



**Sudan University of Sciences &  
Technology**



**College of Engineering  
School of Electrical & Nuclear  
Engineering**

**Simulation of Custody Transfer and  
Metering Stations**

**محاكاة لمحطات قياس ونقل خام النفط**

**A Project Submitted In Partial Fulfillment for the  
Requirements of the Degree of B.Sc. (Honor) in Electrical  
Engineering**

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## الآية

قال تعالى:

(( ولا تيأسوا من روح الله إنه لا ييأس من روح الله  
إلا القوم الكافرون ))

سورة يوسف

الاية 87

# DEDICATION

*We dedicate our dissertation work to our families and our friends.*

*A special feeling of gratitude to our loving parents, whose Words of encouragement and push for tenacity ring in our ears.*

*We also dedicate this dissertation to our many friends and who have supported us throughout the process. We will always appreciate all they have done.*

# **ACKNOWLEDGMENT**

To those who lighting the path for us

To our great teachers& doctors

In Sudan University of Science & Technology

**To the greatest's person that we have met**

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Who leads & guides us to complete this project

## **Abstract**

Custody Transfer in the oil and gas industry refers to the transactions involving transporting physical substance from one operator to another. This includes the transferring of raw and refined petroleum between tanks and tankers; tankers and ships and other transactions. Custody transfer in fluid measurement is defined as a metering point (location) where the fluid is being measured for sale from one party to another. During custody transfer, accuracy is of great importance to both the company delivering the material and the eventual recipient, when transferring a material. The term "fiscal metering" is often interchanged with custody transfer, and refers to metering that is a point of a commercial transaction such as when a change in ownership takes place. Custody transfer takes place any time fluids are passed from the possession of one party to another. This project has been in the program adjusts the amount of crude passing through the pipeline to the refinery design and then monitor and control.

## المستخلص:

نقل ملكية البترول الخام والغاز في مجال الصناعة تشير الى المعاملات التي تترتب على نقل الخام او الغاز من طرف الى اخر .

ويكون نقل الخام او الخام المصفى بين شركات نقل البترول او بين الشركات والحكومات وتعرف نقل ملكية الخام على انها قياس الخام الذي يتم في محطات القياس ( نقطة جغرافيه محددة ) ليتم بيعه بين اي طرفين .

اثناء نقل الملكية تكون الدقه مهمة لكلا الطرفين لكي يتم الحفاظ على حقوق الحكومات او الشركات وذلك يتم عن طريق تصميم نظام يحفاظ على كمية الخام المنقول بين هذه الجهات ومراقبته التامه والتحكم في نقله من محطة الى اخرى .

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## LIST OF ABBREVIATIONS

|      |                                  |
|------|----------------------------------|
| PCV  | Pressure control valve           |
| FCV  | Flow control valve               |
| NGLS | Natural gas liquids              |
| BOPD | Barrel of oil per day            |
| LACT | Lease automatic custody transfer |
| API  | American petroleum institute     |
| AGA  | American gas association         |
| ESD  | Emergency shut down              |
| RTD  | Resistance temperature detector  |
| DVC  | Digital valve controller         |
| PD   | Positive displacement            |
| IT   | Information technology           |
| FBD  | Function block diagram           |
| IL   | Instruction list                 |
| SFC  | Sequential function chart        |
| LD   | Ladder diagram                   |
| ST   | Structured text                  |
| CAD  | Computer aided design            |

# **CHAPTER ONE**

# **INTRODUCTION**

# CHAPTER ONE

## INTRODUCTION

### 1.1 Overview

Petroleum, also called crude oil, is a thick, flammable, yellow-to-black colored liquid. Petroleum was first found oozing out of rocks on Earth's surface. Hence, its name comes from the Latin words *Petra*, meaning rock, and *oleum*, meaning oil. Petroleum is a hydrocarbon, an organic compound containing only carbon and hydrogen. It is a mixture of other hydrocarbon compounds such as natural gas, gasoline, kerosene, asphalt, and, probably most important, fuel oil.

Today, most scientists agree that oil was formed from the remains of plants and tiny animals that settled to the bottom of ancient oceans. These remains or sediments were buried by layers of mud and sand. Gradually, over millions of years, the weight of these accumulating layers built up great pressure and heat. The sediments packed together and became rock. The organic (once living) remains were changed into kerogen, a waxy substance that forms oil and natural gas. Most of the world's petroleum is more than 100 million years old, and is thus called a fossil fuel. Although petroleum is found throughout the world, the Middle East possesses nearly two-thirds of all recoverable oil. Latin America contains about 13 percent, while the continents of Europe, North America, Asia, and Africa have only 4 to 8 percent each. Most North American oil is extracted in Alaska, Texas, California, Louisiana, and Oklahoma. The former Soviet republics, Saudi Arabia, and China are among the world's other leading oil producers. Their petroleum is sent to the United States for refining. While the United States possesses little of the world's

petroleum supply (it must import more than 50 percent of its oil), it is one of the world's leading refiners. It is also the world's heaviest consumer of oil.

### ➤ **Significance of oil in modern times**

At the beginning of the 20th century the Industrial Revolution had progressed to the extent that the use of refined oil for illuminants ceased to be of primary importance. The oil industry became the major supplier of energy largely because of the advent of the automobile. Although oil constitutes a major petrochemical feedstock, its primary importance is as an energy source on which the world economy depends.

The significance of oil as a world energy source is difficult to overdramatize. The growth in energy production during the 20th century is unprecedented, and increasing oil production has been by far the major contributor to that growth. Everyday an immense and intricate system moves more than 80 million barrels of oil from producers to consumers. The production and consumption of oil is of vital importance to international relations and has frequently been a decisive factor in the determination of foreign policy. The position of a country in this system depends on its production capacity as related to its consumption. The possession of oil deposits is sometimes the determining factor between a rich and a poor country. For any country, however, the presence or absence of oil has a major economic consequence.

On a timescale within the span of prospective human history, the utilization of oil as a major source of energy will be a transitory affair of a century or two. Nonetheless, it will have been an affair of profound importance to world industrialization.

## **1.2 Problem Statement**

When flow measurement is performed in process control, the accuracy of measurement is typically not as important as the repeatability of the measurement. When controlling a process, engineers can tolerate some inaccuracy in flow measurement as long as the inaccuracy is consistent and repeatable. In some measurement applications, however, accuracy is an extremely important quality, and this is particularly true for custody transfer.

## **1.3 Objectives**

Custody transfer measurements are the basis for money transfer, either between company and government or between two companies. Any systematic error in the measurement will result in a systematic error in the money flow. Hence, it is of paramount importance that sufficient verification processes are included. The purpose of this project is to simulate the custody transfer meter of muglad oil basin development project.

## **1.4 Methodology**

We attended to design a system to control the procedure of custody transfer metering station by using ABB software. The designed system should be able to control and provide the required observation of the station. And the system must be able to developing or expanding in the future, so that we use the ABB software which is provide us with this advantages.

## **1.5 Layout**

In This project is we have five chapters, in chapter one we are going to talk about introduction of the project, problem statement, objectives, and the methodology of this project. In chapter two we are going to talk about introduction of general information's in custody transfer and pipelines, the methods of custody transfer, measuring over view, and the transmitters that used in the system. In chapter three we are going to talk about the metering

stations .introduction about it, and the components of the station. In chapter four we are going to talk about the software that we are used to design this simulation system, the application and it is conditions. In chapter five we are going to show the conclusion of our project and the recommendations that we see that must be taken in consider for who wants to develop this idea.

# **CHAPTER TWO**

## **GENERAL INFORMATION**



# **CHAPTER TWO**

## **GENERAL INFORMATION**

### **2.1 Introduction**

Pipelines are energy lifelines, making almost every daily activity possible. Pipelines play a huge role in everyday lives and are essential to the nation's industry. There are two general types of energy pipelines – liquid petroleum pipelines and natural gas pipelines.

### **2.2 Pipelines**

Pipeline transport is the transportation of goods or material through a pipe. The best data, in 2014, gives a total of slightly less than 3.5 million km of pipeline in 120 countries of the world. The United States had 65%, Russia had 8%, and Canada had 3%, thus 75% of all pipelines were in three countries.

Pipeline and Gas Journal's worldwide survey figures indicate that 118,623 miles (190,905 km) of pipelines are planned and under construction. Of these, 88,976 miles (143,193 km) represent projects in the planning and design phase; 29,647 miles (47,712 km) reflect pipelines in various stages of construction. Liquids and gases are transported in pipelines and any chemically stable substance can be sent through a pipeline. Pipelines exist for the transport of crude and refined petroleum, fuels - such as oil, natural gas and biofuels - and other fluids including sewage, slurry, and water. Pipelines are useful for transporting water for drinking or irrigation over long distances when it needs to move over hills, or where canals or channels are poor choices due to considerations of evaporation, pollution, or environmental impact. Pneumatic tubes using compressed air can be used to transport solid capsules. Oil pipelines are made from steel or plastic tubes which are usually

buried. The oil is moved through the pipelines by pump stations along the pipeline. Natural gas (and similar gaseous fuels) is lightly pressurized into liquids known as Natural Gas Liquids (NGLs). Natural gas pipelines are constructed of carbon steel. Highly toxic ammonia is theoretically the most dangerous substance to be transported through long-distance pipelines, but accidents have been rare. Hydrogen pipeline transport is the transportation of hydrogen through a pipe. District heating or teleheating systems use a network of insulated pipes which transport heated water, pressurized hot water or sometimes steam to the customer. Pipelines conveying flammable or explosive material, such as natural gas or oil, pose special safety concerns and there have been various accidents. Pipelines can be the target of vandalism, sabotage, or even terrorist attacks. In war, pipelines are often the target of military attacks.

## **2.3 Measuring**

You've got to measure oil and gas in order to get paid for it. Both the Operator and the royalty owner have a vested interest in accurate oil and gas measurement from the lease.

### **2.3.1 Crude Oil Measurement**

The modifier "crude" is used to denote oil that comes from the earth in its raw form, which generally means it contains some saltwater and possibly a few other impurities – thus the term crude oil. The unit of measurement for crude oil as reported on your royalty statement is the barrel. A barrel is 42 U.S. gallons. The first step toward accurate crude oil measurement is to remove any free water and sediment. This is done in one of several types of surface equipment such as a Free Water Knockout, a Gun Barrel Separator, or three Phase Separator. Following this step the oil is now isolated and can be measured. Crude oil is measured in one of two ways, depending on the aggregate volume available for measurement. For smaller volumes in the

range of 1-100 barrel of oil per day (BOPD) let's say, the oil generally flows into an atmospheric storage tank and is held there until sufficient quantity is accumulated to make a "run". A run is simply the act of removing the oil from the lease location, and taking it offsite for further treatment. When a run is ready to be made, the first step is to do a shake-out test. A sample of the oil is taken, and placed in a portable centrifuge which forces entrained impurities to separate from the oil. The results will be used to adjust the final volume on which all owners are paid.

To measure the volume of a run, a measuring strap with a weight on the end is lowered into the oil tank, and an initial reading is taken. Next, a valve is opened which allows the oil to flow by gravity into a pipeline or truck, whichever the case may be. When the tank is nearly emptied, the valve is shut and a second strap reading is taken. The difference between the two tank levels (readings) is now used to calculate the exact volume of oil that has been removed. The person making the run now completes a field run ticket which is made a part of the accounting records for this transaction. For larger volumes in the range of 100-1000 BOPD let's say, the oil generally flows through an automated system called (LACT) unit, which stands for Lease Automatic Custody Transfer. This system provides for the automatic measurement, sampling, and transfer of oil from the lease location into a pipeline. As you can imagine, a system of this type is applicable where larger volumes are being produced, and must have a pipeline available in which to connect. Again, the receipts from a LACT unit become a part of the accounting paper trail.

### ➤ **Methods of Conversion**

Most methods of converting mechanical output to an electrical signal work equally well for the bellows, the diaphragm, and the Bourdon tube.

The conversion typically takes place in two steps. The first step is to convert a mechanical motion to a change in electrical resistance. The

second step is to convert the change in resistance to a change in electrical current or voltage.

In general, an electrical pressure transducer consists of three elements:

- ✓ Pressure Sensing Element

This element is usually a bellows, a diaphragm, or a Bourdon tube.

- ✓ Primary Conversion Element

This element converts the mechanical action of the pressure sensing element into an electrical analog. This analog usually is an electrical resistance or a voltage.

- ✓ Secondary Conversion Element

This element is usually an electronic circuit that produces a standard signal according to the needs of the control system.

