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Institute of Electrical and Electronic Engineering
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Master in Electronics

Option: Computer Engineering

Title:

Automation and supervision for desalination station of SONELGAZ Combined Cycle power plant(Ras-Djinet)

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Abstract:

This project aims to replace the current automated system at the Ras Djinet power plant's desalination station, which employs an ABB PAC8000 (8521-HC-MT) controller. The existing controller has several drawbacks, including high cost, complexity, and challenges with upgrades,these drawbacks necessitate the exploration of alternative solutions to optimize the performance and maintainability of the desalination plant's control infrastructure. To address these issues, we propose replacing the ABB controller with a Siemens S7-300 controller that offers enhanced reliability and user-friendliness, making it a more suitable solution for the desalination station's control system. The handling of alarms and the switching between manual and automatic modes have also been taken into account. In addition, we have used the WinCC program integrated into TIA PORTAL to build a supervision system for the desalination station.

Keywords: Industrial programmable controller, PLC, Desalination station, Alarm, Supervision, TIA PORTAL.

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To my dear parents: ***Benyettou Hocine*** *and* ***Mokrane Fatma***

I dedicate this final year project to you as a sign of gratitude and infinite love. Your unwavering support throughout my academic journey has been a source of strength and inspiration for me. Your unconditional love, encouragement and sacrifices have been key to my success. I can never thank you enough for everything you have done for me. Your values, your education and your advice have allowed me to become the person I am today. This memoir is the fruit of my work, but it is also yours. Your presence and support have been essential for me and I am proud to be able to share this success with you.

To my dear sisters and brothers: ***KHADIDJA, AMEL, NACER, ADEL, ASMA, LOUBNA***

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List Of Abbreviations:

CCPP: Combined cycle power plant.
HRSG: Heat recovery steam generator.
GT: Gas turbine.
ST: Steam turbine.
UAT: Unit auxiliary transformer.
GIS: Gas insulated switchgear**.**
NGSS: Next generation science standards**.**
NG: Natural gas.
GTG: Gas turbo generator**.**
STG: Steam turbo generator**.**
IP: Intermediate pressure**.**
HP: High pressure**.**
LP: Low pressure**.**
GSUT: Generator step-up transformer.
BL: Battery Limit
CS: Control System
DCS: Distributed Control System (by DAEWOO)
CC: Control part.
OP: Operating part.
I/O: Inputs/outputs.
TOR: On/Off.
M.O.V: Motorized Valve.
LCS: Local Control Station
LCP: Logic Programming Controllers.
MCC: Motor Control Centers.
ESD: Emergency Stop
GOR: Gain Output Ratio
HP: High Pressure Steam
LCS: Logical Control System
LPBS: Local Push Button Station
MCR: Maximum Rated Capacity
MED: Multiple Effect Desalination
MU: Sea Water Reintegration
M/S: Main and Secondary
NaCl: Sodium chloride
PB: Push button
PFD: Flow Process Diagram
PLC: Programmable Logic Controller (desalination system)
PPE: Personal Protective Equipment
PPM: Parts per million
P&ID: Piping and Instrumentation Diagram
SP: Set Point
SW: Seawater
SWT: Sea water inlet temperature
TBT: Upper brine temperature
TDS: Total Dissolved Solids
TVC: Thermal Vacuum Compression or Thermocompressor
USD: Shutdown Unit

General introduction:

Environmental protection has become a significant concern in modern society. Research has focused on harnessing renewable and cleaner energy sources, such as combined cycle power generation. As electricity demand continues to rise, it is crucial to balance supply and consumption.

The Ras-Djinet combined cycle power plant is a plant that uses both a gas and a steam turbine together to produce electricity in Algeria.It is a compelling case study due to its strategic location, electricity generation method, and environmental impact. Auxiliary stations play a crucial role in the efficient operation of a combined cycle power plant. Among these, the desalination station is particularly important as it ensures a reliable supply of demineralized water necessary for the steam generation process.

Without a well-functioning desalination station, the power plant's overall performance and electricity output would be significantly compromised. Therefore, the automation and supervision of the desalination station are paramount to the plant's success. The desalination facility at Ras-Djinet currently uses an ABB PAC8000(HC-MT-8521) controller.

However, this controller has drawbacks, including high cost, complexity, and upgrade challenges. To address these issues, we propose replacing it with a Siemens S7-300 controller, which offers enhanced reliability and user-friendliness. Our primary objective is to enhance the efficiency, flexibility, and reliability of the desalination station's control system, while simplifying its maintenance and adaptability to evolving requirements.

The project is structured into four chapters. Chapter one provides a general overview of the Ras-Djinet combined cycle power plant. Chapter two delves into a comprehensive study of the desalination station. Chapter three focuses on modeling and automating the desalination station using the GRAFCET tool, along with its implementation via the S7-300 API. Chapter four presents the development of a secure programmable control solution, including the design of supervision interfaces. By adopting this approach, we aim to design a secure, programmable control solution for the desalination station's control system using a SIMATIC S7-300 programmable logic controller.

Chapter I:
Presentation of the Ras-Djinet combined cycle power plant

I. Introduction:

Ras-Djinet combined cycle power plant is one of the largest thermal power plants in Algeria. It combines two types of turbine, a combustion turbine (gas turbine) and a steam turbine each of these turbines drives a generator that produces electricity ("multi-shaft" configuration) or both types of turbine are coupled to the same generator ("single-shaft" configuration). It is located in the Boumerdes province and plays a significant role in the country's electricity supply. Operated by Sonelgaz, the national electricity and gas company of Algeria.

This plant is equipped with a gas filtration system that effectively reduces emissions of carbon dioxide and other atmospheric pollutants. This commitment to environmental protection is evident. Additionally, the power plant contributes significantly to the country's energy security, as it can provide additional power during electricity shortages. With a capacity of 1,200 megawatts, it accounts for approximately 20% of Algeria's total electricity production. [1] [2]

Ras-Djinet is one of the thermal power plants used to produce electricity in Algeria. It is a production company with various stations, devices and auxiliary equipment. In this chapter, we will explain all the details of this power plant.

II. Presentation of the power plant:

Algerian society of electricity production (" project owner ") constructed an 1131.1 MW natural gas-powered combined-cycle power plant adjacent to the existing 4x176 MW power plant at Ras-Djinet.

It consists mainly of three (3) single-shaft combined-cycle power plant (CCPP) modules and the systems that support plant balance (BOP), it is represented in the figure below:



Figure 1 : Block diagram of combined cycle power plant.[3]

Where:

(1) machine room,

(2) HRSG recovery boilers,

(3) chimney,

(4) UAT transformer,

(5) common electrical and auxiliary control building,

(6) emergency diesel room,

(7) energy evacuation station (GIS),

(8) gas station (NGSS),

(9) fire-fighting water supply,

(10) Fire pump room,

(11) Demineralization station and wastewater treatment plant,

(12) Demineralized water storage,

(13) Compressor room,

(14) Desalinated water storage,

(15) Desalination station and auxiliary boiler station,

(16) Fuel oil storage,

(17) Fuel oil pump room,

(18) Electrochlorination station,

(19) Pumping station,

(20) Hydrogen production station,

(21) Gas cylinder storage room,

(22) Hazardous materials storage area,

(23) Oil drum storage,

(24) Administration building,

(25) Oil drum storage,

(26) Store,

(27) Workshop.

III. Location of the plant:

The power plant is situated between the coast of the Mediterranean Sea and the crossroads between the Bordj-Menaïl highway (CW123) and the coastal road (RN24). It is located 77 km east of Algiers near the town of Ras-Djinet about 3 km south of Ras-Djinet village in the Wilaya of BOUMERDES and occupies an area of 35 hectares. The choice of this site was made based on the following criteria:

1. The proximity of the sea.
2. The proximity of important consumers located notably in the industrial zone of ROUIBA -REGHAIA.
3. Possibility of extension.
4. Favorable subsoil (underground) conditions that do not require deep foundations.

IV. History:

This plant was built between 1980 and 1986, and it began to supply electricity to the grid on 17 June 1986. The commissioning of the production units took place as follows:

1st unit	2nd unit	3rd unit	4th unit
December 1985	April 1986	September 1986	December 1986.

Table 1 Timetable for the commissioning of the production units

The schedule of the main operations can be found in the table

Timetable for the main operations as follows:

	Start	End
Civil engineering Works	June 1981	March 1985
Mechanical mounting	March 1984	September 1986
Electrical mounting	March 1984	1986

Table 2 : Timetable for the main operations

The groups were commissioned as a result of:

- Group 1, grid coupling on 06/17/1986.
- Group 2, grid coupling on 09/17/1986.
- Group 3, grid coupling on 29/11/1986.
- Group 4, grid coupling on 21/02/1987

The thermal power plant was designed and constructed by SIEMENS-KRAFTWERK-AG (FROG)- SIMMERING GRAZ PAUKER, an Austro-German consortium that was accountable for studying, supervising, assembling, and controlling the structure, while Dragados took charge of the seawater connection system.

Other Algerian companies, such as ENCC, ETTERKIB, BATIMETAL, GENISIDER, INERGA, SNLB, PROSIDER, ENATUB, SNIC, GTP, SONATRAM and SOGEP, were also involved in the plant's construction.

Construction work continued to expand the plant by adding the "Daewoo" combined-cycle power station, our focus in this work is on the desalination plant. Where it was built as follows:

The project was carried out in 2008 by the Japanese consortium Mitsubishi corporation, which acted as main contractor the Algerian company Daewoo engineering and construction, which acted as subcontractor. The plant was financed by a loan from the Chinese bank Exim, the Algerian government and several international banks.

In 2013, the project was launched by Sonelgaz, the Algerian national electricity and gas company, in partnership with the German company Siemens and the Italian company Ansaldo Energeia.

The project was implemented in two phases: the first phase involved the construction of two gas turbines with a total capacity of 760 MW, which were commissioned in 2013. The second phase involved the construction of a gas steam generator with an additional capacity of 680 MW, commissioned in 2018.

The plant comprises three combined-cycle gas and steam production lines or units with a capacity of 400 megawatts per unit. The first line went into production in July 2018, the second line in October 2018 and the third line went into production in May 2019, and its official delivery was scheduled for March 2020, but the corona crisis delayed this caused the extension of the project's implementation life, according to Korean agency Yonhap.

The South Korean Daewoo engineering and construction company has officially completed construction of a huge power station in Algeria, 10 years after it began on 03-03-2023, at a cost of $755 million. The station is equipped with several systems to protect the environment and surrounding health, including those linked to the desalination of seawater for cooling, which is used to produce steam after desalination, and another system to produce hydrogen, which is used in cold electrical generators. By auto-production and to filter all types of water coming from the plant**.** [2]

V. Main components of the power plant:

The combined-cycle (CC) power plant is equipped with three single-shaft units with reference SiemensSCC5-4000F1S, as well as three recovery boilers a water/steam cycle with three pressure levels and reheating. Each module of the CCPP has one (1) gas turbine (model: SIEMENS SGT5-4000F), one (1) associated HRSG, one (1) steam turbine (Model: SIEMENS SST5-3000 H-IL) and a common hydrogen-cooled generator (Model: SIEMENS SGEN 5-2000 H) located on the same shaft between the gas turbine (GT) and the steam turbine (ST).

V.1 Main power plant mechanical equipment: [4]

V.1.1 Gas turbine (GT):

The Siemens AG annular combustion chamber gas turbines are single-shaft turbines. It's a single-shaft gas turbine with the common rotor used by the compressor and the turbine. The rotor is supported in two bearings that are outside the pressure zone. The gas turbine is designed for double ignition. Natural gas (NG) must be used as a primary fuel and fuel oil must be used as back-up fuel.

Basic load parameters: Gas Fuel oil

Nominal output at generator terminals: 249.2 MW 210.5MW

Nominal efficiency at generator terminals: 38.4% 36.9

Fuel consumption: 14.3 kg/s 13.2 kg/s

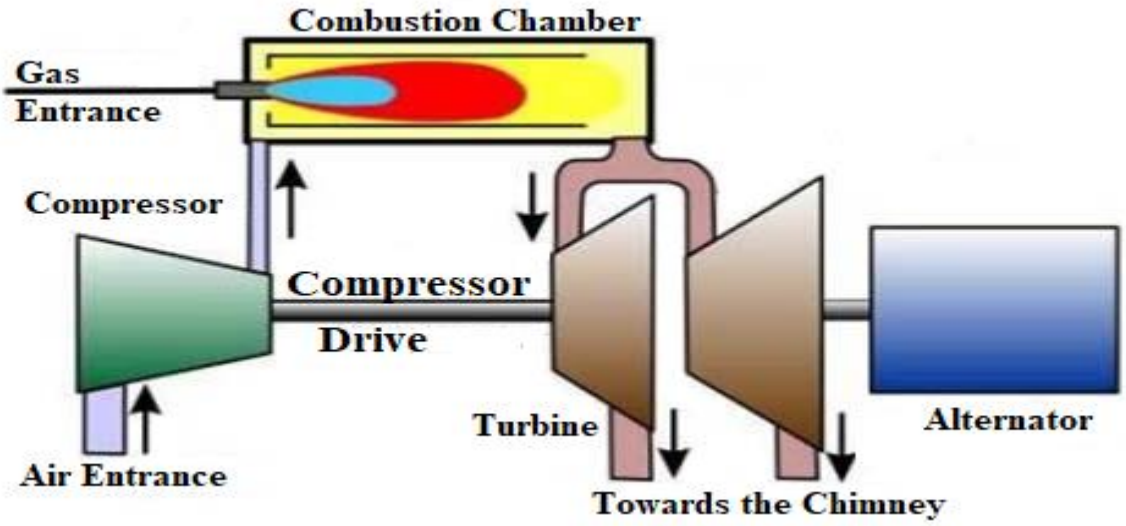


Figure 2 : Block diagram of the gas turbine[4]

V.1.2 Heat recovery steam generator HRSG

The main function of the heat recovery steam generator (HRSG) is to generate the required quantity and quality of steam using the waste heat from the exhaust gases of the gas turbine generator (GTG). The steam generated by the HRSG will be supplied to the steam turbine, which can give me a generator terminal rating equal to 150MW.

- The main components of the heat recovery steam generator (HRSG): The heat recovery steam generator (HRSG) is made up of several important components such as:

a) High-pressure (HP) steam drum (50HAD50BB001)

The HP Steam Balloon is designed to separate the steam and water mixture to supply high-purity saturated steam to the HP 1 superheater, and to absorb evaporator surges during start-up and operating transients.

- **Number of units:** One for each module
- **Nominal pressure:** 139.6 Bar (g)
- **Nominal temperature:** 341°C

b) Steam intermediate pressure vessel (IP) (50HAD60BB001)

Designed to separate the steam and water mixer and supply high-purity saturated steam to the IP 1 super heater.

- **Number of units:** One for each module
- **Pressure rating:** 35 Bar (g)
- **Temperature rating:** 249°C

c) Low-pressure steam balloon (LP) (50HAD80BB001)

The LP Steam Balloon is designed to separate the steam/water mixture and supply high-purity saturated steam to the superheater.

- **Number of unit**s: One for each module
- **Nominal pressure:** 8 Bar (g)
- **Nominal temperature:** 180°C

d) HSRG chimney

The HRSG stack and silencer are provided to carry gas turbine exhaust gases from the HRSG outlet to the atmosphere. Sampling ports are provided in the stack for emission checks. The hot exhaust gases from the gas turbine make noise. For this reason, a silencer is provided to reduce the noise at the stack outlet.

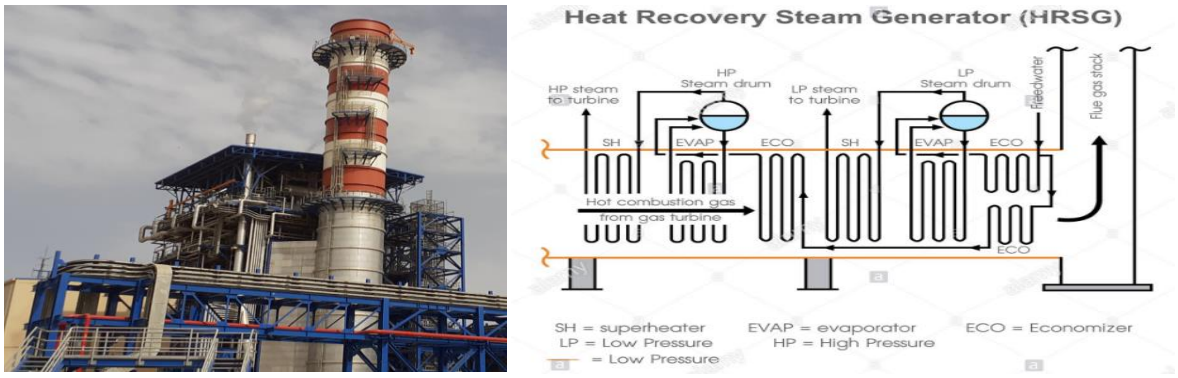


Figure 3:Heat recovery steam generator (HRSG).

V.1.3 Steam turbine (ST):

The steam turbine consists of a cylindrical HP cylinder and a direct-flow IP/LP cylinder. The exhaust steam leaving the steam turbine is condensed in the water-cooled condenser. The HP turbine is of single-flow, double-walled construction with a fixed blade holder and external casing. It is fitted with a welded main steam shut-off and control valve, supported by additional brackets.

The outer casing is cylindrical. The IP/LP outer casing is divided into two sections, the cast inlet casing section and the welded exhaust casing section. The two sections are divided horizontally. The half-housings are bolted together with connecting bolts. The inlet and exhaust sections are also bolted together.

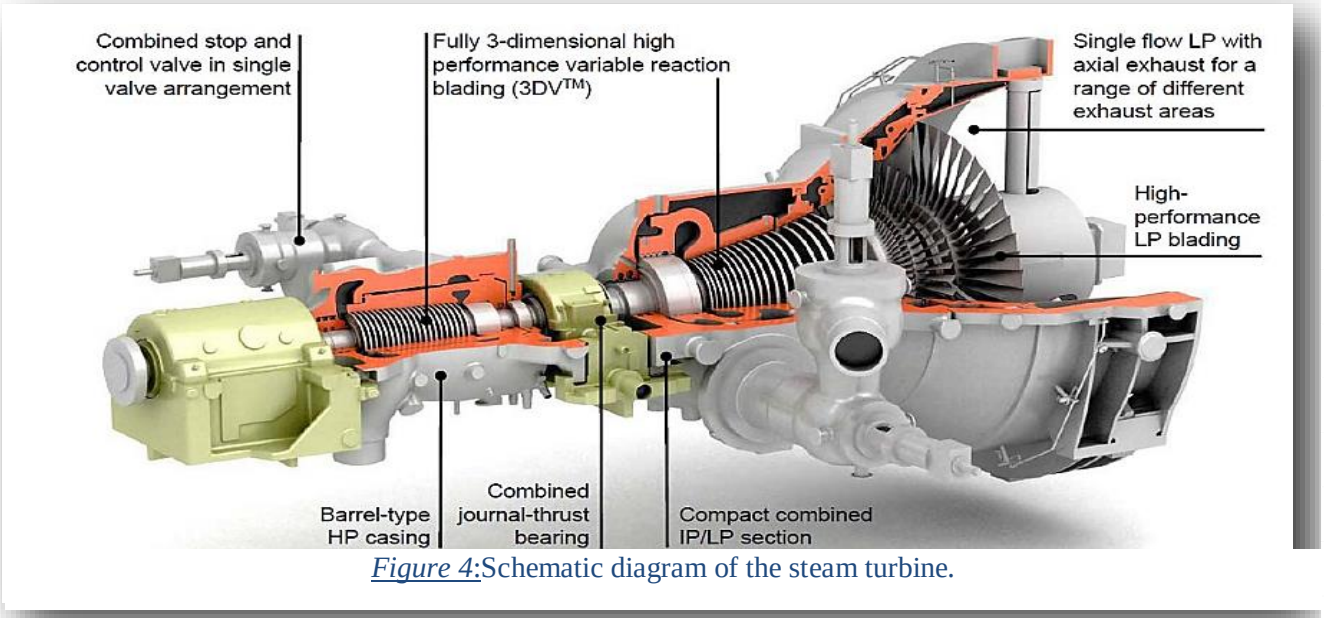


Figure 4:Schematic diagram of the steam turbine.

V.1.4 Boiler water supply pump:

The function of the boiler water supply pumps is to supply water from the LP drum to the high-pressure (HP) economizer section of the heat recovery steam generator, and via an intermediate stage to the intermediate-pressure (IP) economizer section of the heat recovery steam generator (HRSG). The boiler water feed pumps also supply desuperheater spray water for the HP bypass system and desuperheater spray water for the HP superheater.

V.1.5 Condensate extraction pump:

The function of condensate extraction pumps is to do the following:

- Maintain the condenser well level at its normal level by extracting condensate from the condenser well.
- Supply condensate water to the deaerator via the LP economizer.
- Supply desuperheater spray water for IP bypass system, LP steam bypass system, auxiliary steam pressure reduction and desuperheating station (PRDS) and other steam turbine auxiliaries.
- Provide water seals at valves to prevent air from entering the system.

V.1.6 Condenser (50MAG10AC001):

The water-cooled axial condenser condenses exhaust steam from the steam turbine and/or the high-pressure (HP), intermediate-pressure (IP) and low-pressure (LP) steam bypass system. The condenser receives the exhaust steam from the turbine in a horizontal direction. The condenser is equipped with a vacuum valve, pressure transmitters, temperature transmitters and level transmitters for condenser and turbine protection.

V.1.7 Steam jet air ejector:

- Steam jet air ejector ("HOGGING")

The function of the ejector is to evacuate air and other non-condensable gases from the condenser during start-up.

- Steam jet air ejector ("HOLDING")

The function of the steam jet air ejector is to evacuate air and other non-condensable gases from the condenser during normal operation.

V.1.8 Auxiliary boiler:

The function of the auxiliary boiler is to supply auxiliary steam requirements during start-up and low-load operation of the plant. The auxiliary boiler must supply steam for sealing the stuffing box turbine as well as for the desalination plant.

Number of boilers: Two (2)

Fuel: Natural gas and fuel oil

V.1.9 Fuel oil storage tanks:

The function of the fuel oil storage tank is to store fuel oil for the gas turbine. Fuel oil is used as an alternative fuel for gas turbines.

V.1.10 Pumping station:

The pumping station plays an important role in ensuring the quantity of water required to keep the power plant running smoothly.

The pumped water is divided into two parts: one part is used to cool the condenser and the other part is pumped to the desalination plant.

V.1.11 Electrochlorination plant:

This station produces HCL, which is used to clean and protect seawater pipes against fouling caused by marine micro-organisms.

V.1.12 Desalination plant:

The purpose of this plant is to produce thermally desalinated water, which will be stored in two 2700m3 tanks.

V.1.13 Demineralization plant:

Two demineralization lines, each with a capacity of 40m3/h, complete the water treatment process prior to its use in the steam water cycle.

Demineralized water is stored in two tanks, each with a capacity of 1,500m3.

V.1.14 Hydrogen station:

This station produces the hydrogen needed to cool the plant's 3 alternators.

V.2 Main electrical equipment of the power plant: [5]

V.2.1 Generator:

The generator is the most important piece of electrical equipment in the entire power plant. The generator is capable of evacuating current from the gas turbine outlet (gas turbine + steam turbine) to which it is connected without exceeding the permissible temperature limit stipulated by the relevant standard over the entire ambient temperature range of the site.

As shown in Figure I.6 above, a single-shaft generator was used for this project. It is directly coupled to the gas turbine at one end and coupled to the steam turbine at the other end by means of a clamping device.

