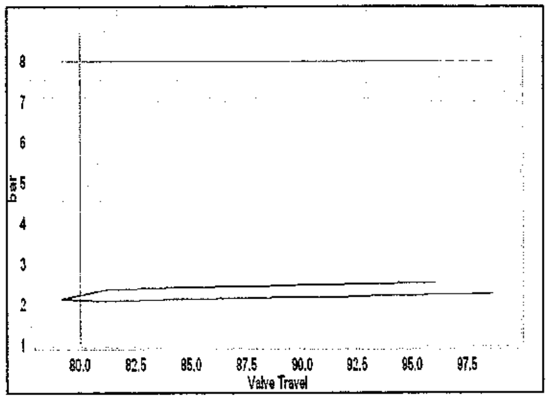
PST + FST:



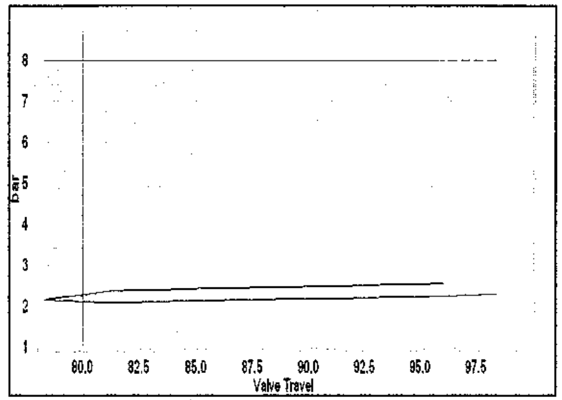
TESTING DAY 33: Butterfly Valve **DATE: Feb 7th , 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

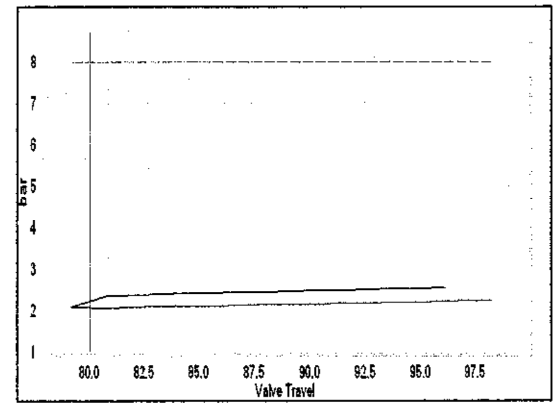
1st Stroked:



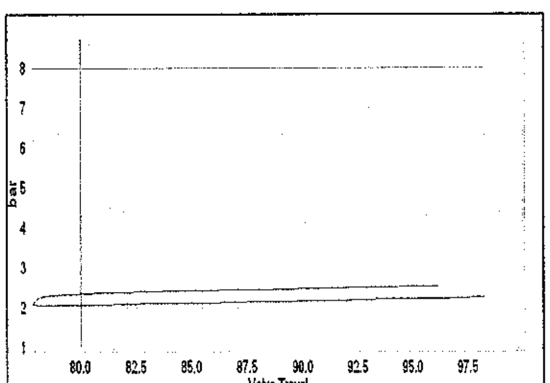
2nd Stroked :



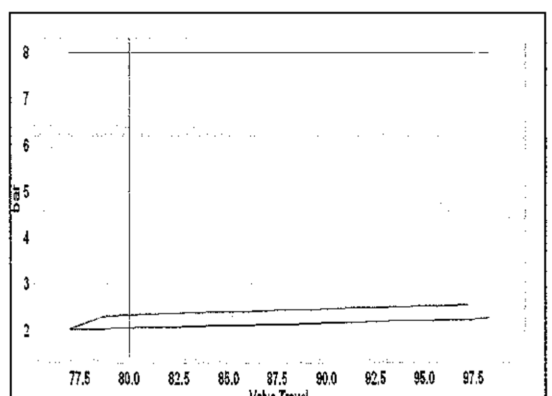
4th Stroked:



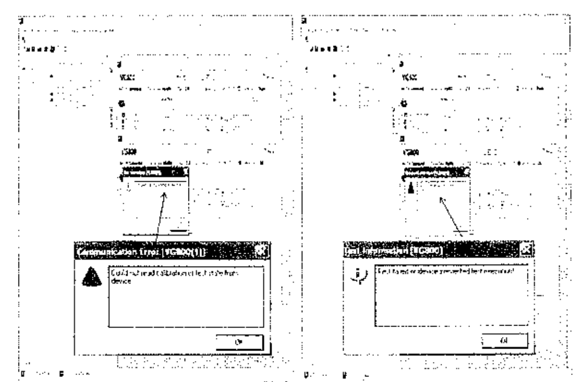
5th Stroked:



6th Stroked:



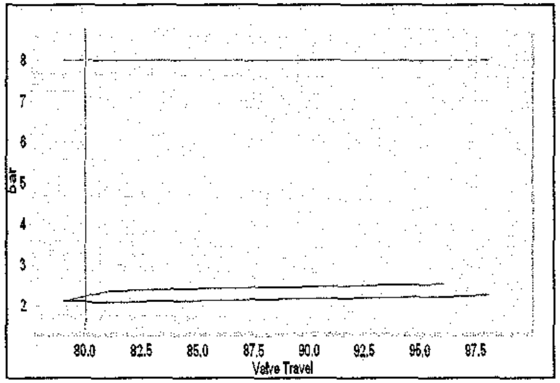
PST + FST:



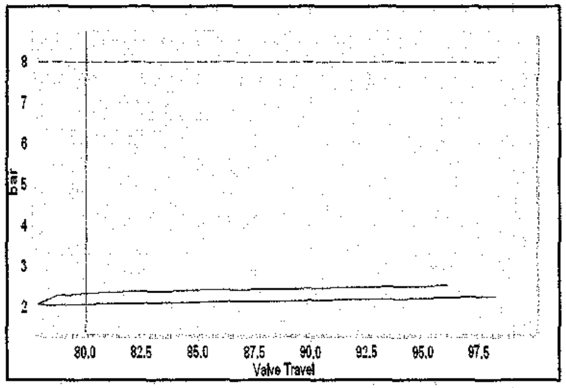
TESTING DAY 35: Butterfly Valve **DATE: Feb 9th , 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

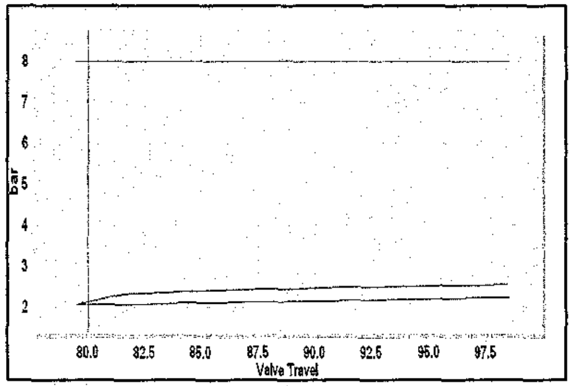
1st Stroked:



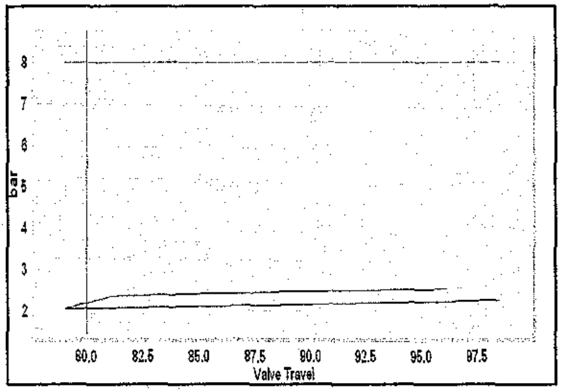
2nd Stroked :