# **CHAPTER THREE**

## **METERING**

## **STATION**

## **COMPONENTS**

# **CHAPTER THREE**

## **Metering station components**

### **3.1 Introduction**

Custody transfer, sometimes called fiscal metering, occurs when fluids or gases are exchanged between parties. Payment is usually made as a function of the amount of fluid or gas transferred, so accuracy is paramount as even a small error in measurement can add up fast, leading to financial exposure in custody transfer transactions.. errors in measurement for custody transfer can be so expensive, custody transfer and fiscal metering are regulated in most countries and involve government taxation and contractual agreements between custody transfer parties. Custody transfers are also influenced by a number of industry associations and standards organizations such as American Gas Association (AGA), American Petroleum Institute (API). Custody transfer applications require more than an accurate flowmeter. There are a number of critical components that comprise a complete metering system including:

- ✓ Multiple meter runs with multiple meters in parallel
- ✓ Pressure and temperature transmitters
- ✓ Flow computers
- ✓ Quality measurement
  - For gas energy content, online gas chromatography
  - For liquids, sampling systems and water monitoring
- ✓ In-situ calibration using provers or master meters
- ✓ Automation.

Each metering station is equipped with pressure regulating, control system, power generation, electrical distribution system, drain system, fire fighting as well as living and service facility,

The crude oil in lateral branch line is transported through Emergency Shut Down(ESD) valve and then pressure regulating valve aiming at regulating pipeline pressure, finally metered through metering skid and then to refinery.

The emergency shutdown valve will perform shut down function in the event of accident at custody transfer metering station, extremely high pressure downstream of control valve refinery's shutdown.

### **3.2 Pressure Transmitter**

pressure is considered a basic measurement because it is utilized in several process applications: pressure and differential pressure, flow, level, density, volume, etc.

#### **➤ Main components**

Pressure is measured by means of transmitters that generally consist of two main parts: a sensing element, which is in direct or indirect contact with the process, and a secondary electronic package which translates and conditions the output of the sensing element into a standard transmission signal.

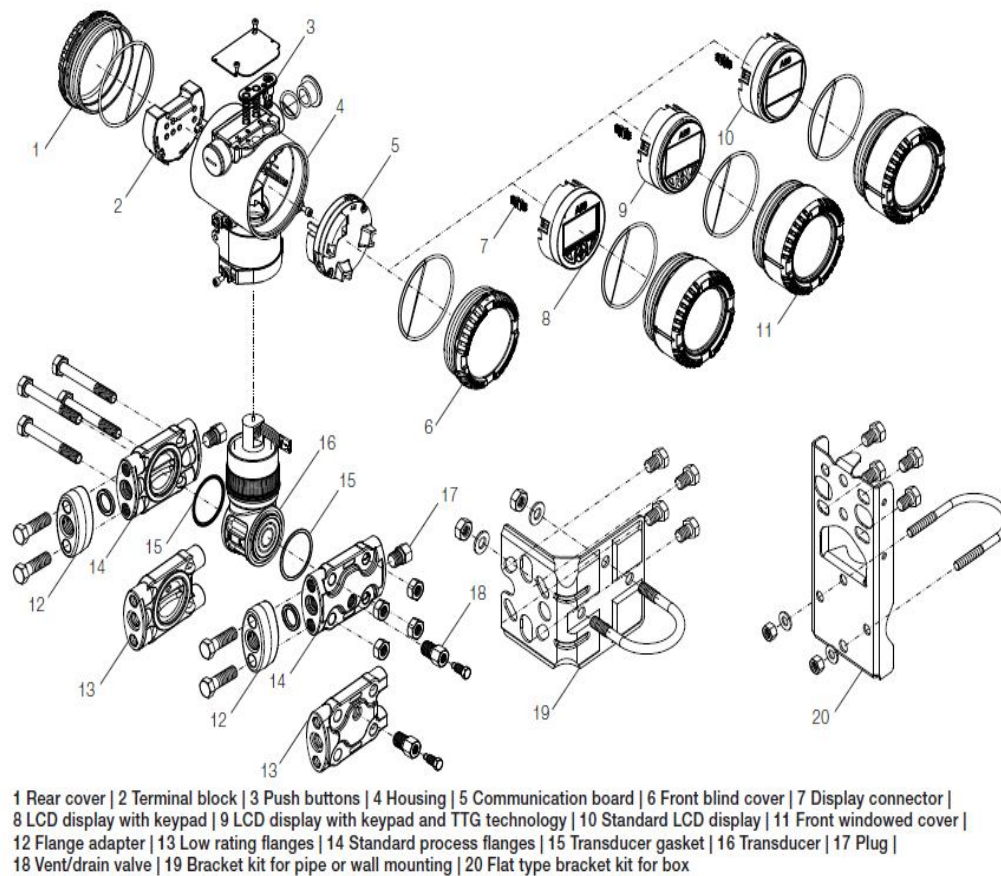


Figure 3.1: Pressure transmitter structure

At the heart of the transducer there is a sensor that creates a low level electronic signal in response to force applied against the sensing element. The sensor in the ABB 2600T Transmitter has different working principle as detailed in the following paragraphs. The sensor does not come into contact with the process, but is protected from it by the use of isolating diaphragm(s) and a fill fluid. Pascal's Law states that whenever an external pressure is applied to any confined fluid at rest, the pressure is increased at every point in the fluid by the amount of that external pressure. This is the basic principle employed in primary element design. The primary element is connected to the process piping in such a way that the process pressure is exerted against the isolation diaphragm(s). According to Pascal's Law, the fill fluid inside the primary element will reach the same pressure as that applied against the isolation diaphragm(s). The fill fluid hydraulically conveys this pressure to



the sensor, which in turn produces an appropriate output signal. The design of the primary element lets the user conveniently pipe the transmitter to the process and provide mechanical protection for the sensor against damage due to process transients like overpressure.

The secondary electronics of the transmitter filter, amplify, condition, and convert the sensor signal into a standard 4-20mA dc output signal. The secondary electronics are highly sophisticated and perform many functions. The output of the sensor is compensated for variations in process and ambient conditions before being converted to a 4-20mA signal. This minimizes unwanted measurement errors due to temperature effects, for example, and gives the transmitter a very stable output. The electronics also let the user calibrate the transmitter over a range of input pressures. For example, the ABB 2600T transmitter can be calibrated to measure a span as low as 0-150 psig, or it can be calibrated to measure a span as high as 0-600 psig. Therefore, the user doesn't have to stock as many versions of transmitters to handle the same range of applications. In addition, the secondary electronics allow the user to bias the output of the transmitter to measure special application.

The secondary electronics are contained in a housing that is integrally mounted to the primary element. This housing is suitable for installation in the plant or in the field. The housing helps protect the electronics from the effects and changes of the environment. The housing also provides convenient termination for the sensor wires coming from the primary element, and for the field wiring.



Figure 3.2: Pressure transmitter

A pressure transmitter that works by changing the reluctance between two coils is called a relative pressure transmitter. Figure (3.3) shows the construction of a diaphragm type relative pressure transmitter. The diaphragm between coils  $B_1$  and  $B_2$  is made of a flexible magnetic material. As pressure  $p_1$  changes compared to  $p_2$ , the diaphragm moves. Even a slight movement changes the reluctance between coils  $B_1$  and  $B_2$ . This change in turn changes the output voltage,  $V_o$ , which indicates pressure.

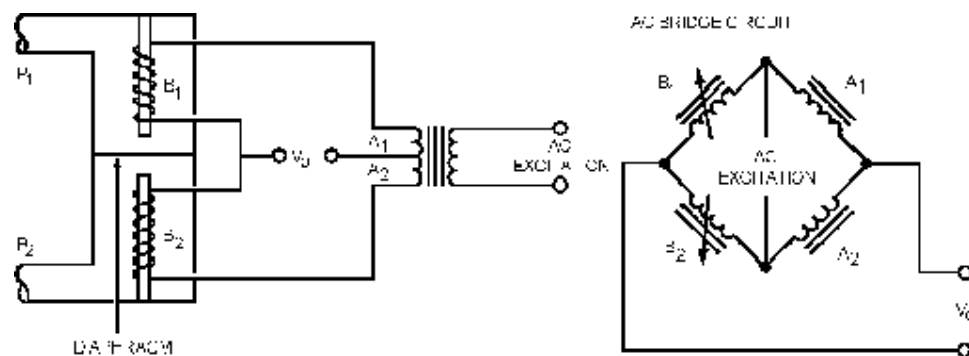


FIGURE 3.3: Relative pressure transmitters

### ➤ Signal Transmission

As already mentioned, the secondary electronics of a transmitter amplifies and conditions the weak electrical signals generated by

the sensor, so that the signals can't be sent long distances without being degraded by noise, and so the signals can be used to drive devices such as indicators, recorders, and controllers. Transmitters use several techniques to transmit their signal. Such as four-wire transmitter and two wire transmitter.

### 3.3 Temperature Transmitter

A temperature transmitter is an electrical instrument that interfaces a temperature sensor (e.g. thermocouple, RTD, or thermistor) to a measurement or control device (e.g. PLC, DCS, PC, loop controller, data logger, display, recorder, etc.). Typically, temperature transmitters isolate, amplify, filter noise, linearism, and convert the input signal from the sensor then send (transmit) a standardized output signal to the control device. Common electrical output signals used in manufacturing plants are 4-20mA or 0-10V DC ranges. For example, 4mA could represent 0°C and 20mA means 100°C.



**Figure 3.4:** Temperature transmitter

#### ➤ Resistance Temperature Detector Bridge Circuits

RTDs are normally used as one leg of a resistance bridge circuit Figure (3.4A). The output of an RTD bridge circuit corresponds to the amount of imbalance in opposite arms of the bridge. That is, the output voltage ( $E_{out}$ ) of

the circuit shown in Figure (4-2) is proportional to the resistance of the RTD sensor ( $R_T$ ). Heating or cooling  $R_T$  causes the bridge circuit to become imbalanced in direct proportion to the unknown temperature. Therefore, if you know the circuit's output voltage, you can determine  $R_T$ 's resistance from a graph such as the one shown in Figure (3.4B). In this sense, an RTD acts like a variable resistor. You can also relate the circuit's output voltage to temperature by adding a second scale representing temperature to the graph see Figure (3.4B). In short, if you know an RTD bridge circuit's output voltage, you can determine the RTD's resistance and temperature.

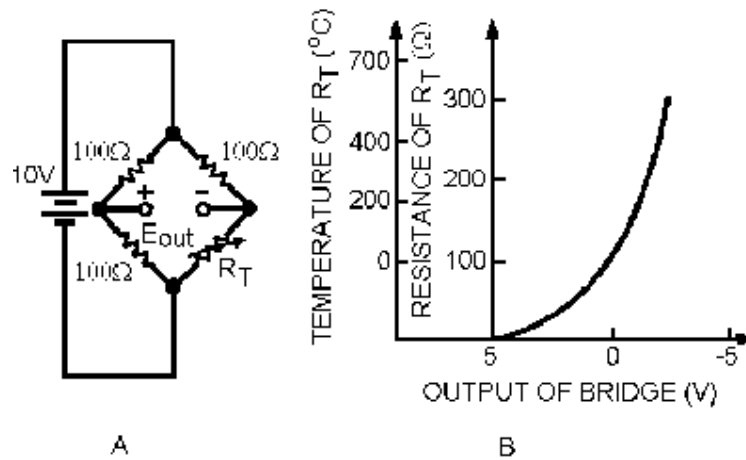


Figure 3.5: RTD Bridge

### 3.4 Emergency Shutdown Valve (ESD)

Emergency Shutdown System (ESD) is designed to minimize the consequences of emergency situations, related to typically uncontrolled flooding, escape of hydrocarbons, or outbreak of fire in hydrocarbon carrying areas or areas which may otherwise be hazardous. An emergency shutdown system for a process control system includes an emergency shutdown (ESD) valve and an associated valve actuator. An emergency shutdown (ESD)

controller provides output signals to the ESD valve in the event of a failure in the process control system. A solenoid valve responds to the ESD controller to vent the actuator to a fail state. A digital valve controller (DVC) test strokes the ESD valve. An impedance booster device enables the dc powering of the solenoid valve and the DVC over a two wire line while still permitting digital communication over the same two wire line.



Figure 3.6: Emergency Shutdown Valve

### **3.5 Pressure Control Valve**

Pressure-control valves are found in virtually every hydraulic system, and they assist in a variety of functions, from keeping system pressures safely below a desired upper limit to maintaining a set pressure in part of a circuit. Types include relief, reducing, sequence, counterbalance, and unloading. All of these are normally closed valves, except for reducing valves, which are normally open. For most of these valves, a restriction is necessary to produce the required pressure control. One exception is the externally piloted unloading valve, which depends on an external signal for its actuation. Most fluid power systems are designed to operate within a preset pressure range. This range is a function of the forces the actuators in the system must generate to do the required work. Without controlling or limiting these forces, the fluid power components (and expensive equipment) could be

damaged. Relief valves avoid this hazard. They are the safeguards which limit maximum pressure in a system by diverting excess oil when pressures get too high.



FIGURE 3.7: Pressure Control Valve

### 3.6 Flow Meter

Petroleum products bought and sold worldwide are transported over thousands of kilometers and change ownership many times from the well-head to the end user. The dynamic measurement provided by meters is a convenient and accurate means to measure valuable petroleum products. Selecting the right meter with a high level of confidence is imperative to ensure accurate measurement.

