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Gas Turbine Unit Type (GE FRAME 9E) The Component of Unit and The Fundamentals of Operation Sequence- A Training Course for New Employees

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Abstract
The evolution of energy generation, from coal to oil to nuclear and now renewable sources, has shaped the global energy landscape. With a growing emphasis on environmental protection and diversification of energy sources, gas turbines have emerged as a prominent player. This paper focuses on the gas generating unit type (GT F9E) manufactured by GE, aiming to inform engineering and technical personnel about its components, operation, and qualifications required for personnel. The research addresses the need to equip new cadre in power plants with knowledge and training for optimal operation of these units. Details include the unit's specifications such as compressor and turbine stages, combustion chambers, and operational principles. Components like the intake air system, compressor, combustion system, turbine, exhaust system, and support system are explained, along with their functions. The gas stream path, from intake to exhaust, is delineated to provide a comprehensive understanding of the unit's operation.
Keywords: Turbine, Iraq, GE Frame 9E, Replenishment Principle.

1. Introduction

Gas generating unit type (GT F9E)

The discovery of various types of coal was the cornerstone of the industrial revolution in the mid-eighteenth century. The discovery of oil in 1859 was a turning point in human history, especially in the field of electric power generation, as steam turbines were developed to run on oil instead of coal. Diesel engines are commonly used to generate power, as are gas turbines that use fuel or gas. In 1956, the former Soviet Union built the first nuclear reactor to produce electricity, followed by Britain in 1956, France in 1959, and America in 1961. Then the use of nuclear reactors with increasing capacities to generate electrical energy spread throughout the world. Due to the increasing rise in oil prices, the interest in protecting the environment from gases resulting from the combustion of coal and oil, and the fear of nuclear pollution that may be generated by nuclear power plants; Interest in generating clean energy from natural sources, such as wind and solar energy, has increased, and this source has become economically competitive with other sources of thermal energy. Figure No. (1) shows the increase in global energy consumption until 2001, as well as the expected increase after that until 2025, when it is estimated that the distribution of energy generation sources will be 39% from oil, 25% from gas, 23% from coal, and 8% from renewable energies. And 5% of the energy Nuclear

Types of power plants

Thermal power plants.
Hydropower plants.
Solar power plants.
Wind power plants.
Power plants generated by sea waves.
Nuclear power plants.

1.1 The goal of this research

Informing the engineering and technical personnel working in gas electrical stations on the parts of the gas generating unit type (F9E) manufactured by the American company (GE), as well as preparing and operating the units and what qualifications are required for the operating personnel for these units.

1.2 The problem

Most of the cadres working in electric power generation plants are new cadres who work under contracts concluded with new projects. This requires giving them a picture of the generating units and the steps to set up and operate the units, as well as introducing them to training courses inside and outside the country) to raise their levels in order to achieve optimal operation of the generating units and in order to Therefore, I prepared this paper which represents an explanation of the parts of the (GE F9E) gas unit, as follows: -
Number of compressor stages: 17 stages.
Number of turbine stages: 3 stages.
Number of combustion chambers / 14 chambers.
Number of stoves: two self-retracting in rooms 13 and 14.
Number of flame detectors: 4 in rooms 4,5,10,11
Number of pregnant women / 3.
Turbine speed 3000 r/min.
It works on the principle of the Simple Cycle. The turbine consists of one axis (Single Shaft) and contains (14) combustion chambers with reverse flow because the air flows inside the chamber.
Combustion in the opposite direction of fuel flow.
The gas unit consists of the following main parts:
. Intel Air System (Intake Air System).
. Compressor.
. Combustion System.
. Turbine.
. Exhaust system.
. Support System.
In this research, we will explain the basic components of the gas unit, how it operates, and what is the function of each unit parts .
The term gas stream means the path taken by the gases inside the unit from the air intake system and its entry into the compressor through the combustion chambers until it enters the turbine to accomplish the necessary work and then the exhausted gases exit (Exhaust Flow Gases) into the exhaust gas stream and then into the chimney as shown in The following simplified form in fig. 1 .

