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Design and Implementation of an Oil and Gas Surface Processing Plant using Digital SCADA

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Abstract: The oil and gas surface processing plant or station is the gathering station where the crude oil is separated into its constituent units of oil, water, and gas. This paper reports the sensor data capturing, the process operation, and the SCADA design of the processing unit using Wonder-ware InTouch Software. The system monitors/controls various process variables including pressure, temperature level, flowrates, and the emergency shutdown system based on the Cause & Effect Chart.
Keywords: Oil and Gas, Oilfield, PLC, SCADA, Automation, Process Plant, Flowstation.

I. INTRODUCTION

The oil and Gas industry projects are very capital intensive and every effort is made to reduce/minimize the OPEX and CAPEX of its investment and optimization becomes the key vehicle in achieving this. However, with the general acceptance of the Digital Oilfield and Industry 4.0 Concepts, Optimization has gone beyond just reducing cost and profit maximization as objective functions but the level of deployment of digitalization, digitization, and the introduction of modern tools such as ML, AI, IIOT, digital twin, block-chain, cloud computing automation, and others. SCADA, in particular, performs supervisory functions, especially with computerized control, and forms the basis for automation. The 5-level generic SCADA architecture is in the figure.1 illustrating the levels and functionalities. [1] Level 0 corresponds to field-level digital equipment, such as PLC and RTIC. Level 2 offers direct level control and monitoring functionalities and a computing platform. Level 3 represents the production control level that monitors targets in level 2. Level 4 corresponds to production scheduling that performs meter control functions or operations and is also the topmost level.

This paper designs a SCADA-based Digital Oil and Gas processing plant. The purpose of the design is to control, monitor and visualize the processes of the plants. Today, different multi-national oil and gas companies have adopted different optimization schemes under different names vis-a-vis smart fields (Shell) [2], field of the future (BP) [3], DOF/Intelligent Systems (KWIDF) [4], Integrated Operations (Statoil) [5],1-Field (Saudi Aramco) [6], and Integrated Operation (Conoco Philips) [7]. These corporate concepts deploy different levels of smart or digital intelligence

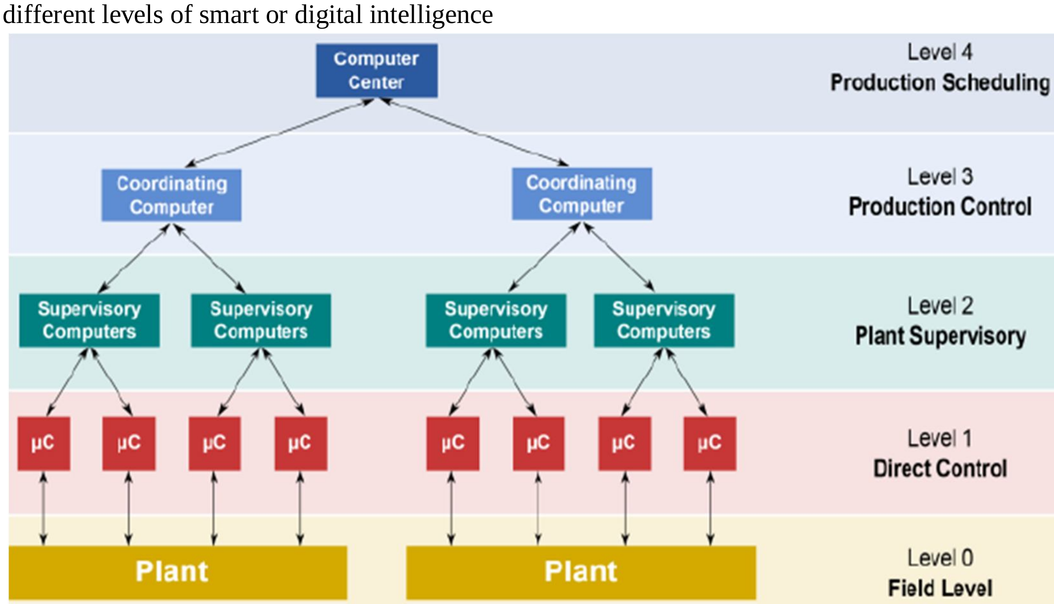

Figure 1. A typical generic SCADA Architecture [1]

II. LITERATURE REVIEW

Mahdi Al-fadhli [8] presented a sophisticated automated approach for monitoring several refinery activities. The proposal's operations include data collecting from tanks, alert notification, pipeline data collection, and the deployment of solutions to faults and other smart features. For its implementation, Lab-view was employed, while Lab-jack was used for wireless data gathering. The integration proved successful in terms of providing real-time and accurate data about field equipment. The system is a decent SCADA version for monitoring pressure, temperature, level, and gas leakage.

Instead of traditional control via DCS, Iman Morsi et al [9] built a SCADA/PLC system that controls the entire oil refinery. The term "Cruise" refers to the process of acquiring a new piece of equipment in order to carry out a certain task, such as cleaning a vehicle. While SCADA is used to monitor the system, PLC is used to store instructions for implementing operations such as logic, sequencing, timing, counting, and arithmetic to control various types of machine processes via digital and analog input/output modules. Mohammad et al. [10] developed a Programmable Logic Controller (PLC) that controls and monitors tank levels through level switches. The design tackles the tank flow problem, boosting the efficiency and safety of the tank and plant. The level switches are the PLC's input values, and the pump is controlled by the PLC's output, which pumps out the solvent. Eric T [11] described a way for constructing a fluid holding tank control system that automatically monitors and pumps fluid into the storage tank while also performing in reverse utilising a programmable logic controller.

The Authors in [12] presented an IoT based prototype implemented for artificial control and monitoring where Fuzzy control is simulated using MATLAB-R2018b, Modbus protocol, and ESP8266 to connect sensors to router through wireless communication. The IoT designed utilized OPC (Object Process Control) and MQTT (Message Queuing Telemetry Transport) and obtained data uploaded to the cloud. Zhang [13] created a multiphase flow loop control and monitoring facility for oil, gas, and water. The s7-200PLC was designed to control valve opening, pump start/stop, sensor data collection, and a monitoring interface. King-view software was used to create the monitoring interface.

The application demonstrates that it is cost-effective, low-cost, and extremely reliable for real-time monitoring.

Venuprasad [14] created a PLC and SCADA-based pressure monitoring and control system. It transferred pressure from an empty vessel to a pipe using an air compressor linked to the empty vessel.

Umar [15] is a plant process visualization software with a human-machine interface. The system simulation makes use of nuclear plant technical data. The device was created using the Wonder-ware InTouch, which came with manual component books. The outcome demonstrated how easily devices can demonstrate the theory of energy flow and conversion in a pressurized water reactor.

III. METHODOLOGY

A Process and Instrumentation Diagram, or P&ID below, shows how the process equipment is linked. It also shows flow directions, safety and control systems, pressure ratings, and other important piping and instrument parts of the system using symbols. Figures 2 to 6 show different units of the process equipment.

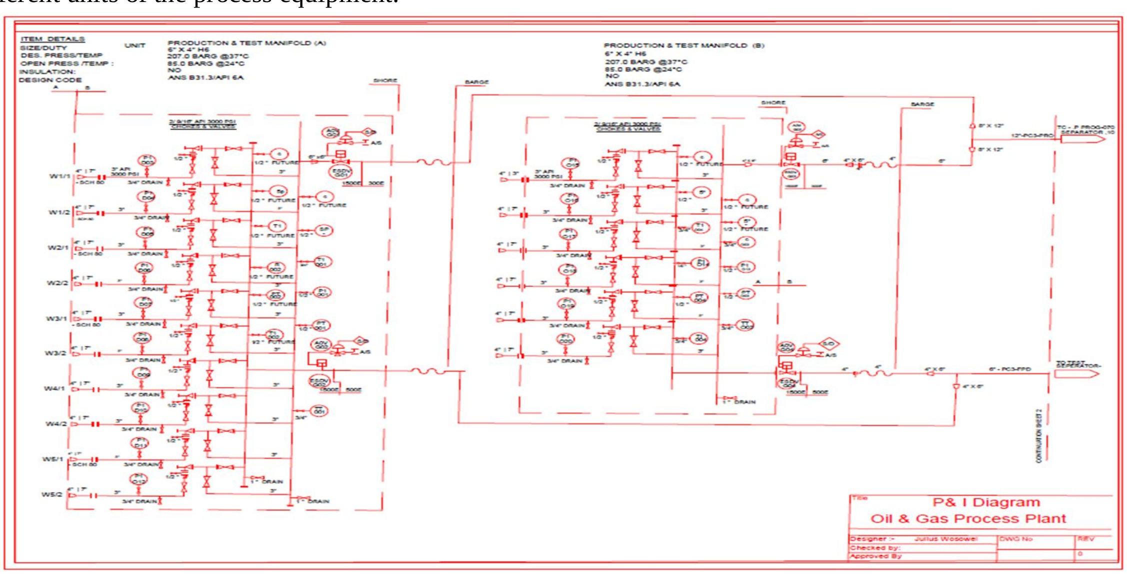

Figure 2: shows the Inlet manifolds (Adjustable and Fixed manifolds)