Currently API recognizes four types of dynamic measuring devices –

Positive Displacement (PD) Meters, Turbine Meters, Coriolis Mass Flow Meters and Ultrasonic Flow Meters. Fluid flow meters can, in general be classified in two categories (Inference type meters, Positive displacement meters). Inference meters infer volumetric rate by measuring some dynamic property of the flow stream. The turbine meters are Inference type meters. Other examples of inference type meters are Orifice plates, coriolis mass meters, vortex shedding meters and ultrasonic meters.

## ➤ Positive Displacement Meter

Positive displacement meters measure volumetric flow directly by continuously separating (isolating) the flow stream into discrete volumetric segments and counting them. For example in a rotating vane PD meter, as the rotor turns, isolated chambers are formed between blades, rotor, base, cover and housing. Like a revolving door, known segments of fluid pass through the measurement chamber and are counted. PD Meters can be broken into three basic groups of components: the housing, the measuring element, and the flow information output (mechanical or electronic). PD meters can be either single or double case construction. In the single case construction, the external housing serves both as a pressure vessel and as the measurement element housing; whereas, with double case construction, the separate external housing surrounds the measuring element. This offers the advantage of eliminating the pressure differential across the measuring element. Another advantage of the double case meter is that the measuring element can be easily removed for hydrotest and line flush on start-up or for service. PD meters measure flow directly by separating the flow stream into discrete volumetric segments (measuring chambers). By totalizing these segments, it is possible to determine the quantity passed through the meter. The measuring element also serves as a hydraulic motor, absorbing energy from the flow stream to produce torque to overcome internal friction and to drive accessories in the mechanical flow information output.

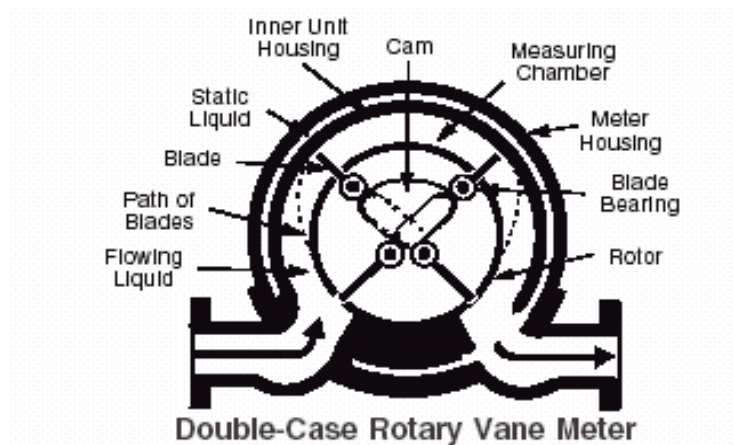


Figure 3.8: Double Case Rotary Vane Meter

PD meters normally have a mechanical flow information output that is fitted with either mechanical counters or pulse transmitters. Mechanical counters directly register volume while pulse transmitters must be connected to electronic volume registration instrumentation. A gear train is used to convert the arbitrary displacement volume of the measuring element into a convenient volume-per-revolution of the accessory drive. When mechanical counters are used to indicate the true volume throughput, the meter is generally fitted with an adjuster or calibrator. This device is used to make fine adjustments compensating for manufacturing variations and liquid properties. For PD meters fitted with pulse transmitters, the throughput information coming from the measuring element is converted into a precise ratio of pulses per unit volume. In this case, there is no adjuster or calibrator since the electronic instrument is programmed to make adjusted to true volume.

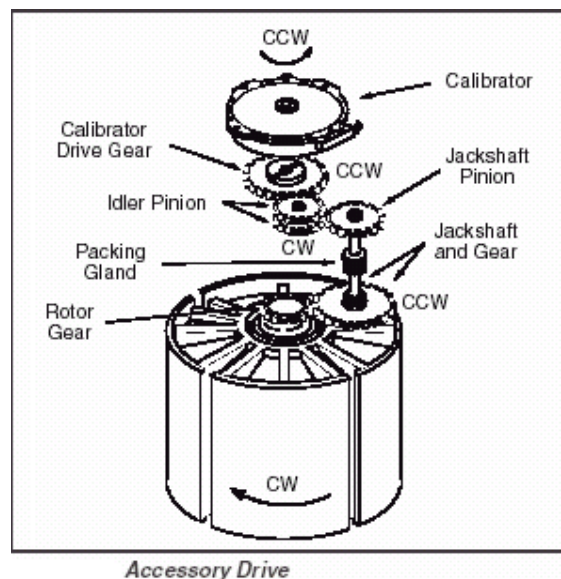


Figure 3.9: PD Meter

The factors affecting the accuracy of PD meter can be divided into two groups; those that affect the displacement of the measuring element and those



that affect the amount of slippage bypassing the measuring element. The displacement of a PD Meter is determined by the size of the volumetric segments formed in the measuring element. Factors affecting the physical and apparent size of these segments will affect the accuracy of the meter:

- ✓ Temperature– Increasing the temperature increases the displacement of the meter because of thermal growth. This can be related to the cubical expansion coefficient of the material forming the segments.
- ✓ Wear– Wear has the effect of increasing the displacement. As the cam or blade bearings wear, the blade is allowed to move outward, sweeping a greater volume.
- ✓ Viscosity– The viscosity of liquids causes a film to cling to the surfaces of the measuring element. As the film thickness increases, the displacement is reduced.
- ✓ Coatings– Coatings or deposit can build up and reduce the displacement of the measuring element.

PD meters have clearances between moving and stationary parts in the measuring element. These are sometimes referred to as capillary seals. Differential pressure across these parts will cause a flow that is not accounted for in the displacement. This flow is commonly referred to as “slippage”. Flow rate, viscosity, friction, wear etc. affect slippage.

### ➤ **Factors to be considered when using a PD Meter**

- ❖ Flow Rate – Line size, flow rate and flow range are important factors in sizing a meter. In high flow rate situations, multiple parallel meter runs are normally more economical since the prover can be much smaller. Another advantage of multiple meter runs is the ability to isolate one meter for servicing while diverting the flow stream to the other meters. It is advisable to operate the meter at reduced flow rates. This will extend the life of the meter. The life of a PD meter is considered to be inversely proportional to the square of the flow rate.

- ❖ Pressure – The maximum working pressure rating of the meter should always be higher than the maximum pressure of the application.
- ❖ Viscosity– When the viscosity of the liquid being metered is very low, the lubricity is also very low. Use of low friction bearings is recommended for lighter liquids.
- ❖ Strainers– Strainers should be used to protect the meter.

Precise measurement is required for custody transfer in petroleum industry. While there are other measurement technologies available, the PD meter continues to be the meter by which all other meters are compared. Figure below indicates that PD meters excel when the application is on higher viscosity oils.

### ➤ **Master Meters**

PD meters make excellent master meters because they are not affected by flow profile and other installation conditions. In some applications, such as loading terminals that utilizes turbine meters as the primary flow measurement device, a PD Master Meter is used to prove the line meters.

## **Meter Selection**

Design considerations

- ✓ Accuracy
- ✓ Space
- ✓ Pressure loss
- ✓ Cost

The following general rules for good metering should be considered in selecting meters for a pipeline –

- ❖ For large custody transfer applications, the type of meter, which will provide best overall measurement accuracy, should be chosen. The most accurate measurement system is the most economical in the long run.

- ❖ If there is no strong reason to select a turbine meter over a PD meter, it is best to use a PD meter, as it is a direct volumetric measuring device.
- ❖ Strainers should always be installed ahead of meters to protect these very accurate instruments against damage by pipeline debris.
- ❖ Significant amount of air in the flow stream must be removed to protect the meter from damage and to assure good metering accuracy.
- ❖ For higher flow rates, many parallel PD meter runs would be required, so turbine meter is preferred.
- ❖ Turbine meters should not be used on liquids having high paraffin content.
- ❖ Turbine meters should be avoided on higher viscosity liquids if the viscosity varies substantially between meters proving.
- ❖ A PD meter has a greater turndown ratio than a turbine meter. Turbine meter turndown is limited to about 10:1 on low viscosity liquids and generally becomes less with increasing viscosity. PD meter turndown ratio increases greatly with increasing viscosity.
- ❖ Typically, a turbine meter will require more space than a PD meter system, due to requirement for upstream and downstream straightening sections.
- ❖ Pressure loss costs money in terms of wasted energy and capacity. Increasing the size of headers, meters and valves will reduce pressure drop through the system, but would involve extra cost.
- ❖ In case of larger size, turbine meters are less expensive compared to PD meters.
- ❖ Normally, the higher the degree of automation, the greater the initial cost. However, higher automation systems will save time, improve the accuracy and improve safety.

# **CHAPTER FOUR**

# **SIMULATION AND**

# **OPERATION**

## **CHAPTER FOUR**

## **SIMULATION AND OPERATION**

### **4.1 Overview**

Control Builder F, part of the Engineer IT suite, is the perfect tool for application building, display and documentation. Control Builder F is a single

tool for configuring and commissioning all units from the top level down to the field device level. Applications can be created with different editors (in accordance with IEC 61131-3) and use the function blocks provided by the control software. Control Builder F is the programming tool for AC 800F as well as Freelance 2000 controllers. The Control Builder F is available in the following variants: Control Builder F Standard, Control Builder F Professional. To make projects with Control Builder F it is needed in addition to the Control Builder F license at least one Control IT software license basic or advanced.

All Control Builder F variants support the following functions:

- ✓ Configuration and commissioning of user programs
- ✓ Tree view of the programs for convenient program overview and selection
- ✓ Graphical configuration with powerful editor according to IEC 61131-3 in the programming languages: Function Block Diagram (FBD), Instruction List (IL), Sequential Function Chart (SFC), Ladder Diagram (LD), StructuredText (ST).
- ✓ Graphical hardware configuration
- ✓ Integral field bus configuration for Profibus and Foundation Field bus
- ✓ IEC 61131-3 data types and user-defined (structured) data types
- ✓ Project-wide variables and function block lists
- ✓ Online cross-reference
- ✓ Efficient plausibility check
- ✓ Extensive online help
- ✓ Graphical documentation of the entire user program including the system documentation in a system-wide manner.
- ✓ Online test functions
- ✓ Demo mode

## ➤ **Control Builder F Standard**

Control Builder F Standard supports:

- ✓ As many programs as desired
- ✓ A maximum of 100 clients like operator stations or gateways
- ✓ A maximum of 10 links between a controller and clients like local operator stations and/or gateways.
- ✓ A maximum of 100 controllers
- ✓ A maximum of 9 user tasks per controller
- ✓ Tag names of max. 16 characters

An expansion to Control Builder F Professional is available.

## ➤ **Control Builder F Professional**

The Control Builder F Professional license includes all of the Control Builder F Standard license as well as the following additional features:

- ✓ Access protection (Security Lock)
- ✓ User-defined function blocks

To operate this software some requirement must be available

- ✓ Microsoft® Windows 2000, 500 MHz, 256 MB RAM
- ✓ available hard-disk space for installation 100 MB and recommended for projects 1 GB
- ✓ CD-ROM
- ✓ 3½" drive
- ✓ Graphics card 4 MB
- ✓ Mouse
- ✓ Keyboard

- ✓ Ethernet card 3COM, BNC/AUI/TP

## **4.2 Project Manager**

Project management is started through the dialog in the Control Builder F software application. Control Builder F is the tool for configuring, commissioning and documenting the user programs and displays in a Freelance 2000 system. Configuration using Control Builder F is based on the IEC 61131-3 standard. You can use Control Builder F to configure the entire process control level as well as create programs. This is facilitated by the fact that all components access a common database. The system configuration is saved as a project file and is located in a preset project directory. To process a project, you must first open a project file. You then have unrestricted access to all project data within the project file. Project name and file name of the project file can be selected independently from one another. From the Project Manager function, you can save, rename or delete projects. The actual configuration, commissioning and documentation of the project take place in the project tree which you can access from the Configuration or Commissioning menus. If there is an old project which you can use to base a new project on, it can be imported into the current database. You can also import project parts.

## **4.3 Function Block Diagram (FBD)**

Function block diagram (FBD) is a graphically oriented IEC 61131-3 programming language. FBD's CAD (Computer Aided Design) functionality permits simple positioning and connecting of functions, function blocks and their variables. The working area of an FBD is laid out on 10 x 10 screen pages. The individual pages can be accessed via vertical and horizontal scrolling. The entire work area is covered by a grid. The divisions between the individual pages are shown as dotted lines on the screen. The printed form

of the program contains page-for-page exactly what is seen on the screen. An FBD program consists of the following graphic elements: Connections and lines, Variables and constants, Functions and function blocks. The signal flow of a FBD is from left to right. The signal flow lines are edited either with the left mouse button and CTRL key depressed simultaneously or alternatively by activating an appropriate "Line drawing" mode. If the Shift key is depressed in addition to the left mouse key and the CTRL key, the course of the signal line is automatically determined by the system. The named variables can be either selected from the list of system-wide variables and copied in, or declared directly in the program. In FBD programs the processing sequence of the blocks can be set individually. As an extension of the IEC language definition, variables and their components of the structured data types may be used. After loading the programs, in commissioning mode the Editor can be activated if there is an existing connection to the process stations. The current values in the FBD program may be displayed.