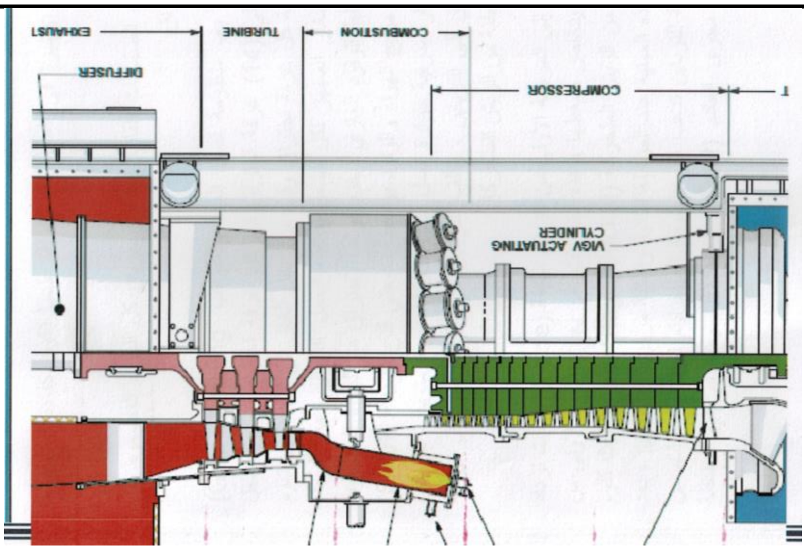

Figure 1air flow inside the gas turbine unit type GE F9E

When the unit begins to rotate using the Starting System, and because of the speed resulting from this rotation, the compressor pulls atmospheric air through it passing through a system of filters, and after passing through the filters, the atmospheric air enters the compressor to compress it through the 17 stages in the compressor.

To avoid the reverse flow of air inside the compressor (pumping), a portion of the incoming air was drawn from stage No. (11) through four lines emerging from this stage, and on each line there is a valve. These valves are called "bleed valves." These valves are open at the beginning. Operating when the compressor speed is low, as through these pipes a portion of the air is extracted from the compressor directly to the chimney without passing through the turbine.

To prevent the air from receding in the final stages of the compressor, especially when the compressor efficiency is low (at low speed). After connecting the unit to the network, these valves close automatically, so that all the compressed air continues to flow into the compressor and then into the combustion chambers.

The gaseous fuel prepared for the unit after the water and impurity separation system (Reducing Station) is fed evenly into (14) combustion chambers. In each combustion chamber there is a fuel nozzle installed at the front of each combustion chamber, and before the gas enters each combustion chamber, a system of valves regulates The gas pressure supplied to each burner is according to the load required from the unit (Control Valve, the gaseous fuel is mixed inside the combustion chamber with the compressed air coming from the compressor, where the air and fuel mixture is sparked by two Spark Plugs), and the mixture burns and becomes hot gases at a temperature of up to (1200) Degree Celsius, these hot gases pass after the combustion chamber to the turbine. The turbine consists of (3) stages, each stage consisting of a ring of fixed blades and a ring of moving blades. After the combustion chamber, the gases enter the first stage of the fixed blades (nozzle), where the speed of the gases increases at this stage and their pressure decreases. These gases pass after the first stage of the fixed blades to the first stage of the moving blades, the First Stage Bucket, where they the gases rotate the turbine, and this process continues at the second and third stages of the turbine blades. After the gases exit the third stage of the turbine, they go to the exhaust system, so that the gases are directed through the diffuser to the exhaust duct and then to the stack.

2. COMPRESSOR

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The axial-flow compressor (the air flow inside the compressor is parallel to the axis of rotation of the compressor) consists of two parts: a fixed part, which is the compressor cover (Case), and a rotating part, which is the compressor axis (Rotor).The compactor consists of (17) stages, (17) rotating vanes mounted on the rotating axis and (17) fixed vanes mounted on the compactor cover. In the entry area of the compressor and on the front of the fixed part (case), there is a ring of fixed blades called entry directional blades (IV). These blades, because of the possibility of controlling the angle of movement of the blades around their mounting axis, regulate the amount of air drawn into the compressor. During the passage of air from the front of the compressor and through stage (17), and because of the compressor, the air is forced to compress from atmospheric pressure at stage No. (1) to a pressure of about (11) bar) at stage No. (17), as a result of air compression, which causes air molecules to collide and friction. On the surface of the different blades, the air temperature at the end of the compressor increases to reach more than (320) degrees Celsius.