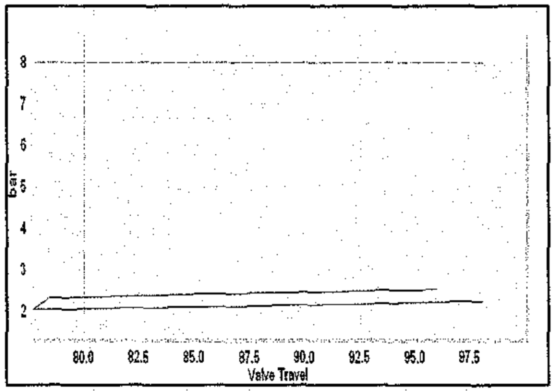
4th Stroked:



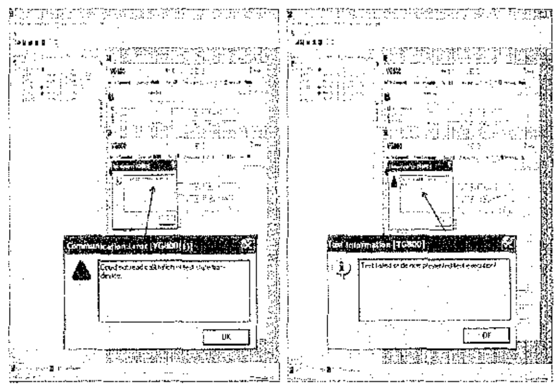
5th Stroked:

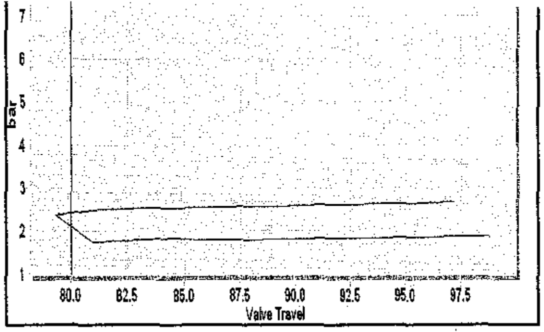


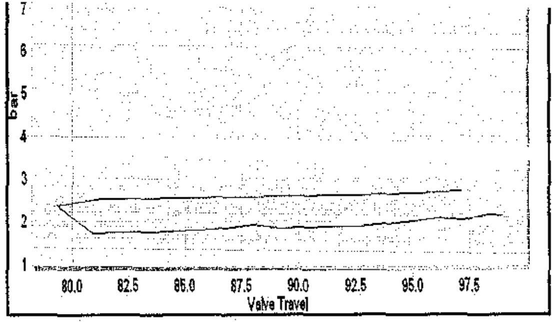
6th Stroked:

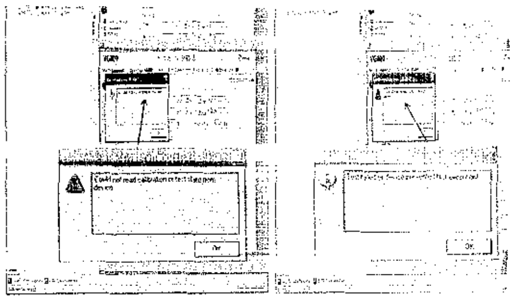


PST + FST:

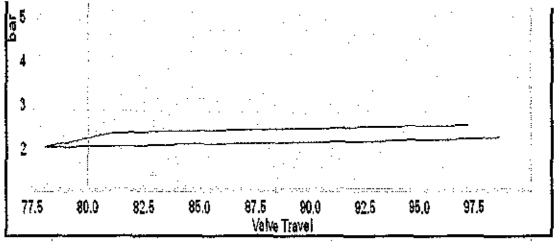



bar
7
6
5
4
3
2
1
80.0
82.5
85.0
87.5
90.0
92.5
95.0
97.5
Valve Travel


bar
7
6
5
4
3
2
1
80.0
82.5
85.0
87.5
90.0
92.5
95.0
97.5
Valve Travel



102


bar
5
4
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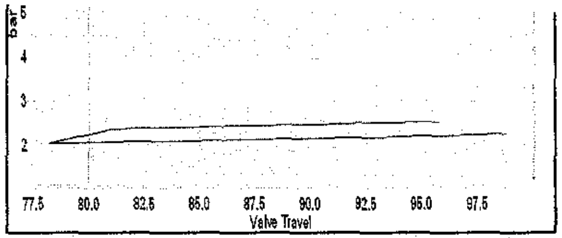
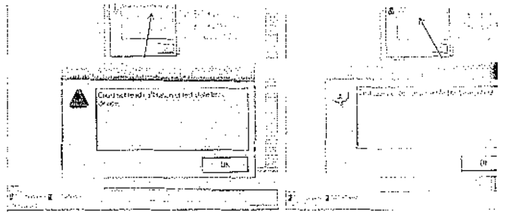
2
77.5
80.0
82.5
85.0
87.5
90.0
92.5
95.0
97.5
Valve Travel

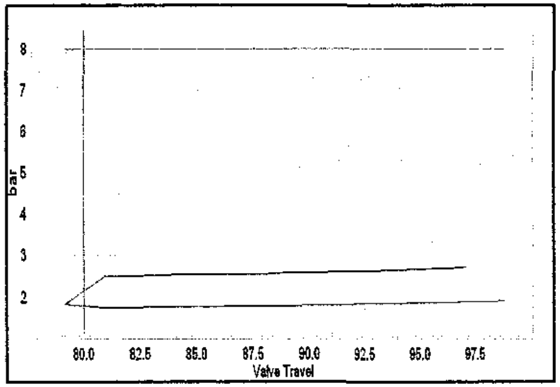

bar
5
4
3
2
77.5
80.0
82.5
85.0
87.5
90.0
92.5
95.0
97.5
Valve Travel



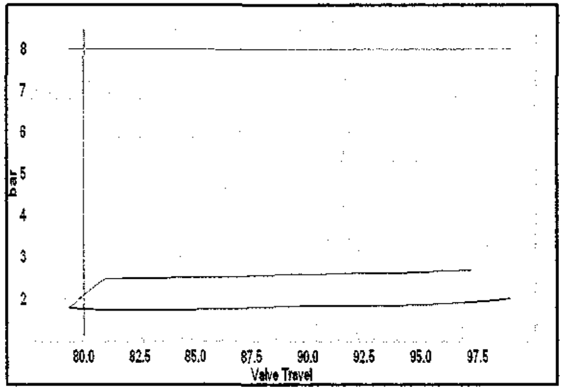
TESTING DAY 39: Ball Valve **DATE: Feb 13th , 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

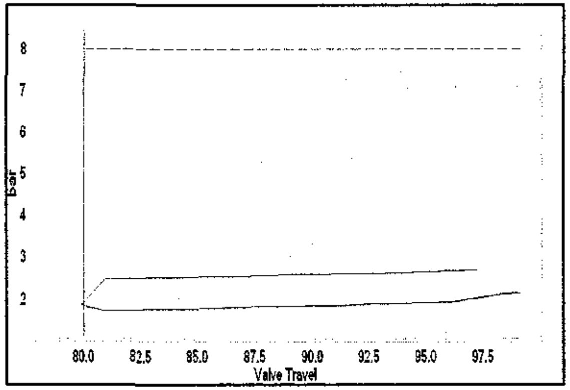
1st Stroked:



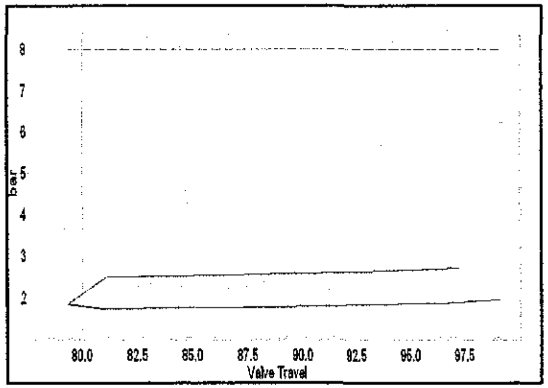
2nd Stroked :



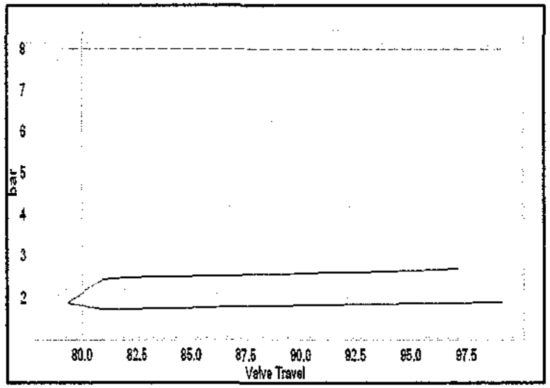
4th Stroked:



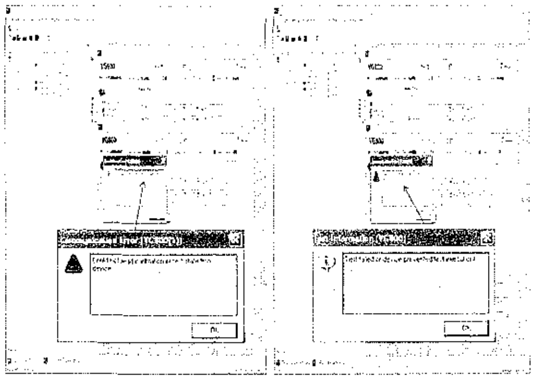
5th Stroked:



6th Stroked:



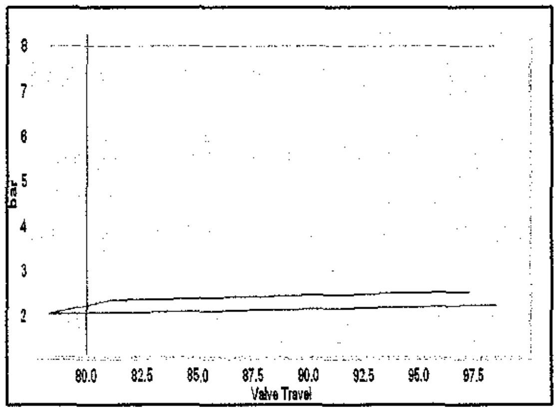
PST + FST:



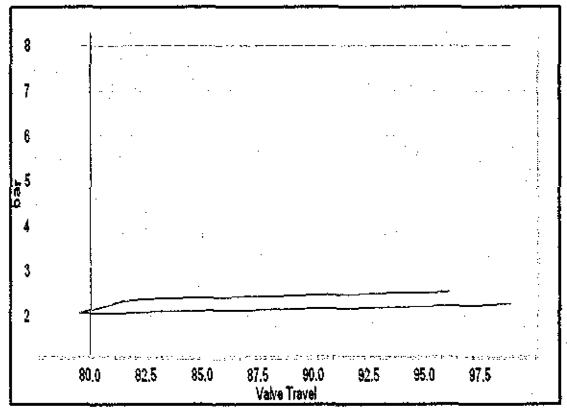
TESTING DAY 39: Butterfly Valve **DATE: Feb 13th , 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = 0.05 bar

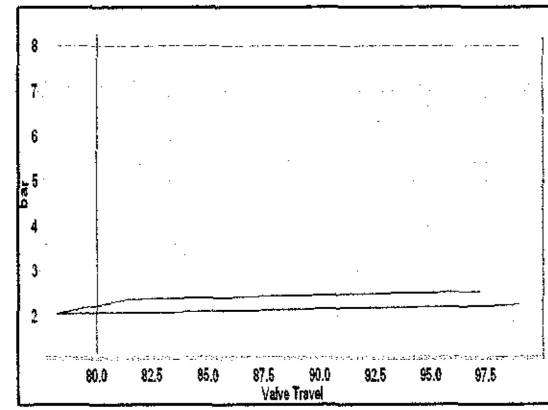
1st Stroked:



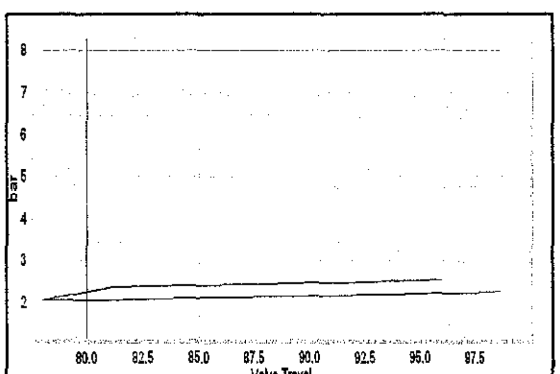
2nd Stroked :



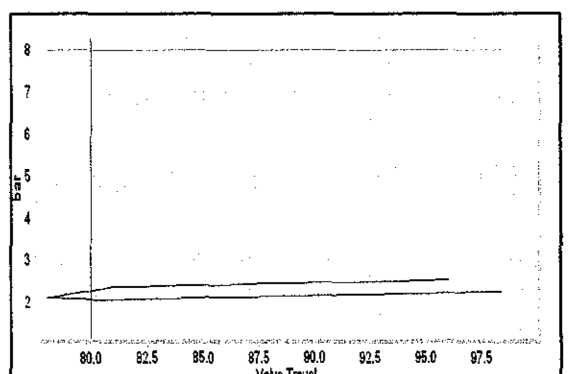
4th Stroked:



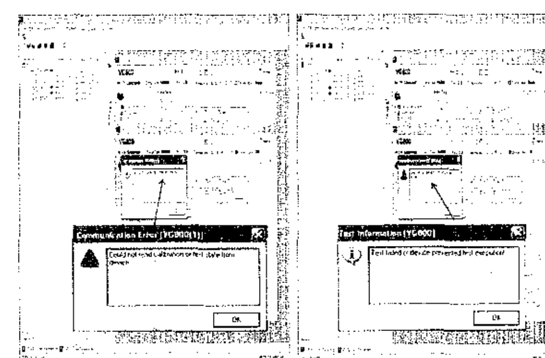
5th Stroked:



6th Stroked:



PST + FST:

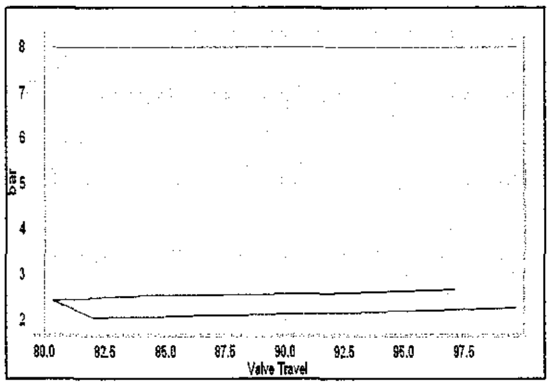


APPENDIX II : TESTING RESULT FOR 0.005 BAR PRESSURE STEP

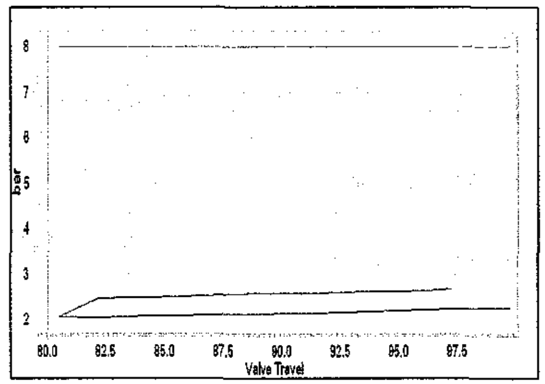
TESTING DAY 1: Ball Valve **DATE: APRIL 2nd , 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = **0.005 bar**

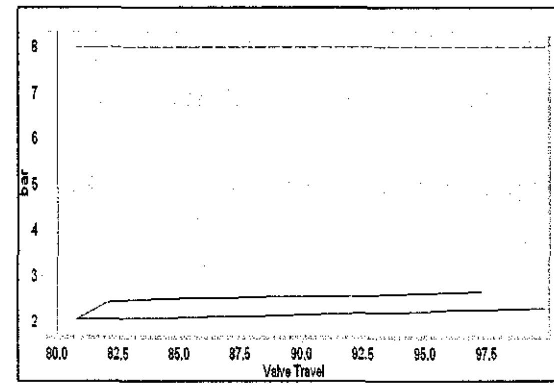
1st Stroked:



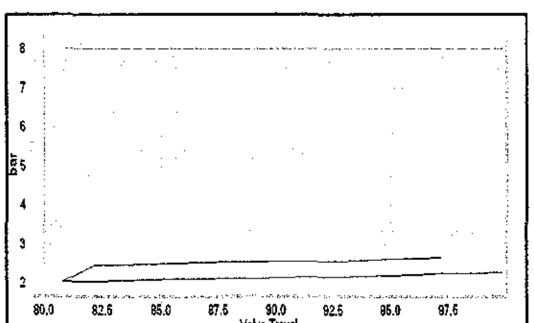
2nd Stroked :



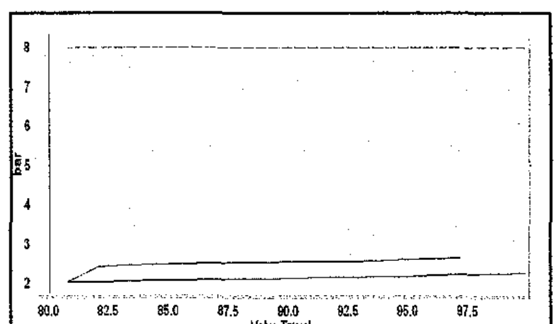
4th Stroked:



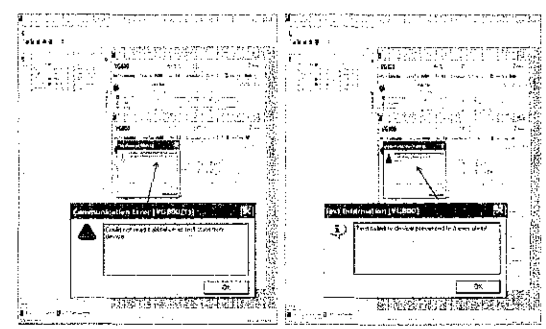
5th Stroked:



6th Stroked:



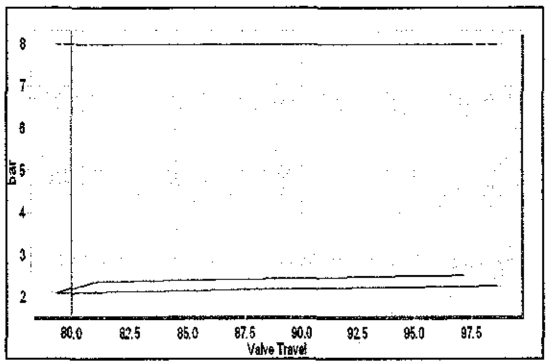
PST + FST:



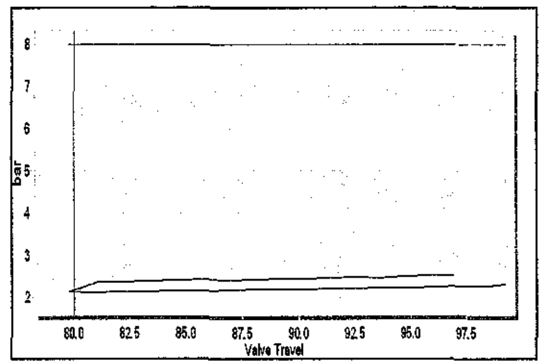
TESTING DAY 1: Butterfly Valve **DATE: APRIL 2nd , 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = **0.005 bar**

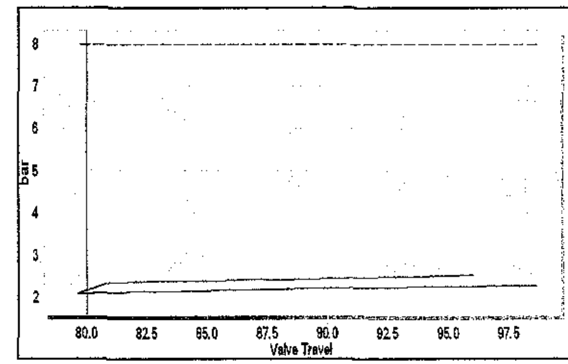
1st Stroked:



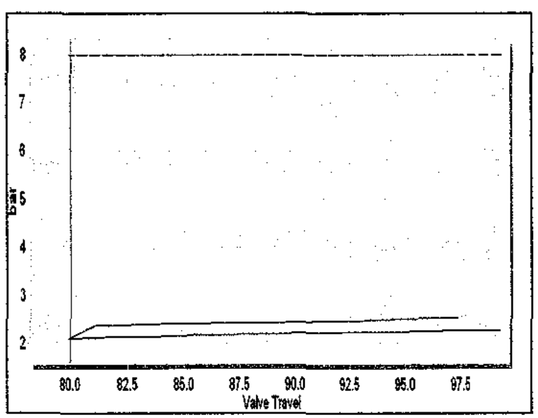
2nd Stroked :



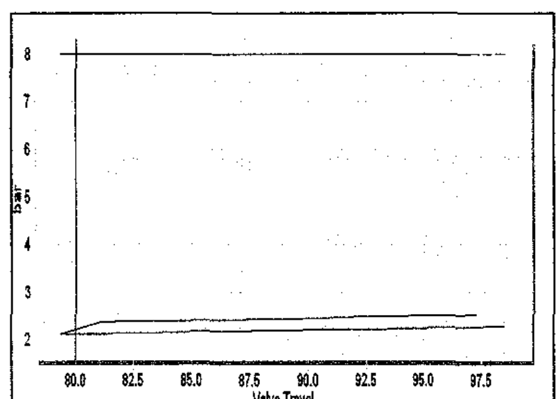
4th Stroked:



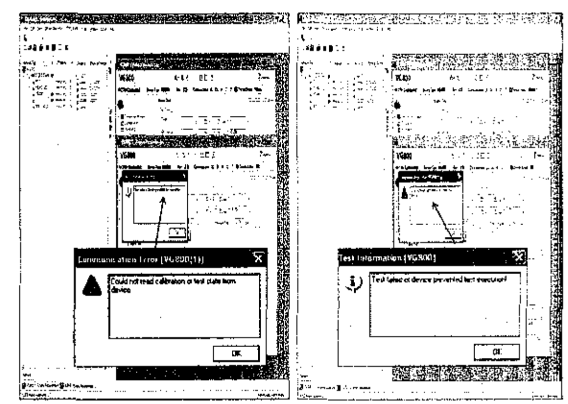
5th Stroked:



6th Stroked:



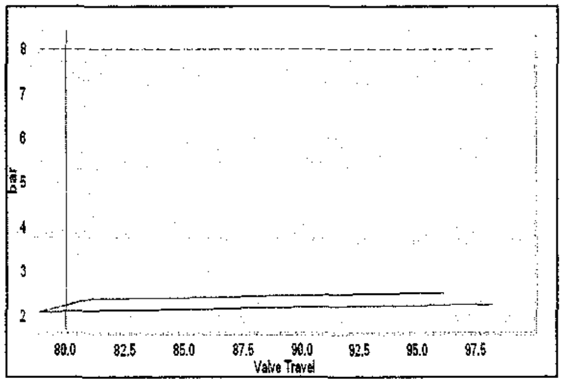
PST + FST:



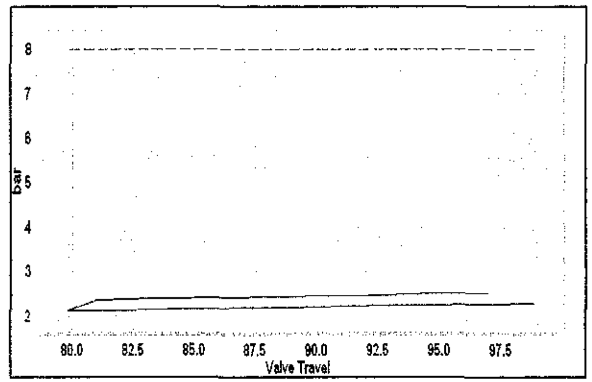
TESTING DAY 3: Butterfly Valve **DATE: APRIL 4th, 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = **0.005 bar**