## **4.4 The System Work Method**

Our project or the system that we admit to design is a metering station of petroleum by using the ABB software. This is displayed and controlled the flow of the custody from the main pipeline to the refinery through the metering station. The ABB software has been used because it provides us with the controllability and the observation on the computer through the display screen. The general characteristics for the appendix equipment's and which is connected to the input units have been shown and especially the pressure transmitter, flow, temperature, and the equipment's that connected on the display screen.

### **➤ The Basic Components of the System**

This system basically consists of:



➤ The valves

It is an electrical valves works on 24 VAC through the outputs of the controller. And is always be at the state of normally close when the electricity is shutdown.

- ✓ Emergency shutdown valve (ESD) valve which is shutdown the whole station in emergency cases.
- ✓ Pressure control valve (PCV) which is controlled the input pressure of the station.
- ✓ Flow control valve (FCV) which is open the stream for flowing the custody in.

➤ transmitters

We used two transmitters

- ✓ Pressure transmitters to measure the pressure comes from the main line and the pressure inside the station.
- ✓ Temperature transmitters which are measure the temperature or the custody.

➤ The counters

We have three counters

- ✓ The streams counter which is calculate the quantity of the custody that measured by flow meters.
- ✓ The daily counter which is calculates and shows the quantity that delivered to the refinery at the time.
- ✓ The yesterday counter which is show the quantity of the custody that delivered to the refinery at the end of the day (12:00 am).

➤ The flow meter

It is a device that calculates the quantity of the custody that flowed along every stream, and it has a many types

- ✓ Positive displacement meter (PD meter).
- ✓ Turbine meter.

- ✓ Ultrasonic meter.

And the type that used in this system is the PD meter.

### ➤ The System Work Conditions

Notice: all these conditions on this simulation system have been putted as same as the conditions that should be in the real system.

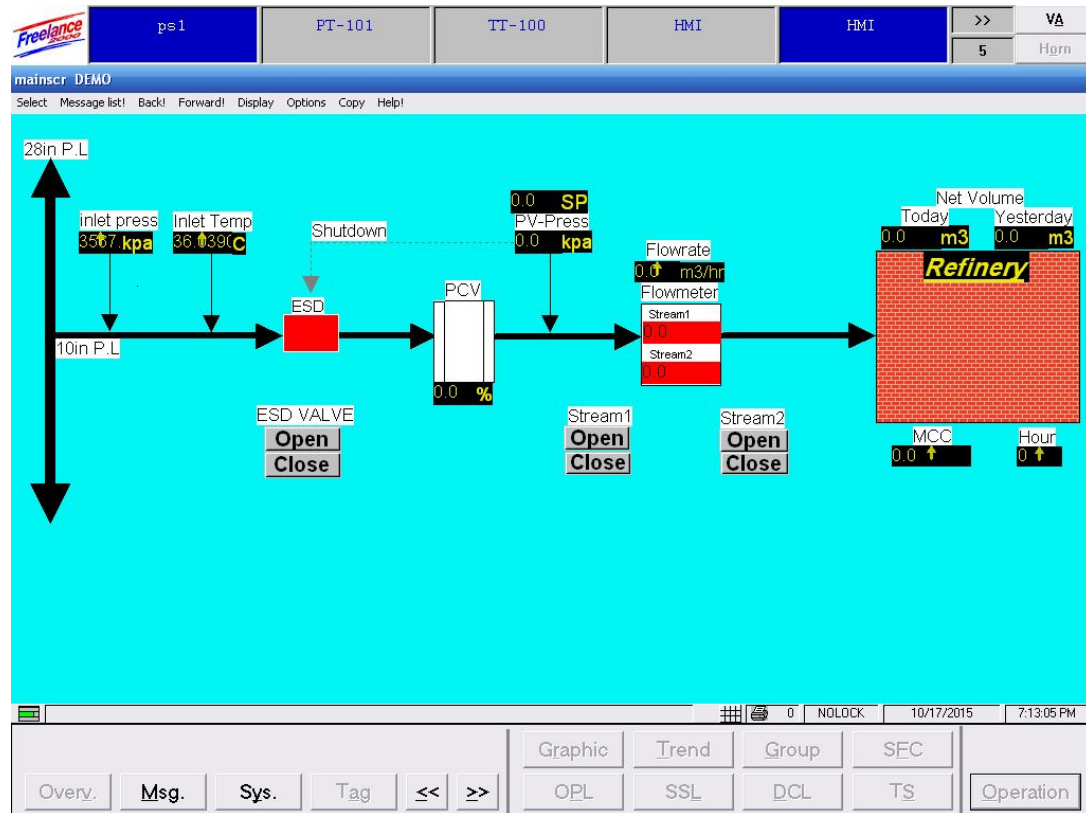


Figure 4.1: The System With No Operate

### ➤ The ESD Conditions

The operations of open and close of this valve done by the operator and then it depends on these conditions

- ✓ The open conditions: it is open manually by the operator and still open if it does not have an order to close.

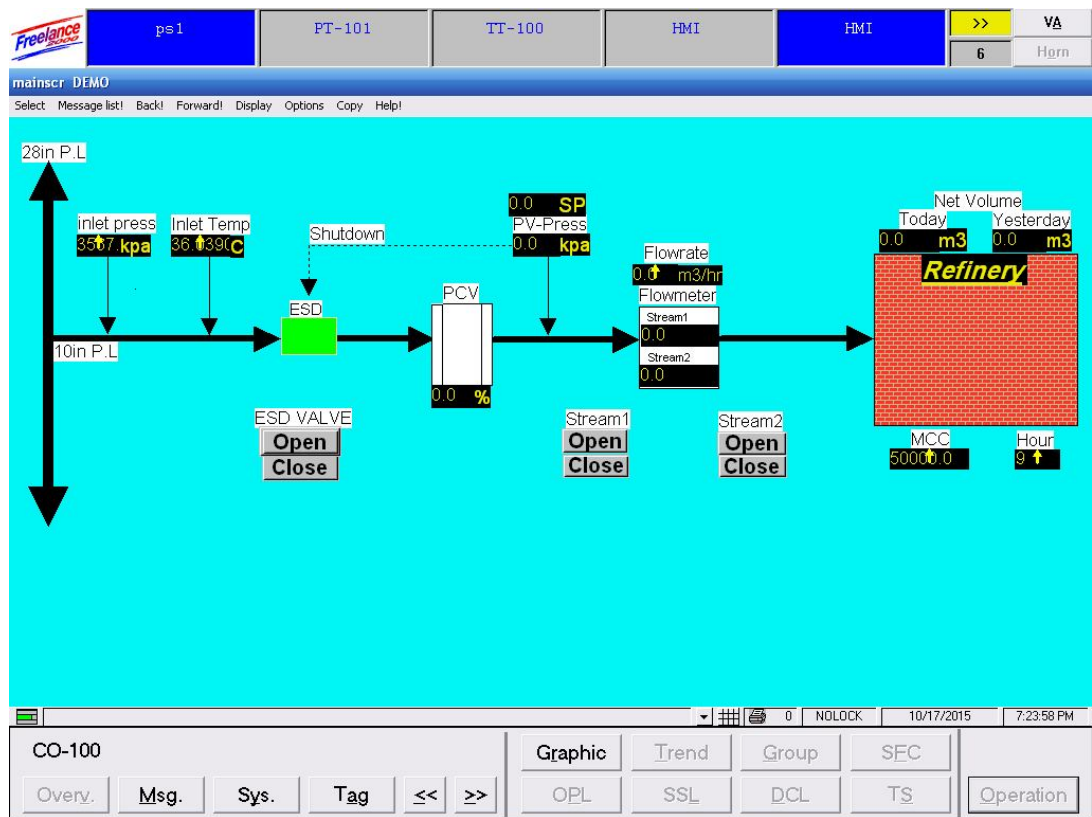


Figure 4.2: ESD is open

- ✓ The close conditions: if it closed by the operator or if it receive an alarm from the pressure transmitter that shows the pressure is too high (more than 16 bar).

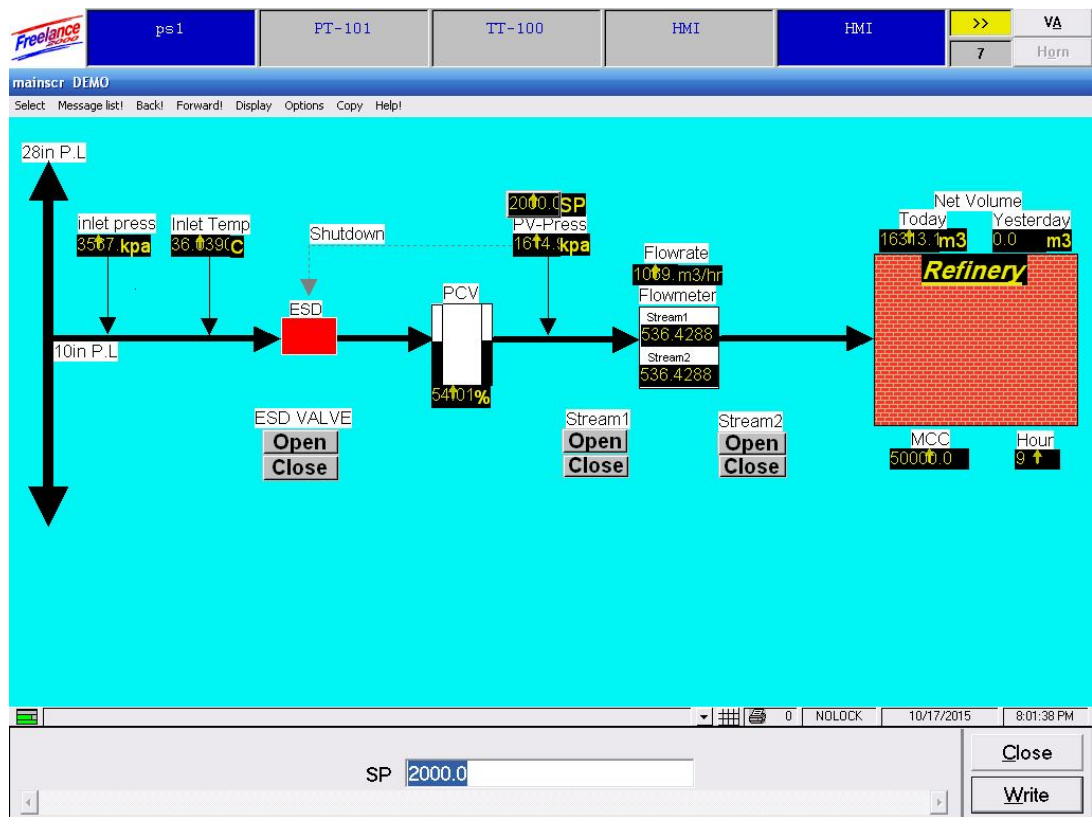


Figure 4.3: ESD closed at pressure more than 16 bars (as 20 bar)

### ➤ The Pressure Control Valve Conditions

The operations of open and close of this valve done by the operator and then it depends on these conditions the open conditions: a set point pressure must be determined by the operator and the value of the pressure in the transmitter must be less than the set point. And the ESD valve must be open.