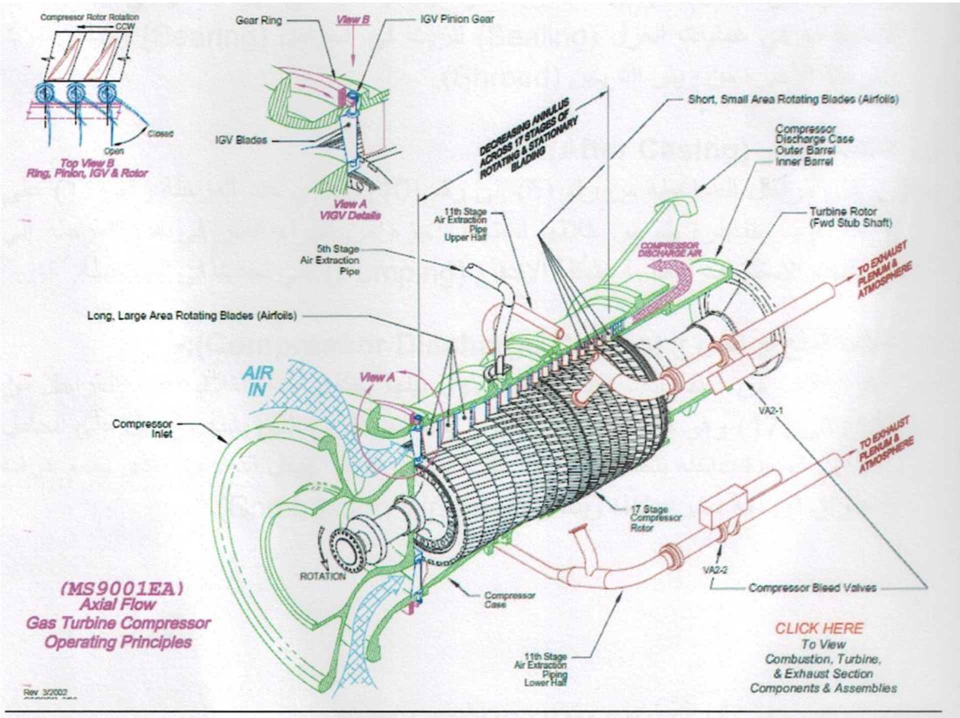

Figure 2 The axial-flow compressor

COMPRESSOR CASING (STATOR CASE) :-

The compressor casing consists of four separate casings that are connected to each other by means of...
Screws.
1. Inlet Casing
Its location is at the front of the compressor and its function is to direct the air drawn from the filters to enter the compressor. It is a double cover that contains within it the holder No. (1) for the Turbine unit).Bearing)
The front of the entry housing is shaped like a bell, so it is called the bell mouth. It is considered the largest mass in the compressor.
At the end of the inlet casing, inlet guide vanes (IGV) are placed, their function is to control the amount of air entering the compressor at different loads.

2. Front cover (Forwarding Casing):-
This casing, which comes after the entry casing, contains the fixed stages of the compressor blades from No. (1) to No. (5) inside it.
There are also two drain tubes in stage (5), which draw in an amount of air passing through this stage for use in sealing operations for the oil in the bearings, as well as for cooling the final stage of the turbine blades (Shroud).
3. After Casing:
It contains stages of the compressor from No. (5) to No. (10). At stage No. (11), it contains four symmetrical holes through which part of the air passing through this stage is drained to the drain valves to address the pumping problem that occurs in the compressor.
4 Compressor Discharge Casing: It is the last casing of the compressor casing and is the longest among them. This casing contains stages from (11) to (17). It is a double casing. The inner casing, which resembles a barrel, contains holder No. (2) for the unit inside it. Attached to the rear end of the thrust housing is the circular structure that houses the fourteen combustion chambers inside it (called the Combustion Wrapper).
Combustion System:
The combustion system consists of (14) combustion chambers with reverse flow, the direction of the air flow opposite to the flow of fuel. These chambers are arranged in a circular shape at the end of the compressor's propulsion casing. This system also contains torches, nozzles, spark plugs, flame detectors, and connecting tubes. Each combustion chamber contains On the following parts:-
1. The igniter (Fuel Nozzle):- Its function is to ignite the mixture of air and fuel. This igniter is capable of burning both types of gaseous fuel.
And the liquid (Dual Fuel).
2 Flow Sleeve:-
Its function is to pass the air coming from the end of the compressor and direct it to the combustion chamber, and it also installs
The combustion plate is in its horizontal position.
3. Combustion Liner:-
It is a thin, perforated cylinder containing several holes of different diameters. It is a curvy plate. The plate contains inside it the fire resulting from the torch. Through the various holes present, a larger amount of air coming from the compressor is mixed with the fire to form the burning gases. This plate is covered with a heat-resistant ceramic material. To prolong its working life, the plate is also made of special metal resistant to high temperatures.
4. Transition Piece:-
It is a curved cylinder with a circular front section and a rectangular rear section. It receives the burnt gases from the combustion plate and transfers them to the first stage of the turbine Fixed blades.
5. Crossfire Tubes:-
They are tubes that connect the combustion chambers (14) to each other in order to spread the fire formed at the beginning of operation at torches No. (13) (14) to all other torches when the sparking process occurs.