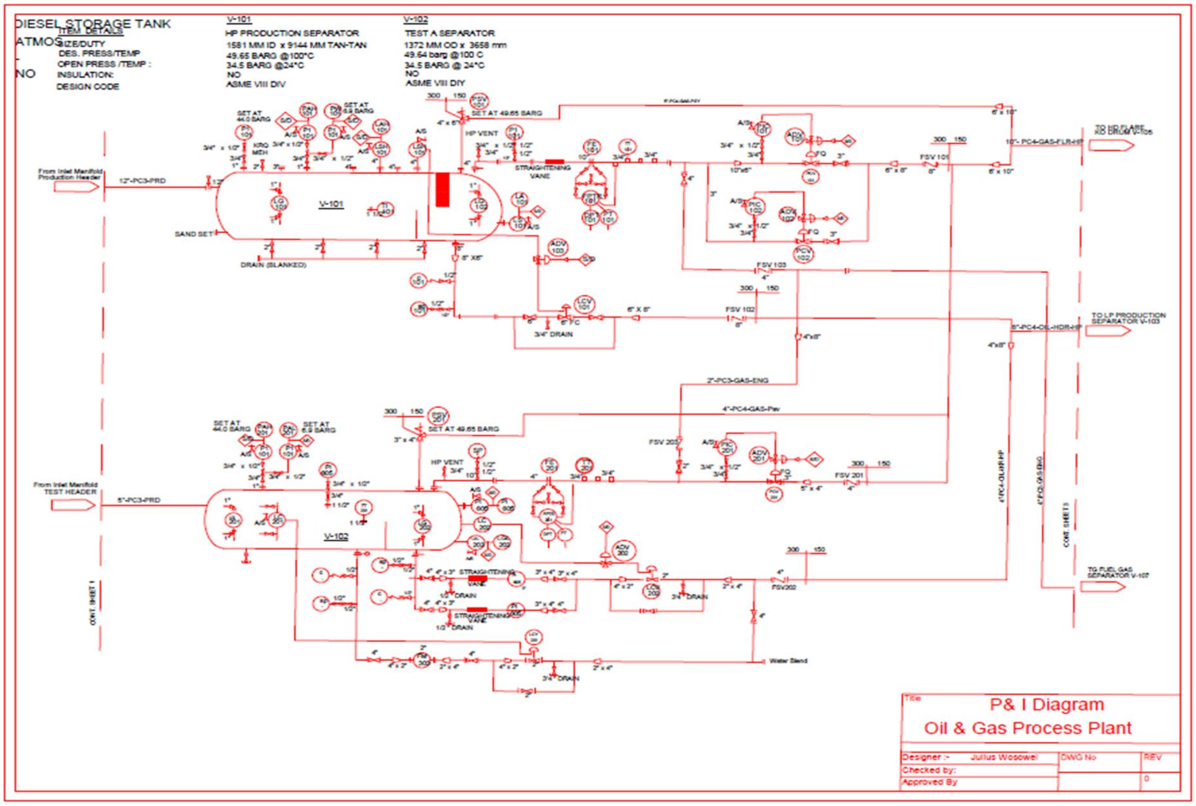

Figure 3: Shows the HP & Test Separators

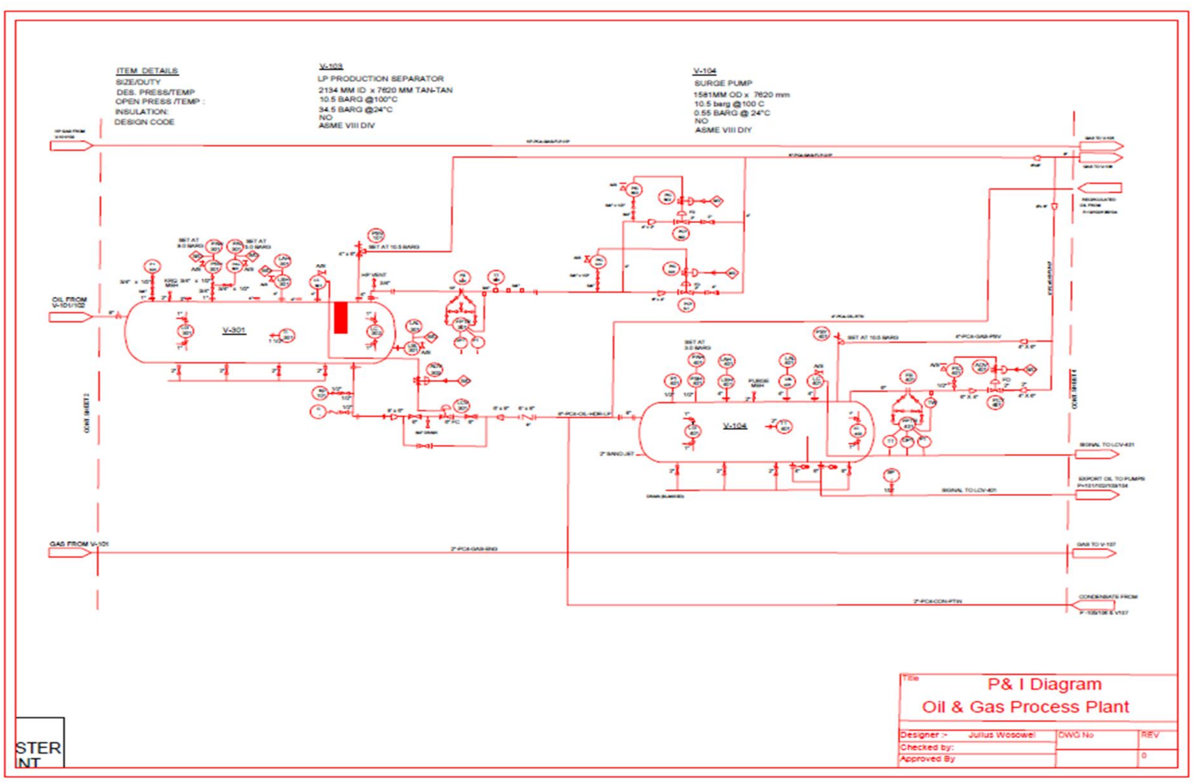

Figure 4: Shows the LP and Surge Vessels

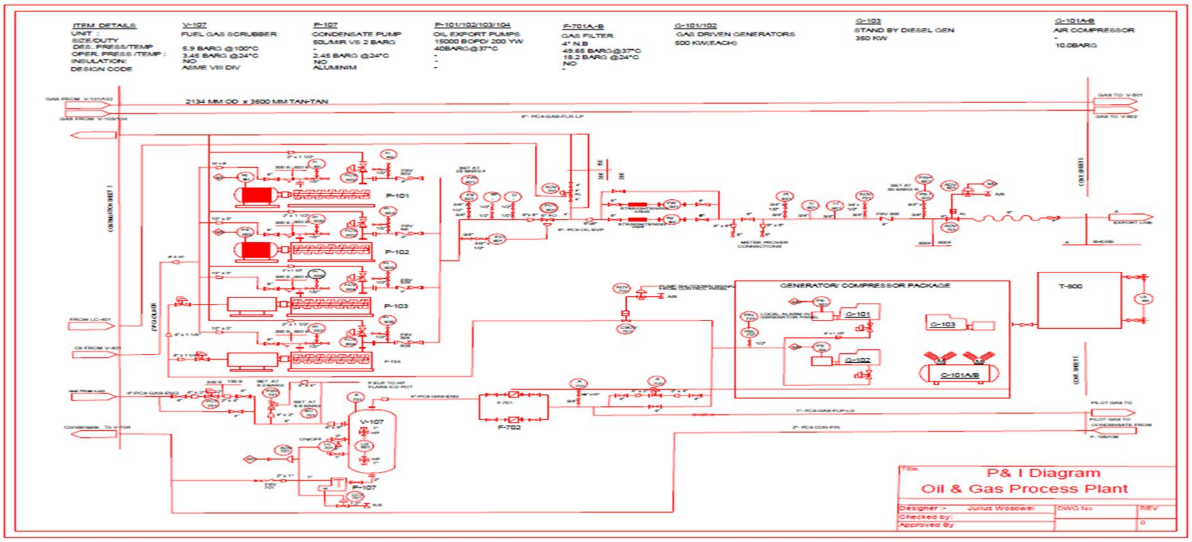

Figure 5: Shows the Pumps, generators, Scrubbers and Compressors.

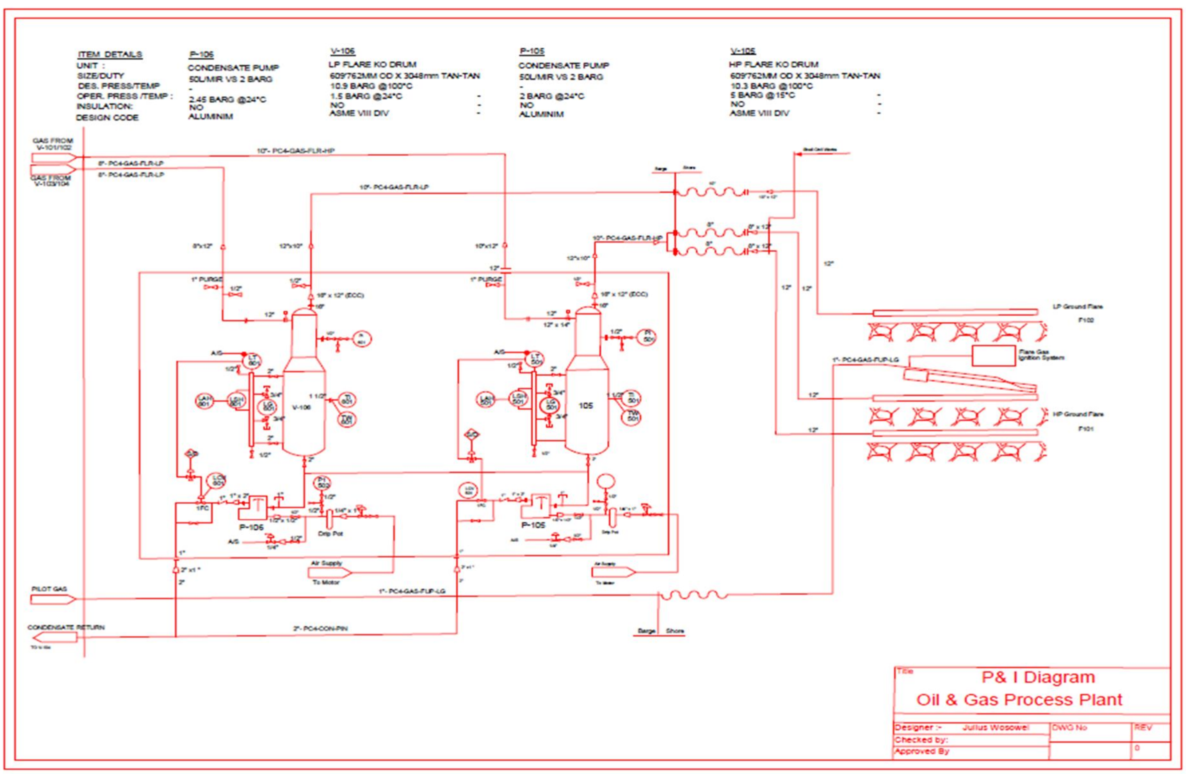

Figure 6: Shows the HP and LP KoPs & Flare System

A. Process Operation

The well stream enters the facility through up to ten well inlets and is guided through adjustable chokes to either the production or test header from mixing fluids to the H.P Production Separator V-101 or testing individual wells through the Test Separator V-102.