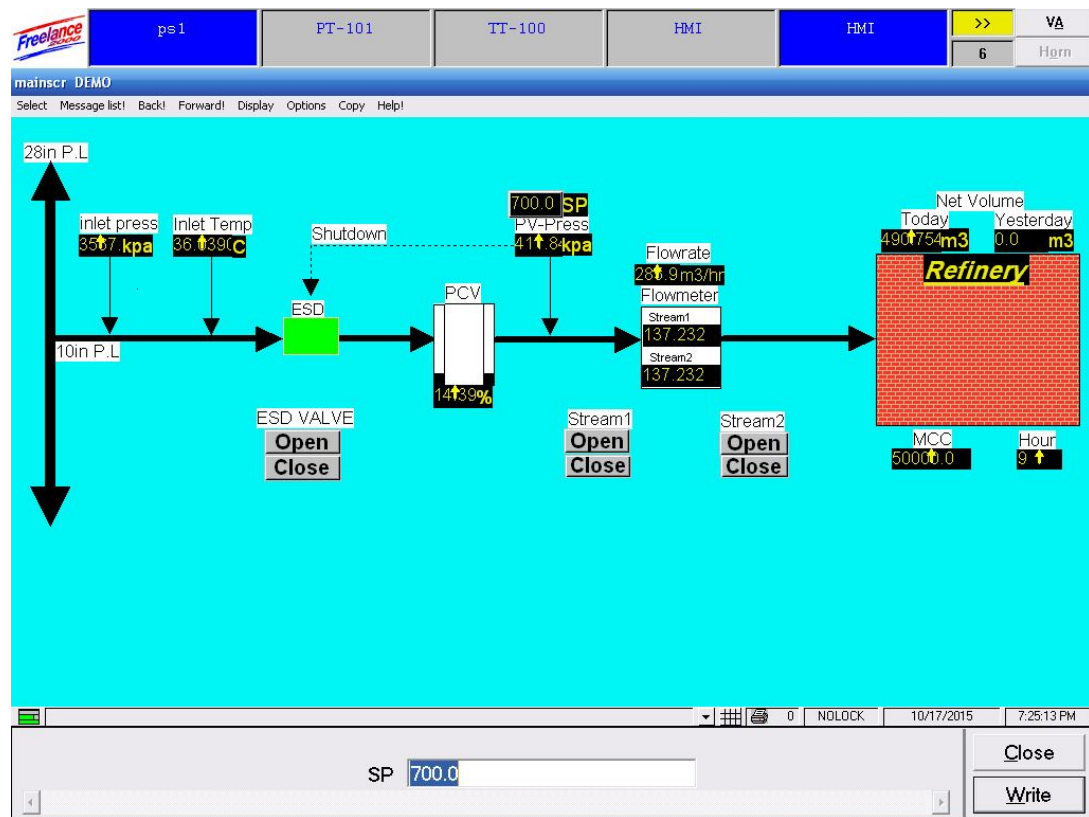


Figure 4.4: PCV is open with set point and ESD also open

### ➤ The Stream Valve Work Conditions

The operations of open and close of this valve done by the operator and then it depends on these conditions

- ✓ The open conditions: the required quantity (the quantity of the custody that must delivered to the refinery during the day) must be specified by the operator, the PCV must be open and the value of the daily counter did not reach the required quantity.

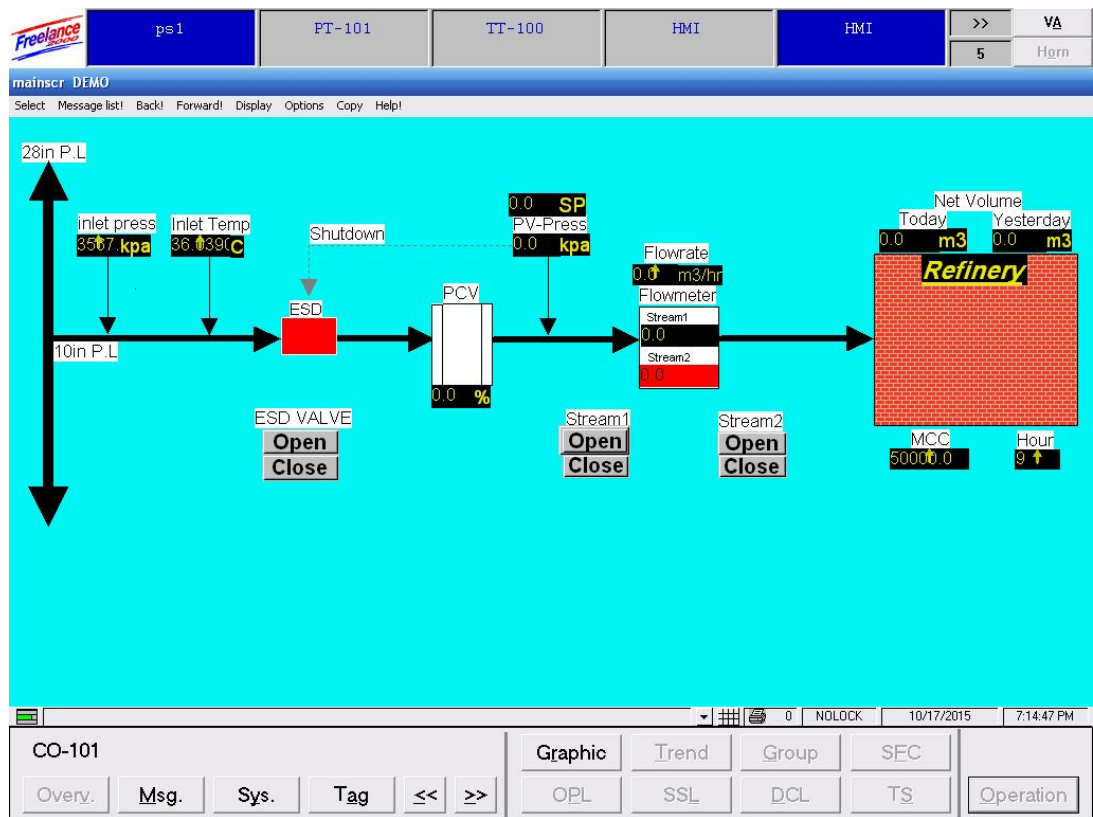


Figure 4.5: stream one is open and stream two is closed

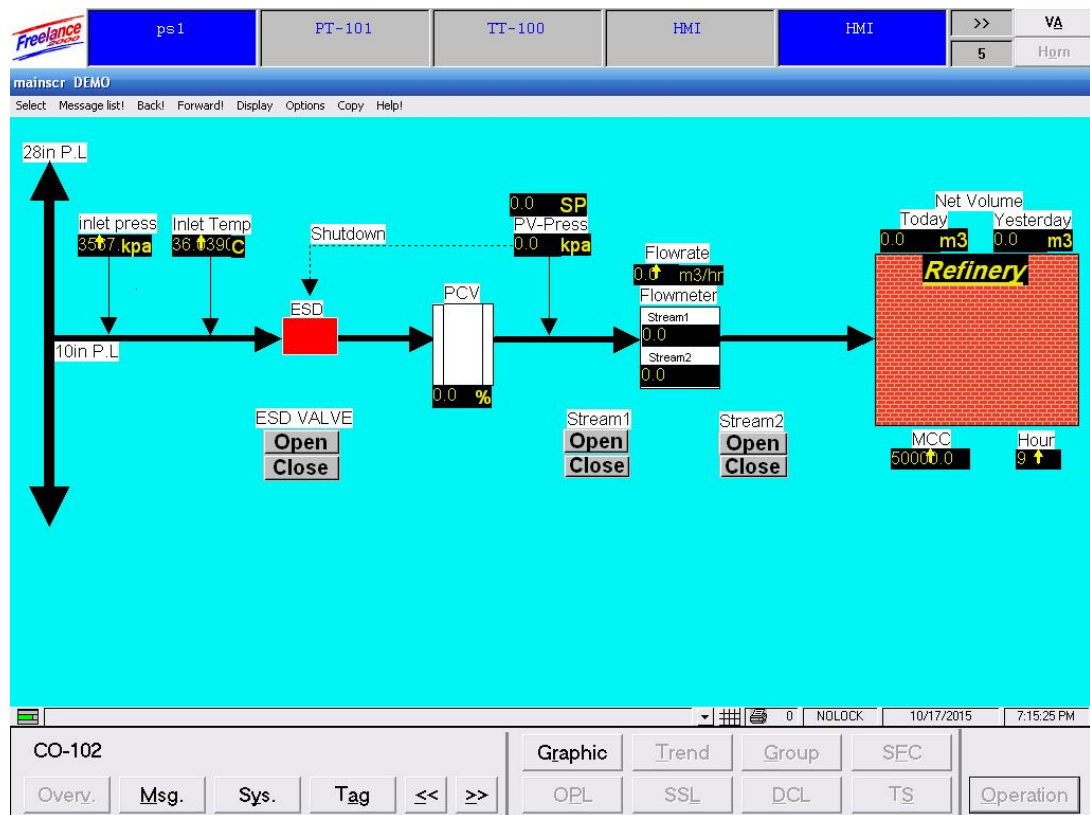


Figure 4.6: both streams are open

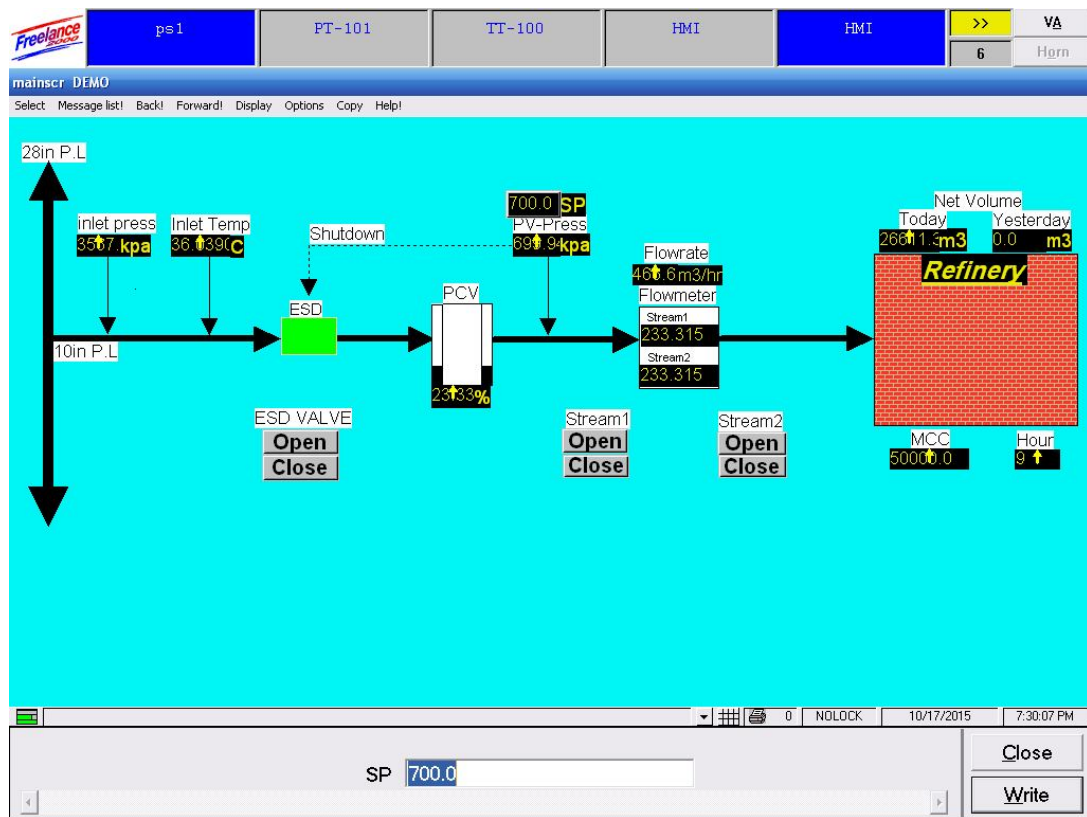


Figure 4.7: both streams are count the flow rate volume

- ✓ The close conditions: if the required quantity has been delivered to the refinery. Or by the operator.

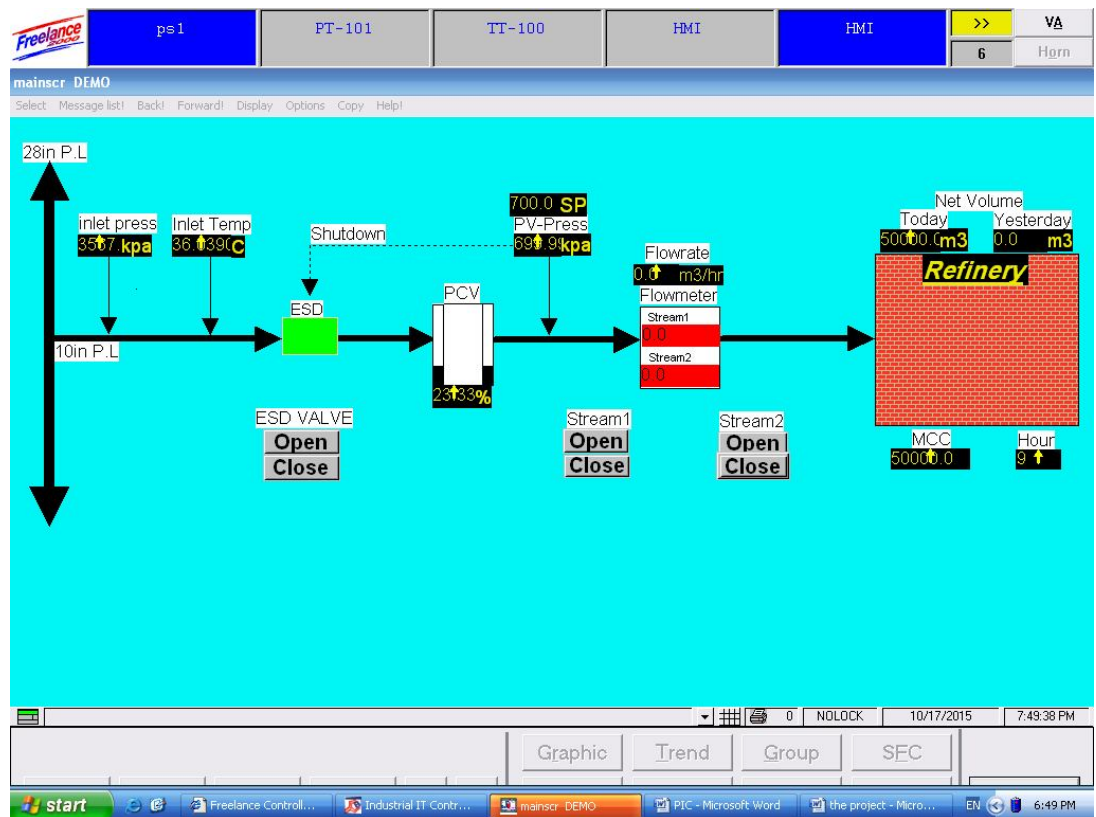


Figure 4.8: the streams are closed automatically because the required quantity has been delivered

### ➤ The Inside Pressure Transmitter Conditions

It is located inside the stream and it has been programmed to work as a scale for the pressure, and send the value of the measured pressure to the ABB software in the computer, and also this value has been programmed to show the state of the pressure and send it to the ESD valve to act upon it.