6. Spark Plug
It is a means of creating an electric spark resulting from the electrical discharge process that occurs between the two electrodes of a spark plug, in order to create a spark at the beginning of operation.

High voltage is delivered to the mug candle via two voltage transformers mounted on the outer base

For terpene. The mug plug head has a spring that inserts the mug plug into the combustion chamber when switched on and after flame formation.

Because of the pressure created in the combustion chamber, the firing pin pushes out to protect it from burning and damage, so it is called a self-extracting spark plug.

7. Flame Detectors: They deliver information to the control system about the presence or absence of flame inside the combustion chamber. The principle of their work is that each detector contains within it a gas that senses the ultraviolet rays emerging from combustion. The ionization of the gas as a result of the rays generates Direct current (DC) is amplified by an electrical circuit to send to the control room and protection devices.

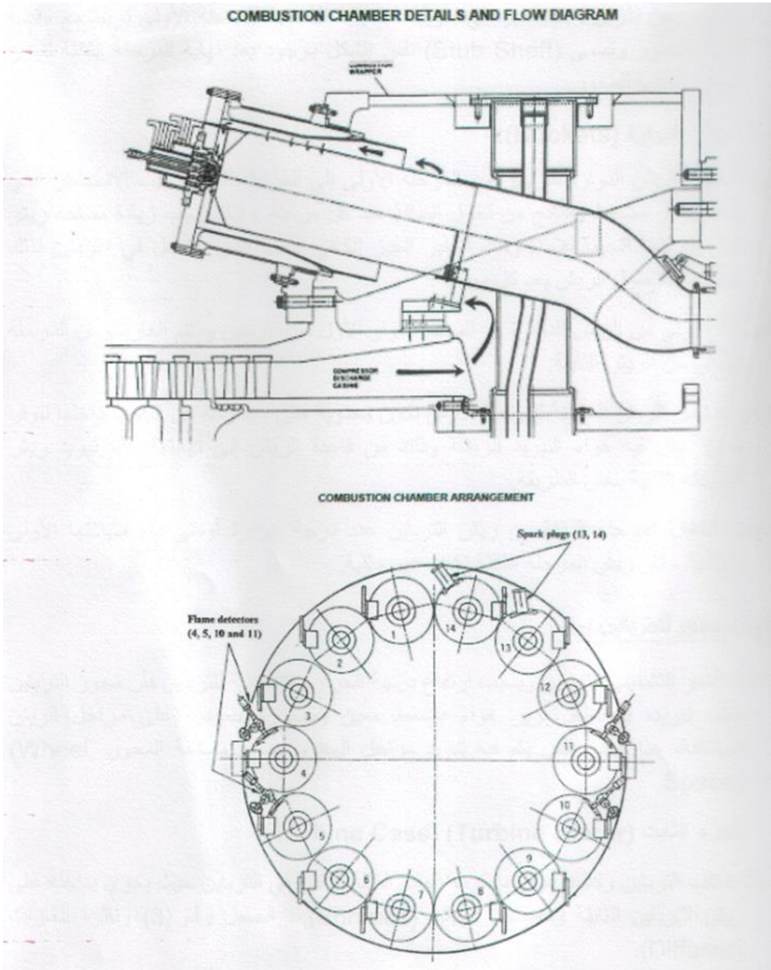

Figure 3combustion chamber details and flow diagram

TURBINE

Turbine Rotor:-

The rotating part consists of the rotating blade ring of the first stage, the rotating blade ring of the second stage and the rotating blade ring of the third stage, and it contains two rings of spacers that separate the three stages. The feather rings of the different stages are assembled together to form the axle is connected with long bolts. The front end of the first stage connects with the front of the axle flange and is called (Stub Shaft). The same shape exists after the end of the third stage to be the rear end of the axle.