At 375 psig (34.5 Bar g), crude oil enters the two-phase H.P Production Separator, V-101, where oil and gas are separated. The petrol is metered by Daniel Senior Orifice Fitting, FE 101, and then flows under pressure control (PCV 101) to the H.P Flare K.O drum, V-105, before flaring via the H.P Ground Flare, F-101. The separated oil exits the vessel through LCV 101 under level control to the L.P Separator, V-103.

The V-102 test separator separates crude oil in the same manner as the V-101, but it is configured to work as a three-phase unit to test for generated water from any of the incoming well streams. The gas unit examines any incoming well stream for generated water. The unit's gas offtake is metered via the Orifice Fitting, and FE 201 combines with gas from V-101 to flare after passing through PCV-102. The separated oil is metered using Floco PD Meters, FM 201/2, before flowing to the L.P Production Separator under level control (LCV-201/2). Any separated water is metered using a Floco Meter, FM-203, and then blended with the oil flow.

Crude oil from V-101 and V-102 enters the L.P Production Separator, V-103, which operates as a two-phase unit at 100 PSIG. The flashed gas is metered by Daniel Senior orifice fitting, FE 301, and flows under pressure control (PCV 301) to the L.P Flare K.O Drum, V-106, before flaring via the L.P Ground Flare, F-102. The oil flows from the vessel under level control to the Surge Drum, V-104, through LCV-301.

The Surge Drum runs at a pressure of around 10 psig and provides final crude stabilization as well as sufficient suction head for the Export pumps. The stabilized oil from the surging Drum is delivered to the Oil Export Pumps, P-101/2/3/4, Sulzer Multi-Stage Centrifugal Pumps, which are duty/standby to supply 45,000 BPD of produced fluid, including 37,500 b/d (corrected volume) of export quality crude.

The surge tank oil level controller, L.C-401, controls oil transfer to the export line by operating a crude recirculation valve, LCV-401, located downstream of the Export Pumps on the Metering Skid. This strategy also enables a smooth system start-up at modest production rates while keeping a regular liquid level in V-104.

PVC-801 keeps export crude at a minimum pressure of 522 PSIG (36 Bar) and is metered on the crude oil metering skid by one of two Halliburton turbine flowmeters, FM-801/2. The export oil is transferred from the production barge to the Client's export line via the export flexible flowline.

The H.P Flare Gas K.O Drum V-105 receives gas via PCV-101/201 from the H.P Production Separator and Test Separators. Condensate Pump P-105 transports flare gas from V-105 to Surge Drum V-104 for re-processing.

The gas is delivered to the LP Flare Gas K.O Drum V-106 through PCV-301/401 from the L.P Separator & Surge Drum. The V-105 flare gas is transferred to the L.P Gas Flare. Condensate Pump P-106 pumps any liquids accumulated in V-105 to V-104.

Fuel gas for the Gas Driven Generators is drawn upstream from the pressure control valves (PVC 101, PCV 201) mounted on the H.P Production and Test Separators and processed through the Fuel Gas Scrubber V-107 and pressure regulators (PVC 701, PCV 702) to meet the engines' fuel requirements.

The G-101/2 Gas Generators are duty/standby machines that supply 500 kW of electrical power to a distribution system that serves the export pumps, accommodation, and all other electrical users aboard the barge. A control panel is provided with the caterpillar gas engines to synchronize the units during the automatic transition from one gas engine to another, as well as the automatic changeover to the 350 kW Diesel Standby Generator, G-103.

Clean, dry instrument air is supplied to the process control panel and all other air users by duty/standby electrically powered Air compressors, C-101A/B, complete with air dryers and receivers.

B. Flow Station

Flow stations, also known as production stations, block stations, satellite stations, or gathering stations, are production installations that receive the output of a group of wells and separate the incoming fluid into Oil, Gas, and sometimes Water before transferring the separated products to their respective collecting or disposal points. Oil may be routed to a crude oil dehydration plant or an oil terminal; gas may be routed to a gas plant, compressor plant, consumption line, or flare system; and water may be sent to a water injection plant, disposal plant, wells, or a drainage system [16].

C. Separation Unit

The Separation Unit's primary job is to separate the crude into its useful components of oil, water, and gas. The separator is the piece of equipment in charge of this task.

The oil component is transported via the trunk line to the terminal, tank farm, or ship. The Water Component is either drained or re-injected into the reservoir to increase output, whilst the Gas Component is either compressed, re-injected, or flared depending on government regulatory restrictions or the company's purpose.

Aside from the Scrubbers and knock-Out Pots (KoPs), the procedure has four main separators. There are either two or three phases [17], [18]. They are as follows:

1) High Pressure Separator (HP)

The High-Pressure Separator (HP), Low-Pressure Separator (LP), and Surge Vessel are the three main production separators. The Gravity Type Separator is used in this design, and the HP Separator is also known as the first stage separator. The inlet manifold pressure is 3000Psig, and the reduced pressure allowed to the HP Separator, which is also the operating pressure of the HP Separator, is 375Psig or 34.5 Barg @24°C, with a temperature range of 100-150°C and a flow rate of 10Wells. The calculated retention time of the HP Separator is 2.77 minutes. The retention time is the amount of time it takes for the gas to bubble out, the water to settle at the bottom, and the oil to be extracted in the middle. The retention time might range from 30 seconds to 3 minutes. It is calculated by dividing the liquid volume inside the vessel by the flowrate of the liquid. A foaming crude's pressure could increase retention time by four times its normal amount. Additional factors influencing retention duration include analytical condition, column type, column deterioration, and the presence of active sites such as contamination. The water cut (the percentage of water in the well flow) in this oilfield is around 20%, which is considered moderate. Furthermore, the facility's oil export pressure is 350 - 580Psig via 4 off-stage centrifugal pumps with power generation of up to 500kW by gas c/w 100% standby and up to 300kW by diesel. The flow station has a gas flaring capacity of 65MMSCF/d and an oil capacity of 45,000Bbl/day bulk and a corrected output of 37,500Bbl/day. Additional anticipated data includes a maximum gas flowrate of 11MMSCF/d, a GOR of 200-330 Scf/Bbl, a liquid density of 21°API, and a gas gravity of 0.65.

2) Low Pressure Separator (LP)

The second stage separator works in the same way as the first stage separator (HP), but at a lower pressure of 7.17Barg at 19°C and a water content of 2%. The Low-Pressure Separator is another name for the second stage separator (LP). It should also be mentioned that, depending on the configuration, the LP Separator can receive crude directly from the manifold.

3) Surge Tank/Vessel

The Surge Vessel is the final or third stage separator. At 19°C, the pressure dropped to 0.55Barg and the water cut was 0.8bbl/d. In some operations, heating exchangers can be built between separators to provide the best separation, and Level and Pressure Controllers aid in the separation process. The term "Knockout" refers to the process of removing something from the environment.

4) Test Separator and Well Test

The Test Separator is mostly used for surface well testing to identify the parameters of a certain well. This could comprise a PVT analysis of a single well as well as comprehensive flow measurement. In other words, a specific well is extracted and routed to the test header, while others stay in production at the inlet manifold.

This allows the behaviour of each well to be determined under different pressure and flow circumstances, and it is done at regular intervals. Perhaps 1-2 months. Unwanted behaviour, such as slugging or sand, can also be determined, and the separated components are examined in the laboratory to determine the hydrocarbon makeup of the gas, oil, and water, as well as the Basic Sediment and Water (BS+W).

D. Scrubbers and Drum Knockout

Scrubbers may remove mist and other liquid droplets, as well as liquid drops of water and hydrocarbon generated when the gas cools in the heat exchanger.

The procedure is required to prevent liquid droplets from entering the compressor and eroding the fast-rotating blades. A scrubber is used to remove a little amount of liquid from a gas.

While Knockout pots (KoPs) or knockout Drums (KoDs) comprise part of the flare header system and act to remove liquids and oil from flare gases. A flare system is required in an oil and gas processing plant. It ensures that undesirable or unutilized gaseous wastes from the processing setup are safely disposed of [19].

E. Compressor

For gas compression, numerous compressor types are employed, each with different qualities in terms of operating power, pressure, volume, and speed. They could be of the reciprocating, screw, Axial blade and fin, or centrifugal variety. It is a device that reduces the volume of a substance (typically gas) to increase its pressure. It is mostly utilized in the oil and gas industry for gas treatment and compression. It also allows field instrumentation to accomplish a variety of functions by powering such gadgets [20].