### ➤ The Time Counter

It has been used to replace the clock, because it is difficult to use the clock in this simulation .and it will takes a lot of time (24 hours exactly) to complete a full round. That we insert the time by one number (one variable) which is the hour. And when it became twelve am at the midnight (we put the value (zero) in the counter to represent it) the daily counter will reset and it is last value



will move to the yesterday counter and the daily counter will begin from the zero point.

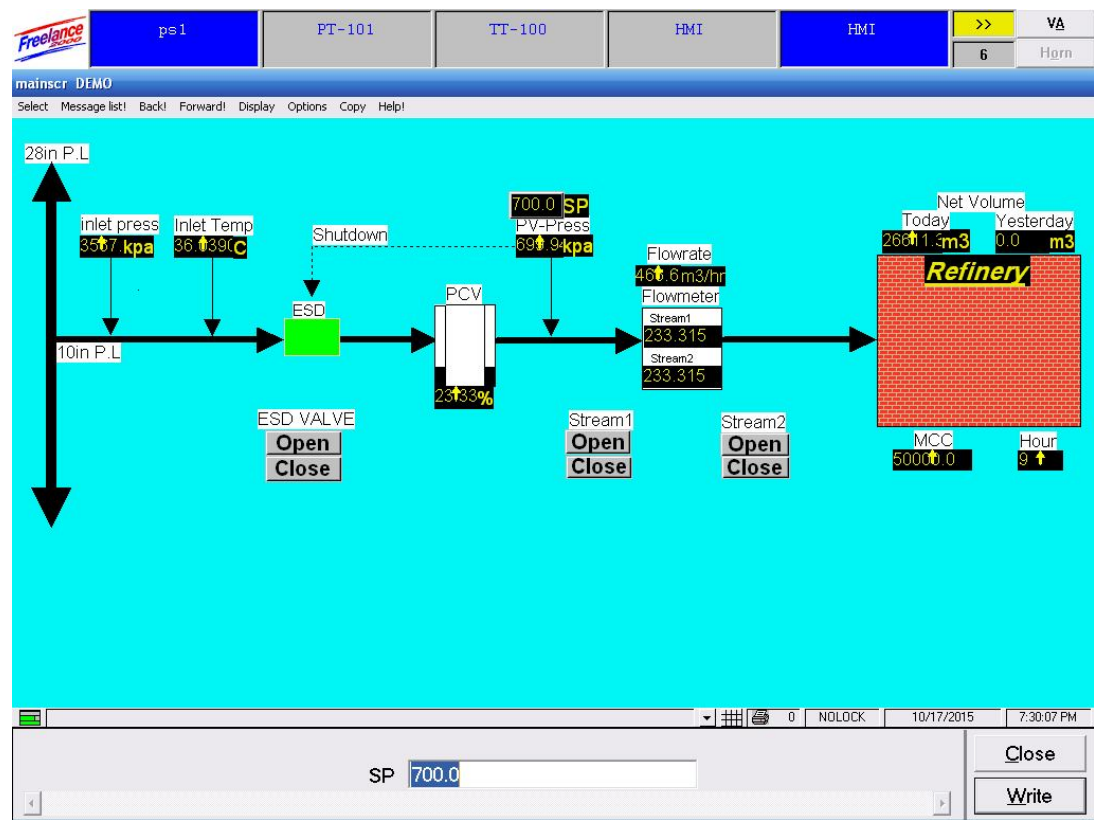


Figure 4.9: Count of Today Net Volumes (initialization)

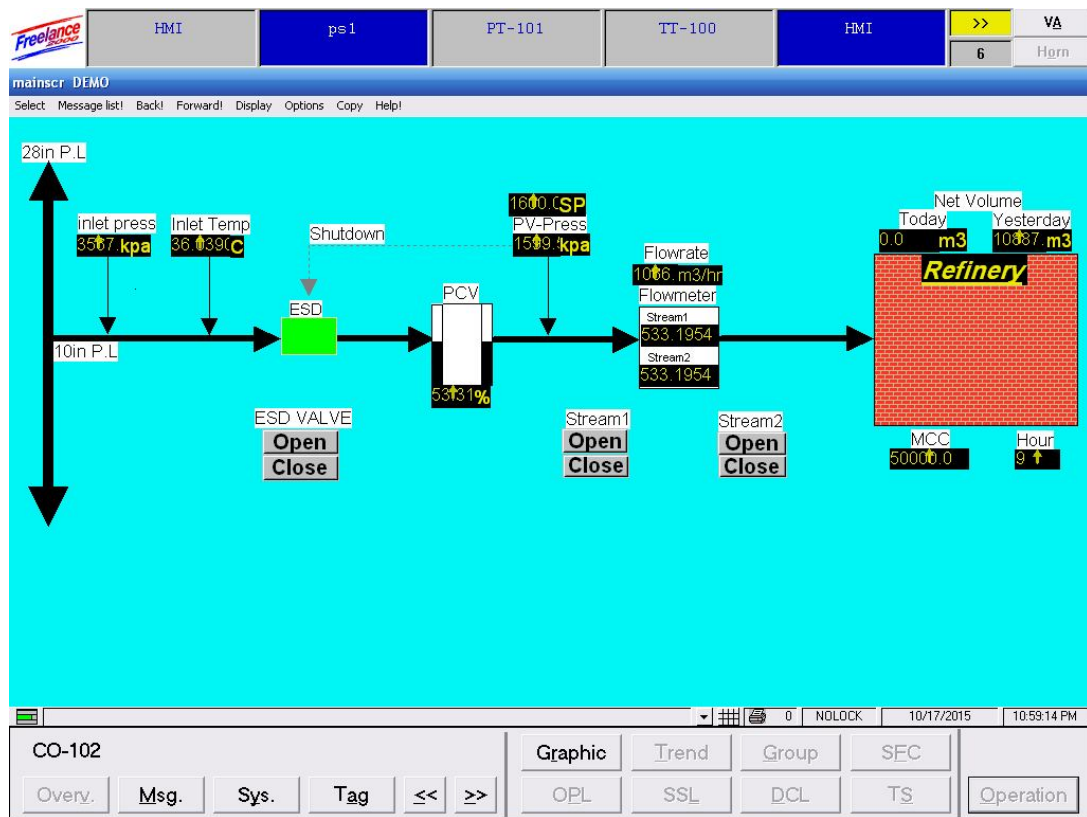


Figure 4.10: Reset of Today Net Volumes and Count of Yesterday Volumes (at midnight)

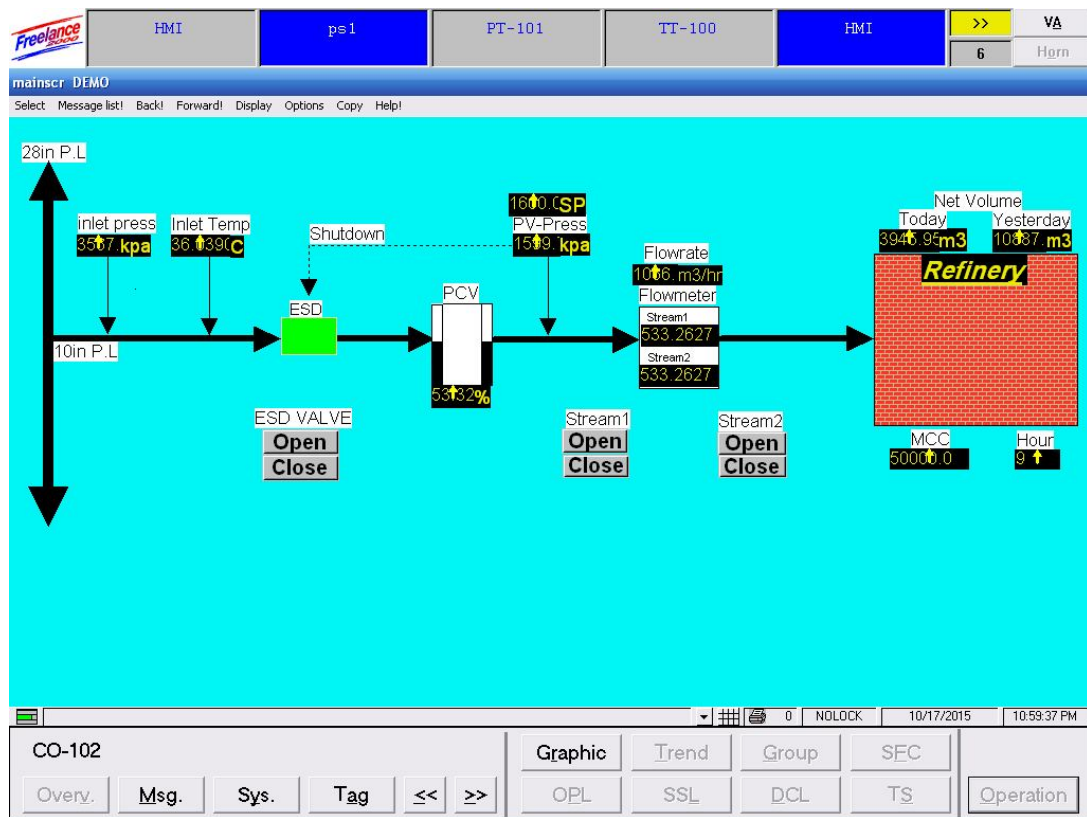


Figure 4.11: Count of Today Net Volumes and Count of Yesterday Volumes (after midnight)

# **CHAPTER FIVE**

# **CONCLUSION**

# **AND**

# **RECOMMENDATION**

# **CHAPTER FIVE**

## **CONCLUSION AND RECOMMENDATION**

### **5.1 Conclusion**

In this project we have been designed a program system to control the procedure of custody transfer metering, the designed system has proved the required observation of the station and the system is able to be reprogrammed or expanded in the future.

### **5.2 Recommendation**

Recommendation will be presented in this project on several points form

- ❖ The system in the future can include more devices to work best like density transmitter and flow computer
- ❖ Full knowledge of all the oil used for measuring devices details.

## **REFERENCES**

- GNPOC Library “ Basic theory of petroleum “ , Pipeline system volume “ Operator’s manual 1955.
- Custody transfer “ flow measurement “1985 .
- Furness, Richard A.(1989). Fluid flow measurement. Harlow: Longman in association with the Institute of Measurement and Control.