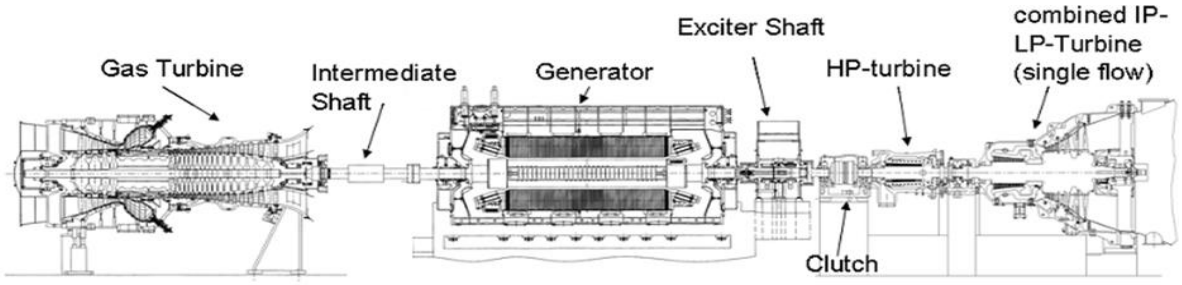


Figure 5 : Single shaft configuration with H-IL turbine

- **Rated parameters**

Apparent power 431 MVA at 35°C

Nominal armature current 11,310 A

Nominal armature voltage 22.00 kV ± 5% Speed

Speed 3,000 rpm

Power factor 0.9 (inductive)

Excitation Static excitation

Type of cooling Hydrogen-cooled

V.2.2 Generator circuit-breaker:

The generator circuit breaker is designed to isolate the generator from the mains during normal shutdown or in the event of a gas turbine or generator failure.

- **Rated parameters**

Nominal voltage 22 kV

Circuit breaker type SF6

Rated current 14,000 A Opening current 110 kA for 1 s Closing current 305 Ka

V.2.3 Main transformer (GSUT):

The main transformer (GSUT) is connected between the generator and the main 400 kV gas-insulated power substation.

The power generated by the generator is raised by the GSUT for evacuation at 400 kV.

This same power is to be used to supply the plant's auxiliary loads from the 400 kV grid during start-up.

- **Basic parameters:**

Rated power 306/408/510 MVA

Transformer ratio 420/22 kV

Typical temperature 20 °C

Cooling method ONAN/ONAF/OFAF

V.2.4 Cold start diesel generator (BSDG):

A cold-start diesel generator is supplied to handle the following loads:

- STG and GTG emergency loads

Unit start-up load requirements (400 V auxiliary, excitation loads, CW pumps, condensate pumps, HP feedwater pumps and compressors).

- Two (2) diesel generators are envisaged for three (3) production units.

- **Nominal parameters**

Rated power 2 x 7 MVA

Rated voltage 6 kV

Power factor 0.8

VI. Description of how the production unit working:

Electricity is generated by 2 processes:

- **The thermal process in the desalination plant**
- **The chemical process at the demineralization station**

And by 3 energy transformations :

- **Calorific energy in the boiler**
- **Mechanical energy in the turbine**
- **Electrical energy in the alternator:**

The localization circuit in the power plant began with a gas station located to the east of the power plant. The function of this station is to receive the fuel gas from the HASI RMEL and carry out separations, filtering and also increase the temperature and expansion of this gas (from 52 bar to 35 bar).

Before feeding the turbine with fuel, this gas passes through a final chamber filter, which is supplied after performance heating for final GT protection against condensation.

The ultimate filter is used to melt condensate droplets or liquid plugs that may form in the pipeline, and remove solid particles (such as pipe corrosion products).

High-efficiency filter elements are supplied to remove solid particles and liquid droplets of 0.3 microns or more from gas streams.

The circuit continued in the machine room of module 50, beginning with the condenser and its extraction pumps (CEP1 and CEP2), which extract condensed water to feed the LP, IP and HP (First Filling) vessels on one side, and on the other side to pass condensed water through a preheater in the HRSG (the boiler) before entering the LP vessel, the steam preparation circuit.

Condensate arrives via start-up ejectors and service ejectors, which create a vacuum in the condenser to obtain condensed water.

Cooling water comes from the sea in two pipes from two pumps for each unit used for steam cooling in the condenser. This water is also used for cooling demining water, which is used in a closed circuit (CCW) for cooling equipment and lubricating oil.

Feed pumps (BFP1 and BFP2) are used to extract water from the LP storage tank to the IP and HP storage tanks through two separate pipes.

In the recovery boiler (HRSG) there are 15 tubes which are divided into five sections, in each section the condensed water heats up and turns into steam.

After vaporization in the HRSG, LP and HP balloon steam attack the LP and HP bodies in the steam turbine (engine room), the HP steam leaving the HP body is mixed with IP balloon steam (Cold ReHeater CRH) and reheated once again in the HRSG (reheater 1 and reheater2) to produce HRH (heatReHeater) after which it attacks the IP body, this steam turns the steam turbine shaft which is attached to the generator and gas turbine in the same shaft and enables the production of 22kv electricity.

The condensed water in the boiler is reheated by compressed air (with compressor) in the gas turbine due to the combustion of gas or diesel in the combustion chamber (approx. 600°C).

The next tower was at the desalination level to monitor the formation of the water used in vaporization. In desalination, an auxiliary boiler boils the seawater before it is vaporized in evaporator 1 and evaporator 2. After vaporization, the seawater is used in the evaporator to condense this steam to produce desalinated water, which is stored in two large tanks.

The desalinated water is treated at the demining stage, which removes the minerals from the desalinated water by adding HCl+ and NaOH- to produce demined water, which is stored in two large tanks and used by the condenser.

There is also an electro-chlorination room, the function of the electro-chlorination system is to produce a sodium hypochlorite solution from the seawater, store it and inject the appropriate amount of NaOCl into the intake system to control the biological growth of the seawater. Sodium hypochlorite is produced by electrolysis.

The voltage generated (22 kV) is stepped up to 400 kV by the unit's transformer for power evacuation to the national grid. The generated voltage (22 kV) is stepped down to 6 kV by the step-down transformer to supply auxiliary equipment.

The 6 kV (MV) voltage is stepped down to 400 V (LV) by air-cooled dry-type transformers installed indoors.

Unit and step-down transformers are oil-cooled. These transformers are installed outdoors.

There is also additional auxiliary equipment:

- **Air compressor:** The compressed air system supplies compressed air to meet the requirements of the plant's service air system (cleaning and multi-purpose) and instrumentation air system (instruments and pneumatic valves).
- **Fire station**: The fire alarm and detection system is designed to ensure early detection of fires, warning of personnel and automatic activation of extinguishing systems. There are two fire water tanks and 6 pumps powerd by diesel or electricity (6kv/400v).
- **Hydrogen station:** hydrogen is used to cool the generators.

- **Turbine oil system:** Turbine oil comprises mainly lubricating oil, lifting oil and hydraulic oil (control oil).
- **Oil cooling system:** used to cool lubricating oil, hydraulic oil and control oil for reuse.

All equipment is controlled at the CCR control room level.

In the control room, there is a shift team of 2 production engineers who manage power generation with the TPCCs who manage the equipment in each module remotely using the control room Operating Workstations (OWS). They are programmed with 2 main control systems DCS (Distributed Control System) OVATION EMERSON for the control of the HRSG and BOP (auxiliary equipment) and SPPA T3000 SIEMENS for the control of the Steam Turbine, Gas Turbine and Generator, there are also in the team the TCAs who control the equipment on site.

There is a specific architecture for each DCS hardware, the Ovation Emerson hardware is located in the control room and the SPPA T3000 hardware in the PCC (Power Control Center) of each group with the SIMATIC S7 Automation servers.

The OPS (Object Linking and Embedding Process Control) is the interconnection between the Ovation Emerson servers and the Siemens servers, it is located in CCR in the same room with the Ovation Emerson servers. [6]

VII. Conclusion:

In this chapter, we describe the Ras-Djinet combined cycle power plant, which is considered to be an important project for Algeria, as it will enable the country to diversify its electricity production and reduce its dependence on energy imports. in addition, this power plant has a positive impact on the environment, as it produces less carbon dioxide per unit of energy than traditional power plants.

We began by presenting the plant, its history and geographical location, before describing its general operation and its main components, such as the generator, the generator breaker and the main transformer. We have also described the plant's auxiliary stations, including the auxiliary boiler, fuel oil storage tanks, pumping stations, electrochlorination stations, desalination stations and demineralization stations.

In the next chapter, we will continue our study by focusing specifically on the desalination station, which is an essential component of the Cap Djinet plant's auxiliary stations. We will examine its operation, its role in the power generation process and the different technologies used in its design, as well as its role in the production of electricity.

Chapter II :
Presentation Of The Desalination Station

I Introduction:

The Ras-Djinet combined-cycle power plant is a major energy facility in Algeria that uses the most advanced technology to generate electricity in an efficient and environmentally friendly way.

One of the key elements of this plant is The desalination station it uses a Multi-Effect Evaporation (MED) process with thermal vapor compression (TVC). This technology is well-suited for the station, as it can efficiently produce desalinated water from seawater while minimizing energy consumption and environmental impacts

II Overview of a desalination plant:

Two desalination units that may be operated in a single configuration are among the units provided for the Ras-Djinet combined cycle project.

Each evaporator unit has three effects or cells organized in one vessel in accordance with the "Multiple Effect type with thermal vapor compression (MED-TVC)" arrangement of the units.

The Ras-Djinet desalination units are designed to produce 1100 m3/day of net distillate, excluding steam condensate return flowrate, at a temperature of 16°C to 24°C and 10 parts per million TDS. Each unit can function at a maximum seawater temperature of 28 °C, but with a lower distillate production capacity (880 m3/day).

With a notional capacity of 1100 m3/day and sea water at 24°C, the Gain Output Ratio (GOR) is equivalent to 6 kg of distillate per kg of incoming steam (at 20 barg and 225°C), excluding the condensate return and venting system

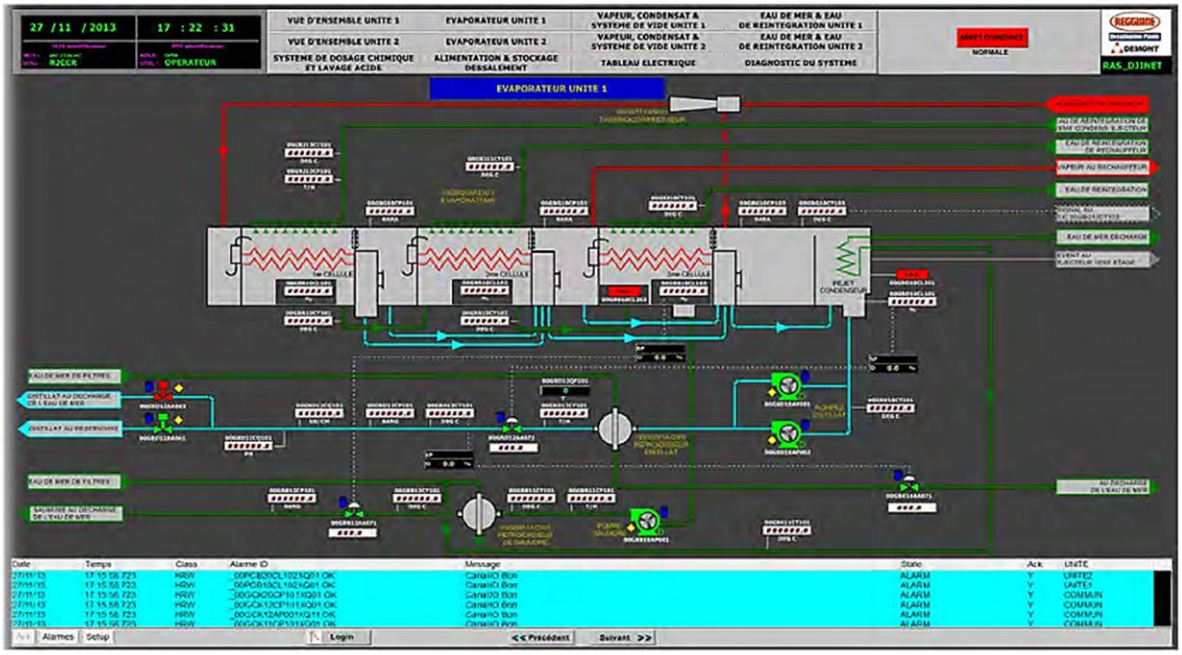


Figure 6 : Desalination plant

III **Process theory**:

RAS DJINET's desalination station process is based on vacuum distillation technology, which reduces the boiling temperature of the water by lowering the pressure. This approach enables water to be desalinated at lower temperatures, which is particularly useful for plants located at great heights where atmospheric pressure is lower.

The RAS DJINET plant comprises two desalination units, each designed to use multiple-effect evaporation with horizontal tube bundles and descending nebulized films. The evaporator, which is the main distillation component, is divided into three compartments called effects or cells. The last compartment is equipped with a distillate condenser, which recovers the distillate. These key elements help maintain optimum efficiency in the desalination process, guaranteeing high purity of the distilled water and maximum energy efficiency.

The component in which distillation takes place is called the "Evaporator", which can contain

several compartments called "Effects" or "Cells"; in the case of RAS DJINET, the cylindrical evaporator is divided into three effects. Attached to the last effect is the rejection or distillate condenser. [7]

III.1 Advantages of vacuum distillation for desalination:

- ✓ **Lower operating temperatures**: Vacuum distillation enables heavier materials to be distilled at lower temperatures than those required for atmospheric pressure distillation. This avoids thermal cracking of components and enables more efficient separation.
- ✓ **Prevention of product degradation:** Vacuum distillation reduces the risk of product degradation or polymer formation due to reduced pressure. Lower tower bottom temperatures and shorter average residence times in packed columns prevent degradation or the formation of undesirable products.
- ✓ **Increased capacity, yield and purity:** Vacuum distillation can increase the capacity, yield and purity of distilled products. By operating at lower pressures, the distillation process can achieve a higher degree of separation and produce purer products.
- ✓ **Lower investment costs:** The use of vacuum distillation enables the height and diameter of a distillation column to be reduced, which translates into lower investment costs. The reduced pressure enables a more efficient separation process, requiring less column height and diameter.
- ✓ **Reduced energy consumption:** Vacuum distillation consumes less energy than distillation at atmospheric pressure, because water evaporates in a vacuum at a lower temperature (around 85°C) than at the normal temperature of 100°C.
- ✓ **Non-specific separation based on boiling points:** Vacuum distillation enables efficient separation of substances based on differences in boiling point, meaning that extremely diverse chemicals can be separated very efficiently.
- ✓ **Water savings:** Vacuum distillation saves water, as water evaporates under vacuum at a lower temperature, reducing the amount of water required for the process.
- ✓ **Separation of explosive substances:** Vacuum distillation is ideal for separating components which need to be separated and which normally have a high boiling point or are explosive.
- ✓ **Preservation of water quality:** Vacuum distillation produces pure, impurity-free water, which is essential for industrial applications and human consumption.
- ✓ **Flexibility and adaptability:** Vacuum distillation can be used in a variety of sectors, such as beverage production, the chemical industry, oil refining and laboratories, making it a highly versatile technology. [8]

III.2 Simple-effect evaporator:

- **Operation:**

The simple-effect evaporator consists of two heat exchangers: one for heating and one for condensation. Heating is provided by the condensing steam, which transfers its energy to the seawater to be distilled on the outside of the tube bundle. The steam produced is then condensed in the condensation exchanger by the cooling seawater.

- **Process:**

Heating: Condensing steam is injected into the tube bundle, where it transfers its energy to the seawater to be distilled.

Evaporation: The seawater to be distilled vaporizes, forming a descending film on the outside of the tube bundle.

Condensation: The vapors produced are condensed in the condensation exchanger by the cooling seawater.

Distillate recovery: The distilled condensate is collected in a condensate box.

- **Brine:**

Seawater that has not been evaporated forms a brine with a high salt concentration. This brine is extracted by a pump and can be used for a variety of applications. [7]

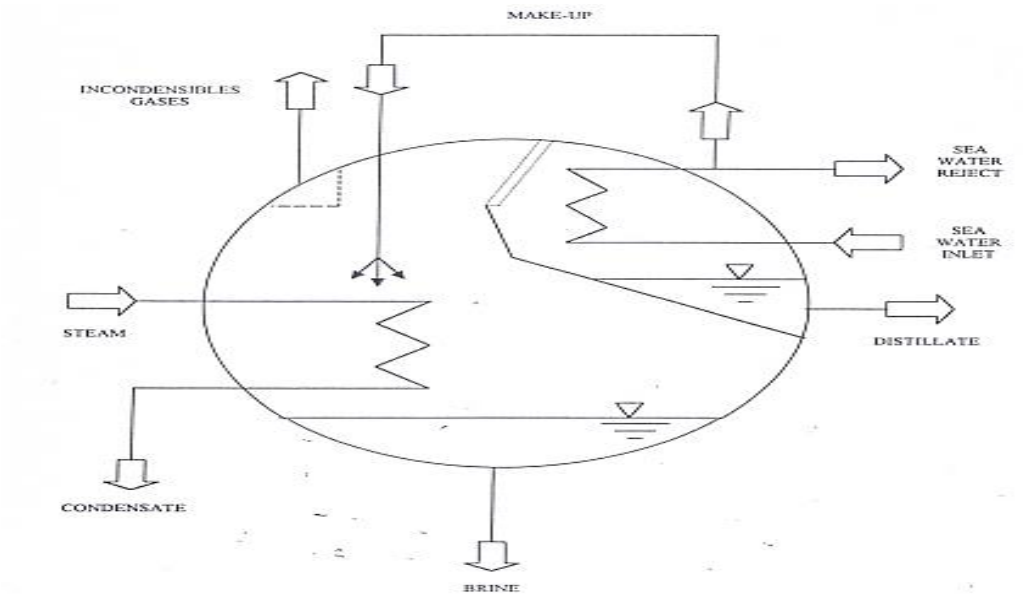


Figure 7 : Simple-effect evaporator

III.3 Multiple-effect evaporator:

- **Operation:**

The multiple-effect evaporator consists of several cells connected in series, with a final condenser after the last cell. Temperature and pressure decrease from the first "hot" cell to the last "cold" cell.

- **Process:**

Heating: Heating steam from the thermocompressor is injected into the first cell, where it vaporizes part of the reintegrating seawater.

Evaporation: The vapors produced condense in the tube bundle of the second effect, where they are cooled by the descending reintegrating seawater.

Condensation: Second-effect vapors condense in the second-effect condensation exchanger, where they are cooled by downward-flowing reintegrating seawater.

Distillate recovery: The distilled condensate is collected in a condensate box.

- **Brine:**

Brine is extracted from the last cell by a pump and can be used for a variety of applications.

- **Thermal equilibrium:** Thermal equilibrium is maintained by using some of the hot water produced as reintegrating water for subsequent cells.
- **Distillate purity:** To improve distillate purity, demister blocks are mounted alongside the tube bundle on each cell.
- **Evaporation temperature:** The maximum evaporation temperature is set at 68°C, corresponding to the brine temperature at maximum evaporator load.
- **Operating conditions:** The evaporation process takes place under vacuum conditions, enabling efficient distillation at low temperatures. [7]

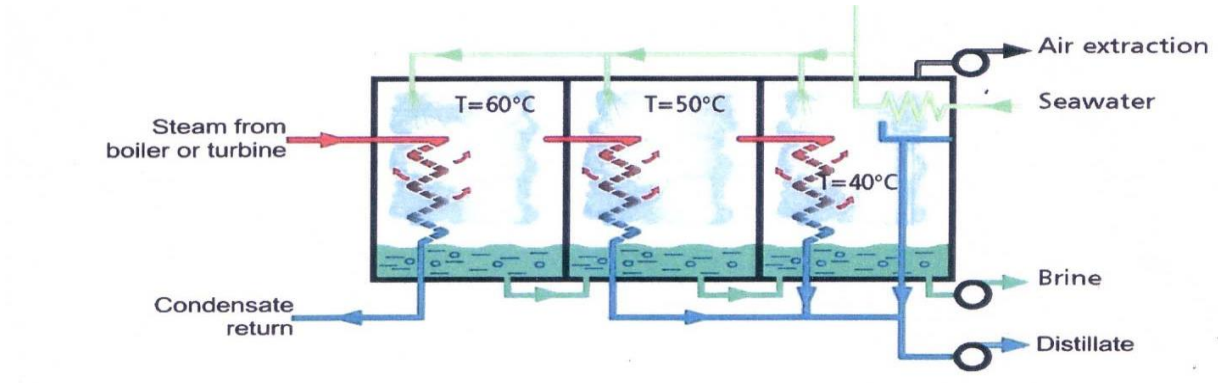


Figure 8 : Multiple-effect evaporator

III.4 Description of The Components and Their Function:

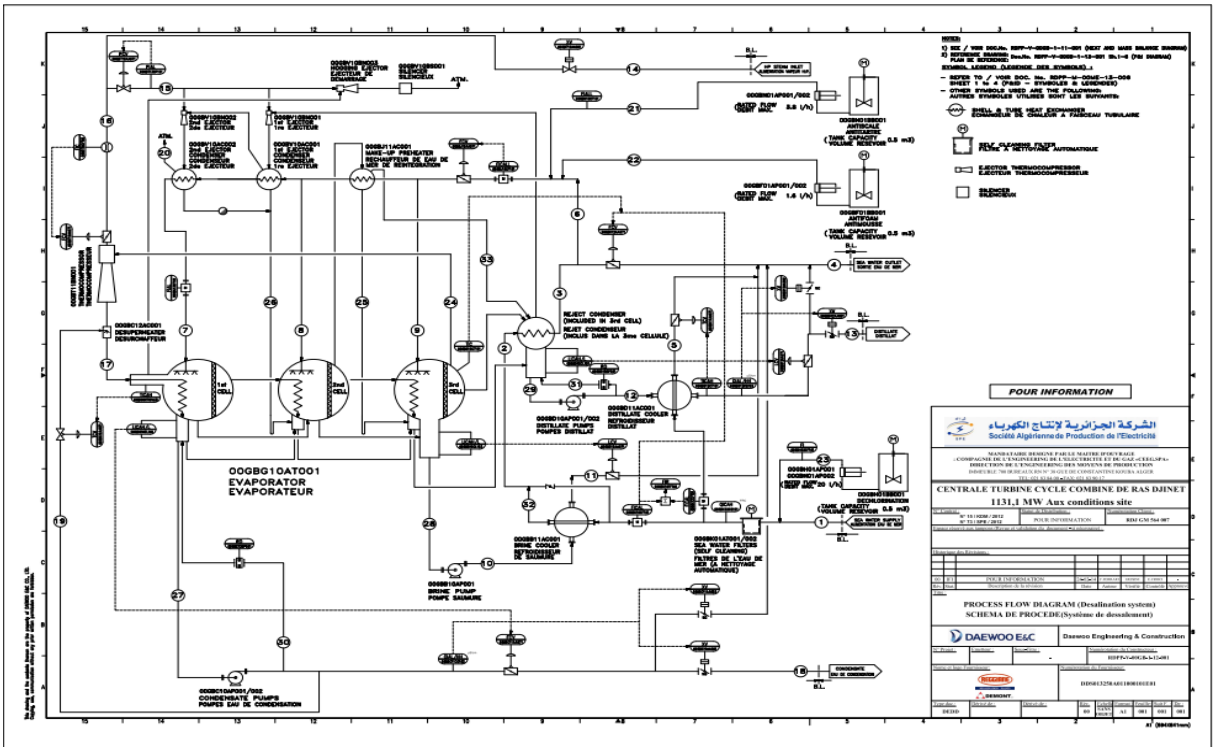


Figure 9:Process flow diagram[9]

III.4.1 Evaporator:

The process takes place inside the evaporator that is the main component of a multi effect desalination plant. Inside the evaporator a progressive amount of distillate is produced by evaporating a certain quantity of sea water, which is sprayed over the evaporator's tube bundles. The heat input is represented by a given quantity of low grade steam introduced in the first effect.

The max. process evaporation temperature is fixed at 68°C, which represent the TBT (top brine temperature) obtained at the maximum evaporator load (100 %) according to the max. design sea water temperature of 24°C (summer load). The evaporation process is done under vacuum conditions.

The low pressure steam enters the first cell, and flows inside the tubes of the bundle; here the latent heat of vaporization is released to the falling sea water sprayed outside the tubes; in such a way the steam will condense inside the tubes and the sea water will vaporize outside. Then, because the vacuum condition created inside the evaporator, the sea water vaporization suddenly take place.

The proportion between sea water make-up and distillate produced in each cell is on average equal to 2.8: i.e. from 2.8 tons of sea water introduced in the effect only 1 tons of distillate

is produced. The second pass, consisting of the remaining tubes, is located in the upper part of the bundle; in this part the vapour is condensed by the make-up entering the effect, at a lower temperature than the one of the effect. Also at the end of the second pass a condensate box collects the distillate water condensed inside each tube. Moreover, the non-condensable gases are extracted, in each effect, by two parallel U pipes connecting tube side and shell side.