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F. Control and Safety System unit

Process Control: A process control system manages machinery and maintains track of data in a plant. A specialized distributed control system is required for a larger plant with 30,000-40,000 signals to and from the process. Hydraulic or pneumatic control systems could be used in a small plant. The use of PLC, SCADA, and HMI may also be required. The system's primary responsibilities include reading data from a variety of sensors, running programmes to monitor the process and activate switches and valves, and managing the process. Additionally, the operator is shown values, alerts, reports, and other information, and command inputs are accepted. Process control systems are made up of the following components in general.

Remote Systems Engineering Designs Servers Operator Statistics Controllers Control or Safety Electrical Control Fieldbus Field input/output etc.

G. Instrumentation

These are the sensors and switches that detect the process's condition. Variables like as temperature, pressure, and flow are examples of variables that are frequently coupled by multiple pair electrical connections (hardwired) on Fieldbus communication bus systems. Control devices, such as actuators for valves, electrical switchgear, and motors, or indicators, are also hardwired or connected through Fieldbus, and the controllers execute the control algorithm to produce the required action. Furthermore, controllers produce events and alarms based on changes in status and alarm circumstances, as well as prepare data for users and information systems. The servers perform data processing tasks such as data presentation, historical archiving, alarm processing, and engineering changes. Human Interfaces are supplied to clients such as operator stations and engineering stations. Communication is organised in various ways, such as links to remote facilities, rural or remote operations, assistance, and so on.

The control system's principal duty is to guarantee that the production, processing, and utility systems run efficiently within the design parameters and restrictions, as well as the alarm set boundaries. It is set up as a blend of logic and control function blocks/Ladder programmes like AND, ADD, and PID. The only way to tell if something is wrong is to look around. The central control room (CCR) is the operations centre, presenting graphical process data, an alarm list, reports, and historical data curves. Desktops, huge screens, and well-designed Dashboards are currently used in displays.

H. Design of SCADA Interfaces

The initial step in building the interface is to define the schematic of the surface gathering facility, followed by the Wonderware InTouch software HMI virtual SCADA Systems for the surface facility. InTouch software is used to generate tag names for each object, as well as the type of memory. Following that, determine animation linkages to objects to enable runtime look-alive effects such as flashing, shifting, and changing colours. Following that, scripts are written to depict the flow of crude oil in its component forms of oil, water, and gas using various colours. Another creation is about a real-time trend, which is exhibiting the graph. A historical trend is an activity that illustrates prior events (history) that occurred within a specific time frame. The alarm system is then constructed, with the function of alerting operators to system anomalies. Following that, a security system was developed that allows access only when the user enters the right account and password. The system testing follows to determine whether the procedures were completed correctly by simulating functions such as real time, trend, historical trends, and others. If a function is not operating properly, the procedure is likely to be restarted by arranging the tag-name dictionary, followed by the next step until the function is performing properly. Figure 7 depicts the procedure for the preceding steps.

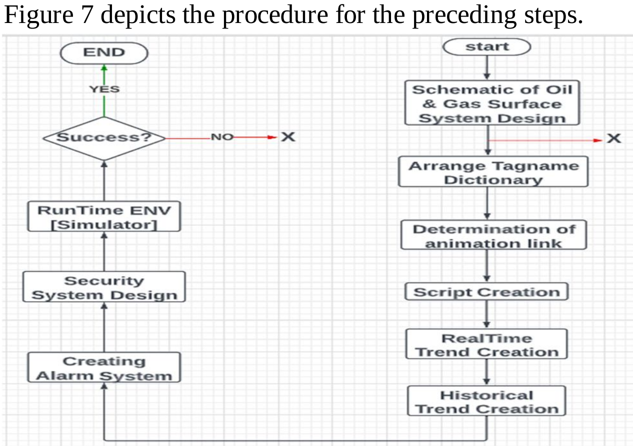

Figure 7: Flow chart of Development of Monitoring Interface

I. AB Allen-Bradley Micrologix1400 Hardware Specifications

A power supply, input and output circuits, a CPU, an isolated combination RS-232/RS-485 communication port, an Ethernet port, and a non-isolated RS-232 communication port are all part of the Micrologix1400 programmable controller. Each controller has 32 discrete I/O points (20 digital inputs, 12 discrete outputs) and 6 analogue I/O points (4analog inputs and 2analog outputs:1766-L32BWAA, and 1766-L32BXBA only).

The controller includes a real-time clock to serve as a reference for applications that require time-based control. A memory module (1766-mm1) as an accessory that provides additional backup for the user programme and data and aids in programme movement between controllers. The programme in the Micrologix1400 is non-volatile and is saved when the controller loses power.

J. The PLC Scanning Procedure

1) *Step 1:* Checking the input state to see if it is On or Off. Determines if a sensor or switch is turned on or off. The received criticism is saved in memory for use in the next action.
2) *Step 2:* Program Execution - Based on the findings of the previous step's input, programme instructions are carried out and the relevant actions are taken. The action to be conducted could include turning on specific outputs, and the results could be postponed, saved in memory, and then retrieved later.
3) *Step 3:* Output Status Monitoring and Correction - Monitors the output signal and makes any necessary modifications. Any modifications are made depending on the preceding step's input signal and the results of the programme execution in step two after step three, and the PLC then loops back through the cycle and repeats the stages.

Scanning Time = Time spent on Step 1 + Time spent on Step 2 + Time spent on Step 3.

At the start of each cycle, the CPU retrieves all of the input signal fields from the module and saves them in internal memory as an input signal process. The name of this CPU’s internal memory is Process Input Image (PII).

The user programme is stored in the CPU programme memory. After the PII has been read, the CPU pointer transfers or goes to the ladder programme from left to right and top to bottom. The CPU processes each rung of the user programme using the input status from the process input image (PII), and the final result of the user programme scan is saved in internal memory.

K. Interfacing

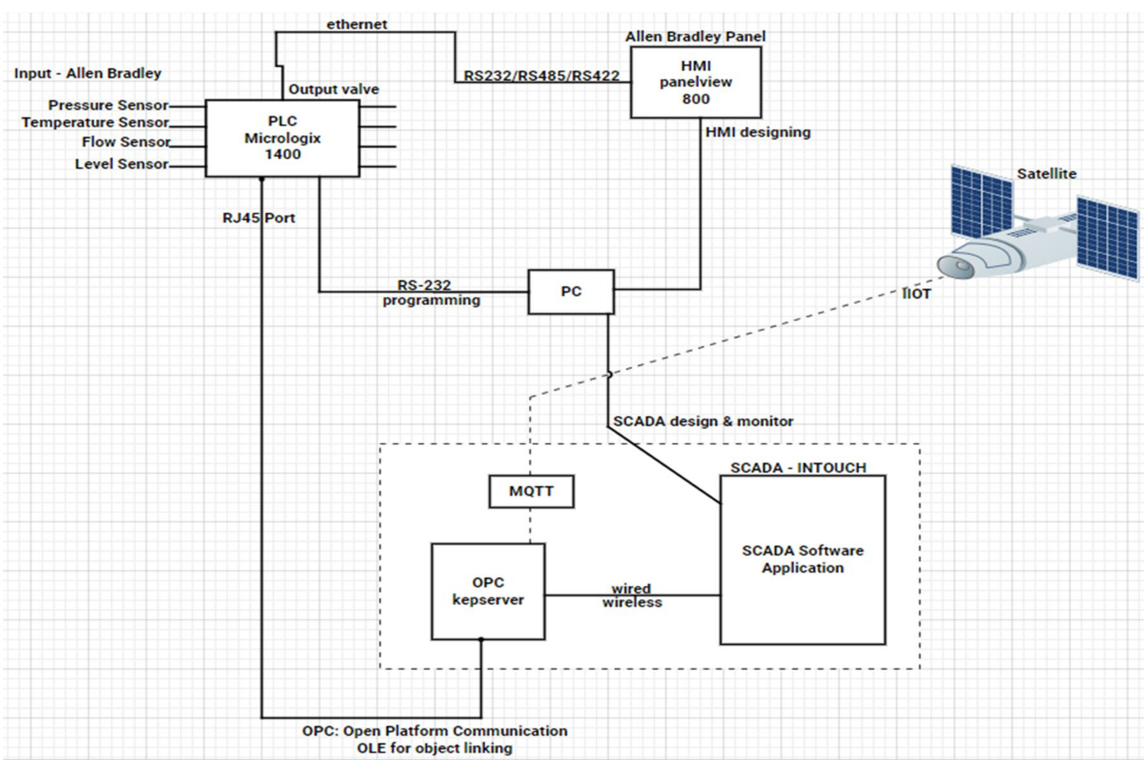

Fig 8: Interfacing diagram showing PLC, SCADA, and HMI.

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The interface diagram of PLC, SCADA, and HMI is shown in figure 8 above. It depicts the MicroLogix1400 PLC communicating with the SCADA software via the OPC KEPServer and the HMI Panel view800 via a PC. The OPC KEPServer was used to connect the MicroLogix1400 PLC to the Wonder-ware InTouch via the Ethernet/IP Protocol. Therefore, while representing tag names in KEPServer, attention must be taken. Tag-names must match their corresponding item in InTouch, and connection between MicroLogix1400 PLC and HMI Panel view800 must be successful. Ethernet, RS232, RS485, or RS422 can be used for communication. The MQTT Protocol, on the other hand, can be used to communicate with remote sites. OPC is an acronym that stands for Open Platform Communications and is used for object linking.