# Appendix

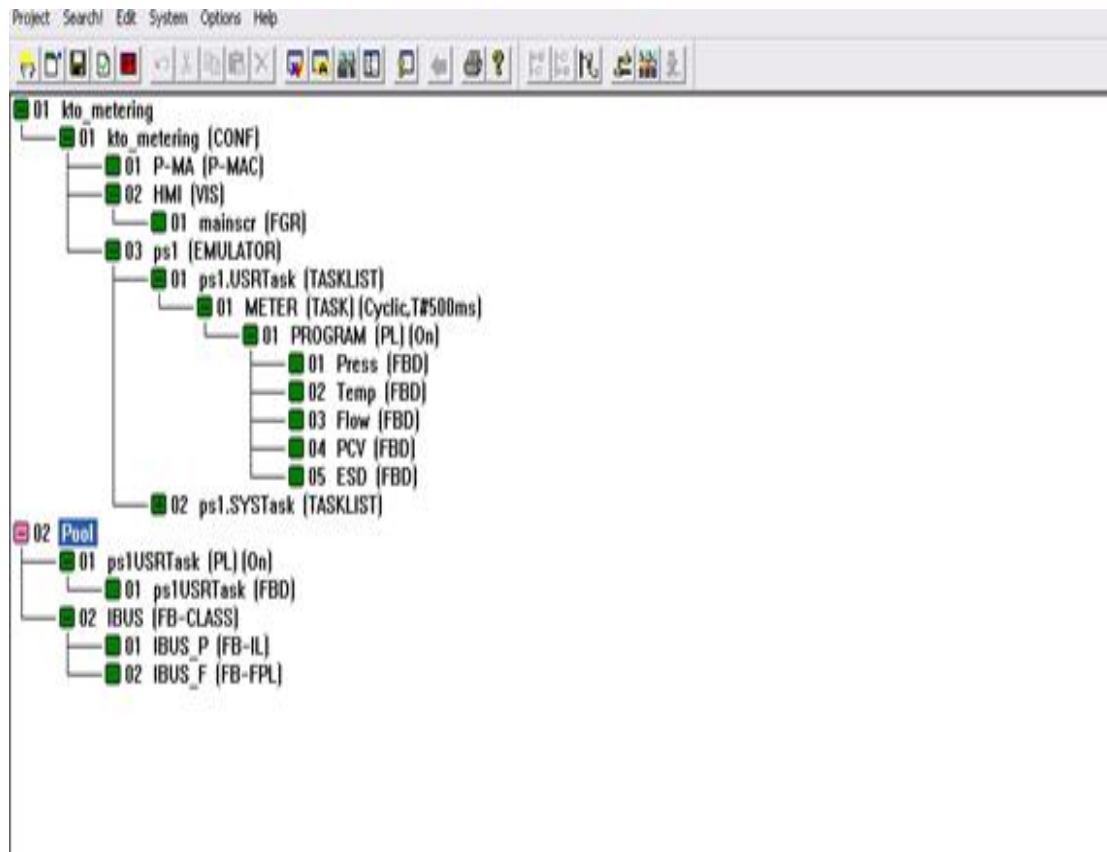


Figure The Tree of Project

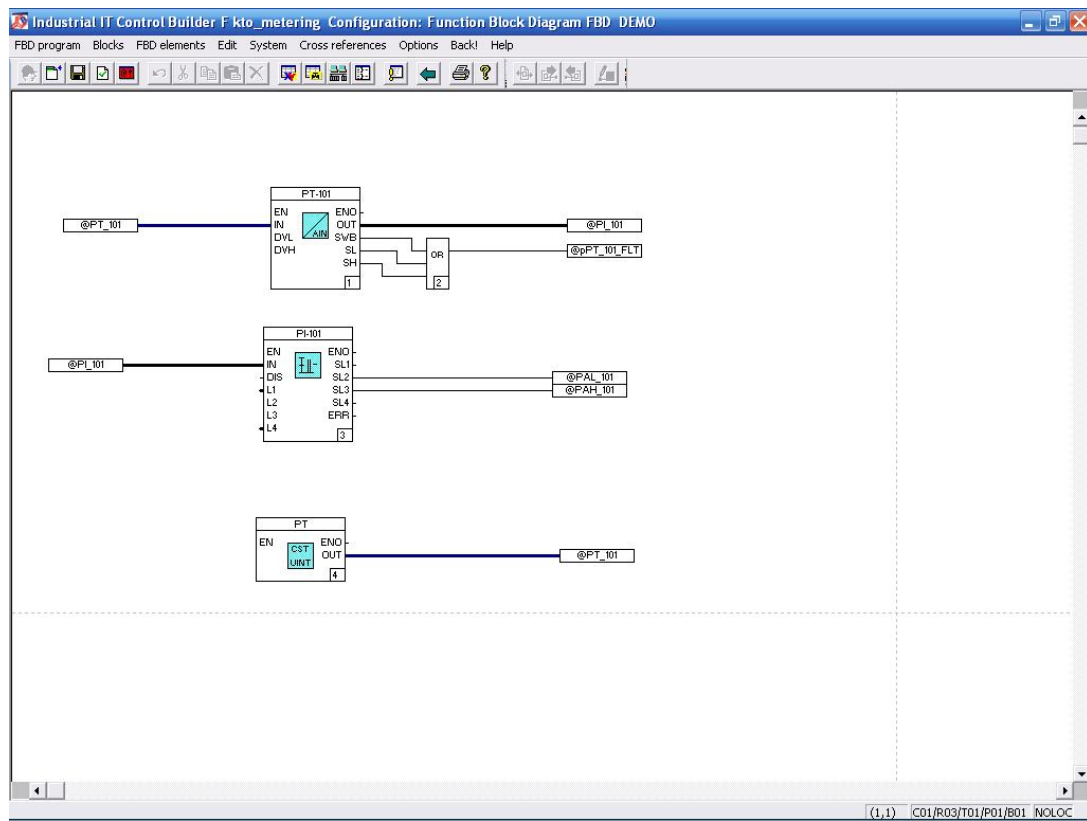


Figure FBD of Pressure

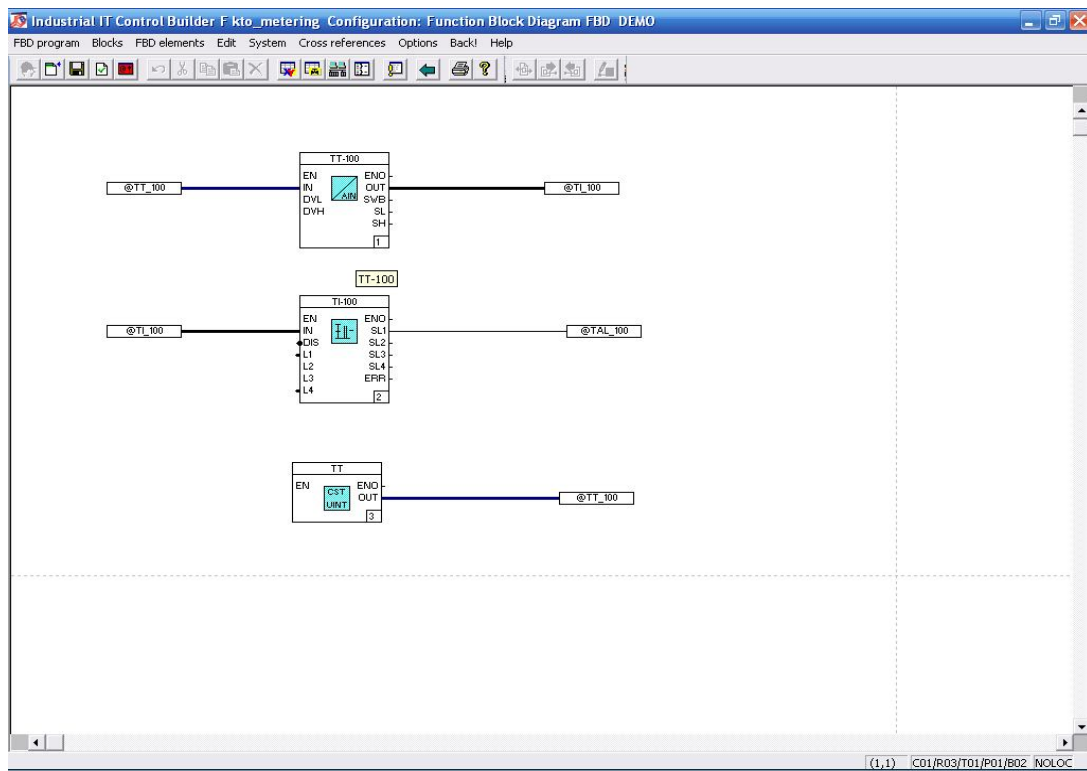


Figure FBD of Temperature



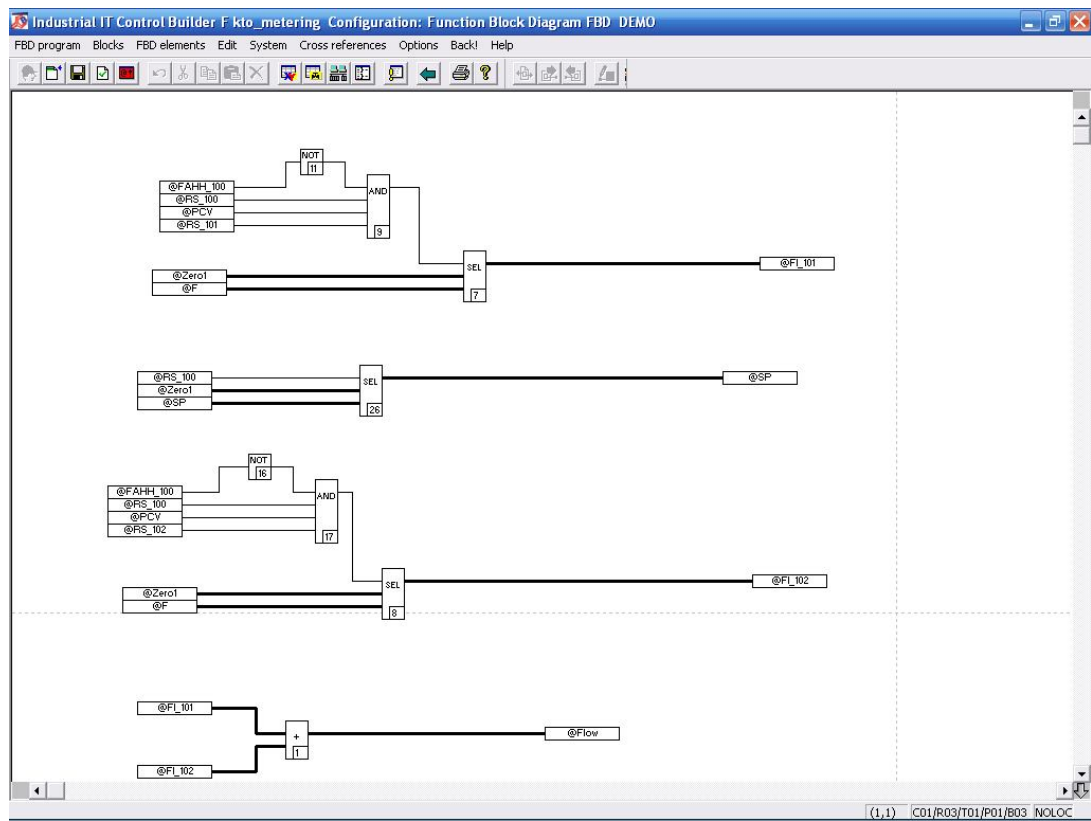


Figure FBD of Flow Meter

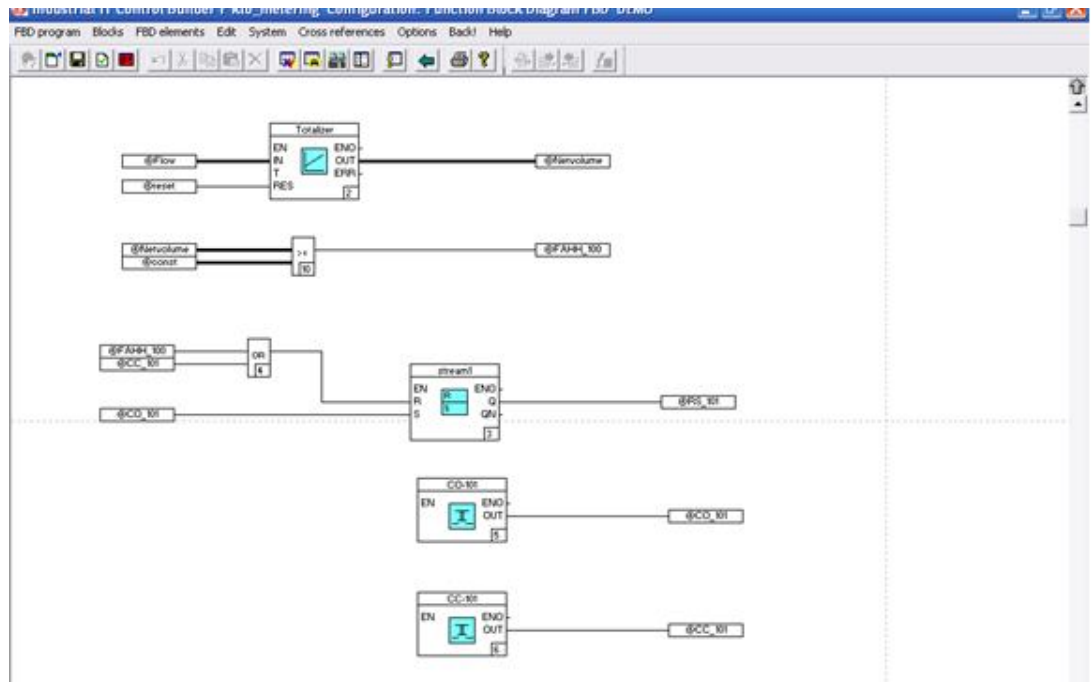