A small part of the distilled vapors produced by the evaporation, is condensed in one special condenser of the shell and tube type, called "pre-heater ". The purpose of the pre-heater is to heat the sea water feed make-up prior to enter the cells. The pre-heater is connected to the vapor space of the 2nd effect, and provides to warm up the make-up water to the 2nd effect. The distillate produced in this pre-heater, is sent to the distillate box of the 3rd effect.

The make-up sea water which feed the 1st effect is heated in two condensers, which condense the steam released by the steam ejectors.

During the vaporization process some non-condensable gases are released (mainly O2 and CO2); these gases pass through the tubes, and then, by means special shaped pipes, fitted in the top of second pass of the bundle, enter inside the vapour space at the top of the bundle (sea water side).

The evaporator is protected against overpressures, by means one safety bursting disc, located at the steam inlet space. [10]

III.4.2 Sea Water Circuit:

The sea water for the desalination plant, is transmitted by (2x100%) centrifugal pumps. The sea water fed to the evaporators reaches the terminal point at 4 barg, then is filtered by two (2x100%) 0.5 mm mesh self-cleaning type filters. From here, the sea water flow (220 t/h) goes toward each unit, where is divided in two streams: one to the distillate cooler and another to the reject condenser. Before to enter the reject condenser, during winter time, the cold sea water feed, may pass through the brine cooler where it is heated by the warm brine extracted from the last effect.

After passing though the reject condenser the sea water flow is controlled by a flow control valve, which has the duty to discharge the excess of warm water from the reject condenser back to the sea. This function is controlled in cascade by the temperature controller sensing the vapour temperature of the last cell and adjusting the valve opening accordingly. Higher is the vapour temperature and higher is opening of the sea water discharge valve.

The remaining part will form the sea water make-up flow (129 t/h) to feed the evaporator cells. Before to enters the evaporator, the sea water make-up is preheated in the following heat exchangers:

- Pre-heater, for make-up to 1st effect and 2nd effect;
- Venting condensers, for make-up to 1st effect;

Inside the cells a series of spray nozzles are installed (Nos. 16 nozzles per cell, on two rows). The nozzles provide to equally distributed the sprayed water to all over the tube bundle. [10]

III.4.3 Distillate Circuit:

The distilled vapour formed in the first effect, is transferred to the second effect, where representing the heating source to vaporize the falling sea water, at this point the evaporating process take place, then the process is repeated at each effect, until the 3rd effect is reached; here the vapour formed is divided in two streams: the first one is recirculated to the first cell by the thermo-compressor; the second stream is condensed in the reject or distillate condenser, by the incoming cold sea water.

Demister pads are fitted in each effect, to prevent the carrying over of salts which may decrease the distillate quality.

The distillate vapours which condensing inside the first and second pass tubes of each effect, are collected in the relevant boxes located at the end of each bundles. Then, by means U tubes they are transferred from cell to cell, until reaching the last effect and the final condenser, where the formed distillate is extracted by two centrifugal pumps; one on duty and one in stand-by.

In order to reduce the distillate temperature to 40°C or less, the unit is provided with a Distillate cooler. The control of the outlet distillate temperature is made by the controller TIC- acting on the seawater control valve.

The distillate pump discharge is controlled by a level control valve; after the distillate LCV the circuit is split in two branches where two valves will control the distillate flow. If the distillate quality goes beyond the specification fixed by the process parameters, the distillate is discharged into the sea water outlet system by means of the reject valve. [10]

III.4.4 Brine Circuit:

The brine is collected at the bottom of each cell and transferred from cell to cell by means of U-channels. In the last cell, the brine is collected at the bottom, from which it is extracted by means of a centrifugal pump (one pump). The pump returns to the sea through the

seawater outlet duct. On its way to the discharge connection in the seawater outlet duct, the brine can pass through the cooling. [10]

III.4.5 HP Steam and related Condensate System:

The HP steam arrives at evaporators B.L. from the auxiliary boilers located in the same building. A pneumatic isolating valve provides to stop the steam flow to each unit, in case of system malfunction. The total inlet HP steam is divided in two streams, one for the thermo-compressor and one for the venting system.

The steam flow to the thermo-compressor is controlled by the flow control valve. A flow-meter is installed to measure the steam flow to the TVC. This is the main controller of the desalination unit as the increasing or the decreasing of the distillate production is directly achieved by increasing or decreasing of the steam to thermo-compressor flow. As the temperature of the vapour mix. discharged by the thermo-compressor is 115°C approx., it is necessary to de-superheat the steam before the inlet to the first effect (temperature reduced to 80°C). The de-superheating flow is set by a temperature control valve. The control is activated by a temperature control loop, which included two redundant temperature indicator controllers.

The steam which enters the first effect is fully condensed in the two pass tube bundle of the cell. The condensate recovered from the first and second pass is collected into the condensate box. From here the condensate is extracted by the two condensate pumps, one on duty and one in stand-by. The amount of the extracted condensate is controlled by the flow control valve depending on condensate flow controller, in order to return to the auxiliary boiler the same flow of the total inlet HP steam.

As shown in the P&ID, the operation of the desalination plant is integrated with operation of auxiliary boiler on the steam side and condensate side (suitable signals of high level of condensate tank to Desal. PLC). [10]

III.4.6 Chemical Dosing System:

Just upstream its common filters the inlet sea water is added with a dechlorinating chemical additive.

A. Dechlorinating Injection System
B. Anti-Scale Injection System
C. Antifoam Injection System

III.4.7 HP Steam to Venting System:

The HP steam for the venting system is derived from the total HP steam inlet header.

The steam pressure to the venting system is controlled by the pressure control valve. A flow-meter is installed to measure the steam flow to the venting system. Then, the steam is distributed to two process consumers: one hogging ejector and two permanent venting ejectors. The steam discharged by the hogging ejector together with the extracted air, is lead to the atmosphere though a silencer. The steam discharged by the two permanent venting ejectors is condensed by two relevant "shell and tube" ejector condensers, called respectively, 1st stage condenser (or inter condenser), operating under vacuum, and 2nd stage condenser (or after condenser), operating at atmospheric pressure. The condensate water from the after condenser (through a trap), and the condensate water from the Inter condenser, are discharged, though a loop, to the evaporator. This condensate water can be sent either to the 2nd effect condensate box, or to the 2nd effect brine space. Normally the system should be connected to the condensate box, but during start-up or, if the condensate quality discharged by the system goes out the specified values, must be connected to the brine space. [10]

III.4.8 Venting System:

The venting or air extraction system comprises one hogging ejector, two permanent ejectors and related condensers. The hogging ejector provides to create the initial vacuum, to allow the start-up conditions. A silencer is also installed to reducing the noise developed by the discharging the HP steam to the atmosphere. The time elapsing to reach the vacuum condition (approx. 0.24 bara) is near one hour. Two permanent ejectors provide to maintain the vacuum conditions during the normal run of the evaporator.

The ejectors are distinguished by: 1st stage ejector (up-stream), and 2nd stage ejector (down-stream).

The 1st stage ejector sucks the air and the non-condensable gases, from the reject condenser. Then the 1st ejector condenser, connected to the ejector, will condense the steam and some vapours sucked and discharged by the ejector; then the rest of the sucked stream from the reject condenser, is sent to the 2nd stage ejector suction port. Then, the 2nd ejector condenser will condense the steam discharged by the ejector. From the 2nd ejector condenser, the non-condensable gases are rejected to the atmosphere. The steam supply to the permanent vacuum ejectors is controlled by two automatic ON-OFF isolating valves. The condensate stream from both ejector condensers is sent to the 2nd effect condensate box. If the quality

of the condensate is out of the specification values, the flow can be diverted to the brine space of the 2nd effect. Two manual valves will provide to this task. [10]

III.4.9 Acid Cleaning and Neutralization System:

In spite the good design and the good plant running behavior, e.g. low brine concentration and right anti-scale dosing, salts deposition over the tube bundles is unavoidable. In RAS DJINET plant, as per design conditions, acid cleaning shall be performed once or twice per year (8000 running hours approx. per year, one unit operating, other unit in stand-by).

The acid neutralization and cleaning system consists mainly of a tank of hydrochloric solution and connected to a ventilation scrubber, a centrifugal acid discharge transfer pump, two centrifugal acid solution transfer pumps, a delivery pipe with two injection points, one for each evaporation unit, a concentrated caustic soda tank, a set of 2 caustic sump pumps. [10]

III Operation of the desalination plant:

- Start Up Modes:

- **Manual Mode:**

The start-up procedures and controls are managed by the control room Operators, helped by the local Operator.

- **Automatic Mode:**

The unit is started up only pushing one software start key, on LCS workstation screen; all the starting procedures and controls are completely managed by the LCS; none action by Operators, only supervision.

- The controls, procedures and checks to be carried out during the normal operation of the unit, with the evaporator on stable working condition, are divided as following:
  A. **Daily Controls:** Data Reading, Sea water quality, Distillate output and GOR, Brine level in cell Nos. 1, 2 & 3, Chemical dosing systems, check of pumps and motors, all valves check, Piping check, Sea water strainers
  B. **Weekly Controls:** Pumps and motors lubrication, Conductivity control, FRC (free residual chlorine) control.
  C. **One Month-Three Months Controls:** Instrument check.
  D. **Six Months-Yearly Controls:** Painting and Acid cleaning, Reject condenser, ejector condensers, preheater, Thermo-compressors and Venting Ejectors, Rupture disk and Make-up nozzles and Internal inspection of the evaporator. [7]

IV Control of installation:

The RAS DJINET Combined Cycle Power Plant Project consists of two independent trains or units. Typically, one Desalination Unit operates while the other remains on standby. The desalination process employs the Multiple Effect Evaporation with Steam Thermocompression (MED-TVC) method to produce desalinated water.

The desalination plant is managed by a Local Control System, which includes a Programmable Logic Controller (PLC) situated in the Desalination Control Room. All analog signals from the unit's analog transmitters and control actuators must be 4-20mA. Control valves are equipped with 4-20 mA position transmitters, and RTD input to the PLC is directly in ohms. The PLC implements all controllers as PID software.

Digital signals not actuated by field switches are generated by PLC thresholds based on analog signals from transmitters. The PLC connects to the Distributed Control System (DCS) installed in the Central Control Room via a Modbus link. Through the DCS, operators can monitor the desalination system's conditions and status on dedicated graphics pages. The DCS can also initiate automatic start-up and shutdown sequences.

The PLC also connects via Modbus to the Demineralization System, and some I/Os are exchanged between the PLC and DCS through hard-wired signals. All motorized pumps and valves can be operated from the PLC control panel or the local control station (LPB), with the choice made by LOCAL-REMOTE selector switches installed in front of the LPB. In the LOCAL position, commands are sent to the LPB, while in the REMOTE position, commands enable the PLC. [11]

V Equipment:

Several pieces of equipment are essential for a desalination plant to function well.

1. Pumps:

- **Seawater Pumps (00GBK11AP001-00GBK12AP001)**: These pumps extract seawater from the intake and pump it into the system for desalination.
- **Brine Pumps (00GBB10AP001)**: These pumps evacuate the concentrated brine, a byproduct of the desalination process, from the system
- **Distilled Water Pumps (00GBD10AP001/AP002)**: These pumps extract the distilled water produced by the condenser and pump it into the storage reservoir.
- **Condensate Pumps (00GBC10AP001/AP002)**: These pumps extract the condensate produced by the condenser and pump it into the system for further processing.

- **Antifoaming Agent Pumps (00GBF01AP001/AP002)**: These pumps inject an antifoaming agent into the system to prevent foaming and ensure proper operation.
- **Antiscalant Pumps (00GBN01AP001/AP002)**: These pumps inject an antiscalant into the system to prevent scaling and ensure proper operation
- **Dechlorination Agent Pumps (00GBH01AP001/AP002)**: These pumps inject a dechlorination agent into the system to remove chlorine and ensure proper operation.
- **Drainage Pumps (00GBS01AP001/AP002)**: These pumps extract wastewater and leaks from the system and pump them into the drainage system. [7]

2. **Valves:**

- **Control Valve (00GBK01AA001)**: This valve controls the flow of seawater into the system.
- **Cleaning Valve (00GBR10AA001)**: This valve is used to clean the evaporator
- **By-pass Valve (00GBJ10AA003)**: This valve is used to bypass the system during startup.
- **Isolation Valves (00GBK01AA002)**: These valves isolate sections of the system for maintenance and repair.
- **Drainage Valves (00GBJ11AA401-402)**: These valves drain the system during maintenance and repair. [7]

3. **Cooling Systems:**
   - **Cooling System (00GBD11AC001)**: This cooling system reduces the temperature of the distilled water to 40°C or less.
4. **Mixers:**

- **Antiscalant Solution Mixer (00GBN01AM001)**: This mixer mixes the antiscalant solution with water in the reservoir
- **Antifoaming Solution Mixer (00GBF01AM001)**: This mixer mixes the antifoaming solution with water in the reservoir.
- **Dechlorination Agent Mixer (00GBH01AM001)**: This mixer mixes the dechlorination agent with water in the reservoir. [7]

5. **Sensors:**
   - **Conductivity Sensor (QIAH/HH-00GBD12CQ102)**: This sensor measures the conductivity of the distilled water.
   - **pH Meter (QIAL-00GBD12CQ101)**: This pH meter measures the pH level of the distilled water.

- **Flow Recorder (FIQAL-00GBD12CF101)**: This flow recorder measures the quantity of distilled water produced. [7]

6. **Regulators:**
   - **Flow Rate Regulator (00GBJ12DF151)**: This valve regulates the flow rate of the distilled water.
   - **Temperature Regulator (00GBG10DT103)**: This valve regulates the temperature of the distilled water. [7]

VI Alarms and Possible main causes:

Main alarms that can occur in a water treatment plant and their possible causes are provided in the table [7]

Table 3 :Main alarms and possible causes

Alarm	Possible Main Causes
Evaporator cells high pressure (Loss of vacuum)	HP steam pressure and flow too low, ejector filters clogged, wrong operation of ejector nozzles, wrong operation of condenser condensate trap, hogging ejector suction valve not properly closed or leaking
Make up flow to cell No. 1 flow low or very low	Total make up flow too low, spray make up nozzles of cell 1 plugged, ejector condensers tubes are plugged, wrong operation of make-up flow meter
Total make up flow low or very low	Insufficient sea water pressure at unit inlet, S.W. supply pumps malfunction or trip, sea water filters clogged, distillate condenser tubes plugged, preheater and/or ejector condenser tubes plugged, make-up spray nozzles plugged
HP steam pressure low	Steam pressure from boiler low, wrong operation of steam to ejectors pressure control loop
Cell No. 1 brine temperature high	Set point of PID controller too high, cell No. 3 vapour temperature too high, insufficient make up flow to cell No. 1, insufficient make up total flow, vacuum trouble, excessive brine level in cells

Alarm	Possible Main Causes
Steam to cell No. 1 temperature high or very high	Wrong operation of steam to first cell control loop, desuperheating condensate circuit valves closed, steam temperature from boiler too high, desuperheating spray nozzles plugged
Cell No. 1 condensate level low or very low	Wrong operation of the level switch, wrong operation of the flow/level control loop
Cell No. 1 condensate level high	Malfunction of Flow/Level Control loop, valves on condensate return line are closed or partially opened, wrong operation of condensate pump/motor
Cell No. 3 brine level very low	Wrong operation of the level switch, no more sea water make up flow due to supply pump malfunction, wrong operation of cell No. 3 brine level control loop
Cell No. 3 brine level low	Make up flow too low, wrong operation of brine pump/motor, wrong operation of brine level control loop
Cell No. 3 brine level high	Make up flow too high, wrong operation of brine pump/motor, wrong operation of brine level control loop
Reject condenser distillate level low and very low	Wrong operation of the level switch, wrong operation of distillate level control loop
Instrument air pressure very low	Air compressor malfunction, instrument air piping leakages, pressure transmitters malfunction
Emergency shut-down ESD push button	Warning
Power supply main failure	
Distillate storage tank level control	
Distillate production temperature high and very high	Set point of PID controller too high, wrong operation of distillate temperature control loop, cell No. 3 vapour temperature too high, vacuum trouble, distillate cooler by-pass valve open

Alarm	Possible Main Causes
Distillate production conductivity high and very high	Brine high level, excessive sea water foaming, reject condenser tube leakage, sampling point under vacuum
Auxiliary boiler condensate tank level high	
Condensate conductivity high and very high	Bad quality of the HP steam
Antiscale flow low and very low	Antiscale pumping stroke bad set, antiscale pump suction strainer clogged, antiscale tank empty, no antiscale pump in operation
Antiscale tank level low and very low	Desalination operator forget to refill the tank, large spillage occurs in the tank body or in suction piping
Antifoam tank level low and very low	Desalination operator forget to refill the tank, large spillage occurs in the tank body or in suction piping
Dechlorination flow low	Dechlorination pumping stroke bad set, dechlorination pump suction strainer clogged, dechlorination tank empty, no dechlorination pump in operation
Dechlorination tank level low and very low	Desalination operator forget to refill the tank, large spillage occurs in the tank body or in suction piping
Sump pit level low and high	
Acid cleaning system	Operator does not fill correctly the tank, operator does not stop the acid pump, operator does not stop the caustic soda dosing pump
Further alarms	Various alarms for different systems

VI Maintenance:

The following table lists specific components and services that require regular attention and maintenance. [10]

Table 4:Components that require attention and maintenance

Component or measure	General considerations
Instrument readout verification	Verify instrument settings, alarm and interlock set points, check redundant instrument readouts, check the field instrument read-out (level indicators, pressure gauges, temperature gauges etc.) versus PLC data, check logical sequences and progress of temperature, pressure, brine concentration in the various sections of the desalination unit.
Material and heat balance verifications	Check the Heat Balance and Material balance data with the following equations: Brine flow rate * Brine TDS = Make-up flow rate * Make-up TDS Distillate flow rate + Brine flow rate = Make-up flow rate
Cause/effect relationship	Cause / effect relationship is not a 1 to 1 relation, in that a process disturbance may produce multiple effects and by reverse an effect may be produced by several prime causes. In the desalination unit the process disturbance producing the largest number of effects is the loss of vacuum
Trouble shooting and emergency actions	Verify when a sequence of trouble shooting actions may be carried out simultaneously in order to speed up the remedial solution
Instrumental data verification	Prior to calling a process trouble shooting case, make sure the instrument readout is correct and is consistent with other upstream and downstream readouts. Ask for laboratory support with appropriate sampling if this may help acquiring more information
Expected performance	The desalination plant is an unit at revolving decaying performance for (a) increasing fouling/scaling, (b) decreasing vacuum tightness in the vacuum section. Performance shall be measured versus the expected performance under the running fouling/scaling/vacuum tightness conditions

VII Conclusion:

In this chapter we have discussed the operation of the desalination plant and the measuring instruments used to assess its performance and ensure its proper operation. An in-depth analysis of these instruments allows us to better understand the operation of the desalination plant and identify potential areas for improvement. And also we focus specifically on the desalination station control system.

In the next chapter, we will move on to modelling the operation of this desalination plant using the GRAFCET tool. This step will allow us to set up an appropriate programming logic for the control of the pumping station. To achieve this, we will use the Siemens programmable controller and the SIMATIC S7-300 series with the TIA PORTAL software

Chapter III:

Modelisation and Automation Of The Desalination Station

I. Introduction:

Modeling the system to be controlled is a key stage in the design of industrial automation systems, as automating a system involves meeting the requirements of the specifications by linking the control part to the operative part and enabling effective dialogue with the operator; to design, study and build an automated system, it is essential to use tools for describing sequential automated systems, such as GRAFCET, which enable the various stages to be described chronologically, and the use of tools such as GRAFCET and programmable logic controllers (PLCs) is essential for designing, studying and building an automated system, as modeling and automation are indispensable processes in industry, with PLCs at the heart of these industrial control systems, which today are veritable communicating objects, contributing to the growing importance of remote management; to develop a PLC program, it is essential to equip the station with the necessary hardware, and in this case, the researchers used the Siemens S7-300 PLC and TIA Portal software to configure and program them efficiently, as the use of tools such as GRAFCET and PLCs, combined with configuration and programming software such as TIA Portal, make it possible to design and manage high-performance, efficient industrial control systems, and in this chapter, the researchers define GRAFCET and the TIA PORTALE software, and present the GRAFCET for the desalination station, including a simulation of their program.

II. Modeling with the GRAFCET tool

There are two types of representation:

1 The functional representation (or level 1) gives an interpretation of the solution for a given problem, specifying the coordination of operational tasks. It provides an overall understanding of the system.

2 Technological representation (or level 2) provides an interpretation, taking into account technological choices relating to the control part of the automation system; the type and designation of equipment (e.g. S1, KM, Ka ...). [12]

II.1 Definition of GRAFCET:

GRAFCET (the acronym of GRAphe Fonctionnel de Commande Etape/Transition or, in. English, *Step Transition Function Charts*) is a graphic tool which describes the different behaviors of the evolution of an automatism and establishes a sequential and combinatorial correspondence between:

 INPUTS: i.e. the transfer of information from the operating part to the control part.

 OUTPUTS: information transfers from the Control part to the Operative part.

It's a powerful graphic tool that can be used directly, as it's also a language for most of the PLCs on the market. When the word GRAFCET (in capital letters) is used, it refers to the modeling tool. When the word grafcet (in lower case) it refers to a model obtained using GRAFCET rules.

GRAFCET includes:

- **Steps:** associated with actions;
- **Transitions:** associated with receptivity
- **Oriented links:** connecting steps and transitions.[12]

II.2 GRAFCET representation

Its representation is based on basic graphical elements which include:

II.2.1 The steps of a GRAFCET:

 Initial  **step**:

The initial stage characterizes the state of the system at the start of operation.

 Step: 

A step corresponds to stable system behavior. The stages are numbered in ascending order. Each step can be associated with one or more actions.

II.2.2 Transitions and receptivity

➢ **Transition:** 

Transitions indicate possible evolutions of the cycle. Associated with a receptivity.

➢ **Receptivity:** 

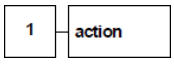
Receptivity is the logical condition for grafcet evolution. If receptivity is true (=1), the cycle can evolve. Receptivity comes from the control panel, limit switches or information from the operating part.

II.2.3 Oriented links

 Oriented links: 

The grafcet is read from top to bottom, otherwise it is necessary to indicate its evolution with oriented links made up of arrows indicating the direction.

Some definitions:

- **Action:** 

The action is associated with a step, and is active when the cycle has reached the step. It is possible to define conditional actions, timed actions, etc. (solenoid valve, contactor engagement, etc.).

- Active step: ●

The dot indicates that the step is active.

Example: Functioning a milling machine

- The milling machine's start button is pressed.
- The milling cutter descends.
- Once in the down position, milling begins.
- The stop button is pressed.
- Milling stops and the cutter moves up.
- Once the upper limit switch has been reached, the milling machine returns to its initial position.