L. SCADA - SUPERVISORY Control and Data Acquisition

A SCADA, or supervisory control and data acquisition system, is a widely distributed computerised system that is used to remotely operate and monitor the condition of field-based assets from a centralised location. Valves, tanks, wells, pump stations, and treatment facilities are examples of field assets. SCADA Systems, as the name suggests, are required to:

1) Monitor the system;
2) Reduce operational manpower through automation;
3) Reduce power consumption through operational optimization; and
4) Minimize trips to operational sites.
5) Data storage of the system

IV. RESULTS AND DISCUSSION

SCADA screens are used to monitor operations such as wellheads, manifolds, pipelines, flow lines, gathering stations, separation water treatment, gas compression, scrubbers, knockout pots (KoPs), metering control and safety, storage, and export, and ESDSs via communication links/cables. To monitor the system, the plant consists of many main cycles with a significant number of input and output signals coupled to an Allen Bradley PLC controller and also connected to SCADA systems based on Wonderware InTouch Software. The SCADA solution has advantages in terms of operations, maintenance, and process development. A SCADA application is installed on an oil and gas collection station or surface production facility with a hardware interface to create a full real-time application management environment for a digitally automated operation.

A. Graphic User Interface (GUI) System for SCADA

As previously said, the oil and gas surface production system is comprised of various units, however, the following GUI system elements are intended to monitor and control the surface production system.

SCADA GUI consists of the following screens:

- Menu page
- Main screen (oil and gas production system)
- Separator Screen (HP).
- The monitoring screens
- The parameter indicator screen
- Trend1 – oil, water & gas.
- Trends – pressure & temperature values
- Alarms.

Operators viewed the process on a SCADA screen (graphic pages), navigating the graphic pages using a keyboard and mouse. Page relationships are depicted in Figure 10.

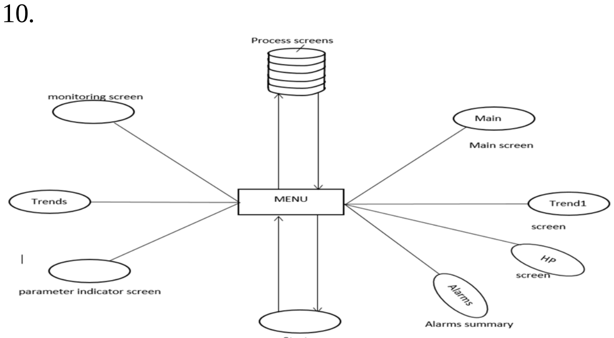

Figure 9: Menu page.

1) *Menu Page*

The menu page button displays all pages, including process pages, trend pages, and the ability to login and logout of the operator station. The graphic pages are linked together so that operators can traverse without having to reload the menu page.

2) *Process Display Page*

The design and specification document defines the objects and their attributes in graphic pages in accordance with the P&ID drawings and end-user requirements. For the operators, there are several process displays accessible, spanning from the manifold to the separation unit, which includes the first separation (HP Separator), second separation (LP Separator), third phase separation (surge vessel), and test separation (test separator). The following pages, however, are displayed:

3) *Main page*

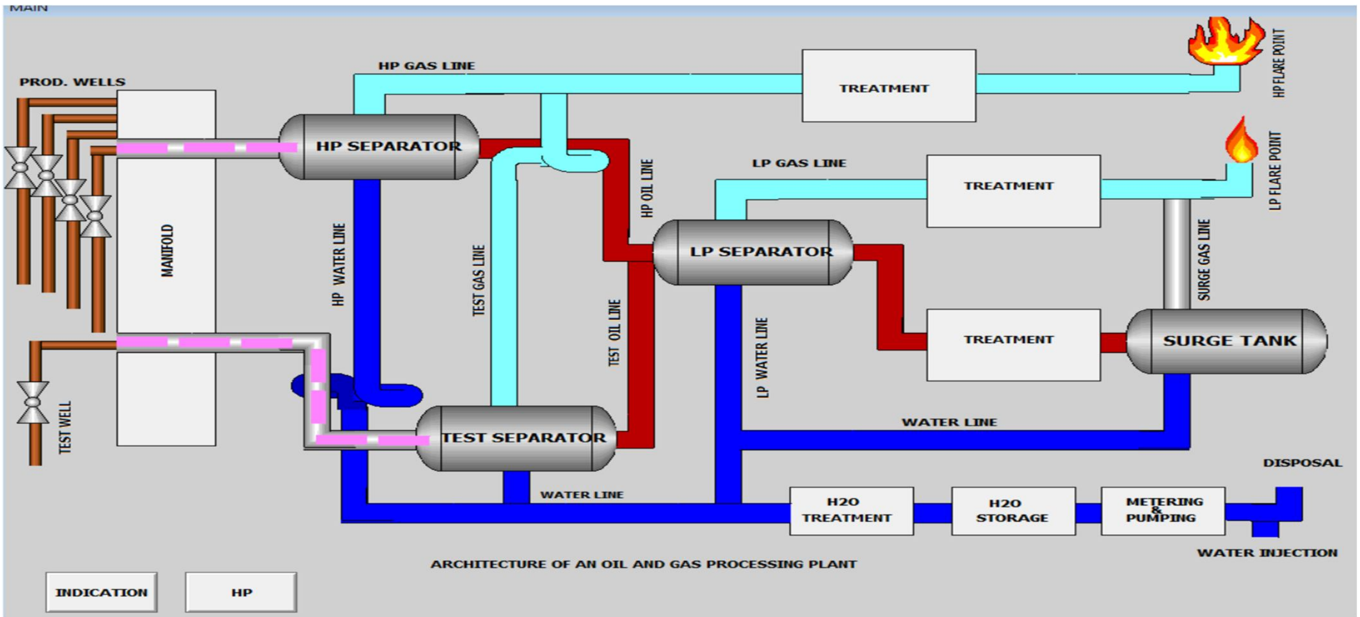

Figure 10: Showing the Main Screen.

Figure 10's main page depicts the schematic design of the surface processing facility created with the AB Allen Bradley Wonderware InTouch Software. It is an abstraction of the complete plant's core P&ID design. The wells, manifold, HP Separator, LP Separator, Test Separator, and Surge Vessels are all depicted. Oil lines, gas lines, water lines, flare lines, water treatment, water storage, and metering are among the other elements mentioned. Some units, however, are not represented due to limited tags in the demo version.

The designed pages have the following features:

a) Sending ON|OFF Commands to Export Pumps.
b) Sending ON|OFF Commands to Generators.
c) Sending OPEN|CLOSE Commands to ESDV 001.
d) Sending OPEN|CLOSE Commands to ESDV 002.
e) Sending OPEN|CLOSE Commands to ESDV 003.
f) Sending OPEN|CLOSE Commands to ESDV 004.
g) Sending OPEN|CLOSE Commands to ESDV 801.
h) Sending OPEN|CLOSE Commands to PCV 101.
i) Sending OPEN|CLOSE Commands to LCV 202.
j) Sending OPEN|CLOSE Commands to PCV 201.
k) Sending OPEN|CLOSE Commands to LCV 301.
l) Sending OPEN|CLOSE Commands to PCV 301/302.

m) Sending OPEN|CLOSE Commands to PCV 401.
n) Sending OPEN|CLOSE Commands to LCV 501.
o) Sending OPEN|CLOSE Commands to LCV 601.
p) Sending STOP Commands to P101.
q) Sending OPEN|CLOSE Commands to ESDV 701.
r) Sending STOP Commands to G101/G102.
s) Monitoring the pressure, level, and temperature readings.
t) Monitoring the flow transmitter values.
u) Monitoring the status of pumps.
v) Monitoring alarms for each object on its corresponding page

4) Separator page (HP) Page.

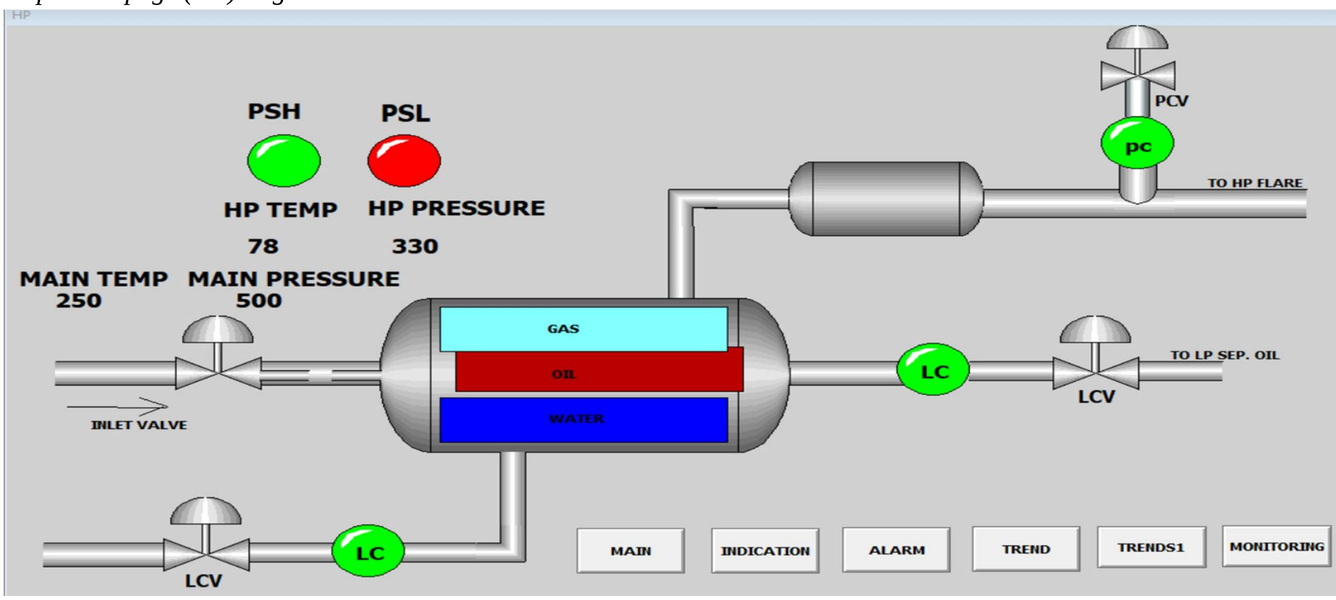

Figure 11: HP Screen.