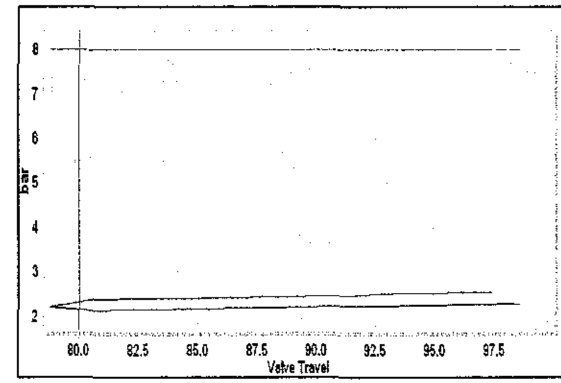
1st Stroked:



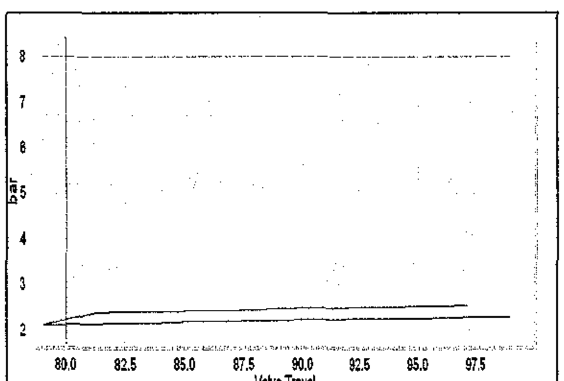
2nd Stroked :



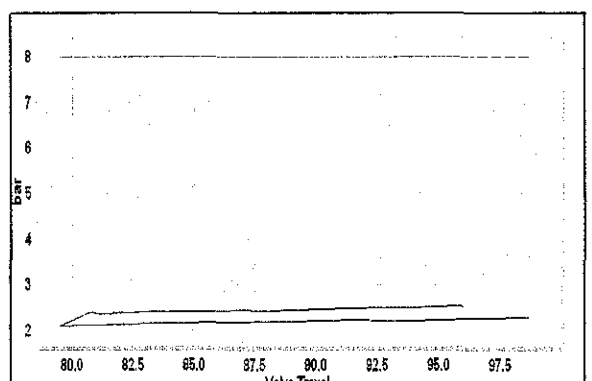
4th Stroked:



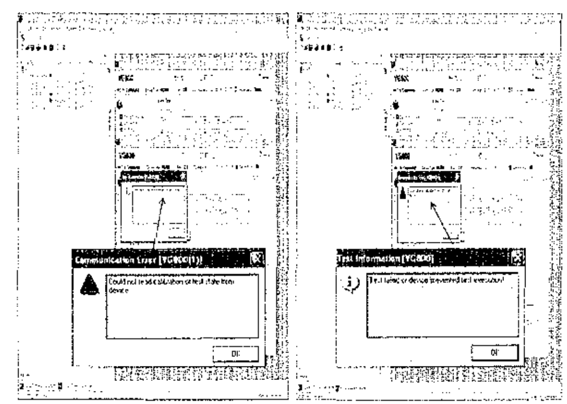
5th Stroked:



6th Stroked:



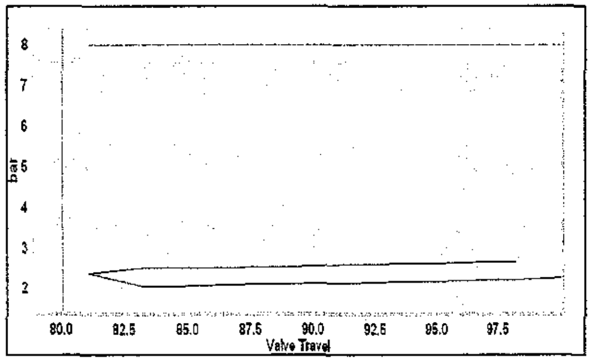
PST + FST:



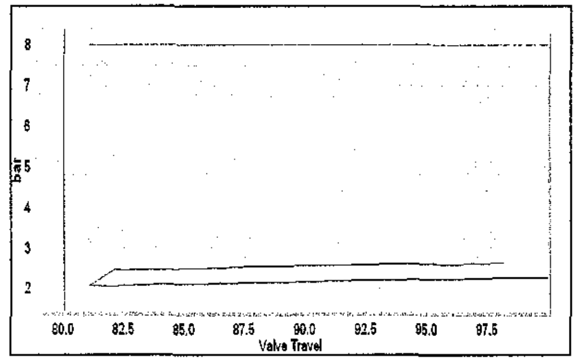
TESTING DAY 5: Ball Valve DATE: APRIL 7th, 2008

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = **0.005 bar**

1st Stroked:



2nd Stroked :



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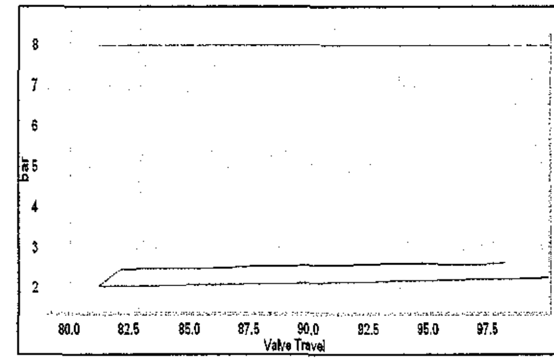
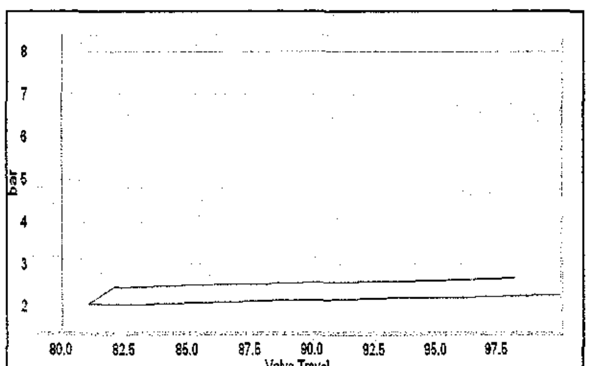
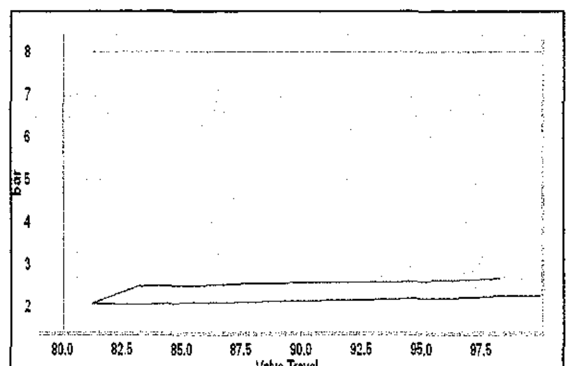


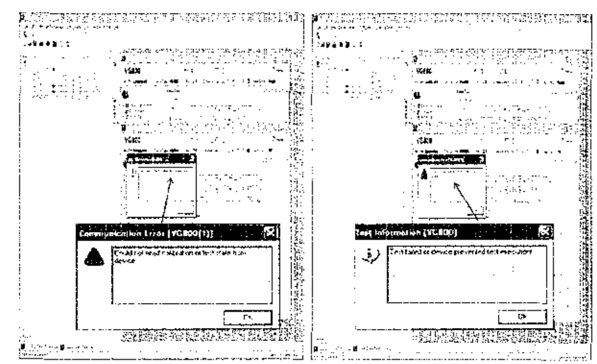
5th Stroked:



6th Stroked:



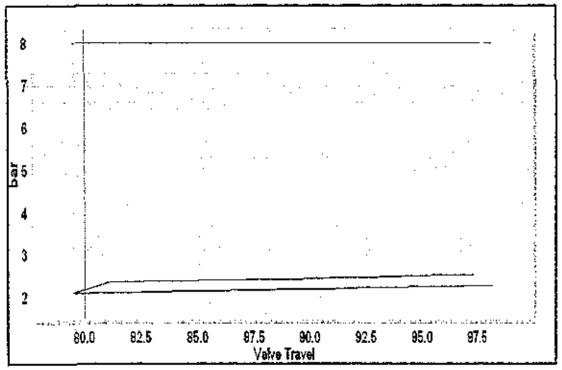
PST + FST:



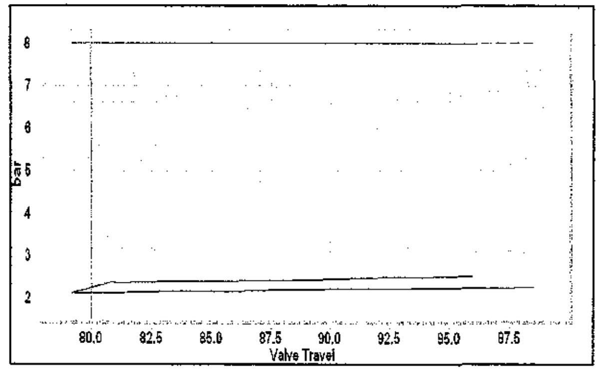
TESTING DAY 5: Butterfly Valve **DATE: APRIL 7th, 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = **0.005 bar**

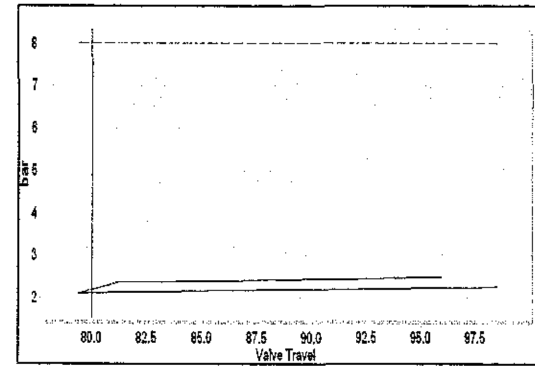
1st Stroked:



2nd Stroked :



4th Stroked:



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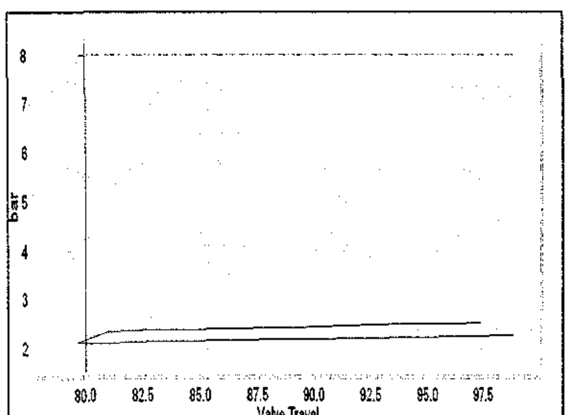
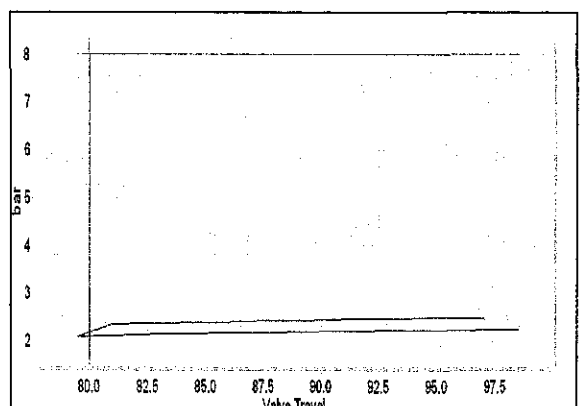
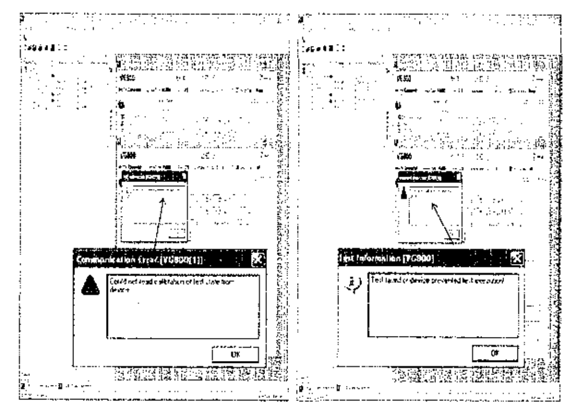


6th Stroked:



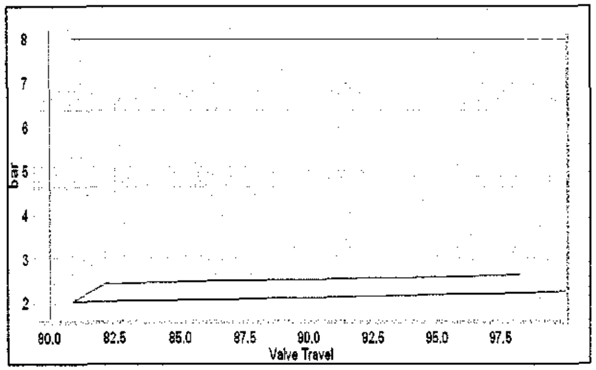
PST + FST:



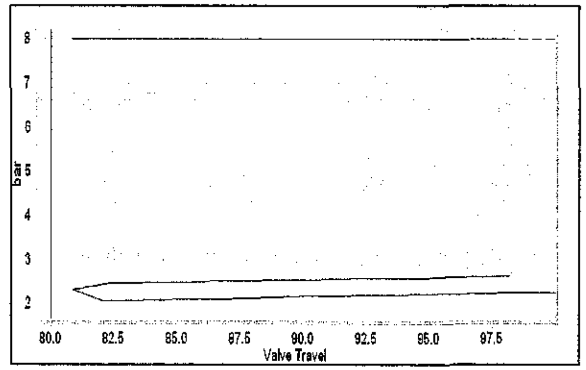
TESTING DAY 7: Ball Valve **DATE: APRIL 9th, 2008**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = **0.005 bar**

1st Stroked:



2nd Stroked :



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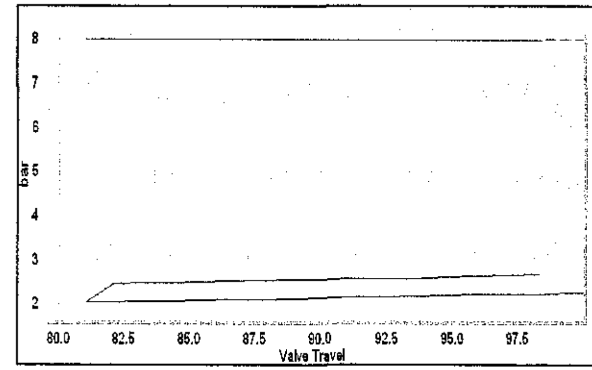

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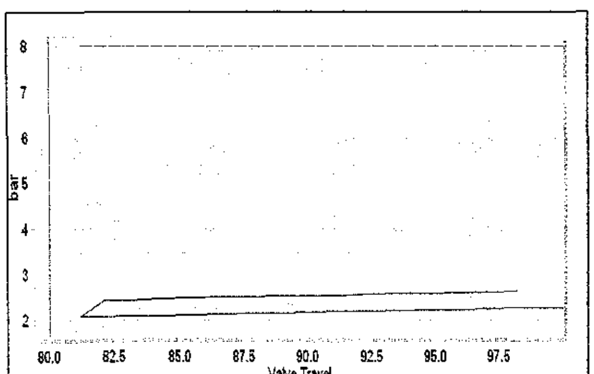
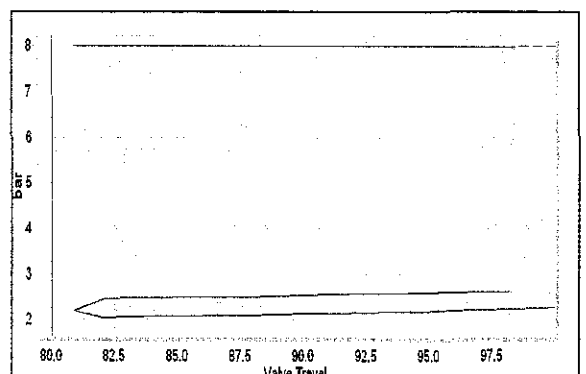
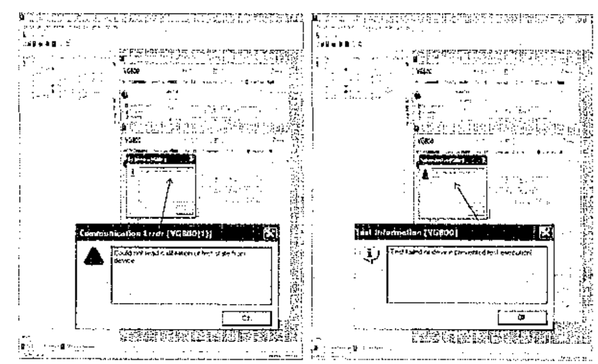