Simple grafcet representation to illustrate and understand the operation of a milling machine: [12]

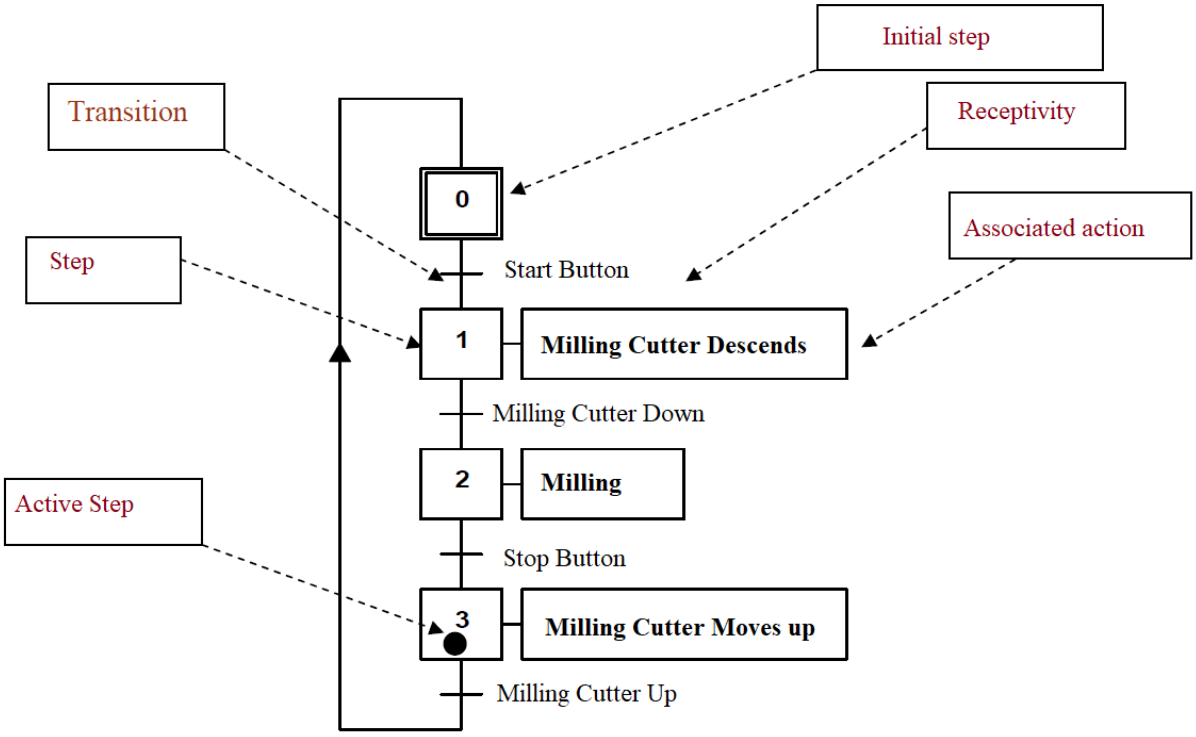


Figure 10 : Milling machine grafcet

II.3 GRAFCET levels:

➢ GRAFCET level 1:

Also known as the control level. It describes the functional side of the system and the actions that the control side must take in response to information from the operational side, whatever the technology used. Receptions are described in words, not abbreviations. We combine the verb with the action infinitive.

- **GRAFCET level 2:**

And under another name: the operative part level. The presentation of actions and receptivity are written in abbreviations rather than words, with a capital letter for the action and a capital letter for the receptivity.

- **GRAFCET level 3:**

In this case, the level 2 GRAFCET is used, assigning information to the PLC input labels and commands to the PLC output labels. It adapts to the processing characteristics of a given PLC, so that the program can be created, implemented and upgraded. [13]

The diagram below shows the three levels of GRAFCET:

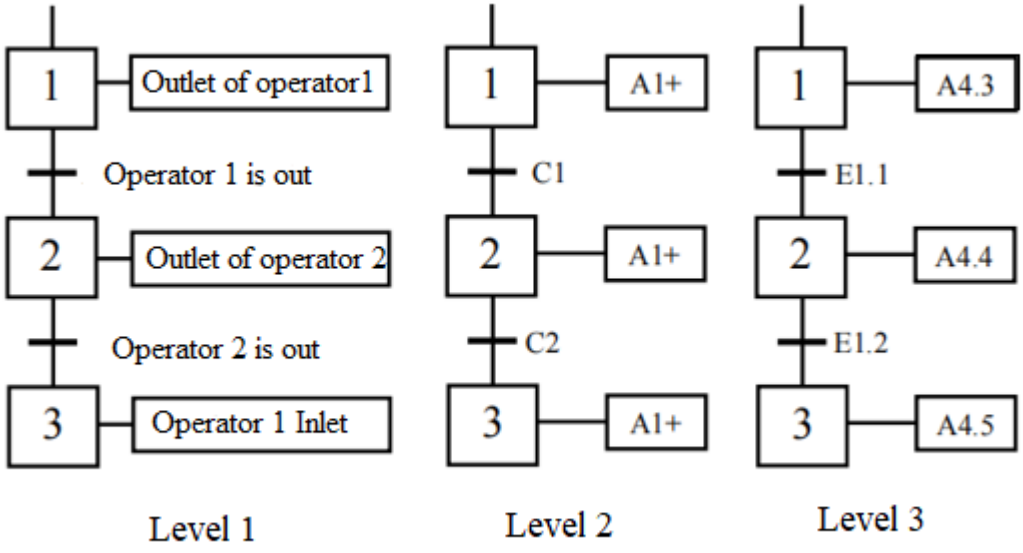


Figure 11 : The diagram of the three levels of GRAFCET

II.4 Basic structure of a GRAFCET:

In a complete machine cycle, we can have simultaneous sequences, or sequence choices:

1 Single sequence (linear structure):

The beginning of the Grafcet is made up of a sequence of steps that can be activated one after the other. This sequence of steps is called a single sequence.

Each step is followed by only one transition, and each transition is validated by only one step.

The sequence is said to be active if at least one of the steps is active. It is said to be inactive if all the steps are inactive. [14]

The diagram below shows the single sequence:

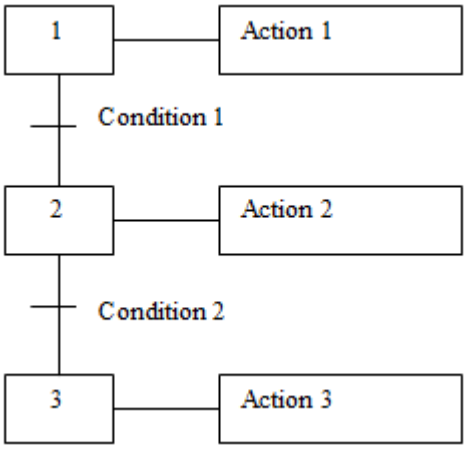


Figure 12 : Single sequence diagram

2 Simultaneous sequences:

When the crossing of a transition leads to the activation of several sequences at the same time, these sequences are referred to as simultaneous sequences. After the simultaneous activation of these sequences, the evolution of the active steps in each sequence becomes independent. [14]

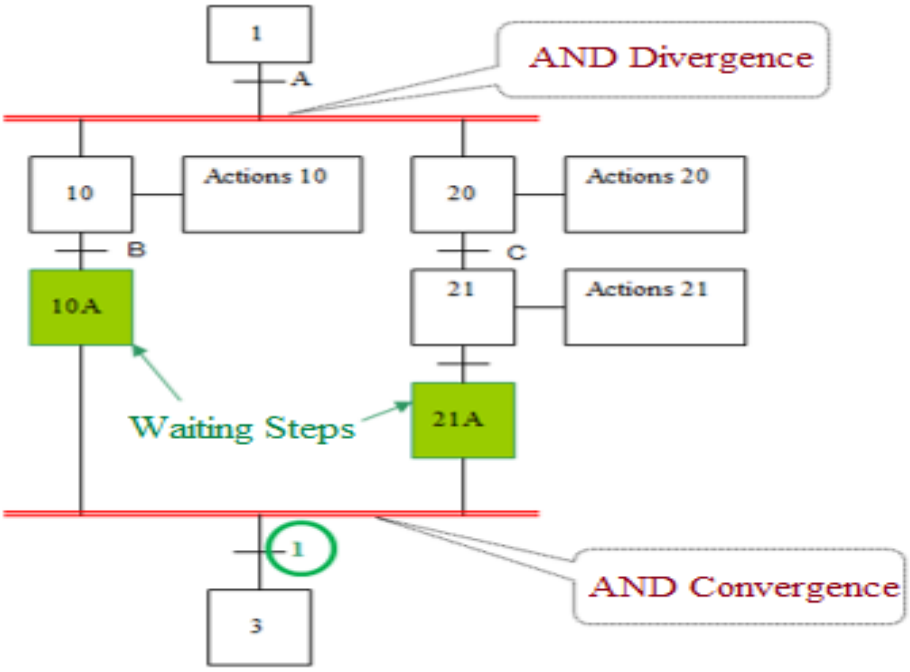


Figure 13: The Simultaneous sequences

NB: To ensure synchronized deactivation of several sequences at the same time, reciprocal waiting steps are generally provided.

3 Sequence selection:

A selection or choice of evolution between several steps or sequences is represented, starting from one or more steps, by as many enabled transitions as there are possible evolutions.

The diagram below shows Simultaneous sequences (sequence selection):

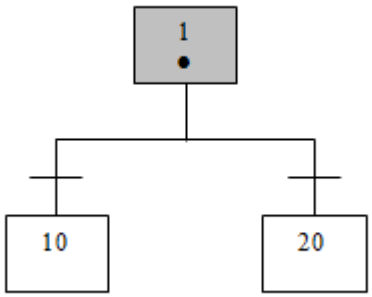


Figure 14 :Simultaneous Sequence Selection

From step 1, two possible evolutions (10 OR/AND 20) [14]

Note: To obtain an exclusive selection between several steps, the receptivities must be exclusive.

- It should be noted that the grafcet tool is the most widely used tool for studying, developing and implementing PLC-based automation solutions.
- In the remainder of this chapter, we will present the grafcet model which will handle the constants imposed on the desalination station.

II.5 GRAFCET evolution rules:

To ensure the correct operation of a GRAFCET, it is essential to respect five evolution rules. If one of these rules is not followed, the graph can no longer be considered a GRAFCET. The first rule is the mandatory alternation between steps and transitions, regardless of the order in which they are traversed. The following rules are based on this alternation.

- Rule 1 "Initial situation

A grafcet begins with an initial situation, represented by a double square, which characterizes the initial behavior of the control part (CP) with respect to the operating part (OP), and corresponds to the set of active steps authorizing the start of operation.

Consequences:

- The initial situation often corresponds to the reference position of the OP.
- In general, no action is associated with the initial steps. [15]

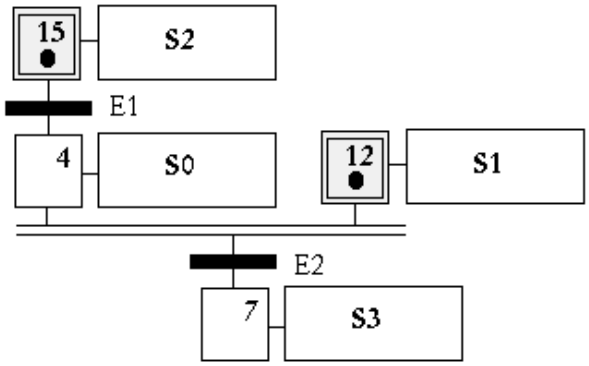


Figure 15 : Initial Situation[16]

- Rule 2 "Crossing a transition

A transition is either validated or not validated; it is validated when all the immediately preceding steps are activated. When the transition is valid and the associated receptivity is true, it must be crossed. [15]

The diagram below illustrates how a transition is crossed.

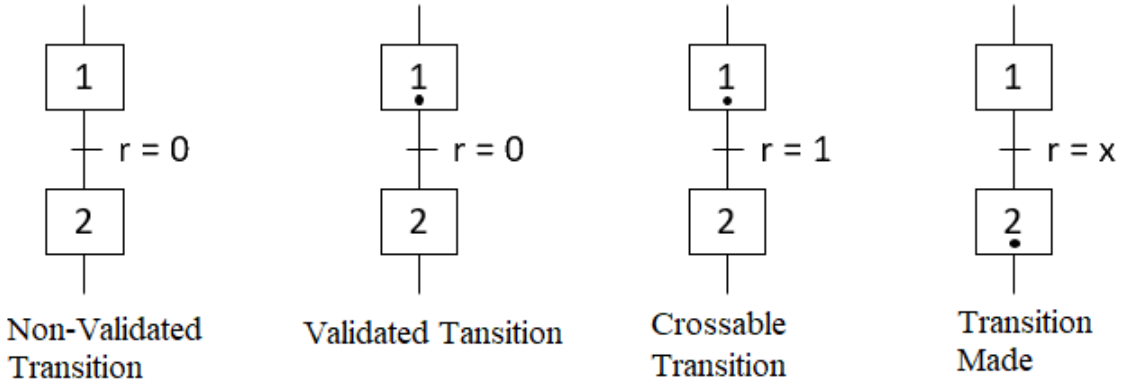


Figure 16:Transition Crossing

- Rule 3 "Evolution of active stages

The crossing of a transition leads to the activation of the immediately following stages and the deactivation of the immediately preceding stages. [15]

- Rule 4 "Simultaneous evolutions

Several simultaneously passable transitions are simultaneously passed. [15]

- Rule 5 "Simultaneous activation and deactivation

If, during operation, the same step must be activated and deactivated simultaneously, it remains active. [15]

NB: The transition time can never be strictly zero, although it can be made as small as desired. The same applies to the activation time of a step.

III. Final model of the desalination station using GRAFCET:

III.1 Technical specifications for the start-up of desalination plant units

1. Ensure that all actuators (valves and pumps) are in the off state:
   - ✓ Seawater supply pumps “seawater supply pump 1” and “seawater supply pump 2” are off.
   - ✓ The seawater inlet valve “seawater valve” is closed.
   - ✓ Desalinated water pumps “dessal water pump 1” and “dessal water pump 2” are off.
   - ✓ Main desalinated water valve “princ dessal water valve” is closed.
   - ✓ Brine pump “brine pump” is off.
   - ✓ Brine valve “brine valve” closed.
   - ✓ Reject valve “reject valve” is closed.
2. Start the DCS automatic system “DCS” or the HMI (“HMI”. DCS), and check the auxiliary boiler storage level “STEAM SUPPLY DRUM LOW LEVEL” (not LOW LEVEL).
3. After system start-up, auxiliary boiler burner “BOILER” is switched on, and seawater valve “seawater valve” opening signal is sent.
4. If the valve is not opened after 20s, the “seawater valve fault” alarm is triggered and the "seawater valve” is opened manually using the “seawater valve opened manually” program or the HMI “HMI”. “seawater valve opened manually”.
5. After opening the valve, we check the steam conditions feeding the desalination plant evaporator:
   - ✓ Steam pressure “steam pressuree” >= 20 bar.
   - ✓ Steam temperature “steam temperaturee” >= 225 °C.
6. Once these conditions have been met, the seawater supply pump 1 “seawater supply pump 1” start signal is sent.
7. If PUMP 1 has not started after 20s, the seawater pump 1 fault alarm “seawater pump 1 fault” is triggered and the “seawater supply pump 2” start-up signal is sent.
8. If PUMP 2 has not started after 20s, the seawater pump 2 fault alarm “seawater pump 2 fault” is triggered and both pumps need to be repaired before starting up again using the “repair pump” program or the HMI “HMI”. “SEAWATER REPAIR PUMPS”
9. After switching on PUMP 1 or PUMP 2, the brine pump “brine pump” is switched on and The start signal for desalinated water pump 1 “dessal water pump 1” is sent.

10. If PUMP 1 has not started after 20s, the desalinated water pump 1 fault alarm "dessal water pump 1 fault" is triggered and the desalinated water pump 2 "dessal water pump 2" start signal is sent.
11. If PUMP 2 has not started after 20s, pump 2 fault alarm "dessal water pump 2 fault" is triggered and both pumps need to be repaired before starting again using the "repair dessal pumps" program or the HMI "HMI". "DESSAL REPAIR PUMPS".
12. The brine valve "brine valve" and the main desalinated water valve "princ dessal water valve" are open.
13. After opening the previous valves, we will check the desalinated water specifications:

- ✓ Desalinated water flow "DESSAL WATR FLOW" >= 35 m /h.^{3}
- ✓ Desalinated water conductivity "HIGH Conductivity" < 10 µs/cm.
- ✓ Desalinated water PH "HIGH PH" < 9.5.

14. Once these conditions have been met, the opening signal for desalinated water tank supply valve "dessal tank valve supply" is sent.
15. If the valve is not opened after 20s, the for desalinated water tank supply valve fault alarm "dessal tank supply valve fault" is triggered and the desalinated water tank supply valve "dessal tank valve supply" is opened manually using the "dessal water supply valve opened manually" program or the HMI "HMI". "dessal tank valve supply opened manually".
16. After opening the valve, we will check the following conditions:

- ❖ If Desalinated water conductivity "HIGH Conductivity" > 10 µs/cm or Desalinated water PH "HIGH PH" > 9.5.

OR:

- ❖ The desalinated water tank level is high "dessal tank high level".

17. Once these conditions have been met, the desalinated water tank supply valve "dessal tank valve supply will be closed and the reject valve "reject valve" will be opened.
18. If the desalinated water specifications to open desalinated water tank supply valve are not satisfied within 60s, the whole system will automatically stop.

III.1 GRAFCET modeling of specifications:

The Siemens TIA Portal V13 platform is the latest development in Siemens programming software, allowing us to create a program in GRAFCET language for basic control of the desalination station and to test it in the Siemens S7-300 PLC. We have therefore created these grqfcets in the FB function blocks in our program for the operation of our station.

For better visibility and understanding of the grqfcets, we plotted and tested them on the Tia portal software as follows:

BLOC1

BLOC2

BLOC3

BLOC4

BLOC5

Our grafcet is given as follows:

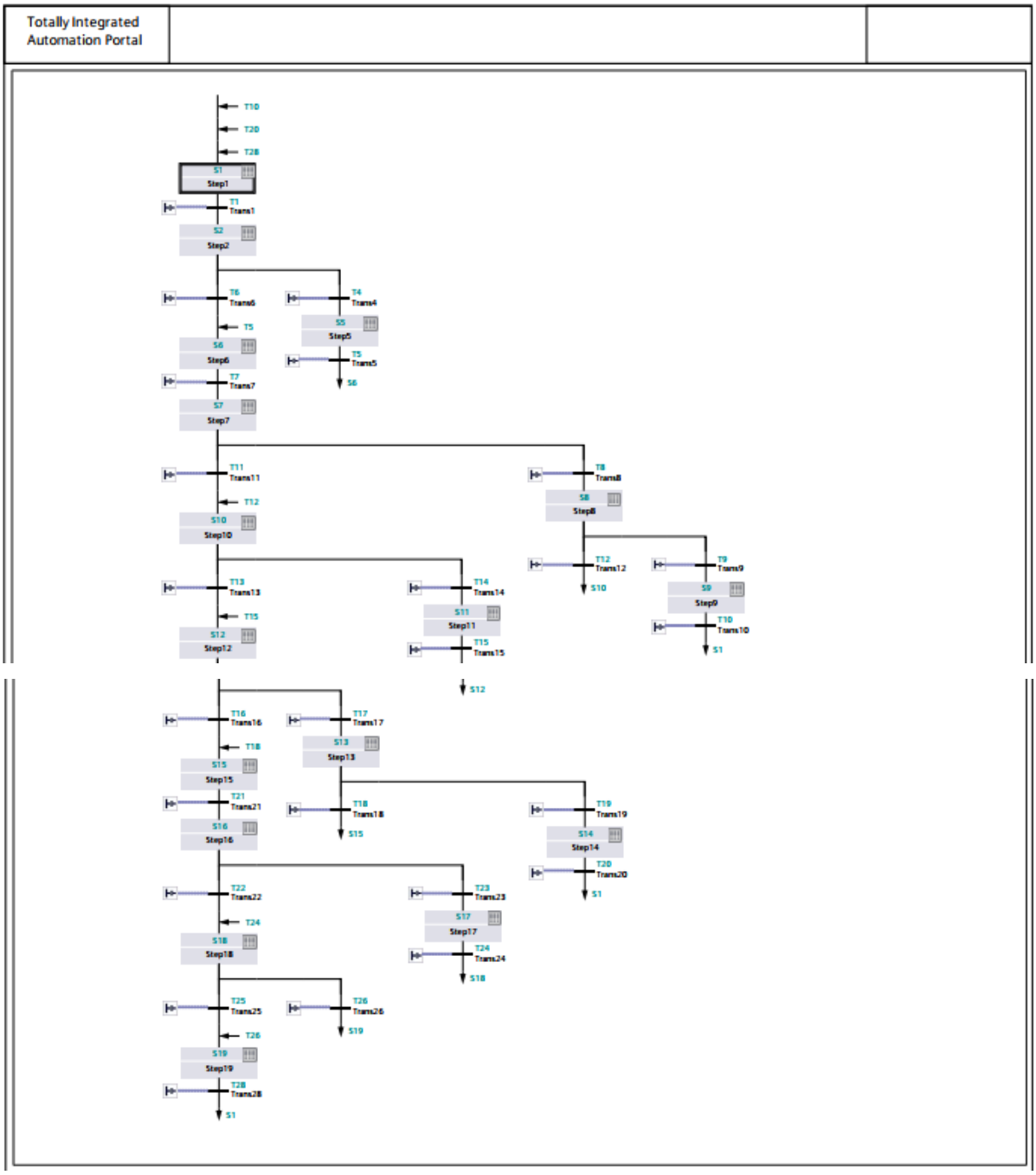


Figure 17:The grafcet of the desalination station

- Here are some comments on Steps and Transitions and Emergency Stop grafcets, that corresponds to technical specifications given in **Page 53**

Step 1 &Transition 1 &Step 2:

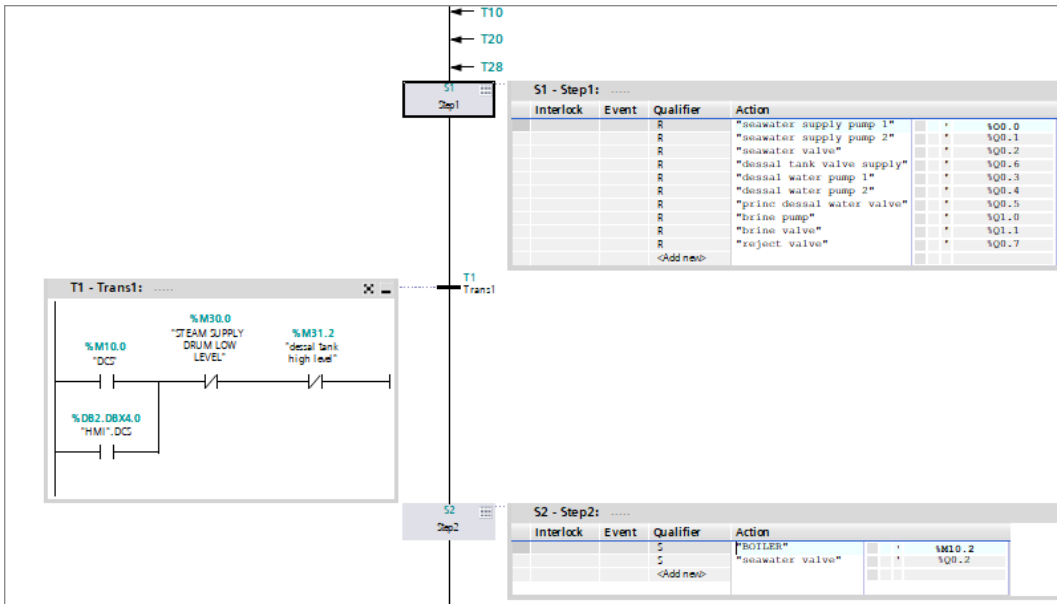


Figure 18:Step 1 &Transition 1 and Step 2 of the grafcet

Transition 4 &Step 5 &Transition 5:

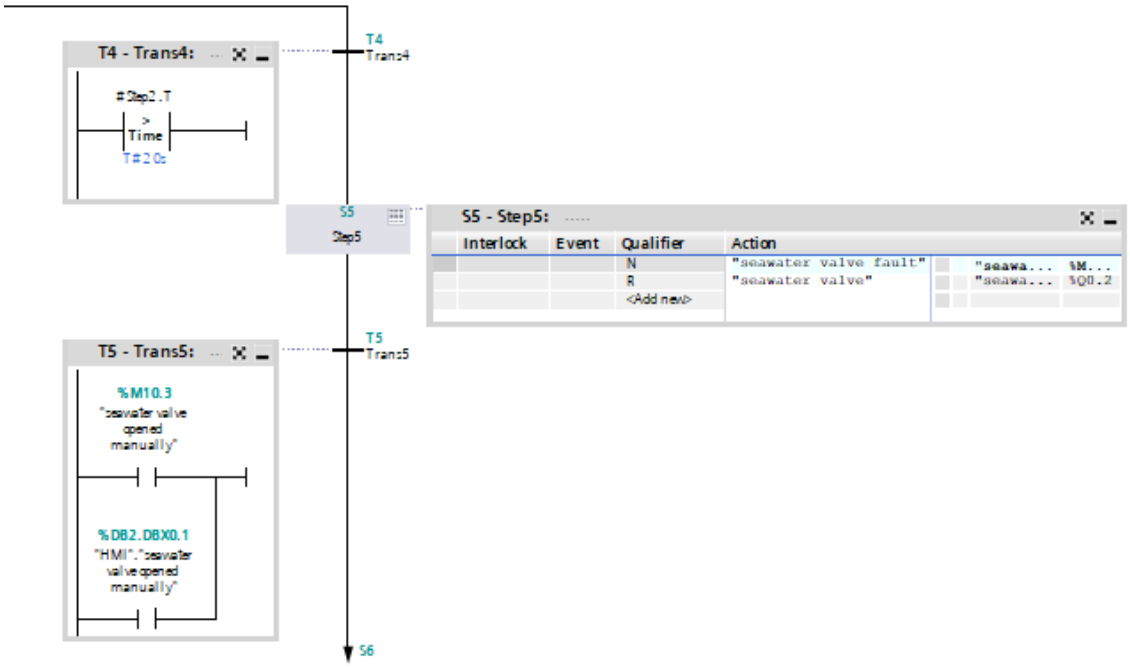


Figure 19:Transition 4 &Step 5 and Transition 5 of the grafcet

Transition 6 &Step 6 &Step 7 &Transition 7:

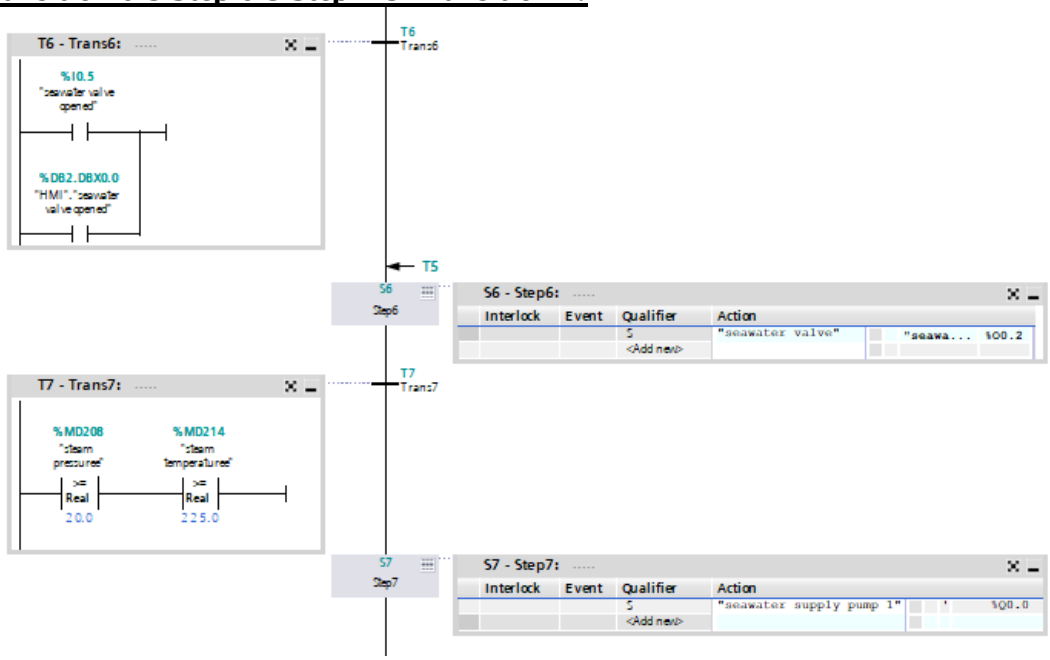


Figure 20:Transition 6 &Step 6 &Step 7 and Transition 7 of the grafcet

Emergency Stop grafcet:

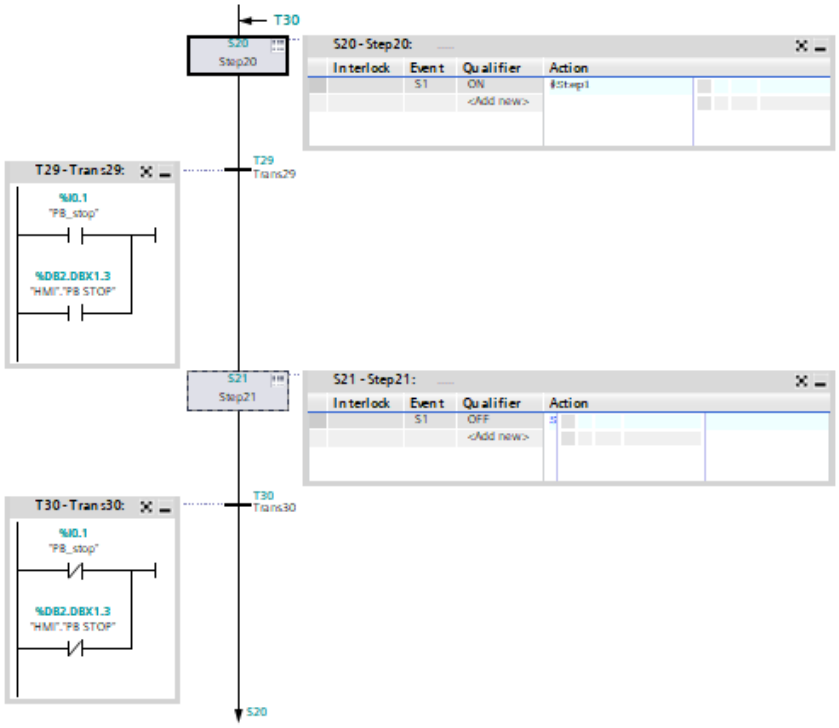


Figure 21:Emergency Stop grafcet

IV. Desalination station automation with (SIMENSE S7-300)

IV.1 Description and structure of an SAP automated production system:

SAP, which stands for "Systems, Applications, and Products in Data Processing", is an automated production system that integrates different company processes to improve the efficiency and transparency of operations.

A system is said to be automated when the process involved in moving from an initial situation to the final one is carried out without human intervention, and when this behavior is repetitive. An automated system performs a certain number of actions through a number of components. See figure below:

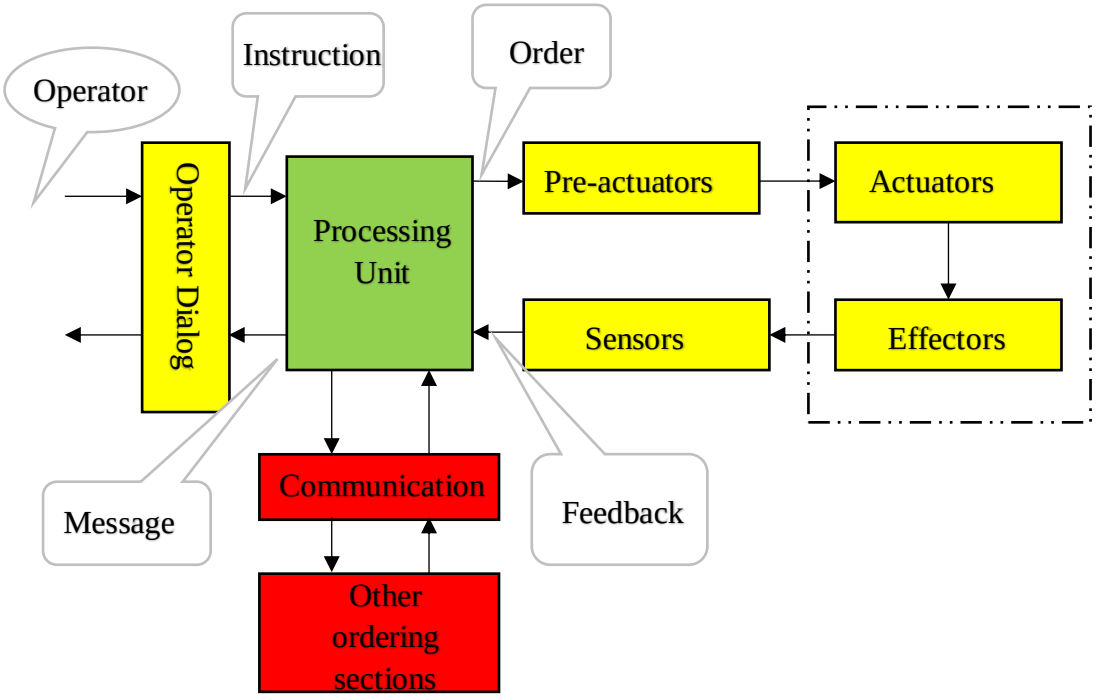


Figure 22 : *APS automated production system*

The automated production system is therefore a machine that creates added value. For ease of analysis, it can be represented in the form of a diagram identifying three parts: an operating part and a control part, with a Connection part or, under another name, a dialogue panel (OP; CP; CP) of the system, and expressing their interrelationships (Information, Orders, Feedback, Instructions). These are closely linked and work together, as does a control station: [17]

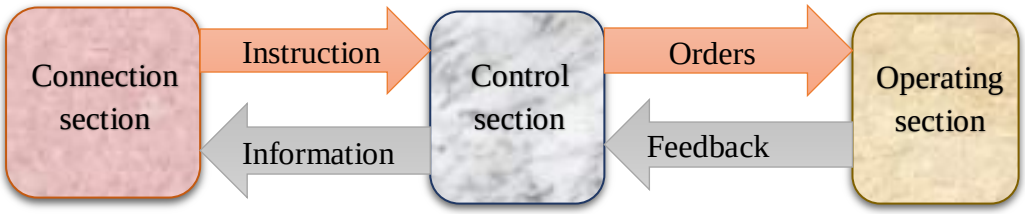


Figure 23:Diagram of APS parts interrelationship

The CP sends commands to the OP to achieve the desired effects, based on available information, reports, instructions, etc. and a behavior model. It can communicate with operators or with other systems. [17]

- The OP executes orders from the CP to add value to the incoming material. It is usually a mechanized unit using electrical, pneumatic or hydraulic energy. It sends reports to the CP.
- The CP Its complexity and size depend on the importance of the system. It groups together the various commands required for the correct operation of the process: start-stop, emergency stop, automatic operation, cycle/cycle operation, etc. The description tool is called "GEMMA" (Study Guide for Stop & Go Modes). These graphic tools (GRAFCET and GEMMA) are also used by maintenance technicians and engineers to troubleshoot APSs (Automated Production Systems). During operation, a continuous dialogue is established between the three sectors of the system, thus enabling the correct running of the cycle defined in the specifications.

It also enables the various system states to be visualized by means of LEDs, a dialogue terminal and a human-machine interface (HMI). [17]

IV.2 Definition of a Programmable Logic Controller (PLC):

A PLC, also known as a "Programmable Logic Controller", is a programmable electronic system for real-time process control in an industrial environment. The PLC is programmed to execute cyclic operations that process incoming data through its inputs and provide results using its outputs to control the system. This tool can be used by non-computer scientists to control the operative parts of industrial processes. [19]

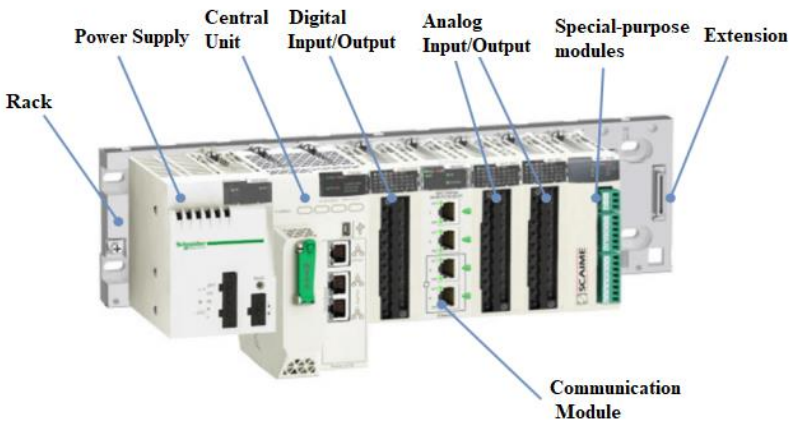


Figure 24 : Programmable Logic Controller

IV.3 History of a programmable logic controller (PLC):

The history of the programmable logic controller (PLC) starts in the 1960s, when factories began using electromechanical relays to automate manufacturing processes. These relays were used to control machines and equipment according to electrical signals received from sensors and actuators.

In 1968, American engineer Dick Morley invented the first programmable logic controller, known as Modicon. This PLC revolutionized industry by enabling the control logic to be programmed electronically, making it possible to replace electromechanical relays with electronic circuits.

The use of PLCs grew rapidly. Over time, PLCs have been enhanced to offer more advanced functionalities, such as networked communication capabilities, human-machine interfaces (HMI) and advanced safety functions.

Today, PLCs are widely used in industrial process control systems, mass production and many other areas of industry. They enable efficient, real-time control of production processes, optimize equipment performance, improve product quality and reduce maintenance costs. [19]

❖ **Automation objectives**

- Aimed at staff: to improve working conditions by eliminating the most arduous tasks and increasing safety.
- Product-related: Improve feasibility, quality and reliability over time.
- Targeting the company: Improve competitiveness (by reducing production costs), productivity, production quality, control, management and planning capacity. [17]

IV.4 Architecture of a Programmable Logic Controller (PLC):

The hardware of a PLC consists mainly of:

- The inputs to which the sensors are tuned, providing information relating to the equipment or process to be controlled or monitored.
- The arithmetic and logic unit, or processing unit, which carries out logical (AND, OR...) and arithmetic (addition, counting) instructions.
- A programming console, which may or may not be integrated into the machine, used to convert "user" instructions into instructions that can be executed by the PLC.
- The outputs, which send the commands generated by the processing unit to the actuators (contactors, solenoid valves.... etc.).
- The power supply and various ancillary circuits. [20]

The diagram below shows the internal architecture of a PLC:

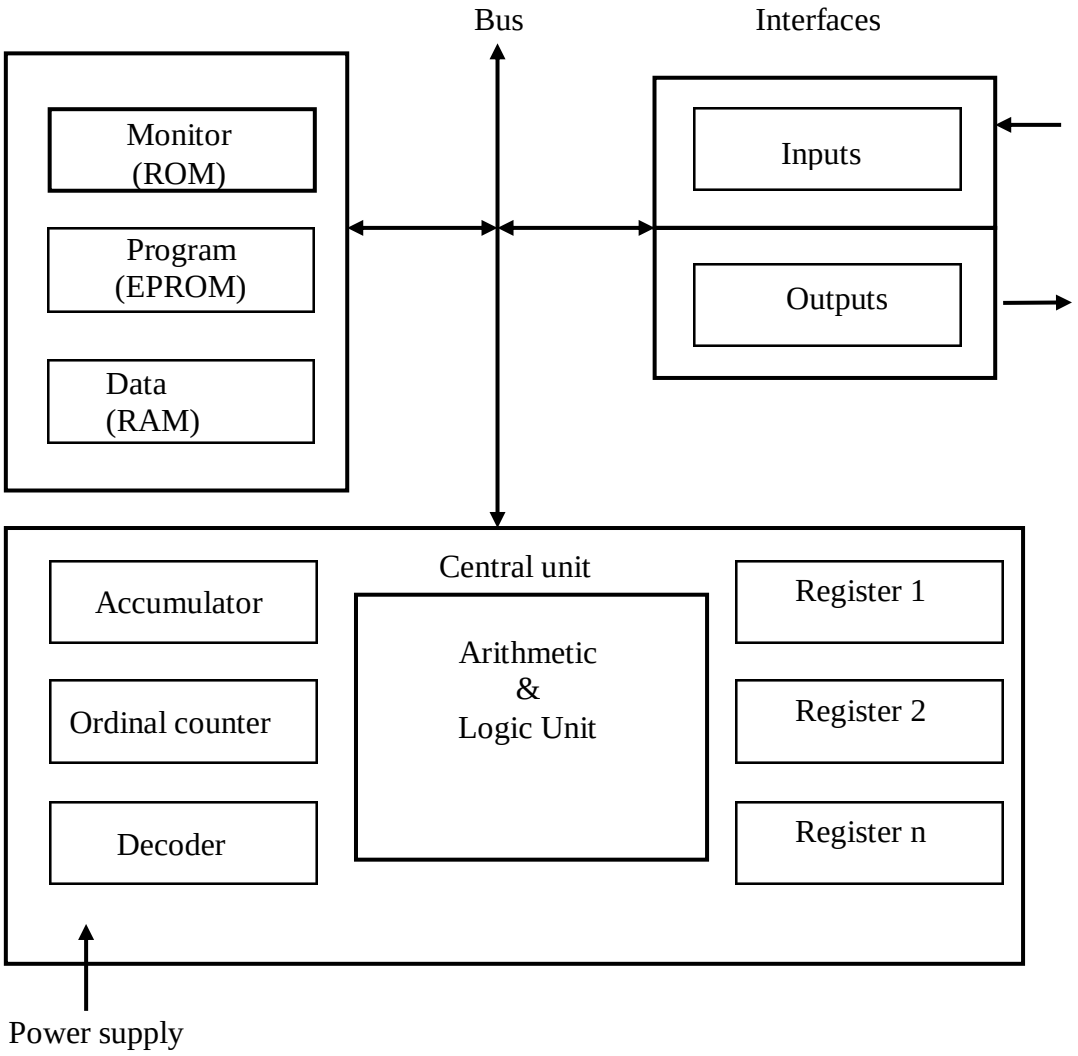


Figure 25 : The internal architecture of a PLC

The choice of a PLC depends on a number of criteria, including:

- The technical characteristics of the system to be automated: size, complexity, number of inputs/outputs, types of sensors/actuators used, etc...
- Real-time requirements: does the system need to be controlled in real time, or can it operate with a slower response time
- Communication functions: must the PLC be able to communicate with other equipment or control systems
- Availability of documentation and programming tools: the PLC must be accompanied by comprehensive documentation and user-friendly programming tools to facilitate implementation and maintenance of the automated system.
- Cost: the cost of the PLC must be in line with the budget allocated for the project.

Depending on these criteria, you can choose from different makes and models of PLCs, such as Siemens S7-300, Schneider Modicon, Allen-Bradley CompactLogix and others. It's important to carry out market research and consult experts to ensure you make the most suitable choice for your project. [21]

IV.5 Comparison Siemens S7-300 CPU VS ABB CPU 8521 HC MT :

When comparing the Siemens S7-300 CPU with the ABB CPU 8521 HC MT, several factors can be taken into account to determine why one might be perceived as better than the other. Here are a few reasons why the Siemens S7-300 might be preferred:

1. Industry standard and reliability:
   - The Siemens S7-300 series is widely regarded as an industry standard in many automation applications due to its reliability, robustness and long-standing presence in the market.
   - The extensive use and positive reputation of the S7-300 series in various industries can make it a trusted choice.

2. Availability of Support and Resources:
   - Siemens offers extensive documentation, user manuals and online resources. In addition, a large community of users and professionals can provide support.
   - Training programs and certification courses for Siemens PLCs are widely available.

3. Integration with TIA Portal:

- The S7-300 can be seamlessly integrated into Siemens' Totally Integrated Automation (TIA) Portal, enabling a unified engineering environment.
- The TIA Portal facilitates efficient project design, commissioning, diagnostics and maintenance.

4. Wide range of modules and expandability:

- The S7-300 series offers a wide range of modules (I/O, communication, function modules, etc.), enabling flexible, scalable automation solutions.
- This modularity makes it easier to extend and customize the system to meet specific needs.

5. Performance and functionality:

- S7-300 CPUs are renowned for their high performance in terms of processing speed and memory capacity.
- Features such as integrated communication ports (such as PROFIBUS and Ethernet), diagnostic functions and real-time capabilities are well regarded.

6. Worldwide Presence and Supplier Support:

- Siemens has a strong global presence with widespread service and support centers.
- This can be crucial for multinational companies requiring constant support in different regions.

7. Interoperability and Standards Compliance:

- The S7-300 series adheres to various international standards, guaranteeing

interoperability with other devices and systems.

While these points highlight the strengths of the Siemens S7-300 series, it is important to note that the choice of PLC should be based on specific application requirements, budget and existing infrastructure. ABB PLCs, including the CPU 8521 HC MT, can also offer unique features and benefits tailored to specific scenarios. For example, if an existing existing system is already heavily based on ABB equipment, it might make sense to stay within the same ecosystem for compatibility and ease of integration.

In conclusion, the Siemens S7-300 is often considered better in many scenarios due to its reliability, support infrastructure, integration capabilities and performance, but the final choice should always be made according to the specific needs and context of the application.

IV. Conclusion:

After reviewing the contents of this chapter, we can conclude that GRAFCET is an effective modeling tool for describing the expected behavior of the control part of an automated system, and for creating a link between the control and operative parts. It also makes it easy to move from a functional specification to an operational implementation language.

By using GRAFCET, we were able to model the expected behavior of the automated system, which will facilitate the programming of the operative part that will drive the process. GRAFCET is a valuable tool for modeling automated systems, and its use in conjunction with TIA Portal will enable us to develop a complete supervision platform to improve the operational efficiency and profitability of automated systems.

In the following chapter, we will use TIA Portal to program the operative part and create a supervision platform. We will endeavor to provide as complete a platform as possible to enable real-time monitoring and efficient data analysis.

Chapter IV:
Supervision of the desalination station using TIA Portal

I. Introduction:

Industrial supervision plays a crucial role in collecting, processing, and displaying data from various industrial equipment. As process complexity increases machines and plants must meet increasingly stringent functionality specifications, it becomes essential to provide operators with maximum transparency. The Human/Machine Interface (HMI), which serves as an interface between the operator and the process itself, enables this transparency.

The establishment of industrial supervision of the desalination plant modeled in the previous chapter is the main topic of this chapter. To start, we will introduce the TIA PORTAL programming software and the S7-300 programmable logic controller (PLC), emphasizing a portion of our program focused on the desalination plant.

Using the WINCC software that is integrated into TIA Portal, the second section of this chapter will discuss the various levels of industrial supervision. We will outline the supervision functions that are now available and how the desalination plant can use them.

finally, we will talk about supervisory control of the desalination plant, emphasizing important elements like alarms, statistics, regulation, and data processing and gathering. This section will emphasize how vital the supervisory system is to the desalination plant's efficient functioning.

VII The S7-300 PLC and TIA PORTAL programming software presentation:

The S7-300 PLC is a high-performance PLC for complex industrial applications. It offers a wide range of functions, including digital and analog inputs/outputs, industrial communications, large internal memory and high processing capacity, manufactured by Siemens. [22]

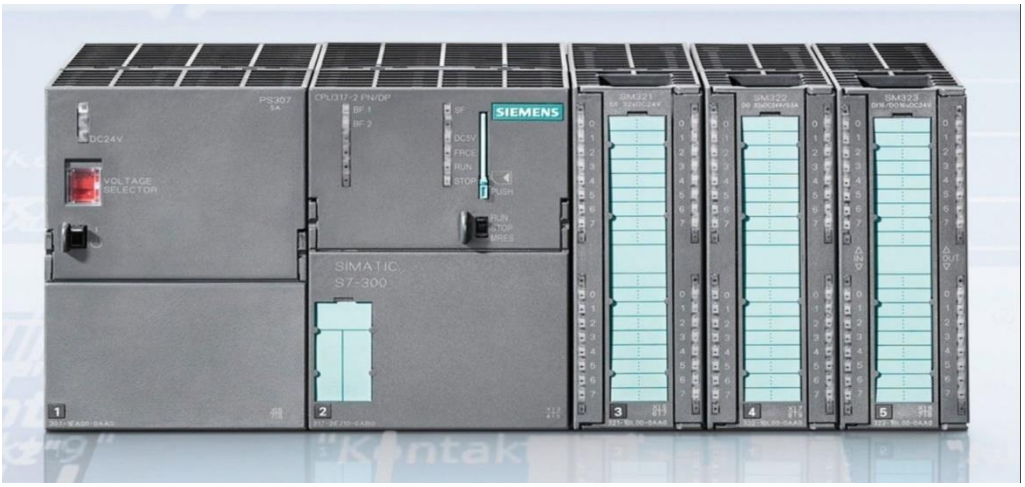


Figure 26 : The S7-300 PLC[26]

The S7-300 PLC is programmable from a PC using STEP 7 software or the Siemens TIA Portal platform. In this chapter, we use the TIA PORTAL programming software.

PORTAL "Totally Integrated Automation", an integrated development environment (IDE) (IDE) offering an intuitive, user-friendly graphical interface for easy programming, diagnosis and maintenance of Siemens PLCs such as the S7-300.

TIA PORTAL also features advanced debugging tools to improve the productivity and efficiency of the development process. The software is compatible with several programming languages, such as contact language, grafcet, function block language and instruction list language.

By using the S7-300 PLC with TIA PORTAL software, engineers can design and implement advanced industrial automation systems with great efficiency and flexibility.