For the purpose of the limited tags in a demo version, we created and simulated the High Pressure (HP) Separator only instead of creating for HP, LP, Surge, and Test Separators. Besides, the same features are found except for the parameters. The pages set up the operating parameters of the process plant. It shows the operating pressure, Pressure Switch High (PSH), Pressure Alarm High (PAH), Level Switch High (LSH), Level Alarm High (LAH), Level Controllers (LC), Level Control Valve (LCV), Pressure Controllers (PC), Pressure Control Valve (PCV) and several others as indicated in the P&ID and the cause-and-effect chart. This enables us to make comparisons between the operating condition and simulated condition. The operating features of the separation unit is as follows:

a) HP Separator: The HP Separator has a dimension of 1981mm*9144mm and the PAH101 is set at 44.0BARG, PAL101 at 6.9BARG, LSH101 at 4” above Centre Line(C|L), LSL101 at 4” below C|L, Process Safety Valve (PSV) or Relief Valve is set at 49.65BARG, operating pressure is 34.5BARG at 24°C and has a retention time of 2.77mins. 1. Based on oil and gas output, the Gas-Oil-Ratio (GOR) and Basic Sediment and Water (BS+W) are determined.
b) The Low Pressure (LP) Separator has the following setting: Dimension of 2134mm*7620mm, PAH301 @ 9.0BARG, PAL301 @ 6.0, LSH301 @ 4” above C|L, LSL301 @ 4” below C|L, PSV @ 10.5BARG, Retention Time calculated is 2.74mins and operates @ 7.17BARG @ 19°C.
c) The Surge Vessel settings are: PAH401 @ 3.0BARG, PAL401(None), LSH401 @ 4” above C|L and LSL301 @ 4” below C|L, PSV401 @ 10.5BARG, Retention Time calculated is 2.36 and operating pressure @ 0.55BARG at 19°C.
d) The Test Separator set values are as follows: PAH201 @ 44.0BARG, PAL201 @ 6BARG, PSV201 @ 49.69BARG, Retention Time calculated is 2.5, the operating separator pressure @ 34.5BARG. LSH201 @ 2” above C|L and LSL201 @ 2” below C|L, and has a dimension of 3658mm*1372mm

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5) Monitoring Page

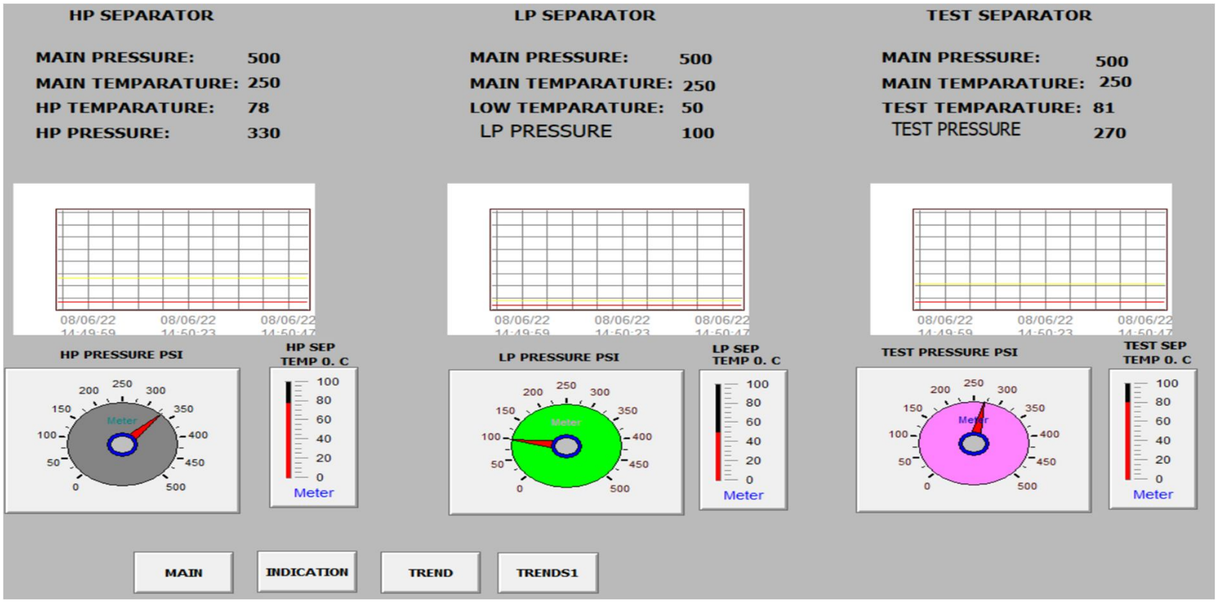

Figure 12: Showing Monitoring Page

For monitoring to be established, there must be communication between the SCADA and PLC. The PLC used is AB Allen Bradley and the SCADA Software is Wonderware InTouch Software for monitoring. Micrologix1400 is the PLC controller of AB Allen-Bradley while RSlogix500 is used to program the micrologix1400 controller. For the driver setup and communication; RSlinx classic is used while RSlogix Emulate is the simulator.

The monitoring interface has two (2) parts, the main system interface and the monitoring interface. The main system interface is shown on the main page while the monitoring interface is shown in figure 12 below and it shows the instrument display screen, parameter adjustment and display screens, and real-time display curve. It also shows the real-time values of main pressure, main temperature, HP Temperature, and HP Pressure as well as the same values as in LP and Test Separators.

6) Indicator Page

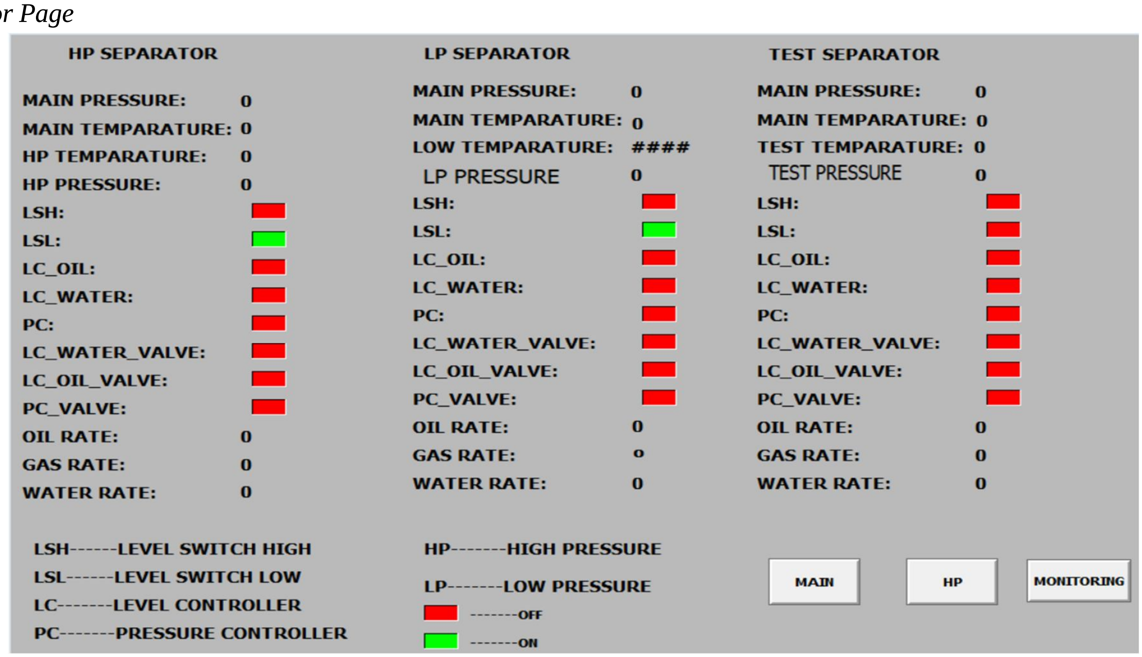

Figure 13: Showing the Indicator Page

This page in figure 13 serves as a process control panel that shows the status of field equipment. It is an indicator. Red colour indicates an unhealthy state while Green indicates a healthy state. All main field parameters are indicated. In a simulated state, values can be inputted to represent real time values for analysis. Any value inputted here is reflected on all pages. The simulated values are inputted to compare with field values to simulate alarm conditions.