Rotary blades (Buckets):-

The length of the turbine's rotating blades increases from the first stage to the third stage due to the decrease in pressure resulting from the energy transformation at each stage. Therefore, the area of the turbine blades must be increased as we move forward in order to provide sufficient space for the expansion that occurs in the turbine. Therefore, the length of the blades must be increased after each stage. phase.

The first stage of the rotor blades is the first rotating surface of the turbine that receives gases from the first stage of the fixed blades.

Each of the feathers that make up the first stage contains a group of holes inside it to provide a passage through which the cooling air passes for the feather, from the base of the feathers to its end, and the blades of the second stage are cooled in the same way. Because the third stage of turbine blades operates at a lower temperature than their first counterparts. Secondly, the feathers of the third stage are not perforated.

Cooling of the turbine axis:-

To maintain the operational life of the turbine and because of the high operational temperature of the turbine, the turbine axis must be cooled by passing air at a certain pressure and vertically over the different blade stages. This space in which the axis stages are cooled is called the wheel space.

Turbine Case:-

The turbine casing, as well as the structure of the exhaust system, represents the largest mass in the turbine, as it contains inside it the fixed turbine blades, the blade catchers (Shrouds), the holder No. (3) and the gas diffuser.

Fixed blades Turbine Nozzle):-

There are three stages of fixed blades, which direct gases from one rotating stage to the other, and also contribute to increasing the speed of gases passing through the rotating blades.

The terpene has three stands

bearing No. (1): It is located in the inner part of the inlet casing of the compressor. It consists of three holders in one cover.

bearing No. (2): It is placed inside the compressor's thrust casing. It is a very important holder because placing it inside this casing is difficult to reach, so attention should be paid to the operational conditions for the operation of this holder.

bearing No. (3): A stand that supports the forces perpendicular to the axis, placed in the inner shell of the circle. The air for insulation mixes with the oil inside the tank, and to maintain a negative pressure in the tank (Vacuum) and increase the rate of oil flow in the pipes, an air extractor was placed to provide this.

Lubrication: The thrust bearing with sliding pads is classified as a hydrodynamic lubrication carrier, which means that the bearing surface is separated from the rotating tire by a layer of oil, which is formed as a result of the relative movement between the bearing surface. This oil layer supports the thrust forces and prevents direct contact between the metal of the carrier and the metal of the axis. In addition to the function of supporting the thrust load, it removes the heat generated as a result of the oil layer being exposed to the mechanical shear force as a result of the thrust. The thrust carrier pads are free to take their position during work, which ensures an ideal oil layer regardless of the changes in the amount of thrust forces they are exposed to, oil viscosity and temperature. The thrust carrier with sliding pads lubricates by supplying oil at a certain pressure through channels located in the carrier body behind the base ring. Base Ring and flows into the gaps of the thrust carrier, and the oil moves as a result of the rotation of the Thrust Runner, heading into the surface of the carrier.

The process of circulating the oil through the pads is also done with the help of the natural pumping process that the Thrust Runner performs during its rotation.
After completing the lubrication process, the oil comes out through the outer circumference of the cushions, as well as the chlorine, into large gaps and is drained. The drainage gaps for the circuit are made inside the body of the carrier, and sometimes the base ring is pierced near the cushions, and the oil that enters is directed to these.
Holes to insert into the viewing bottle for the purpose of checking the amount of oil flow into the holder. To increase the drainage rate, the lubrication system is equipped with an air-extraction system
(Oil Mist Eliminator)
Expelling vapors and air from the oil (OIL MIST ELIMINATOR): - It is an air fan driven by an electric motor that connects the intake tube of this fan to the tank, where it draws the mixture of air and oil vapors and passes it through two stages of filters. The first stage is a large charcoal filter placed inside The expeller tank separates the oil from the air. The oil drips down the tank and returns to the turbine tank through a 2-inch tube, and the air is pushed out after the oil is extracted from it. The vacuum created by the fan is regulated by a regulator to form a vacuum suitable for drawing vapors and air. There is a pressure differential gauge on the extruder tank whose reading must not exceed (50ml bar).
STARTING SYSTEM:-
Every gas unit needs a system that helps it initially rotate itself to draw in air and thus enter the combustion system for the purpose of sustaining its movement. The starting system comes out and the unit continues to work. The starting system consists of the following parts:
1/ Starting Motor:-
It is an electric motor that operates at a voltage of (6.6 KV) and a power of about (1.4 MW). This motor starts the turbine's movement upon operation.
2 Torque Converter:-
The starter motor is connected by a flexible coupling to a system called a torque converter. This hydromechanical system converts the high speed of the engine into a high torque capable of rotating the turbine. The starter motor initially delivers the turbine speed to about (750 RPM) with the help of the torque converter. Inside the torque converter there is a system Valves that drain the amount of oil in which the torque converter operates, which leads to lowering the turbine speed to (480 RPM), which is the speed necessary for ignition. These valves are controlled by an electric valve (Solenoid 20 TU) controlled by the main control system for the turbine (Hydraulic Break):
These brakes stop the starter system from rotating when the engine stops after it stops working as a result of a signal from the main control device. The electric motor stops after rotating the turbine and ignition occurs, and when the turbine speed reaches approximately 60% of the original speed at
Operation
3/ Clutches
These mechanical devices isolate the starting system from the turbine converter when it stops working and the turbine continues to operate. Another separator also engages the Turning Gear system and disconnects it when it enters and exits work.
4/ Shaft Turning Gear

This system rotates the turbine axis at a speed of about (137 RPM). This speed is necessary when the turbine starts operating. The turbine is also kept at this speed after stopping it in order to ensure homogeneous cooling of the turbine axis until it is completely cooled, and then it is stopped after the internal temperature of the turbine blades reaches (80C).

It is an electric motor connected to a gear box system that rotates the large gear attached to the turbine axis at the necessary speed. The oil level in the gears must be observed through a bottle from time to time.

TURNING GEAR FUNCTION:

The purpose of this device is to rotate the turbine axis during start-up and cool-down operations, as well as during maintenance operations for the purpose of inspection. During cooling operations, the axis rotator rotates the system at a limited speed (137 RPM) for a period of 14 hours for the purpose of protecting the turbine axis from bending, as well as Protecting terpene carriers from the effects of high temperature.

5/ Jacking Pumps:-

Before inserting the axle rotation system, the lift must be activated. It is an AC pump that raises the oil pressure to 123 bar and pushes it down the generator and inductor mounts in order to facilitate the process of rotating it using the rotation system. These pumps work via a control the main device.

6- ACCESSORY GEAR BOX

This group is located on the front side of the compressor. It is a group of gears connected directly via a flexible coupling with the turbine axis whose function is to rotate the various turbine accessories (mechanical pumps) (each according to the speed designed for it, and also provides a means of connecting and isolating the starting rotation device). Device), and also contains the main lubrication and mechanical pump inside the gear box, which distributes the different speeds of the accessory devices, each according to its designed speed. After that, there is an Assembly Clutch Starting system that engages and disengages the starter motor.

SPECIFICATION OF A.G.B (ACCESSORY GEAR BOX):-

- **Mechanical Date .**

Speed Of Shaft 1	3000
Speed Of Shaft 2	3424.2
Speed Of Shaft 3A	1554.2
Speed Of Shaft 3B	6607.2
Speed Of Shaft 4	1421.9

Shaft Speed

- Lubrication Data

Oil Flow L/Min	100
Operating Pressure Bar	1.7
Viscosity	ISO VG 32/46

Pump data-

Oil Flow L/Min	2850
Operating Pressure Bar	8.3
Viscosity	ISO 32/46 VG

Figure 4 ACCESSORY GEAR BOX

Preparations For Operation

A - Requirements for placing the unit in reserve status:-

1 The oil temperature must be good and the oil must be rotated to an acceptable temperature so as to maintain a good viscosity of the oil

2/ The temperature of the control panel heating in the site control room is acceptable

3 The backup oil pump must be operated before an appropriate period for the purpose of getting rid of the dirt formed in the oil system

4/ When it is intended to operate on liquid fuel, it must be heated beforehand for the purpose of obtaining the appropriate viscosity to facilitate ignition.