II.1 S7-300 PLC modules:

In this section, we'll look at the configuration of the PLC modules programmable logic controller (PLC) S7-300 used in our desalination plant supervision system:

- **Slot 1:** 24V/5A power supply;
- **Slot 2 :** CPU 314 ;
- **Slot 4:** TOR 16x24V inputs, simulator switches;
- **Slot 5:** TOR 16x24V encoder inputs;
- **Slot 6:** Digital outputs 16x24V 0.5A simulator LEDs;
- **Slot 7**: Digital outputs 16x24V 0.5A digital display;
- **Slot 8:** 16x24V digital inputs model inputs;
- **Slot 9**: Digital outputs 16x24V 0.5A model outputs;
- **Slot 10:** Analog module 4 AI/4 AO analog part of simulator. [28]

II.2 S7-300 functionality:

The S7 PLC consists of a power supply (PS modules), a CPU and I/O modules.

input/output modules. Siemens supplies:

- IM expansion modules for multi-row configuration of the S7-300
- SM signal modules for digital and analog inputs and outputs
- FM function modules for special functions (e.g. stepper motor activation)

stepper motor)

- CP communication processors for network connection. [23]

The figure below shows how a PLC works:

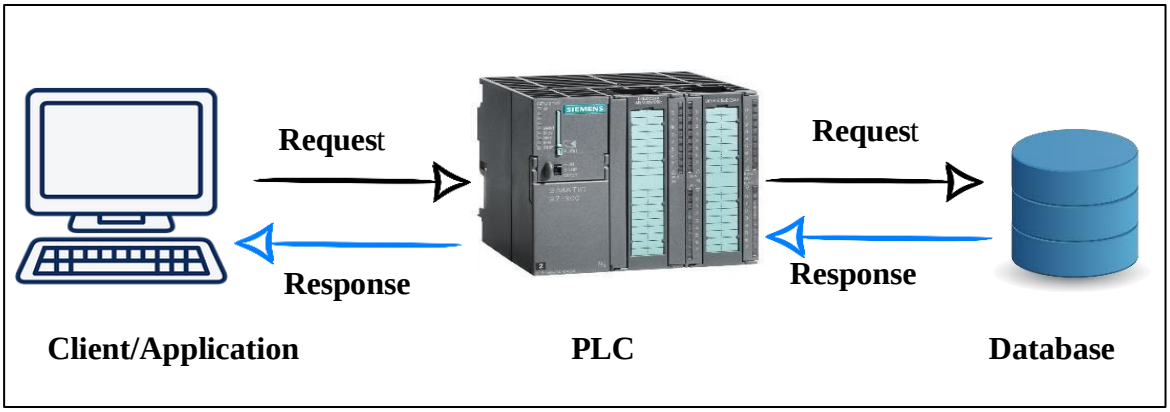


Figure 27: PLC functionality

II.3 Features of S7-300 PLC:

The S7-300 PLC has the following features:

- Wide CPU range.
- Full module range.
- Up to 32 modules.
- Module-integrated backplane bus.
- Possibility of networking with MPI, PROFIBUS or INDUSTRIAL ETHERNET.
- Central PG connection with access to all modules.
- Freedom of mounting in different locations
- Configuration and parameterization using the hardware configuration tool.

Several S7-300 PLCs can communicate with each other via a PROFIBUS bus cable for decentralized configuration**.** [20]

II.4 Programming the S7-300 with TIA PORTAL:

To write our program, we will use the SIMATIC TIA PORTAL programming software, which is a basic tool for SIEMENS S7 family PLCs. This software must be installed on a computer.

1 Portal view and project view:

When TIA Portal is launched, the working environment breaks down into two types of view:

- **Portal view:** focuses on the tasks to be carried out, and is very quick to learn.
- **Project view:** includes a tree structure showing the various elements of the project. The required editors open according to the tasks to be performed. Data, parameters and editors can all be viewed in a single view. [28]

1.1 Portal view Each portal allows you to process a task category (action). The window displays the list of actions that can be performed for the selected task:

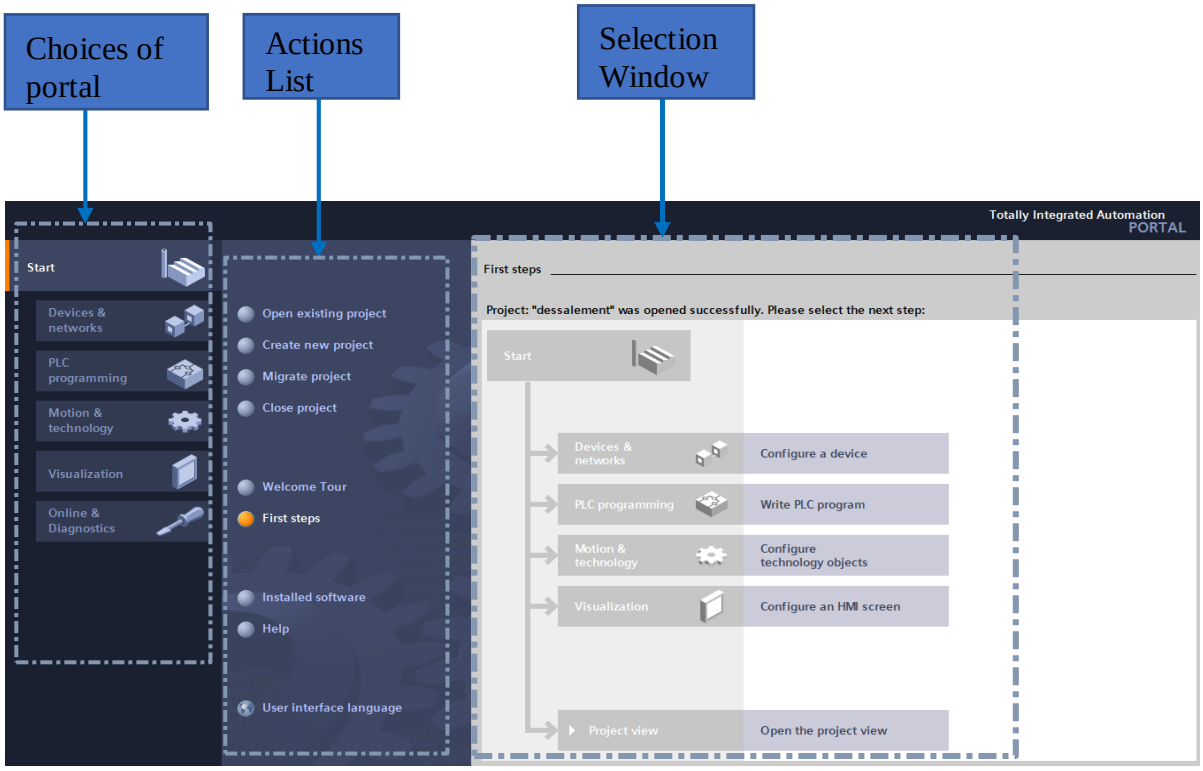


Figure 28 : TIA portal startup view.

1.2 Project view: The "project" element contains all the elements and data required to implement the desired automation solution.

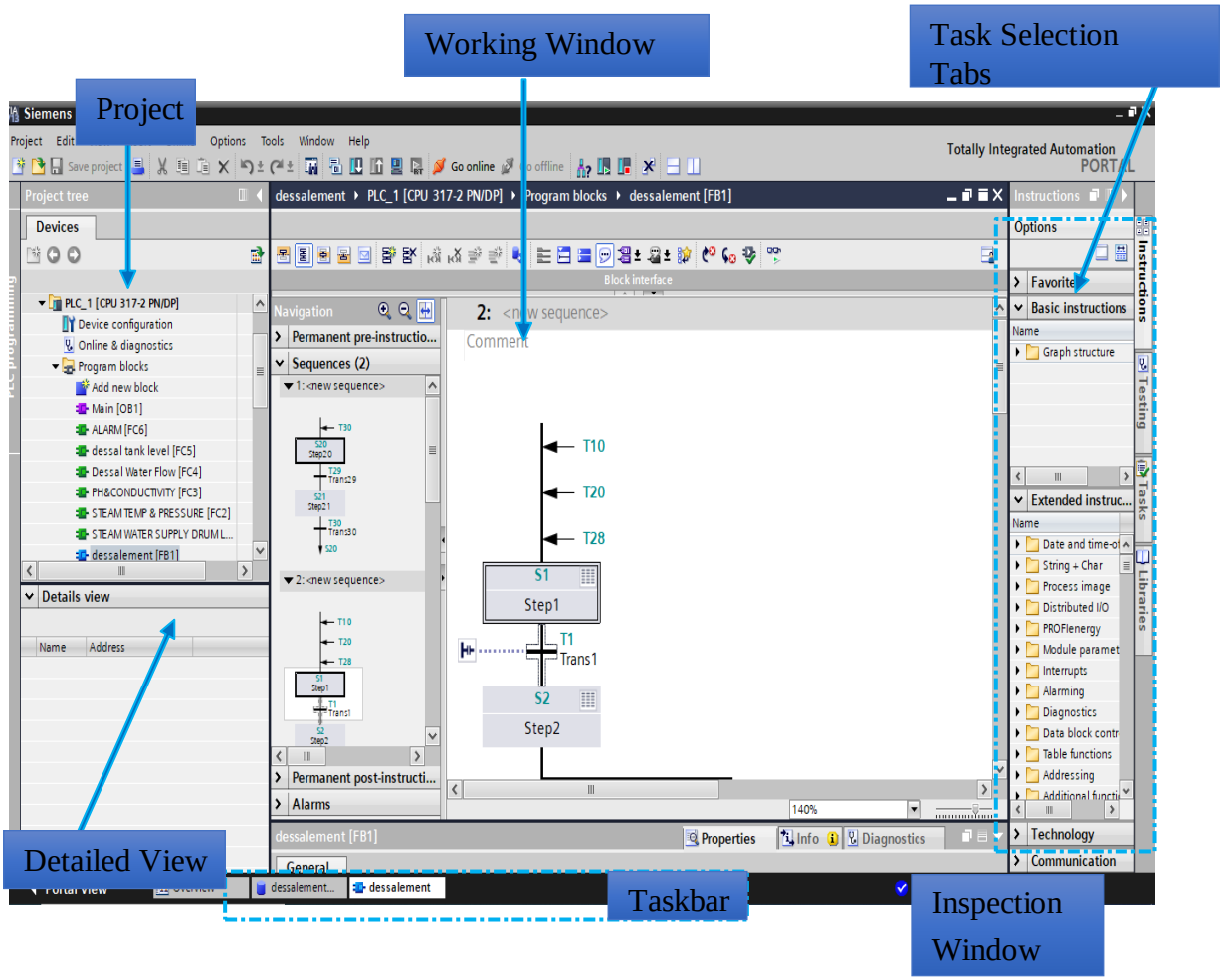


Figure 29:Project View

- The working window displays the objects selected in the project to be processed. These may be hardware components, program blocks, variable tables or HMIs (see figure 36).
- The inspection window allows you to view additional information on a selected object or on actions currently being executed (property of the selected hardware, error messages when compiling program blocks, etc.)
- The contents of the task selection tabs vary according to the object selected, whether hardware configuration, component libraries, program blocks or programming instructions

This working environment contains an enormous amount of data. Some of these windows can be hidden or minimized when not in use. It is also possible to resize, reorganize and remove individual windows.

1.3 Addressing:

To find out how the inputs and outputs in the hardware configuration are addressed, go to "Device and network" in the project browser. In the working window, make sure you're in the "Device view" tab, and select the desired device:

Select the CPU, then use the two small arrows (see figure 20) to bring up the "Device overview" tab. The input and output addresses appear. These can be modified by entering a new value in the corresponding box.

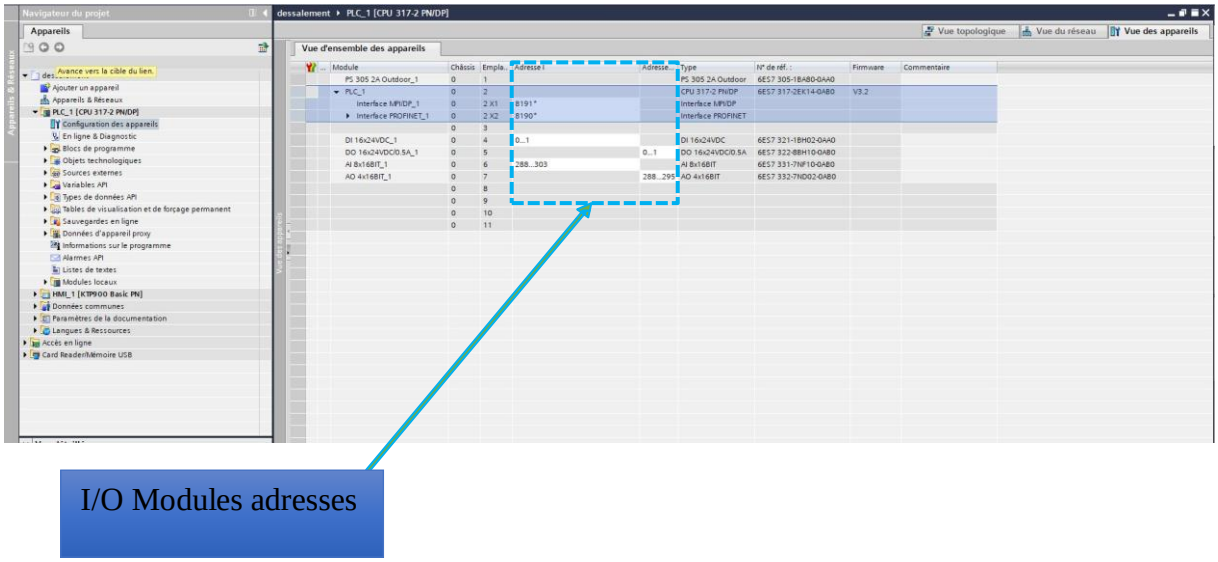


Figure 30: I /O Adressing

III. Creating a project in TIA PORTAL V13:

To create a new project in TIA portal, we need to create and configure it directly, which allows us to easily manage our project.

Double-click on the TIA portal icon to open the main window, select a new project and validate it. select and submit a new project

Moving on to the second step, we click on the "Devices and networks" button to select the devices that will make up our system.

We need to choose a PLC type and a HMI human/machine interface.

1 Hardware configuration:

To insert the CPU, click on "Configure a device" and then on the "Add a device" command This step is important, as it concerns the layout of chassis, modules and decentralized peripherals. Modules are supplied with default parameters.

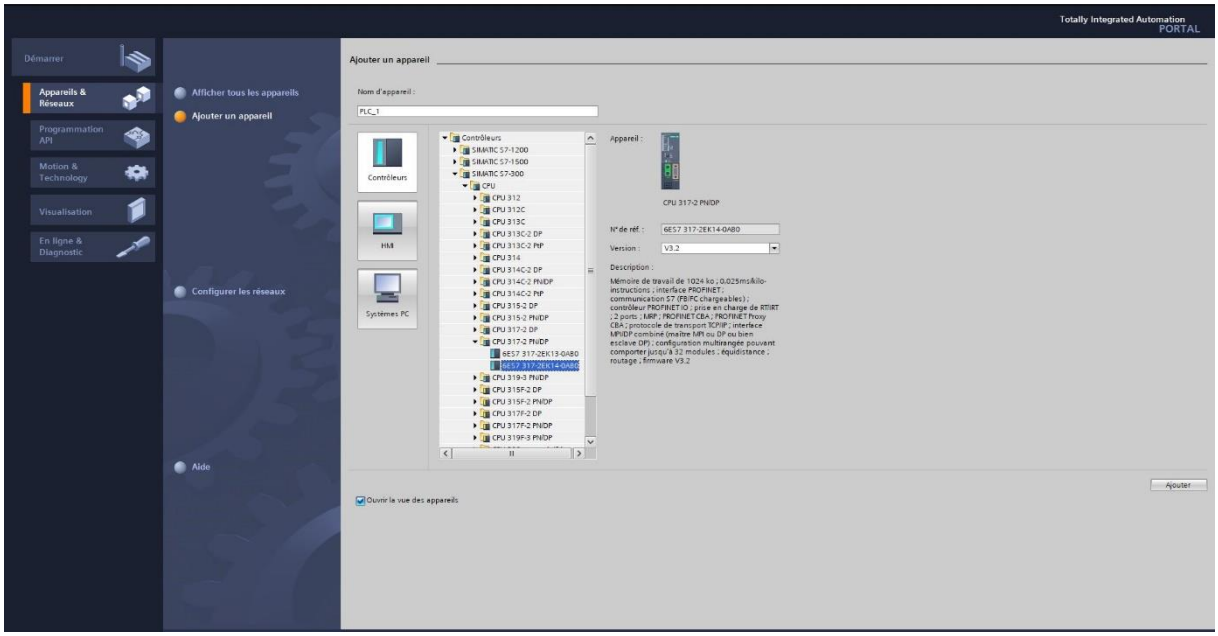


Figure 31: Hardware configuration.

2 Creating the variable table (Software section):

In any program, it is necessary to define the list of variables that will be used during programming. To do this, we create a variable table in the TIA. Using appropriate names makes the program easier to understand and manipulate. This type of addressing is called "relative", and we edit the table of variables according to our specifications, for inputs and outputs. Figure 28 shows some of the variables for our desalination station.

1	PB_start	Bool	%I0.0
2	PB_stop	Bool	%I0.1
3	emergency_stop	Bool	%I0.2
4	seawater supply pump 1 started	Bool	%I0.3
5	seawater supply pump 2 started	Bool	%I0.4
6	seawater valve opened	Bool	%I0.5
7	dessal water pump 1 started	Bool	%I0.6
8	dessal water pump 2 started	Bool	%I0.7
9	princ dessal water valve opened	Bool	%I1.0
10	dessal tank valve supply opened	Bool	%I1.1
11	seawater supply pump 1	Bool	%Q0.0
12	seawater supply pump 2	Bool	%Q0.1
13	seawater valve	Bool	%Q0.2
14	dessal water pump 1	Bool	%Q0.3
15	dessal water pump 2	Bool	%Q0.4
16	princ dessal water valve	Bool	%Q0.5
17	dessal tank valve supply	Bool	%Q0.6
18	reject valve	Bool	%Q0.7
19	brine pump	Bool	%Q1.0
20	brine valve	Bool	%Q1.1
21	system started	Bool	%M0.0
22	DCS	Bool	%M10.0
23	LCP	Bool	%M10.1
24	STEAM WATER SUPPLY DRUM LEVE...	Int	%IW288
25	BIPOLAR1	Bool	%M100.0

Figure 32: PLC variables of the station

3 PLC programming (Software section):

- Code blocks

The block folder contains the blocks to be loaded into the CPU to perform the automation task. It comprises the code blocks (OB, FB, SFB, FC, SFC), which contain the programs, and the instance DB and global DB data blocks, which contain the program parameters.

- **Organization blocks (OB)**

OBs are called up by the operating system. There are several types

- Those that manage the processing of cyclic programs,
- Those triggered by an event,
- Those that manage the PLC's start-up behavior
- And finally, those that handle errors.

Block OB1 is generated automatically when a project is created. It is the cyclic program called by the operating system.

- **Function blocks (FB)**

The FB is a sub-program written by the user and executed by code blocks. It is associated with an instance data block containing its parameters and memory.

SFBs (Special Function Blocks) are used for special functions integrated into the CPU.

- **Functions (FC)**

The FC contains routines for frequently used functions. It is memoryless and saves its temporary variables in the local data stack. However, it can access global data blocks to save its data.

SFCs (Sequential Function Charts) are used for special functions integrated into the S7 CPU, and are called from the program.

- **Data blocks (DB)**

Unlike code blocks, which contain instructions, data blocks (DB) are used solely to store information and data. User data stored in these blocks will later be used by other blocks.

A. Creating the station program

In this section, we'll show the links between the blocks that make up the program. This architecture is shown in the following figure:

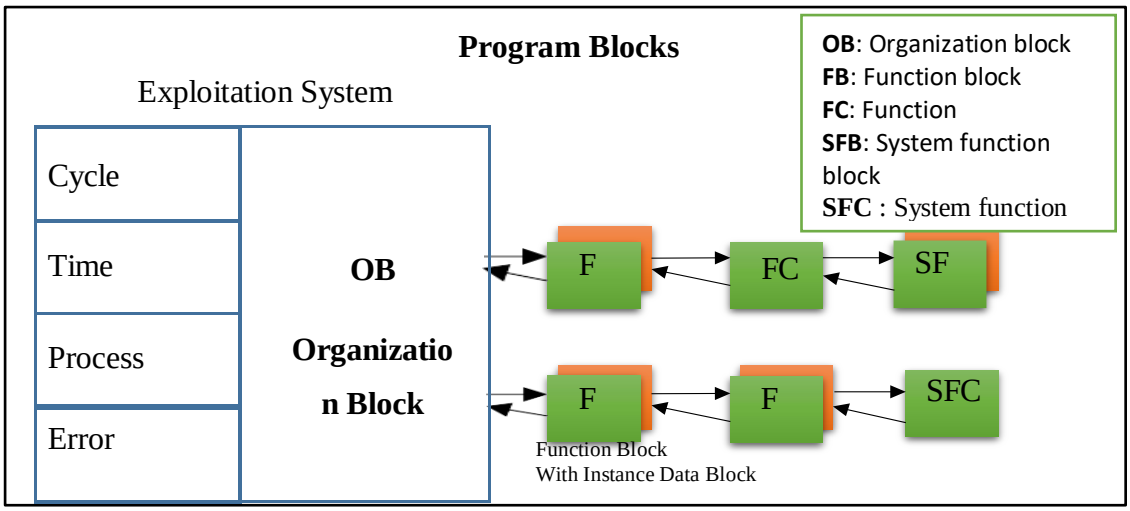


Figure 33: Links between the blocks

B. Block programming:

The blocks are programmed from the deepest sub-block to the main block. The language chosen for programming is (GRAPH), and we'll start by programming the functional blocks. In the following, we present some of the blocks of our desalination station program:

FB: block FB1 is associated with a function block. Function blocks are programming elements used in PLC programming with the graphical programming language S7.