Figure FBD of Flow Meter

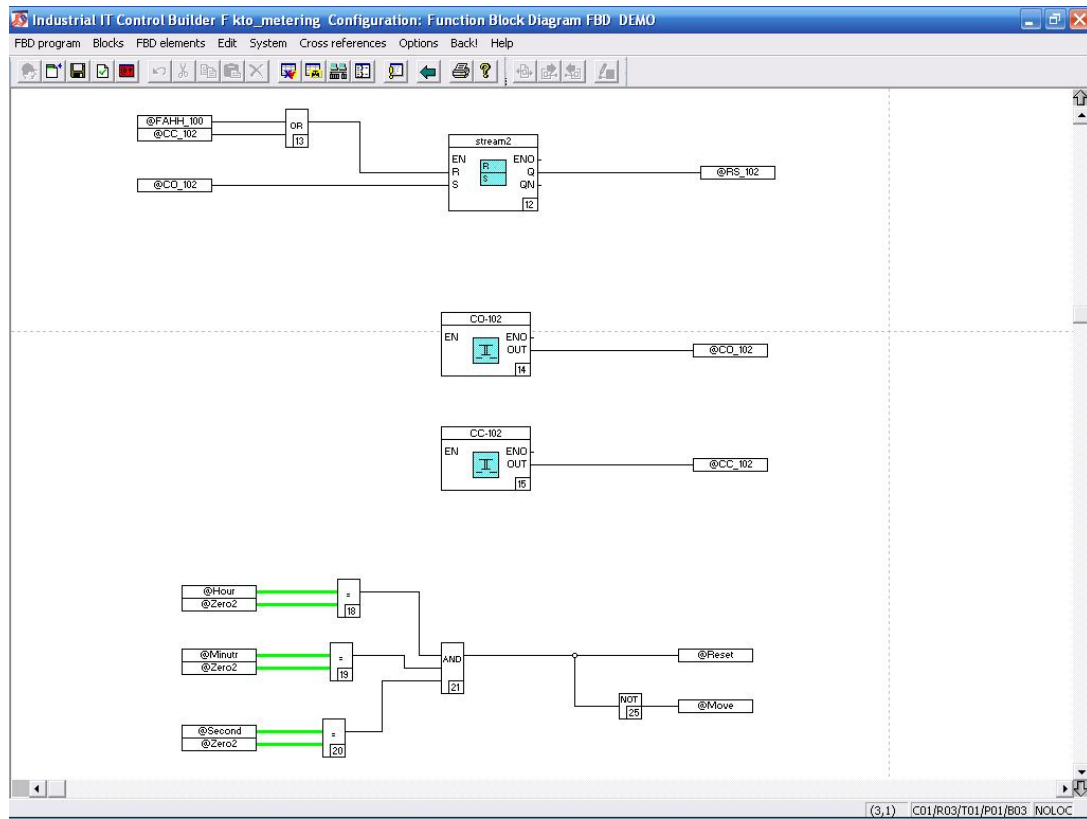


Figure FBD of Flow Meter

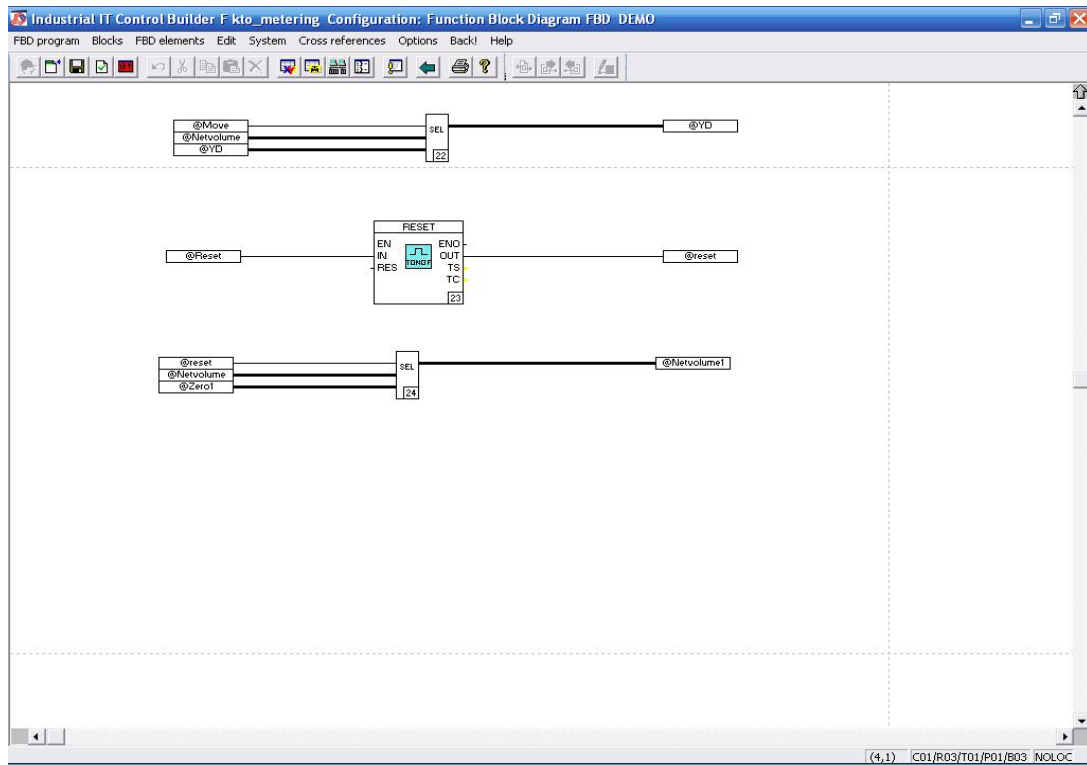


Figure FBD of Flow Meter

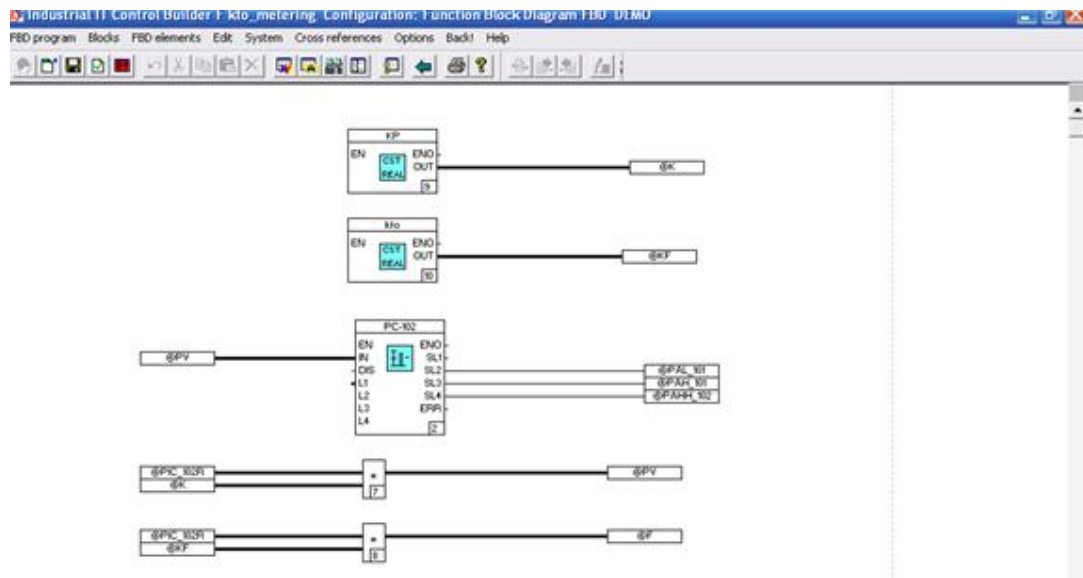


Figure FBD of PCV

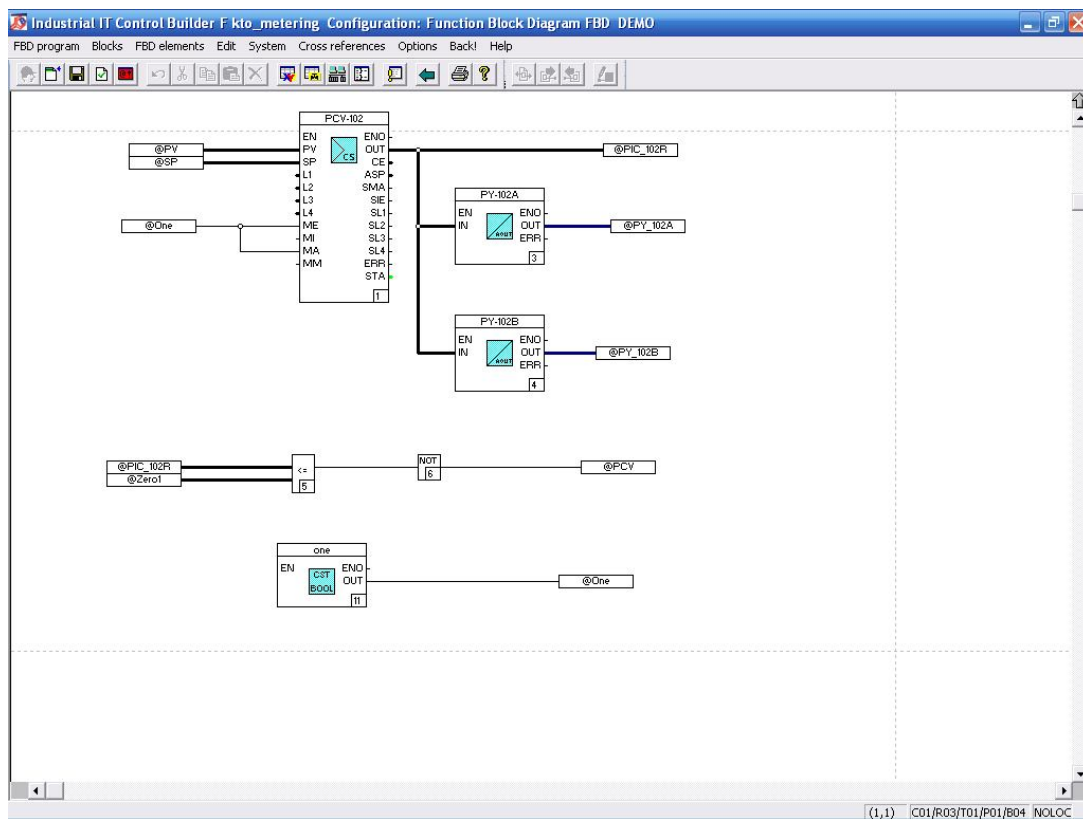


Figure FBD of PCV

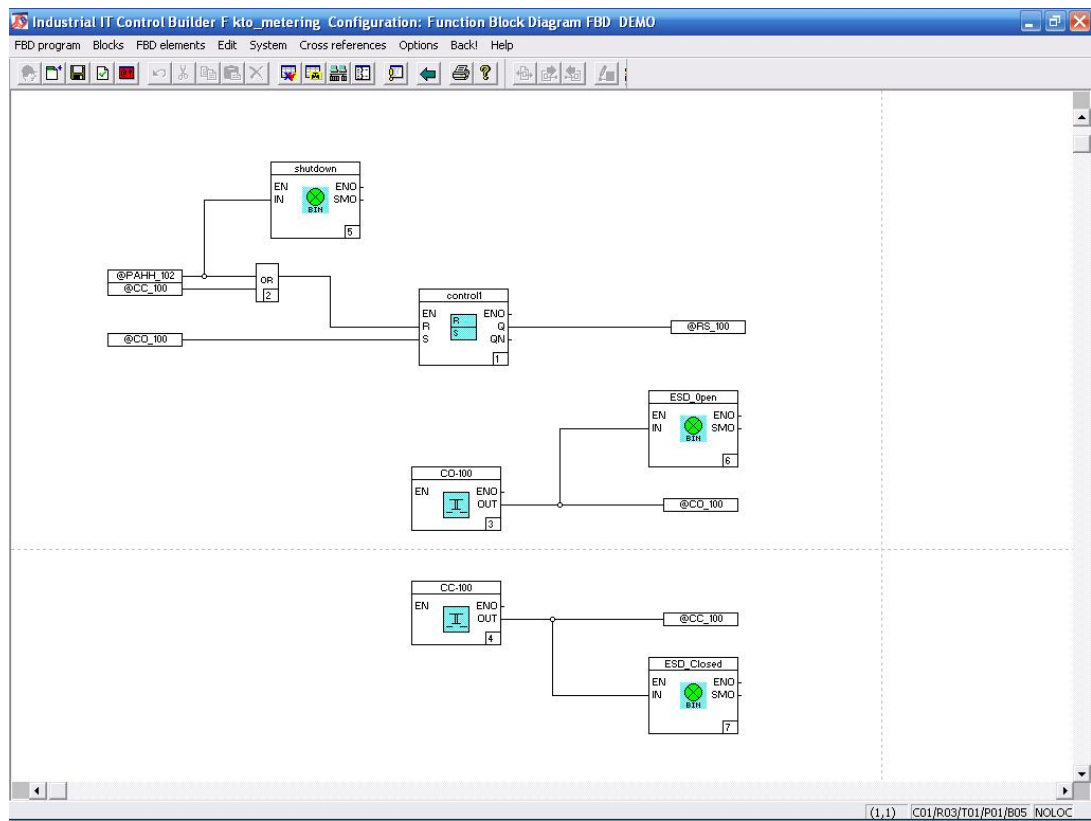


Figure FBD of ESD