7) Trend1 Page

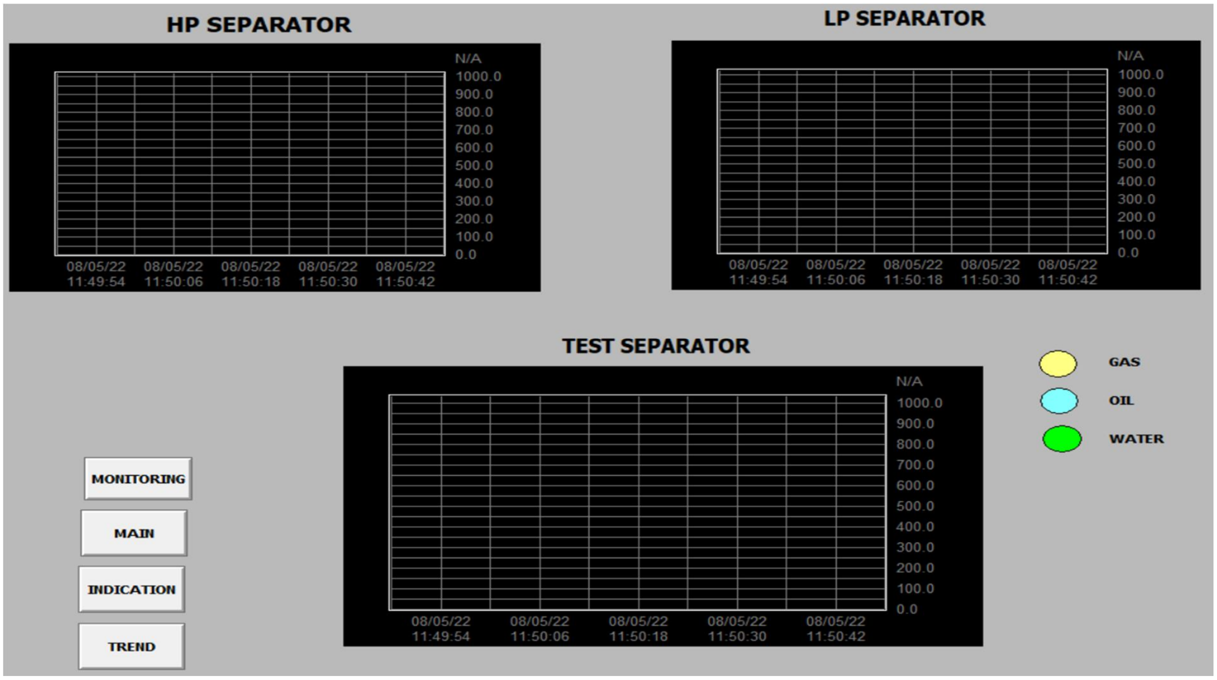

Figure 14: Showing Trend 1Page

The figure in fig 14 shows the plots/trends of HP Separator, LP Separators, and Test Separators in real time as regards the values of gas, oil, and water. This enables us to carry out further analysis as per the Gas-Oil Ratio (GOR), BS+W, Gross Production, Corrected Production, and also deriving the Shrinkage Factor.

8) Trends Page

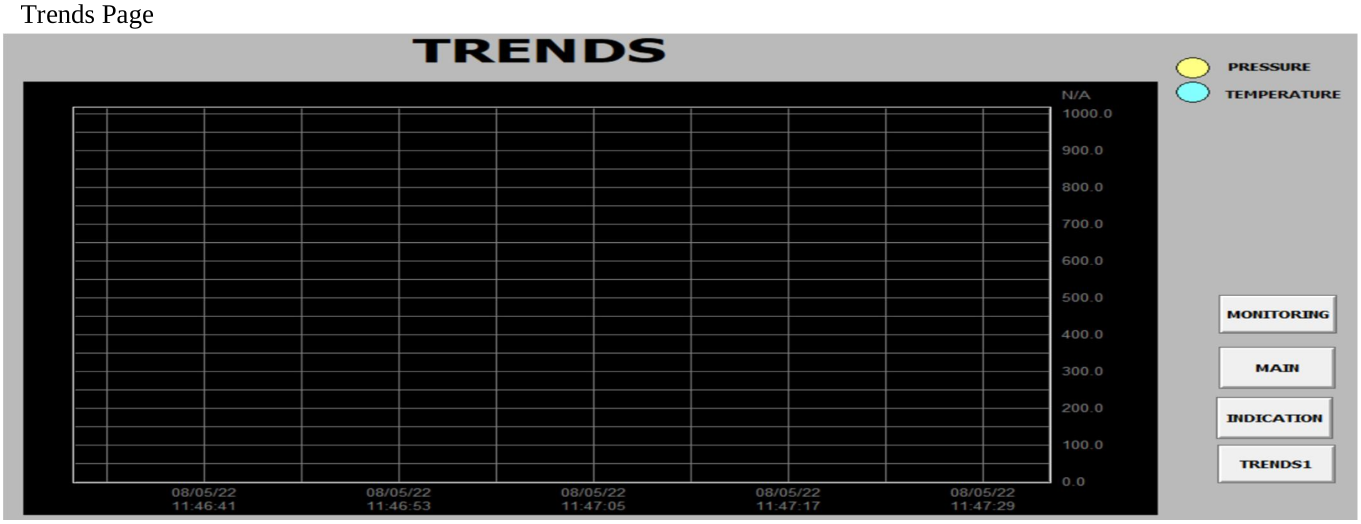

Figure 15: showing Trends Page

This page is designed to show the real time trends of the process pressure and temperature.

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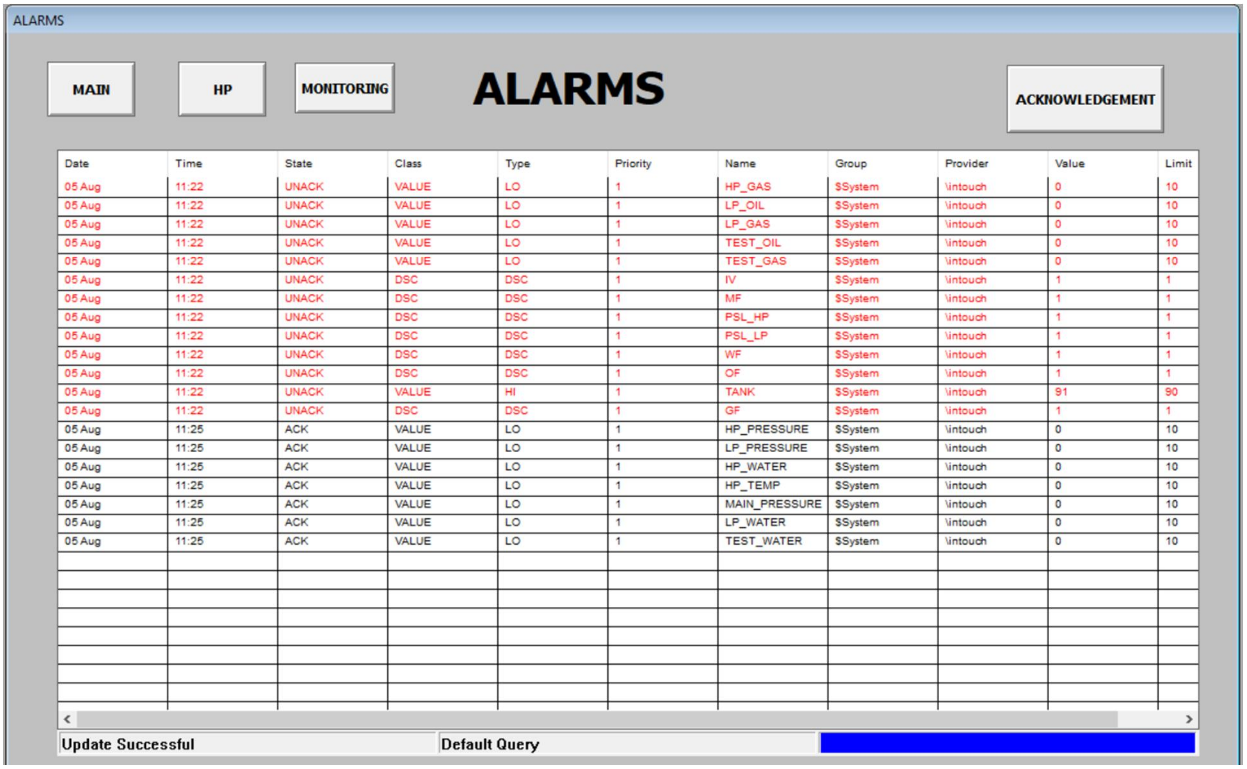
9) Alarm Page



Date	Time	State	Class	Type	Priority	Name	Group	Provider	Value	Limit
05 Aug	11:22	UNACK	VALUE	LO	1	HP_GAS	$System	\intouch	0	10
05 Aug	11:22	UNACK	VALUE	LO	1	LP_OIL	$System	\intouch	0	10
05 Aug	11:22	UNACK	VALUE	LO	1	LP_GAS	$System	\intouch	0	10
05 Aug	11:22	UNACK	VALUE	LO	1	TEST_OIL	$System	\intouch	0	10
05 Aug	11:22	UNACK	VALUE	LO	1	TEST_GAS	$System	\intouch	0	10
05 Aug	11:22	UNACK	DSC	DSC	1	IV	$System	\intouch	1	1
05 Aug	11:22	UNACK	DSC	DSC	1	MF	$System	\intouch	1	1
05 Aug	11:22	UNACK	DSC	DSC	1	PSL_HP	$System	\intouch	1	1
05 Aug	11:22	UNACK	DSC	DSC	1	PSL_LP	$System	\intouch	1	1
05 Aug	11:22	UNACK	DSC	DSC	1	WF	$System	\intouch	1	1
05 Aug	11:22	UNACK	DSC	DSC	1	OF	$System	\intouch	1	1
05 Aug	11:22	UNACK	VALUE	HI	1	TANK	$System	\intouch	91	90
05 Aug	11:22	UNACK	DSC	DSC	1	GF	$System	\intouch	1	1
05 Aug	11:25	ACK	VALUE	LO	1	HP_PRESSURE	$System	\intouch	0	10
05 Aug	11:25	ACK	VALUE	LO	1	LP_PRESSURE	$System	\intouch	0	10
05 Aug	11:25	ACK	VALUE	LO	1	HP_WATER	$System	\intouch	0	10
05 Aug	11:25	ACK	VALUE	LO	1	HP_TEMP	$System	\intouch	0	10
05 Aug	11:25	ACK	VALUE	LO	1	MAIN_PRESSURE	$System	\intouch	0	10
05 Aug	11:25	ACK	VALUE	LO	1	LP_WATER	$System	\intouch	0	10
05 Aug	11:25	ACK	VALUE	LO	1	TEST_WATER	$System	\intouch	0	10

Figure 16: showing Alarm Page

This page in figure 16 indicates the alarm state of the process plant. The cause-and-effect chart defines the causes and probable alarms that will be triggered. The summary of alarms is logged into an alarm file and displayed on the alarm summary page. Alarms can be either based on an analog value or digital value. Analog alarms are triggered depending on the value of the variable and definition of the HH, H, L and LL status of variables assigned during configuration. However, digital alarms are triggered when fault signals are activated. The HH and LL conditions are critical conditions and when activated, trigger the alarm and eventually shut down the plant while H, L conditions are warnings and they do not shut down the entire plant. The moment the alarm is triggered, the faulty field equipment will be indicated RED on the control panel and also shows RED on the displayed alarm summary page. The field production operator mutes the alarm and sets the plant in an override to gradually bring the plant to a normal state. The control room engineer acknowledges the alarm by checking on acknowledgment and the RED state turns Black. The normal state and abnormal state are differentiated by colour.