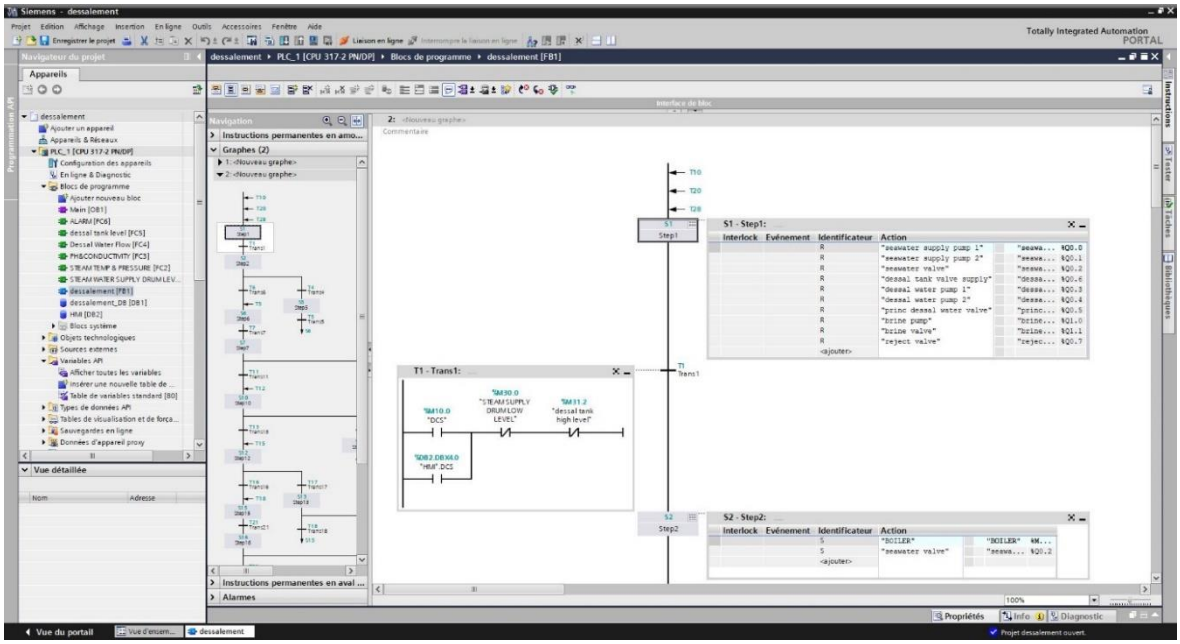


Figure 34:View of function bloc FB1

FC: The blocks FC1, FC2, FC3, FC4, FC5 are programmed to process analog values. The measurement supplied by the sensor is converted from an electrical signal into a digital value to define the thresholds. The SCALE function available in the standard library is used for this purpose. The numerical value is stored in the instance DB specific to each measurement, and displayed on the Control Station. Here's an overview of the internal view of the block:

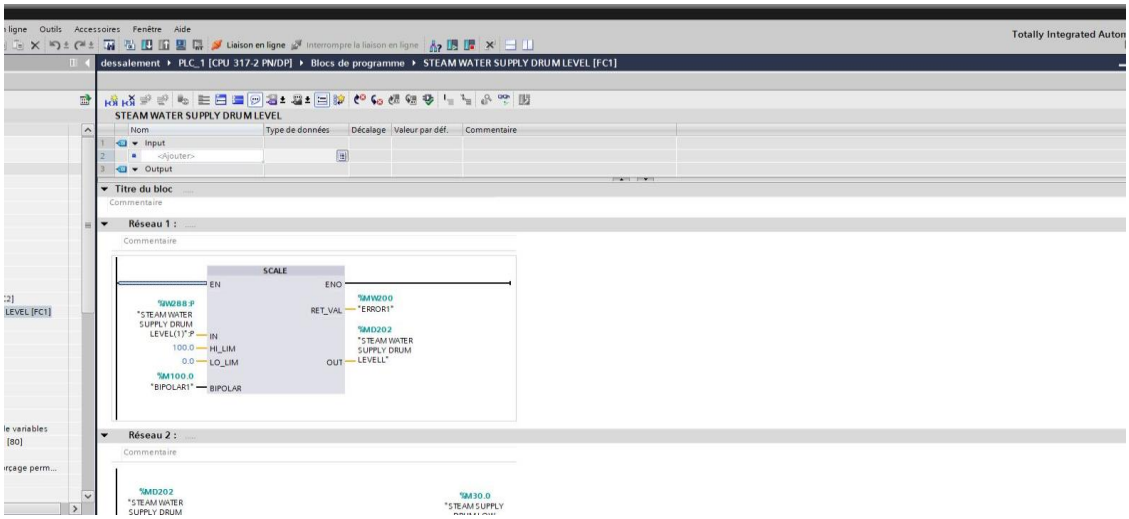


Figure 35: View of FC1 block [STEAM WATER SUPPLY DRUM LEVEL]

ALARM block: The ALARM block provides a hierarchy of alarms according to their criticality, assigning priorities and setting specific actions for each alarm level:

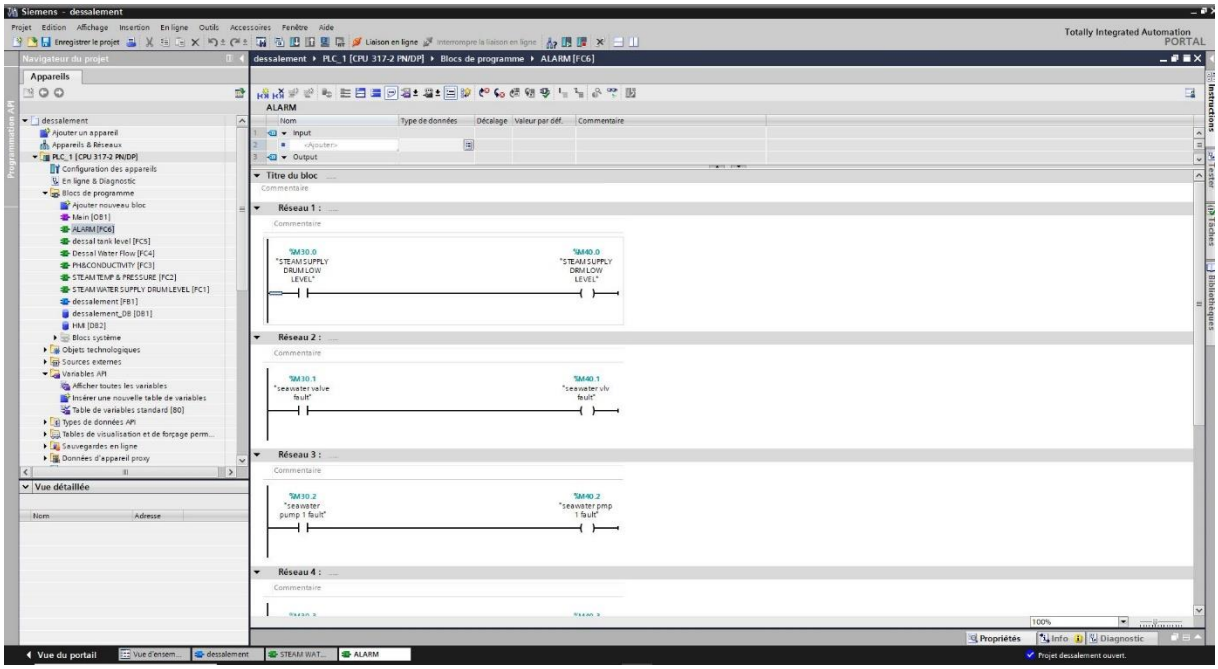
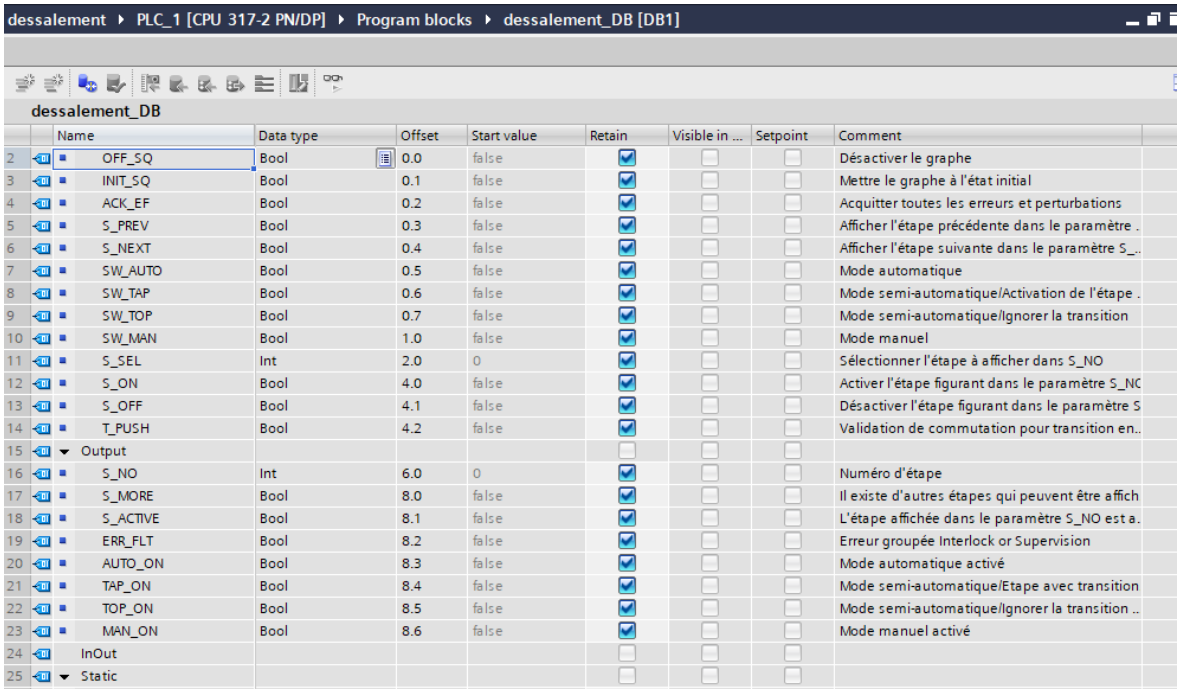


Figure 36: View of the FC6 [ALARM] block

DB: The data block (DB) contains the information exchanged, and is programmed by inserting the data in a table. Here's an overview:



dessalement ▸ PLC_1 [CPU 317-2 PN/DP] ▸ Program blocks ▸ dessalement_DB [DB1]

dessalement_DB

	Name	Data type	Offset	Start value	Retain	Visible in ...	Setpoint	Comment
2	OFF_SQ	Bool	0.0	false	☑	☐	☐	Désactiver le graphe
3	INIT_SQ	Bool	0.1	false	☑	☐	☐	Mettre le graphe à l'état initial
4	ACK_EF	Bool	0.2	false	☑	☐	☐	Acquitter toutes les erreurs et perturbations
5	S_PREV	Bool	0.3	false	☑	☐	☐	Afficher l'étape précédente dans le paramètre .
6	S_NEXT	Bool	0.4	false	☑	☐	☐	Afficher l'étape suivante dans le paramètre S_..
7	SW_AUTO	Bool	0.5	false	☑	☐	☐	Mode automatique
8	SW_TAP	Bool	0.6	false	☑	☐	☐	Mode semi-automatique/Activation de l'étape .
9	SW_TOP	Bool	0.7	false	☑	☐	☐	Mode semi-automatique/Ignorer la transition
10	SW_MAN	Bool	1.0	false	☑	☐	☐	Mode manuel
11	S_SEL	Int	2.0	0	☑	☐	☐	Sélectionner l'étape à afficher dans S_NO
12	S_ON	Bool	4.0	false	☑	☐	☐	Activer l'étape figurant dans le paramètre S_NO
13	S_OFF	Bool	4.1	false	☑	☐	☐	Désactiver l'étape figurant dans le paramètre S
14	T_PUSH	Bool	4.2	false	☑	☐	☐	Validation de commutation pour transition en..
15	Output				☐	☐	☐	
16	S_NO	Int	6.0	0	☑	☐	☐	Numéro d'étape
17	S_MORE	Bool	8.0	false	☑	☐	☐	Il existe d'autres étapes qui peuvent être affich
18	S_ACTIVE	Bool	8.1	false	☑	☐	☐	L'étape affichée dans le paramètre S_NO est a.
19	ERR_FLT	Bool	8.2	false	☑	☐	☐	Erreur groupée Interlock or Supervision
20	AUTO_ON	Bool	8.3	false	☑	☐	☐	Mode automatique activé
21	TAP_ON	Bool	8.4	false	☑	☐	☐	Mode semi-automatique/Etape avec transition
22	TOP_ON	Bool	8.5	false	☑	☐	☐	Mode semi-automatique/Ignorer la transition ..
23	MAN_ON	Bool	8.6	false	☑	☐	☐	Mode manuel activé
24	InOut				☐	☐	☐	
25	Static				☐	☐	☐	

Figure 37: DB1 data block

OB: OB1 groups the instructions that the program will execute in a cyclical manner, calling all functions:

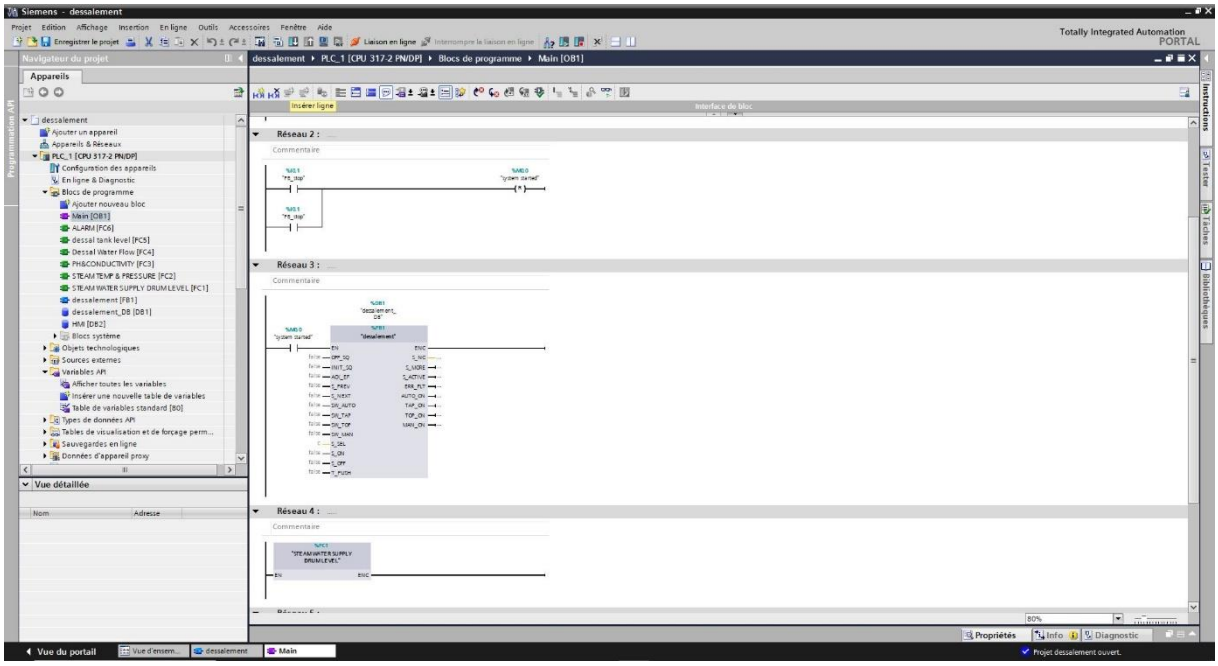


Figure 38: View of block OB1 [MAIN].

IV Supervision of the desalination plant using the TIA PORTAL:

IV.1 Definition of industrial supervision:

Industrial supervision is used for monitoring an industrial system or machine in real time. It provides a dynamic display of the process, including alarms, faults and events during operation. Recently, new supervision processes have begun to be deployed, based on distributed system architectures that enable remote monitoring or supervision.

Supervision software often incorporates data and event logging systems, enabling data to be exported in Excel or CSV format, for example. This functionality enables the production operator to optimize production by determining required raw materials, and to plan maintenance operations. Supervision is therefore virtually indispensable on complex automated installations. Supervision systems can also include alert systems that can send an alert SMS or warn the operator in the event of a problem on the production line.

IV.2 Constitution of a supervision system:

Most supervision systems comprise a main driver (software), to which data from the equipment (PLCs) is attached. The supervision software is responsible for display, data processing, archiving and communication with other peripherals.

The supervision system is made up of several modules with specific roles:

- The visualization module provides operators with real-time information on the process through a variety of data.
- The archiving module stores data, such as alarms and events, over a long period of time. It can then be used for maintenance or production control applications.
- The processing module formats the data so as to present it to operators via the visualization module, using a predefined presentation.
- The communication module acquires and transfers data, and manages communication with PLCs.

Together, these modules enable the supervision system to obtain, process, archive and communicate data for effective process control and monitoring. [26]

IV.3 Presentation of WINCC supervision in TIA PORTAL software:

Win CC (TIA portal) is an engineering software package used to configure SIMATIC panels, SIMATIC industrial PCs and standard PCs via the visualization software. SIMATIC WinCC in the TIA Portal is part of a new, integrated engineering concept that offers a homogeneous engineering environment for programming and configuring control, visualization and drive solutions. It's the software for all HMI applications, from simple control solutions with basic panels to SCADA applications for PC-based multi-station systems.

So it's the software for all HMI applications ranging from simple control solutions with basic panels to SCADA applications for PC-based multi-station systems. [28]

The steps in the WinCC supervision process are summarized in the following figure:

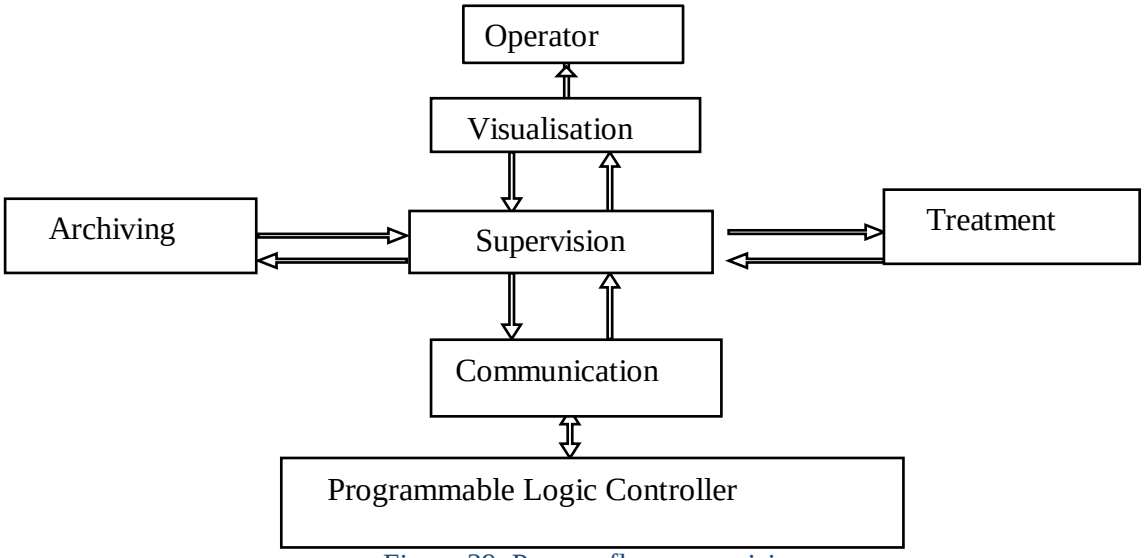


Figure 39: Process flow supervision

IV.3.1 Advantages of WINCC:

The SIMATIC WinCC program enables:

- improve productivity (configuration efficiency) when creating HMI projects.
- implement innovative HMI and automation concepts using TCP/IP networks and the web.
- Increase machine and installation availability through new maintenance concepts.
- access processing data easily and securely from anywhere in the world.
- Consistent configuration software reduces training, maintenance and servicing costs, and ensures product scalability.
- Minimized engineering costs thanks to TIA (totally integrated automation).

- ❖ Intelligent tools for simple, efficient configuration.
- ❖ Comprehensive multilingual configuration support for global implementation.
- ❖ Optimized price/performance factor thanks to customizable system functionalities.
- ❖ Flexible runtime functionality thanks to Visual Basic scripts.
- ❖ Innovative maintenance concepts with remote control, diagnostics, administration via intranet/internet and e-mail communication enhance availability.
- ❖ Support for simple distributed automation solutions based on TCP/IP networks at machine level. [29]

IV.3.2 Available applications in WINCC:

WinCC offers several applications for supervision:

- **Graphic Designer:** Creates process views by configuring the corresponding variables using an object library. Provides the visualization function via graphics runtime.
- **Tag Logging:** Allows you to define archives, process values to be archived and logging cycle times.
- **Alarm Logging:** Manages the acquisition and archiving of alarms, providing the necessary functions for processing, viewing, acknowledging and archiving process alarms.
- **Global Script Runtime:** Includes editors for C and Visual Basic (VBS), enabling the creation of customized actions and functions not provided for in WinCC Flexible.
- **Report Designer:** Creates print reports using specific information and customizable layout templates.
- **User Administrator:** Manages users and authorizations. Create new users, assign passwords and specific authorizations.

Using these different applications, WinCC Flexible offers a complete range of functionalities for the supervision and management of industrial processes.

IV.4 Development of a supervision system under WINCC:

The supervision program we developed was based on the WinCC software developed by SIEMENS.

IV.4.1 Implementation of a supervision system:

To create a human/machine interface, it is necessary to be familiar with the elements of the installation, as well as the PLC programming software used. We created the supervision interface using TIA PORTAL V13, the latest software developed by SIEMENS and the best suited to the hardware used. The main steps involved in creating our WinCC application are as follows:

- Create a project.
- Select and install the API.
- Define variables in the variable editor.
- Create and edit views (home view, all works view) in the Graphics designer editor.
- Set WinCC runtime properties.
- Activate views in WinCC runtime.
- Use the simulator to test process views.

IV.4.2 Establishing a direct link:

The first thing to do is to create a direct link between TIA PORTAL V13 and the S7-300, so that TIA PORTAL V13 can read data from the PLC's memory. To create the link, we select our PLC, right-click on it and choose "online and diagnostics". The devices are configured so that the link is in MPI mode, via the PLCSIM card. Here's a preview of the direct link view :

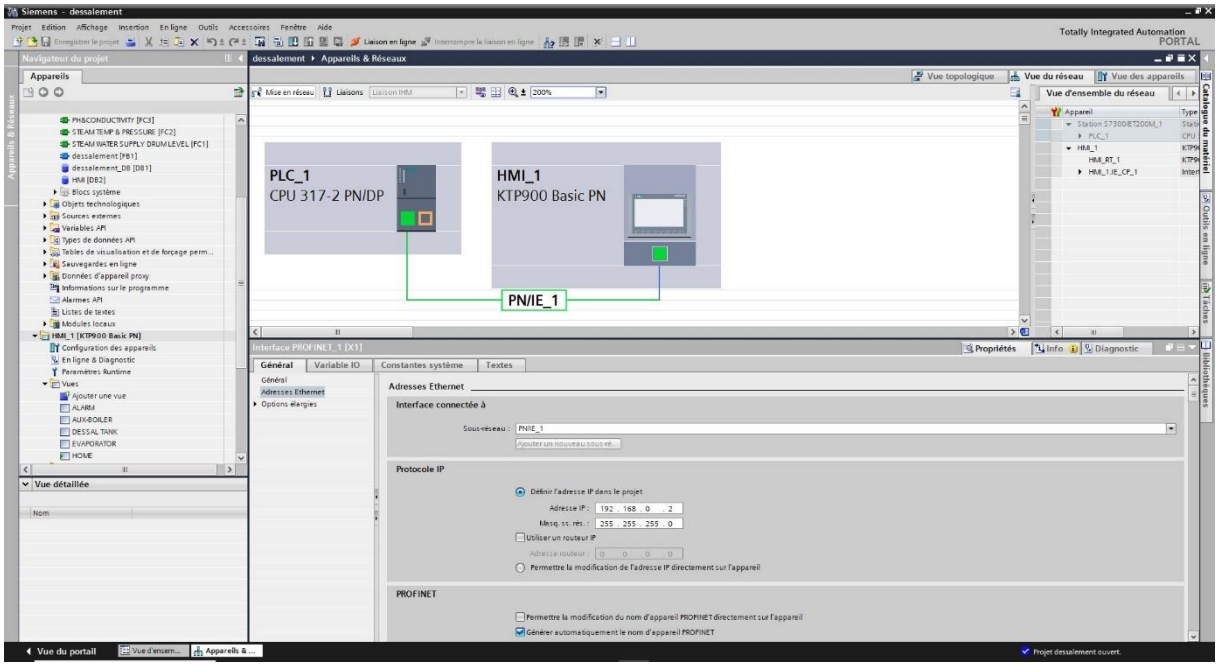
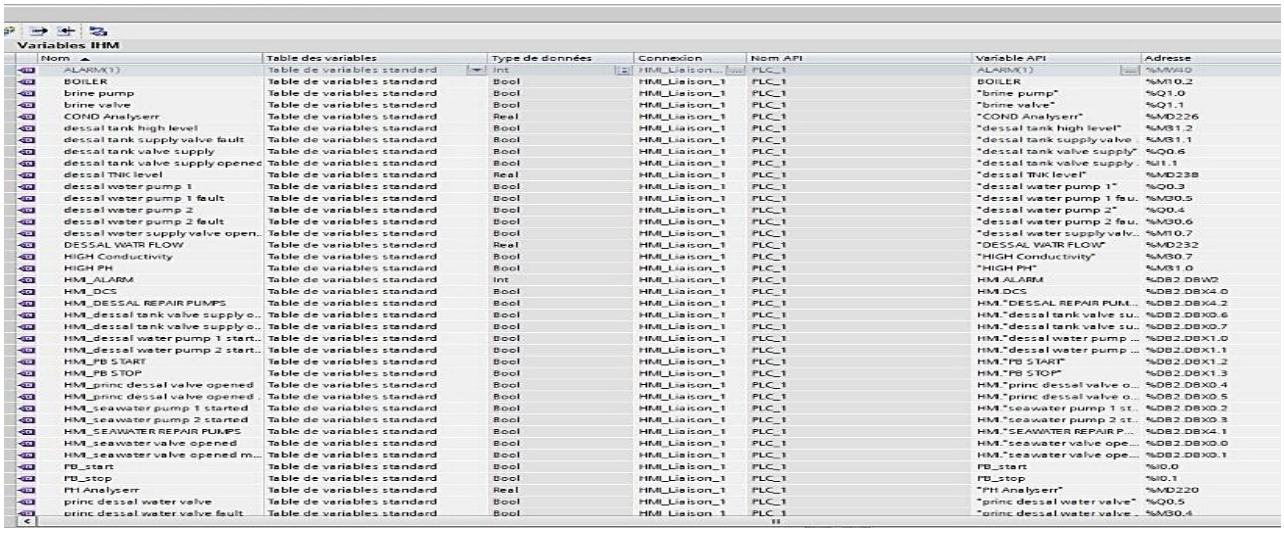


Figure 40: PLC and HMI link.