5 Compartment room temperature

6 The control room air conditioners must be installed before an appropriate period of time to maintain the control devices in good condition

Moderate heat

7/ Battery chargers must be placed

B Pre-operation preparations:-

1- Check all pipes and turbine connections so that they are secure and that all plugs previously placed during maintenance have been removed.

2 -The inlet air ducts, outlet gases, and accessory ducts are clean, all work waste has been removed, and the maintenance gates have been closed

3- Make sure to replace the air, oil and fuel filters and ensure that the filter cap screws are tightened.
4- Make sure that the oil level in the tank is at the operational level and verify the quality and specifications of the oil. If the oil ring is being cleaned (flushing), make sure that the filters are replaced with new ones and that all plugs have been removed.
5 -Make sure to check the operation of the additional (auxiliary) and emergency devices such as the oil pump, water pump, fuel pumps, etc. beforehand and report faults if any, and make sure that there are no abnormalities, vibrations, noises, or a rise in temperature. When these devices are operating
6 -Make sure the oil system is free of leaks. Check the sight bottles at the holder outlets. 7/ Check all thermocouples and thermal resistors on site and ensure that their reading is at the control so that it is close to the ambient temperature.
7- Check that the burner starter is working properly.

CONCLUSION

In conclusion, the gas generating unit type GT F9E represents a significant advancement in power generation technology, particularly in the context of addressing evolving energy needs and environmental concerns. The historical progression from coal and oil-based power generation to more efficient and cleaner alternatives underscores the importance of innovation in the field. With increasing global energy consumption and the shift towards renewable energy sources, gas turbines like the GT F9E play a crucial role in providing reliable and sustainable power generation solutions.

This paper has provided a comprehensive overview of the GT F9E unit, including its components, operational principles, and maintenance requirements. The detailed explanation of the compressor, combustion system, and turbine elucidates the intricate processes involved in power generation. Additionally, the discussion on the starting system highlights the importance of efficient initiation mechanisms for turbine operation. Furthermore, the emphasis on training and qualifications for personnel underscores the importance of skilled workforce management in optimizing the performance of power generation plants. As new cadres enter the field, providing them with adequate knowledge and training becomes essential for ensuring operational efficiency and safety.

Overall, the GT F9E gas generating unit exemplifies a sophisticated and efficient solution for power generation, aligning with the growing demand for clean and sustainable energy technologies. By addressing the challenges posed by traditional energy sources and embracing technological advancements, gas turbines like the GT F9E contribute significantly to shaping the future of power generation towards a more sustainable and environmentally friendly direction.

In addition to its technical intricacies, the GT F9E gas generating unit underscores broader shifts in the energy landscape. As the world faces pressing environmental concerns such as climate change and air pollution, the transition towards cleaner energy sources becomes imperative. The GT F9E, with its efficient operation and reduced emissions compared to traditional coal and oil-based power generation, represents a step towards mitigating these environmental challenges.Moreover, the versatility of gas turbines allows for their integration into various power generation systems, including combined cycle configurations, cogeneration, and distributed generation setups. This flexibility enhances the resilience and adaptability of energy infrastructure, particularly in the face of evolving energy demands and grid stability requirements. Furthermore, the discussion on pre-operation preparations highlights the importance of proactive maintenance practices and stringent quality control measures. By ensuring the reliability and integrity of critical components, operators can minimize downtime and maximize the operational lifespan of gas turbine units like the GT F9E, thereby optimizing overall plant performance and efficiency. Looking ahead, continued research and development efforts in gas turbine technology, including advancements in materials science, aerodynamics, and control systems, hold the potential to further enhance the performance and sustainability of gas generating units. These innovations will be instrumental in supporting the global transition towards a more sustainable energy future while meeting the growing demand for electricity in a reliable and environmentally responsible manner.

In conclusion, the GT F9E gas generating unit embodies not only technological excellence but also a commitment to addressing the challenges and opportunities of the modern energy landscape. By leveraging the inherent advantages of gas turbines and embracing continuous innovation, the GT F9E contributes to shaping a more sustainable and resilient energy infrastructure for generations to come.

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