10) Report Pages

At the request of an operator, loggings for export pumps, gas generators, and status for HP, LP, Test, and Surge values can be viewed by selecting the report page button on the menu page.

11) Security Principle;

The operator enters a password and monitors the entire process plant and acknowledges the alarms. A user classification could either be an operator or supervisor with access to a subset of commands using passwords and user privileges. The supervisor accesses system commands such as ON|OFF Export Pumps, Gas Generator, and all process facilities whereas limited access is given to administrative, MEDIC, Radio Operator, and Safety for specific uses other than production.

12) Legend Page

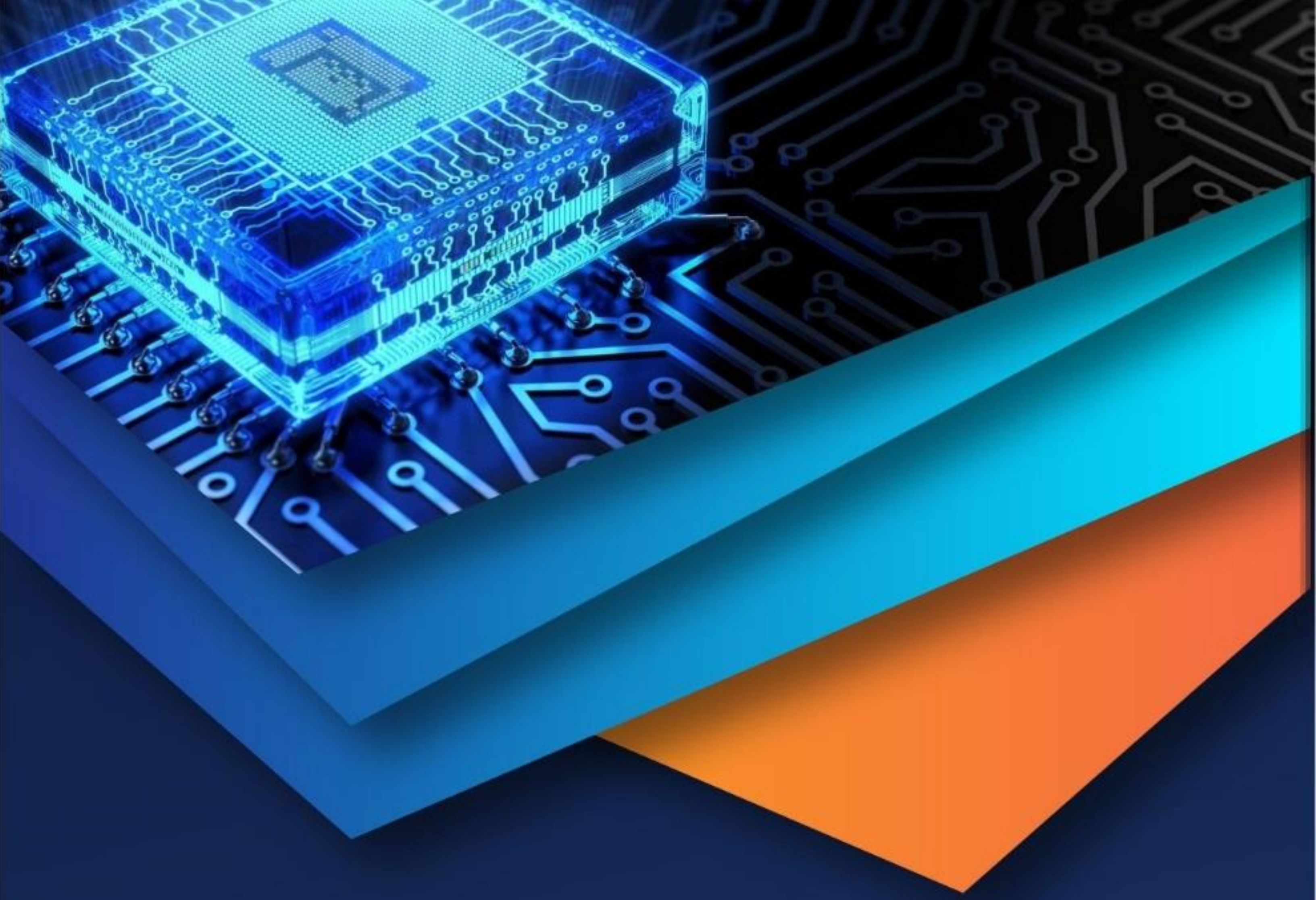
A legend page is created to define useful pieces of information for new operators and it also defines objects and colors used in the monitoring software.

V. CONCLUSION

This design is proof that a SCADA-based Oil and Gas surface processing plant can be designed using the symbol factory of Wonder-ware InTouch software. After the simulation exercise, the system visualizes the surface processing plant or flow station showing fluid, and the separation process with all its unit operations. The SCADA graphic user interface (GUI) is equipped with manual books for each component showing the activities such as historical trends, real-time alarms, security system, plant status, and monitoring in real-time. Therefore, the design is a potential instructional media for SCADA system introduction for an oil and gas processing plant.

REFERENCES

[1] https://en.wikipedia.org/wiki/SCADA.
[2] F. van Berg, R. K. Perrons, I. Moore, and G. Schut, "Business Value from Intelligent Fields," SPE Intelligent Energy Conference and Exhibition. p. SPE-128245-MS, Mar. 23, 2010, doi: 10.2118/128245-MS.
[3] "BP, 2017b. Field of the Future. http://www.bp.com/en/global/corporate/technology/technology-now/digital-technology.html."
[4] A. Al-Jasmi et al., "Maximizing the Value of Real-Time Operations for Diagnostic and Optimization at the Right Time," SPE Digital Energy Conference. p. SPE-163696-MS, Mar. 05, 2013, doi: 10.2118/163696-MS.
[5] S. Jones, "The economic value of integrated operations," Econ. value Integr. Oper. ABB Artic. Oil Gas Petrochemical. Available from https//library.e.abb.com/public/7cc9654e734fde2dc1257b0900361b07/Integrated_operationsUS.pdf, 2010.
[6] A. AbdulKarim, T. AL-Dhubaib, E. Elrafie, and M. O. Alamoudi, "Overview of Saudi Aramco's Intelligent Field Program," SPE Intelligent Energy Conference and Exhibition. p. SPE-129706-MS, Mar. 23, 2010, doi: 10.2118/129706-MS.
[7] G. Krushell, "Integrated operations at Conoco Phillips.," Present. Data Driven Prod. Optim. Conf. Houston, TX, 2015.
[8] M. Al-Fadhli and A. Zaher, "A Smart SCADA System for Oil Refineries," in 2018 International Conference on Computing Sciences and Engineering (ICCSE), 2018, pp. 1–6, doi: 10.1109/ICCSE1.2018.8373996.
[9] I. Morsi and L. M. El-Din, "SCADA system for oil refinery control," Measurement, vol. 47, pp. 5–13, 2014, doi: https://doi.org/10.1016/j.measurement.2013.08.032.
[10] M. M. Iqbal, S. Gupta, and C. G. Nayak, "Overflow protection of level tanks using programmable logic controller," in 2017 International conference of Electronics, Communication and Aerospace Technology (ICECA), 2017, vol. 1, pp. 237–240, doi: 10.1109/ICECA.2017.8203678.
[11] B. Ahmad and P. Prajitno, "Design of neural network and PLC-based water flow controller," J. Phys. Conf. Ser., vol. 1528, 2020.
[12] M. A. Ali, A. H. Miry and T. M. Salman, "IoT Based Water Tank Level Control System Using PLC," 2020 International Conference on Computer Science and Software Engineering (CSASE), Duhok, Iraq, 2020, pp. 7-12, doi: 10.1109/CSASE48920.2020.9142067.
[13] H. Zhang, H. Wang, Z. W. Li, and R. Q. Zhang, "Design of Monitor and Control System of Experimental Facility for Oil-Gas-Water Multi-phase Flow Loop," in 2019 5th International Conference on Control, Automation and Robotics (ICCAR), 2019, pp. 817–820, doi: 10.1109/ICCAR.2019.8813407.
[14] A. Venuprasad and Y. S. Narayan, "Automatic Monitoring and Controlling of Pressure using PLC and SACDA," 2016.
[15] U. Wijaksono, A. G. Abdullah, and D. L. Hakim, "Design of virtual SCADA simulation system for pressurized water reactor," 2016
[16] A. Abubakar and S. M. Shuwa, "IMPROVEMENT OF SEPARATION EFFICIENCY OF THREE-PHASE GRAVITY SEPARATOR AT OML-124 IZOMBE FLOW STATION, IMO STATE," Sci. Forum (Journal Pure Appl. Sci., 2019.
[17] T. Ahmed, N. Makwashi, and M. S. A. Hameed, "A Review of Gravity Three-Phase Separators," 2017.
[18] K. Arnold and M. Stewart, "Surface production operations, Volume 1: Design of oil-handling facilities," 1986.
[19] R. N. Brown, "Compressors: Selection and Sizing," 1986.
[20] H. Devold, "Oil And Gas Production Handbook," 2006.



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