IV.4.3 Creating the table of HMI variables:

Once the link between the TIA PORTAL project and the S7-300 PLC has been established, it is now possible to access all the PLC's memory sections, which can be memories: input/output, mementos, data blocks. Variables are used to communicate and exchange data between the HMI and the machines. A correspondence table of HMI variables is created via the variable tab.

Each line corresponds to an HMI variable. It is specified by: name, data type, variable table, connection, PLC name, address, access mode. The "Variables" editor displays all project variables. As shown in the figure below:



Variables IHM

Nom	Table des variables	Type de données	Connexion	Nom API	Variable API	Adresse
ALARM(1)	Table de variables standard	Int	HMI_Liaison...	PLC_1	ALARM(1)	%MW40
BOILER	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	BOILER	%M10.2
brine pump	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"brine pump"	%Q1.0
brine valve	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"brine valve"	%Q1.1
COND Analyserr	Table de variables standard	Real	HMI_Liaison_1	PLC_1	"COND Analyserr"	%MD226
dessal tank high level	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"dessal tank high level"	%M31.2
dessal tank supply valve fault	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"dessal tank supply valve ...	%M31.1
dessal tank valve supply	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"dessal tank valve supply"	%Q0.6
dessal tank valve supply opened	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"dessal tank valve supply ...	%I1.1
dessal TNK level	Table de variables standard	Real	HMI_Liaison_1	PLC_1	"dessal TNK level"	%MD238
dessal water pump 1	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"dessal water pump 1"	%Q0.3
dessal water pump 1 fault	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"dessal water pump 1 fau...	%M30.5
dessal water pump 2	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"dessal water pump 2"	%Q0.4
dessal water pump 2 fault	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"dessal water pump 2 fau...	%M30.6
dessal water supply valve open...	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"dessal water supply valv...	%M10.7
DESSAL WATR FLOW	Table de variables standard	Real	HMI_Liaison_1	PLC_1	"DESSAL WATR FLOW"	%MD232
HIGH Conductivity	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"HIGH Conductivity"	%M30.7
HIGH PH	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"HIGH PH"	%M31.0
HMI_ALARM	Table de variables standard	Int	HMI_Liaison_1	PLC_1	HMI_ALARM	%DB2.DBW2
HMI_DCS	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_DCS	%DB2.DBX4.0
HMI_DESSAL REPAIR PUMPS	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_"DESSAL REPAIR PUM...	%DB2.DBX4.2
HMI_dessal tank valve supply o...	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_"dessal tank valve su...	%DB2.DBX0.6
HMI_dessal tank valve supply o...	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_"dessal tank valve su...	%DB2.DBX0.7
HMI_dessal water pump 1 start...	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_"dessal water pump ...	%DB2.DBX1.0
HMI_dessal water pump 2 start...	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_"dessal water pump ...	%DB2.DBX1.1
HMI_PB START	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_"PB START"	%DB2.DBX1.2
HMI_PB STOP	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_"PB STOP"	%DB2.DBX1.3
HMI_princ dessal valve opened	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_"princ dessal valve o...	%DB2.DBX0.4
HMI_princ dessal valve opened	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_"princ dessal valve o...	%DB2.DBX0.5
HMI_seawater pump 1 started	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_"seawater pump 1 st...	%DB2.DBX0.2
HMI_seawater pump 2 started	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_"seawater pump 2 st...	%DB2.DBX0.3
HMI_SEAWATER REPAIR PUMPS	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_"SEAWATER REPAIR P...	%DB2.DBX4.1
HMI_seawater valve opened	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_"seawater valve ope...	%DB2.DBX0.0
HMI_seawater valve opened m...	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	HMI_"seawater valve ope...	%DB2.DBX0.1
PB_start	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	PB_start	%I0.0
PB_stop	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	PB_stop	%I0.1
PH Analyserr	Table de variables standard	Real	HMI_Liaison_1	PLC_1	"PH Analyserr"	%MD220
princ dessal water valve	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"princ dessal water valve"	%Q0.5
princ dessal water valve fault	Table de variables standard	Bool	HMI_Liaison_1	PLC_1	"princ dessal water valve ...	%M30.4

Figure 41: Table of HMI variables

IV.5 Desalination plant control and supervision presentation:

The TIA PORTAL V13 interface can be used to create views for monitoring and controlling the plant. When creating views, predefined objects are available for displaying procedures and defining process values.

We have programmed four supervisory views to provide the operator with all the necessary information on our pumping station:

To do this, we have created the home view (figure 38), which contains the enter button. This button will allow us to display the initial view, from which we can select the view to be displayed, in particular:

- BLOCK1: EVAPORATOR
- BLOCK2: AUX-BOILER
- BLOCK3: DESSAL TANK
- BLOCK4: ALARM

❖ The "HOME" view

Through this view (figure 37), we have represented the entry to the general view of our Desalination plant, starting with the blocks, the START button, the STOP button "emergency stop button", "DCS" and "ALARM»:

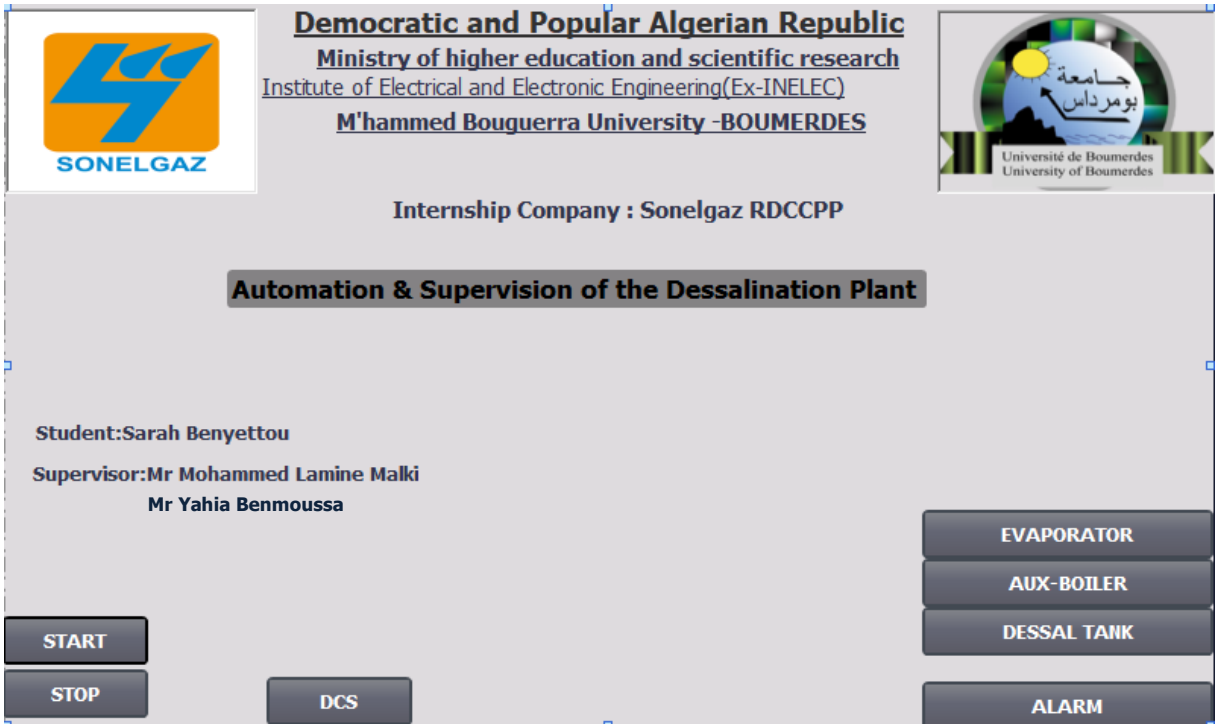


Figure 42: Home view

❖ **The "EVAPORATOR" view**

The EVAPORATOR view represents the evaporator with three cells that receives salted water from the sea. The system involves multiple effect evaporation, which receives boiled water from an auxiliary boiler. The evaporator uses valves, pumps, and sensors for conductivity, pH, pressure, temperature and flow rate to control the process., it is shown in the following figure:

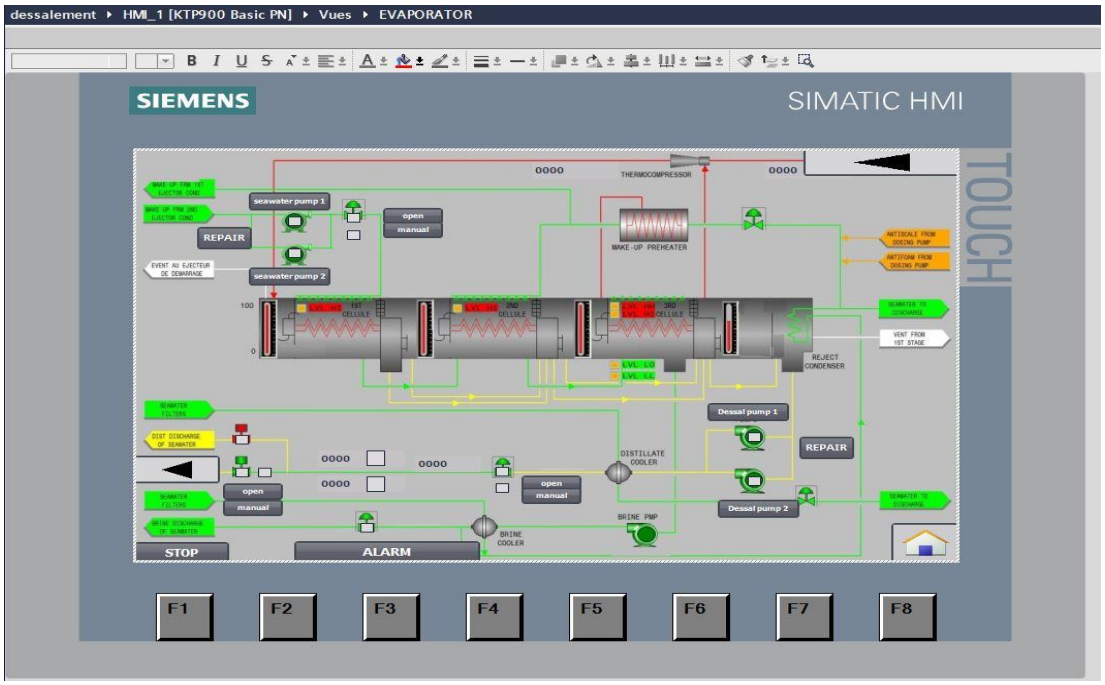


Figure 43: EVAPORATOR view

❖ **The AUX-BOILER view :**

The AUX-BOILER view represents the auxiliary boiler, which primarily consists of a steam drum and a STEAM SUPPLY DRUM LEVEL transmitter, and a feed water tank. The steam drum is a crucial component of the boiler system, responsible for ensuring that the steam supplied is clean and free of moisture. The feed water tank is utilized to store and treat the water that is fed into the boiler to produce steam.

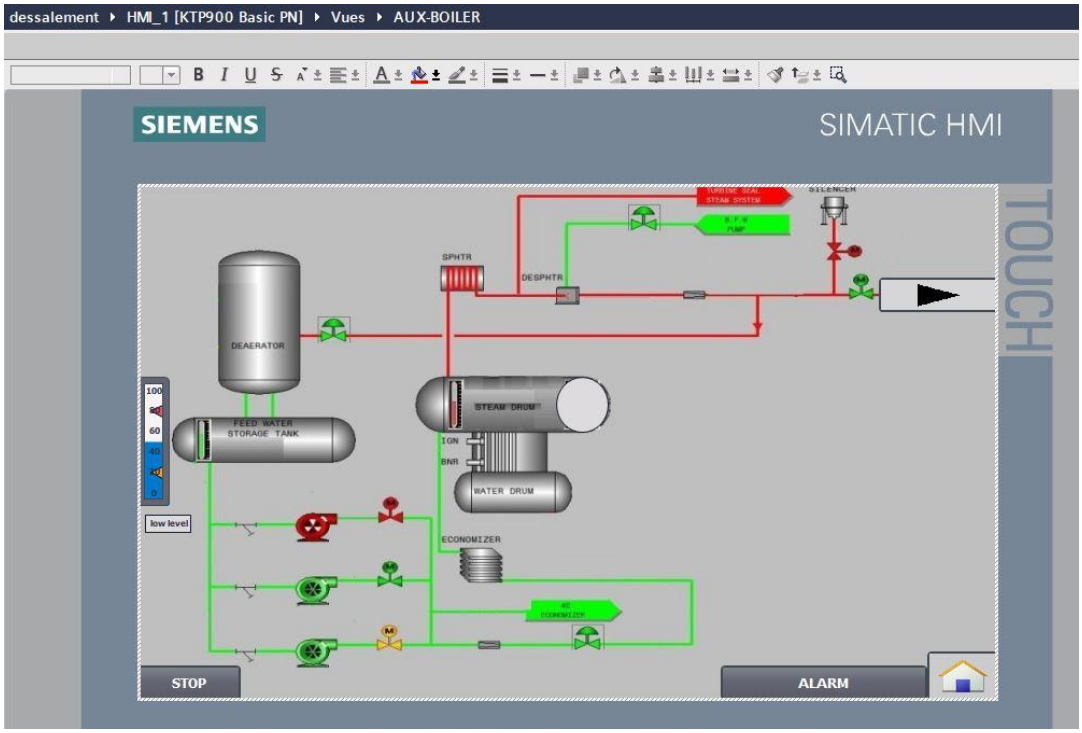


Figure 44: AUX-BOILER view

❖ **The "DESSAL TANK" view**

The DESSAL TANK view represents the 12,000 cubic meter tank, which is accompanied by a level transmitter.

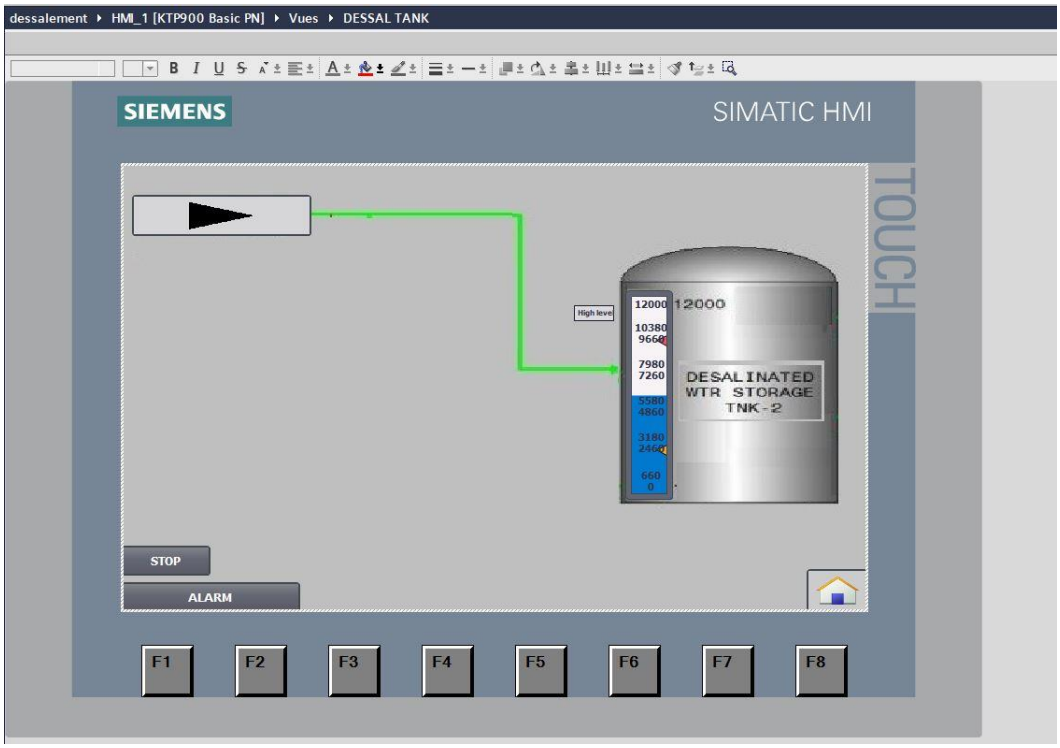


Figure 45: DESSAL TANK view

❖ **The "ALARM" view**

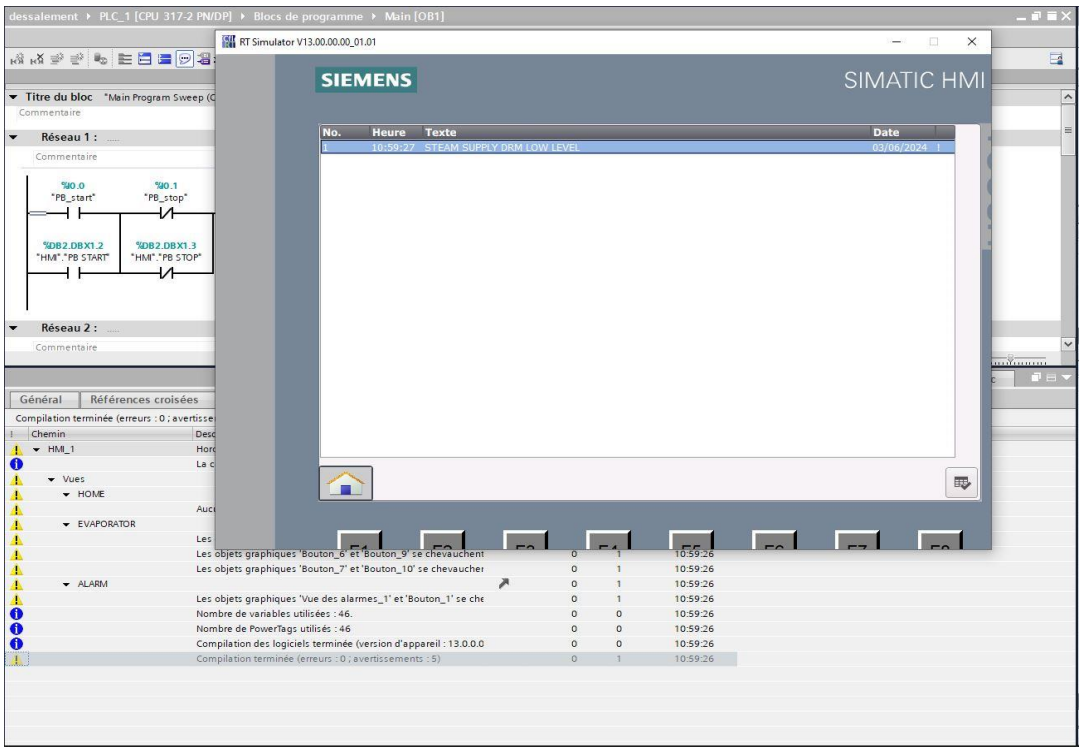
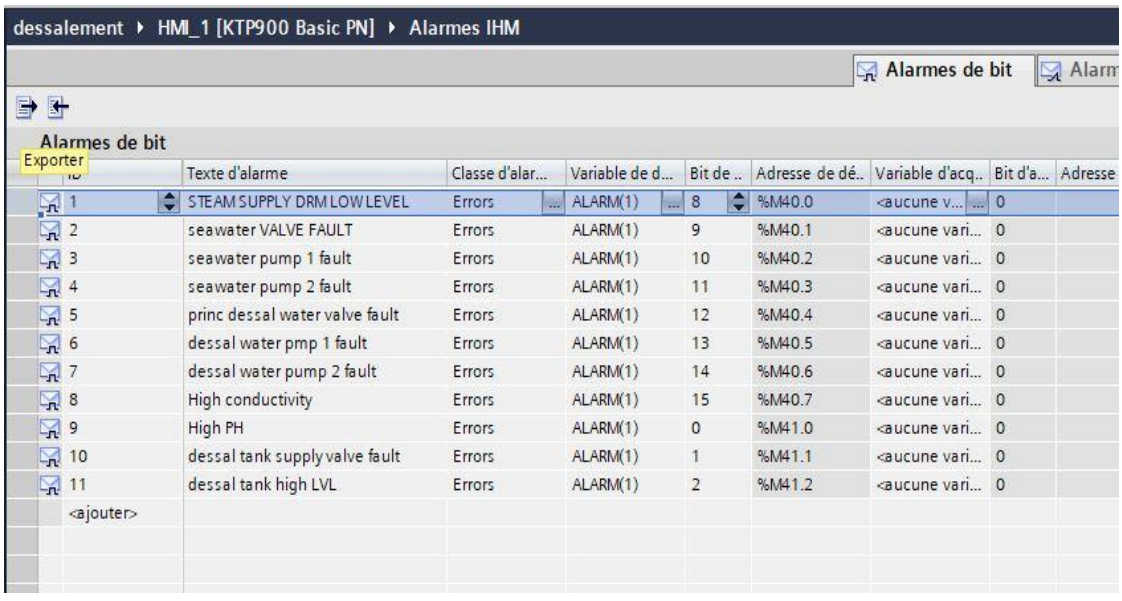


Figure 46: ALARM view

The figure below illustrates the main alarms in our system:



	Texte d'alarme	Classe d'alar...	Variable de d...	Bit de ..	Adresse de dé..	Variable d'acq..	Bit d'a...	Adresse
1	STEAM SUPPLY DRM LOW LEVEL	Errors	ALARM(1)	8	%M40.0	<aucune v...	0	
2	seawater VALVE FAULT	Errors	ALARM(1)	9	%M40.1	<aucune vari...	0	
3	seawater pump 1 fault	Errors	ALARM(1)	10	%M40.2	<aucune vari...	0	
4	seawater pump 2 fault	Errors	ALARM(1)	11	%M40.3	<aucune vari...	0	
5	princ dessal water valve fault	Errors	ALARM(1)	12	%M40.4	<aucune vari...	0	
6	dessal water pmp 1 fault	Errors	ALARM(1)	13	%M40.5	<aucune vari...	0	
7	dessal water pump 2 fault	Errors	ALARM(1)	14	%M40.6	<aucune vari...	0	
8	High conductivity	Errors	ALARM(1)	15	%M40.7	<aucune vari...	0	
9	High PH	Errors	ALARM(1)	0	%M41.0	<aucune vari...	0	
10	dessal tank supply valve fault	Errors	ALARM(1)	1	%M41.1	<aucune vari...	0	
11	dessal tank high LVL	Errors	ALARM(1)	2	%M41.2	<aucune vari...	0	
<ajouter>								

Figure 47: Main Alarms

V. Conclusion:

In this chapter, we have presented an overview of the SIMATIC programmable logic controller we have adopted to control our station, as well as its SIMATIC TIA PORTAL programming software.

In this final chapter, devoted to the HMI supervision of the Cap Djinet seawater desalination station, we describe supervision and explain its place in industry. Using WinCC software in the tia portal, we have developed views that enable you to monitor.

General Conclusion:

After completing our comprehensive study, we have concluded that the success of every automation project is dependent on two essential elements: a comprehensive investigation of the process to be managed and prudent selection of automation to use. In our work, we first studied the operation of the CAP DJINET power plant, focusing particularly on the desalination station that we carefully modeled using the GRAFCET tool.

This modeling allowed us to understand in detail the different steps and actions necessary to successfully automate this station. Next, we introduced the PLCs in general and then focused on the S7-300 controller. Based on the characteristics of this controller, we developed a program using the TIA Portal software to automate the station. Then, we carried out simulations in order to validate the effectiveness of our solution and to identify possible errors or necessary adjustments. Finally, to complete our project, we created a user-friendly supervision interface (HMI) using WinCC software.

This interface allows real-time control of the desalination station, providing operators with a clear visualization of station parameters and status. In conclusion, we look forward to see what applications and developments our work will inspire, and we hope that our findings will be helpful as a reference for upcoming students and experts in the field.

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