6th Stroked:



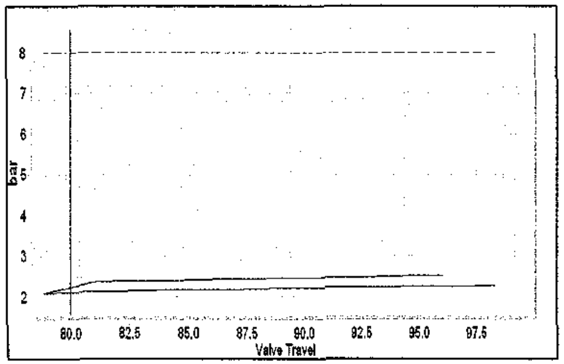
PST + FST:



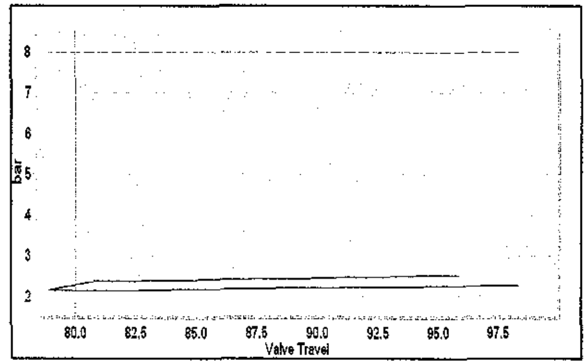
TESTING DAY 7: Butterfly Valve **DATE: APRIL 9th, 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = **0.005 bar**

1st Stroked:



2nd Stroked :



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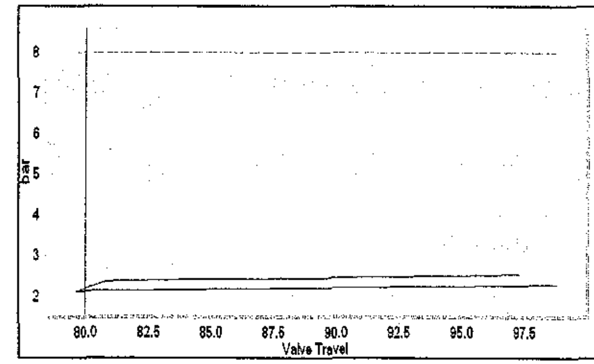

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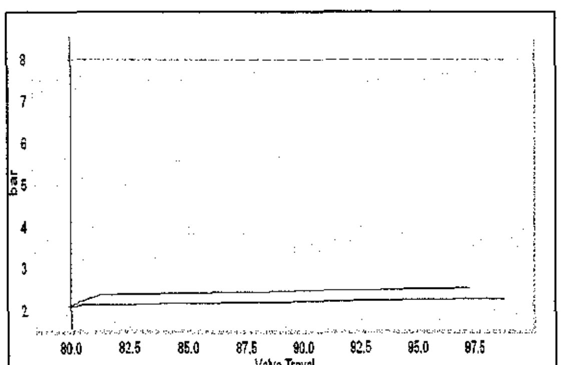
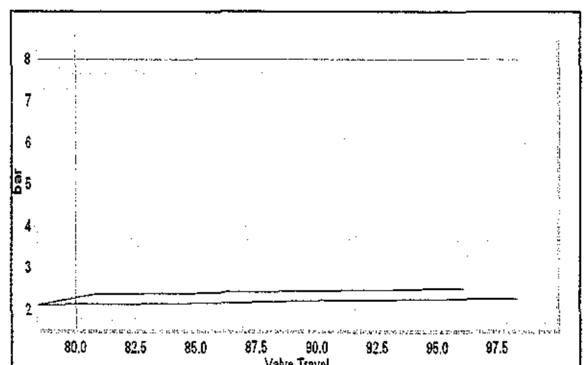
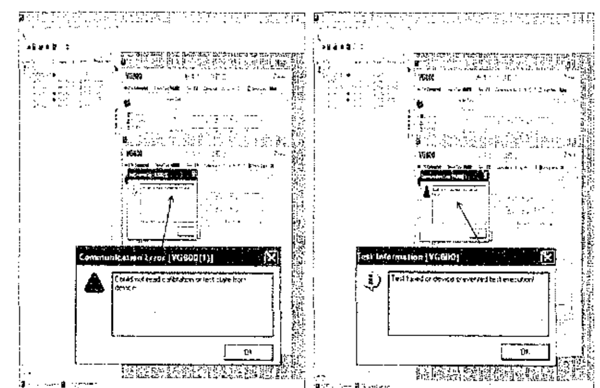


6th Stroked:



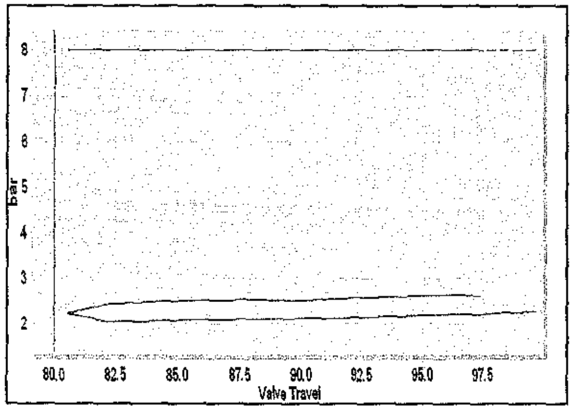
PST + FST:



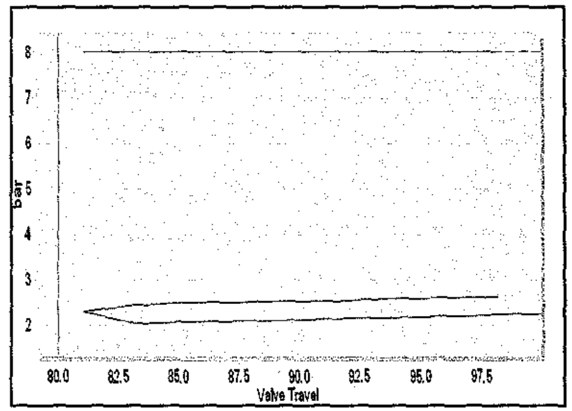
TESTING DAY 9: Ball Valve DATE: APRIL 11th, 2008

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = **0.005 bar**

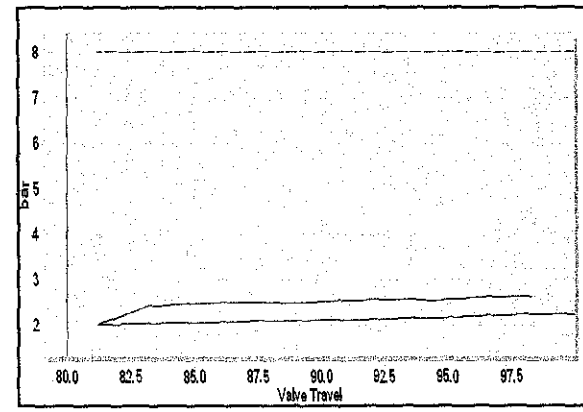
1st Stroked:



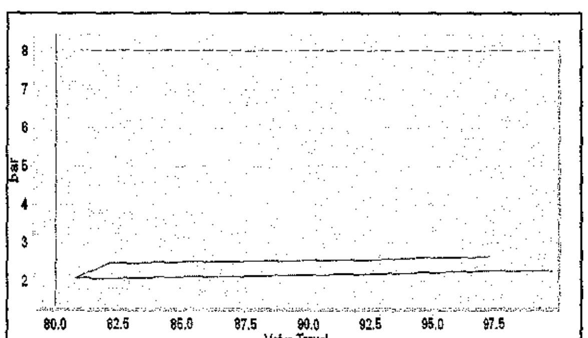
2nd Stroked :



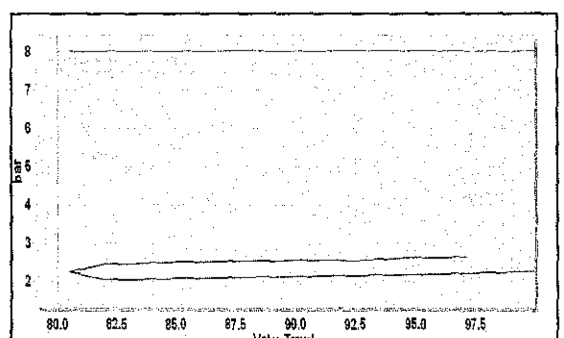
4th Stroked:



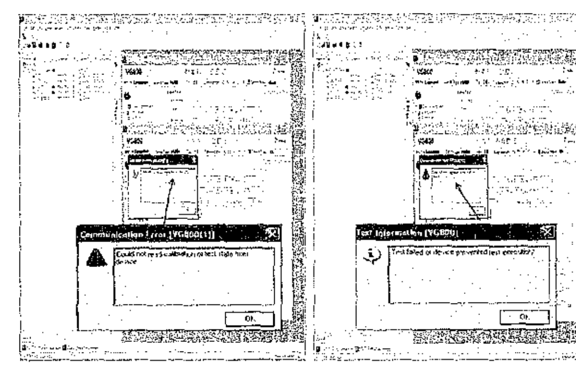
5th Stroked:



6th Stroked:



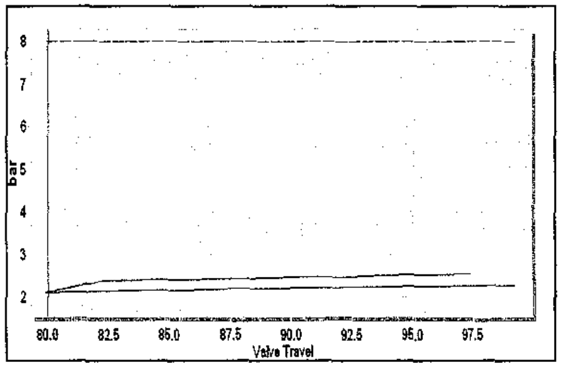
PST + FST:



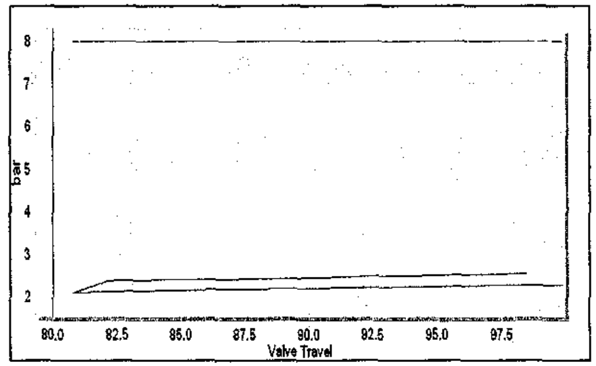
TESTING DAY 9: Butterfly Valve **DATE: APRIL 11th, 2009**

Testing Criteria: i) Valve Travel = 20% ii) Pressure Step = **0.005 bar**

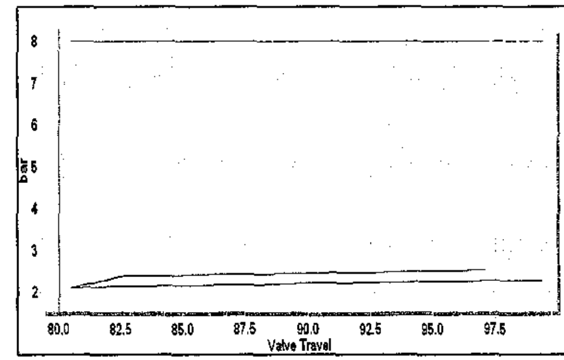
1st Stroked:



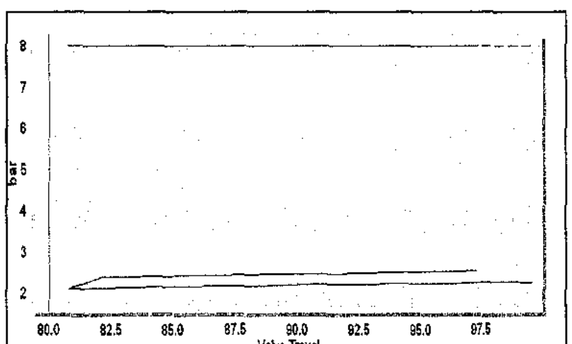
2nd Stroked :



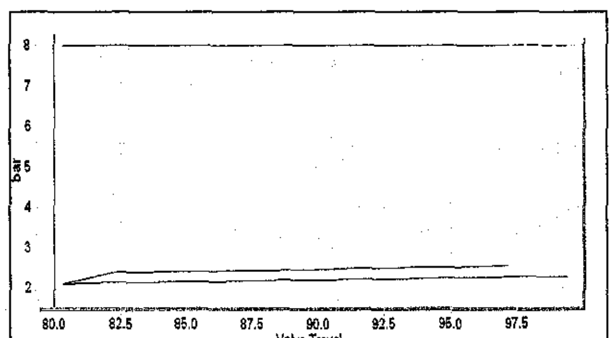
4th Stroked:



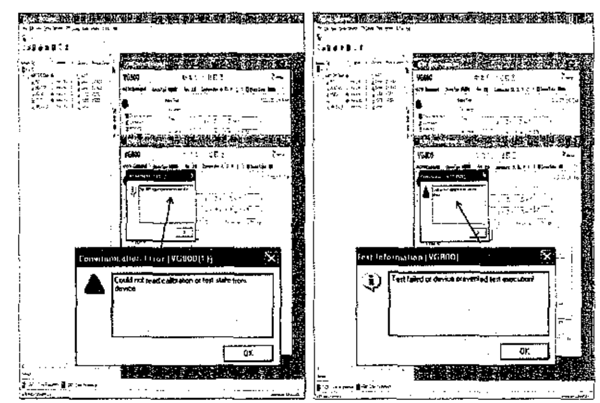
5th Stroked:



6th Stroked:

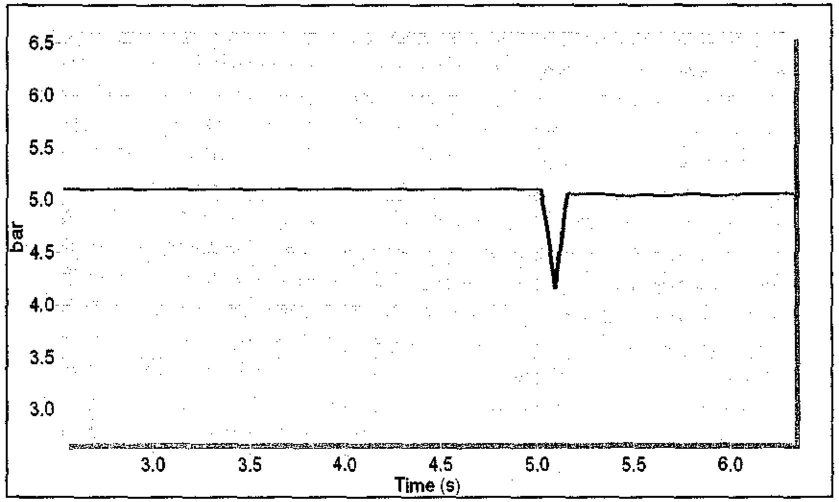


PST + FST:



Pneumatic Test Result:

Ball Valve:



Butterfly Valve: