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Instrument Maintenance and Flame Detector Control in Gas Turbine

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ABSTRACT
Control and automation systems play a very important role in efforts to facilitate industrial processes and all other areas without exception in power generation systems. The control system and automation can facilitate an operation engineer power plant in managing and running the power plant. With the integrated control system, we can monitor the system in real-time, protection system will be easier. The Gas and Steam Power Plant is a combination of a gas power plant and steam power plant. The gas and steam power plant is an installation of equipment that serves to transform the heat energy (fuel and air combustion) into usable electrical energy.Each unit of the gas power plant has an important instrument that can keep the work smooth, and various maintenance methods wereconducted to obtain optimal and effective results. A flame detector is an instrument that detects the value of intensity and frequency of fire in the combustion chamber witha detectable wavelength of 760 nm to 1100 nm. This instrument serves to detect there or not the fire in the combustion chamber.

Key words : Instrument, Maintenance, Flame Detector, Control, Gas Turbine

1. INTRODUCTION
Gas and steam power plants [1] is an installation of equipment that serves to transform the heat energy (fuel and air combustion) into usable electrical energy. Basically, a system of gas and steam power plants is a merger between the gas power plant and the steam power plant. The components of the power plant are gas turbine, HRSG, steam and turbine. Working principle of gas turbine followsthe Brayton cycle and working principle of steam turbine following the Rankine cycle. Therefore, the working principle of a power plant is the combination of the Brayton cycle and Rankine cycle or can be called a combined cycle (Figure 1).

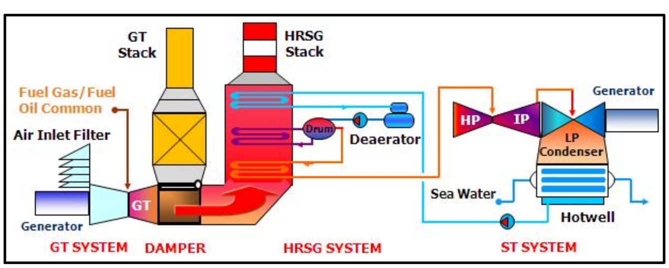


Figure 1: Process of Gas and Steam Power Plant [2]

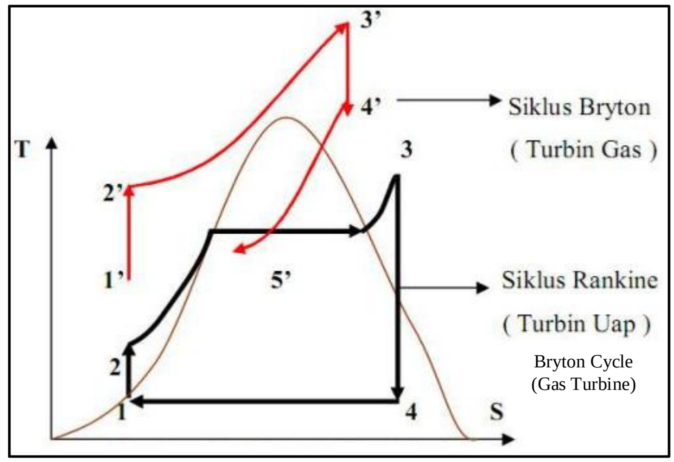


Figure 2: Combined CycleProcess [2]

Rankine Cycle
(Steam Turbine)

The running process (Figure 2) was starting f cyclestate (1) to state (2), the isentropic comp in the gas turbine compressor [3]. Atmospheric air enters into a gas turbine system through the side of the compressor inlet. By the compressor, the air is compressed until a certain pressure is followed by a narrowed volume of space. State (2) to state (3), the combustion process occurs. Fuel is added to the compressed air flowing into the combustion chamber, resulting in a burning reaction that produces hot gases. The combustion heat energy is absorbed by air (Q_{in}), increasing the air temperature and increase the volume of air. State (3) to state (4) is the expansion process for rotating the gas turbine's sudu. Compressed air that has absorbs heat burning result, expanding through the turbine. The turbine sudu that is a small nozzle serves to convert the hot energy of the air into kinetic energy. State (4) on the Brayton cycle leading to the state (2) Rankine cycle for the operation of the HRSG boiler [4]. In the state (2) to the state (3), the high-pressure water enters the boiler to undergo the next process, namely to be heated isobaric (constant pressure). Sources of heat in getting from burning coal, solar etc. The process of state (3) to state (4) is the process of dry steam isentropic expansion to play the steam turbine sudu. The energy stored in the moisture is converted into motion energy in the turbine. The movement's energy is then converted into electrical energy and transmitted to certain loads.

2. MATERIALS AND METHOD

Scope of Instrument Maintenance Division work is shown in Figure 3, which is divided by area gas turbine, HRSG, steam turbine, water-steam cycle, steam turbine and balance of plant (BOP). Then each area has instrument and control equipment, including the parameters of Pressure, Level, Temperature, Flow, Speed, Vibration, Solenoid Valve, Positioner and others. Each area also has control equipment, including HMI, DCS, Diagnostic Tools, PLC, DCS, and calibration equipment.

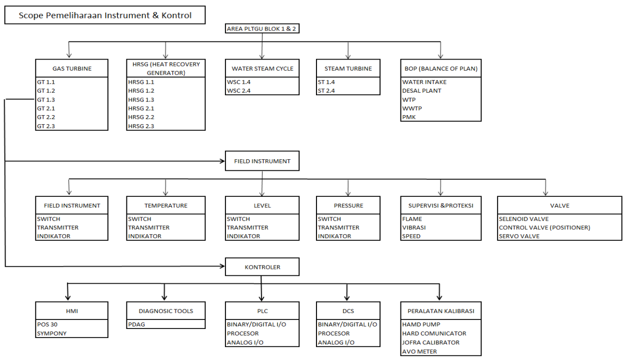


Figure 3: Maintenance Scope of Instrument and Control

The construction of the control system used in the process control Distributed Control System (DCS) based digital control system and combined innovation and extensive functionality with good operational reliability. The process control system used P13 and P14. The control process P14 has features analogue and binary control, including boiler protection, turbine control, engineering and diagnosis. The control process P13 used for steam turbine area. The topology used in the control process is a star topology, a network topology that can connect one computer to another.

Human Machine Interface (HMI) [5] is a system that connects humans with machines. HMI was controlling and visualization status, either manually or through real-time computer visualization. HMI used to improve the interaction between operators and machines through the display on the monitor screen.

HMI systems usually work online and real-time by reading the data transmitted via the I/O ports used by the controller. The HMI system used on block 1 and block 2 is POS 30 and symphony plus. HMI monitor processes that occur in the combustion process. HMI see the flame in an "on" or "Not on" state, the flame interference is detected on the HMI. Figure4 and Figure5are the HMI display in gas turbine and combustion chamber.

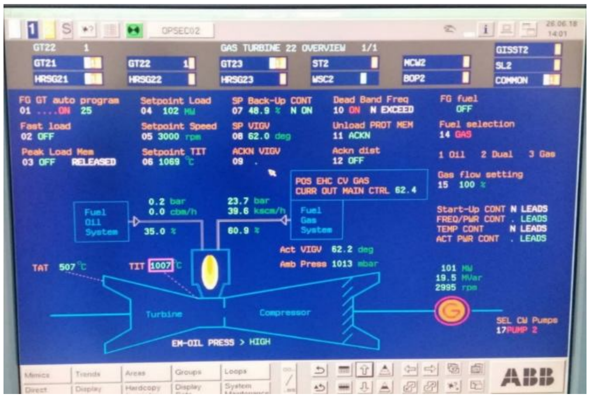


Figure 4: HMI Display in Gas Turbine

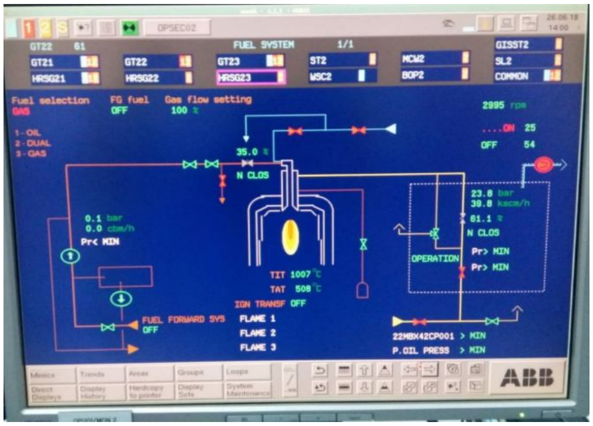


Figure 5: HMI Display in the Combustion Chamber

Work Planning Control (WPC) [6] is a form of asset management by work planning and maintenance control. WPC Management is a series of processes that include planning, implementation, control and evaluation of maintenance activities to achieve optimal work results. Job planning is a process of detailed analysis that determines and explains the work to be done, task sequences, methods used, resource requirements (skills, number of crews, manhours, parts, tools, materials and total cost estimates). Job planning also includes the identification of occupational safety, vigilance, necessary permits, related parties, and reference documents (such as drawing and wiring diagrams).

WPC Management has five main activities that must be run by each fellow employee:

- Run the WPC management cycle
- Run "Daily Activity"
- Planning Maintenance
- Control the WPC process indicator
- Utilizing ProHAR (Maximo 7.6)

WPCmanagementcyclesareobtainedfromseveraldisruptionsor problems,e.g.faultfoundoperator,PMFeedback,PdMrecommendation.ProactiveMaintenanceandsomeotherrequests.

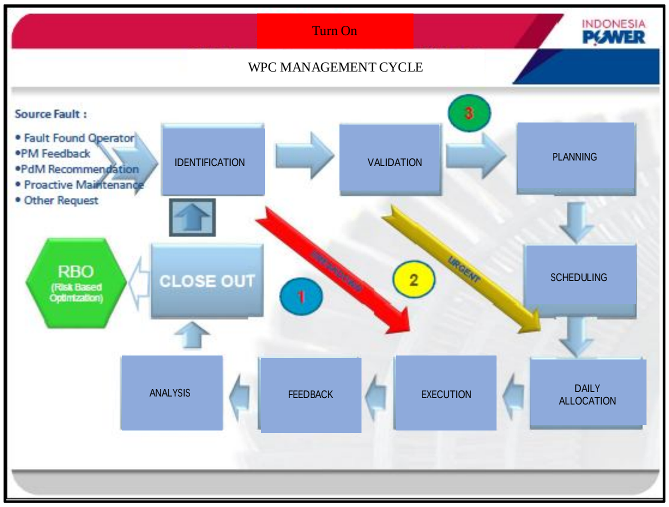


Figure 6: Management of Work Planning Control

Based on Figure 6, 3 forms of work statusis priority 1 (immediately resolved quickly), priority 2 with the duration of the working time maximum of week and priority 3 with a maximum duration of one month. The work is arranged neatly according to the time of the process on the website Maximo 7.6.

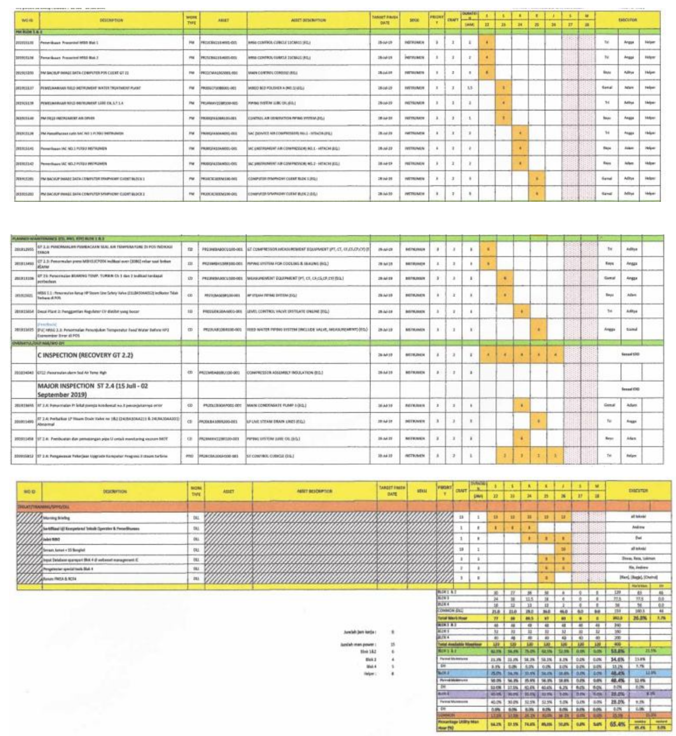
In the Maximo application [7], work management consists of three types of maintenance, namely planned maintenance, unplanned maintenance and other maintenance. In the three types of maintenance, there are nine types of work including preventive maintenance (PM), emergency maintenance (EM), predictive maintenance (PdM), corrective maintenance (CM), condition directed (CD), supporting, run to failure (RTF), overhaul (OH), and proactive maintenance (PRO). The following is an explanation of the work types in work management.

a. Preventive Maintenance is routine maintenance activities carried out at weekly intervals, according to 52 weekly planning PMs that have been prepared.
b. Proactive Maintenance is maintenance activities related to the modification, replacement of equipment, follow up on Engineering Change Project (ECP) or follow up on manufacturer's recommendations which prevent failure.
c. Predictive Maintenance is a routine activity of collecting predictive maintenance data using various PdM technologies, according to 52 PdM weekly planning.
d. Run to failure is maintenance activities for assets that have been defined as RTF, low MPI, redundant or predetermined.
e. Condition Directed is maintenance activities initiated on operating conditions based on operating data and technology owner (PdM) measurements where the data is evaluated by the system owner.
f. An overhaul is a periodic maintenance activity.
g. Corrective Maintenance is maintenance activities in repairing equipment based on findings from the patrol operator where the equipment does not work or function as it should. However, in terms of generating units or equipment systems do not trip.
h. Emergency Maintenance is maintenance activities that must be executed immediately because there has been an interruption or unit trip.
i. Supporting the activity of maintaining facilities, IT and workshop.

3. RESULTS AND DISCUSSION

Maintenance activities (Table 1) are summarized in the weekly schedule, in which maintenance activities have been scheduled either PM, CM, CD, Pro, etc. Table 1 shows the weekly schedule on week 30 in 1 year.

Table 1: Form Weekly Scheduling



Flame Detector

Flame Detector is a fire detector that uses optical sensors to detect it. A flame detector is used to detect the presence of fire, not heat. The working principle of a flame detector that the flame is detected by the infrared and ultraviolet light spectrum. The flame detector has a design, as shown in Figure 7.

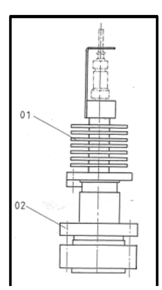


Figure 7: Flame Detector Design

In Figure 7, number 01 shows the flame safeguard - sight glass unit and number 02 shows the sight glass pressure fitting. The main components of a flame detector are divided into two, the photocell sensor and the detector glass. Other supporting components are shown in Figure 8 and Table 2.

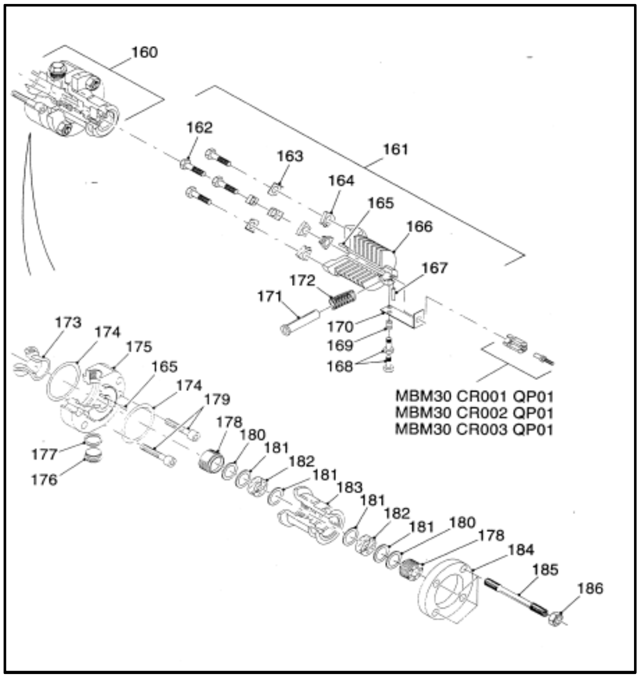


Figure 8: Flame Detector Assembly

Table 2: Description of Flame Detector

Drw-Pos	Order-Pos	Designation	Qty
160	160	Pressure portion, complete	3
161	161	Flame monitor attachment, compl.	3
162	162	Hex head screw, M10 x 12 - 8.8 - A2G	8
163	163	Tabwasher 10.5 - St	8
164	164	Segment	8
165	165	Dowel 4 x 20 - FDST	3
166	166	Cooling pipe	1
167	167	Dowel 4h8 x 40 - St 50k	1
168	168	Hex head screw, M6 x 12 - 8.8 - A2G	2
169	169	Locking plate 6.6/20 - St	1
170	170	Guard plate	1
171	171	Testing pin	1
172	172	Compression spring	1
173	173	Nozzle	1
174	174	Sealing ring	2
175	175	Sealing air flange	1
176	176	Screw plug G1A - 5.8	1
177	177	Copper sealing ring 48/36 x 1	1
178	178	Cylinder screw,F181 M12 - T x 60 - St 460 TS	2
179	179	Socket head cap screw	3
180	180	Washer	4
181	181	Sealing ring	10
182	182	Glass disc	5
183	183	Sightglass holder	1
184	184	Loose flange	1
185	185	Expansion stud, M16 - T x 140	4
186	186	Hex nut M16 - GA	4

Photocel lsensors (Figure 9 and Figure 10) area type of sensor that serves to detect the presence of fire inturbine gases. Photocell sensors are light-sensitive sensors. The working principle of photocell sensors, such as the light-dependent resistor(LDR).The photo cell sensors use dare type 48PT2-1003 and KKSMBM30CR001–003QP01 as many as a piece in each flame detector. The voltage required to power the sensor is 7-15VDC.

Figure 9: Photocell Sensor Type 48PT2-1003

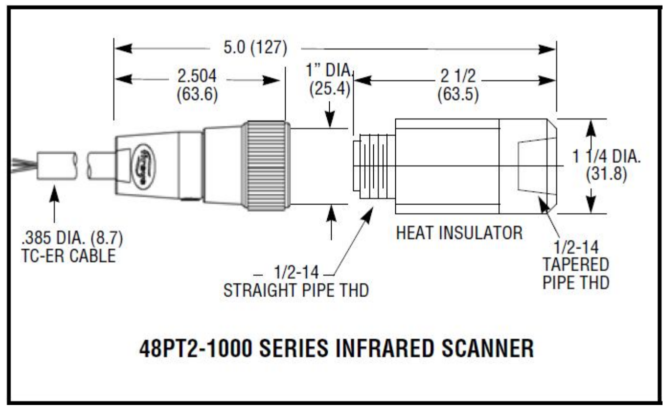


Figure 10: Specification ofPhotocell Sensor Type 48PT2-1003

Table 3: Description of Photocell Sensor Type 48PT2-1003

Scanner Model	Type	Approx. Volts Across Cell	Approx. Resistance* of Cell	Ambient Temp. Limits
48PT1	Infrared	125VDC	1.5 Meg. ohms	140°F/ 60°C, -40°
48PT2 48PT2-CEX	Infrared	7-15VDC	20K - 80K ohms	140°F / 60°C, -40°
69ND1	Flame Rod	280-305 VAC	Infinite	Tip 2460°F 1500°F/816°C, -40°

* Resistance measured with 20K Ohms/ Volt Meter
For proper Flame Signal Voltage see technical bulletin for the appropriate control.
48PT2 scanners comply with NEMA 4X

PART NUMBER	DESCRIPTION	USE WITH
48PT1-1003 48PT1-1007 48PT1-9003 48PT1-9007 48PT1-9007W	IR Straight Head 8 feet (2440mm) leads IR Straight Head 4 feet (1220mm) Leads IR 90 deg. Head 8 ft. (2440mm) Leads IR 90 deg. Head 4 ft. (1220mm) Leads - 9007 Water Repellent	P-Series
48PT2-1003 48PT2-1007 48PT2-9003 48PT2-9007 48PT2-CEX	IR Straight Head 8 feet (2440mm) leads IR Straight Head 4 feet (1220mm) Leads IR 90 deg. Head 8 ft. (2440mm) Leads IR 90 deg. Head 4 ft. (1220mm) Leads IR Straight Head, 1/2" NPT inlet	C & D Series, MicroM, FLAME-MONITOR, BurnerLogix
35-69	Heat Insulator for 48PT Scanners	
69ND1-1000K4 69ND1-1000K6 69ND1-1000K8	Flame Rod 12 inches (305mm) 1/2 in. mount Flame Rod 18 inch (460mm) 1/2 in. mount) Flame Rod 24 inches (710mm) 1/2 in. mount	P, C, D, M-Series, MicroM, MB Systems, BurnerLogix, FLAME-MONITOR

This sensor (Table 3) will undergo resistance changes when receiving light intensity. Sensors can increase and decrease the resistance according to the light intensity received. When the light is dark or dim, the resistance becomes greater and the electric current becomes obstructed. While the light is bright, the resistance becomes small so that the electric current can flow. The Sensor will detect the intensity value and the frequency of fire with wavelengths between 760 – 1100 nm.

Another component of the flame detector is sight glass (Figure 11) which serves as a heat prevention flame on the sensor. In order to look glass sight can cover its heat of fire perfectly, glass sight assembly should also be equipped with several supporting components.

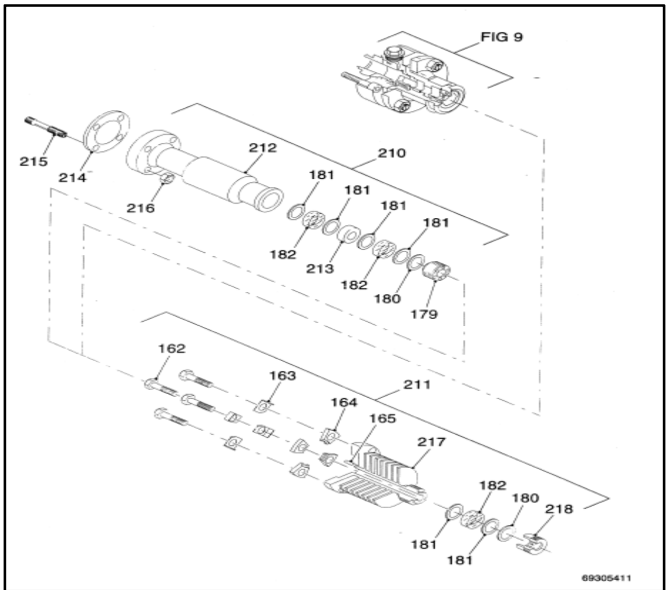


Figure 11: Sight Glass Assembly

Sight Glass is very influential in sensor measurements. When this glass sight is dirty, the sensor can not detect the existence of fire so that the sensor sends a measurement result in the form of flame "Not On" which will cause gas turbine will trip. Therefore, the sight glass inspection is very necessary to prevent the trip to the gas turbine. Figure 12 showed a clean and dirty sight glass.

Figure 12: Comparisonof Clean and Dirty Sight Glass

Flame detector sre quir easy stem that can process and transmit sensor measurements to controllers in order to be monitored by humans.The tools used to process the signal are burner management or amplifier modules.Burner management processes the infrared signal captured by the sensor and then sends the signal to the controller and alsoas a protection system against flame failure.Type70D41Burner management (Figure 13 and Table 4) with three pieces of three flamedetectors.

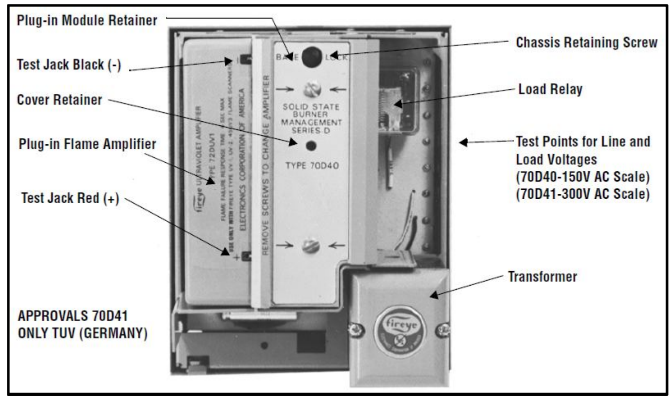


Figure 13: Burner Management Type 70D41

Table 4: Specification of Burner Management

A. Code 1 terminal load ratings all models:	
Max. Rating of each external load terminal:	
120 VAC	230 VAC
5 amps	2.5 amps
125 VA Pilot Duty	125 VA Pilot Duty

B. Terminal Load ratings for 70D40 Code 2 Models:				
TERMINAL	MAXIMUM RATINGS			TERMINAL 7 ONLY: Alternate Rating — 300 VA transformer and 130 VA pilot duty; and maximum combined load of not more than 3 motorized valves — Holding — 180 VA Opening— 635 VA Locked Rotor — 730 VA
3, 5, 6, 8, X, A	125 VA PILOT DUTY			
7 Code 2 or higher models only	250 VA Pilot Duty or Motor rating as given below:			
	Voltage	120 VAC	230 VAC	
	FULL LOAD	9.8 A	5.1 A	
	LOCKED ROTOR	58.8	30.6 A	

C. CE Load ratings for 70D41	
TERMINAL	MAXIMUM RATING AT 253 VAC
3, 5, 6, 8, 13, D	1A RESISTIVE OR ($\cos \phi = 1$)
7, A, M, P, X	4.5A RESISTIVE OR ($\cos \phi = 1$)

Figure 14: Burner Management

Burner Management (Figure 14) number 1, 2 and 3 are used for flame detectors 1, 2 and 3. Burner management also has wiring to connect sensors with controller. Figure 15 showed the Wiring Diagram of Burner Managementand Figure 16 showed wiring sensor to burner management.

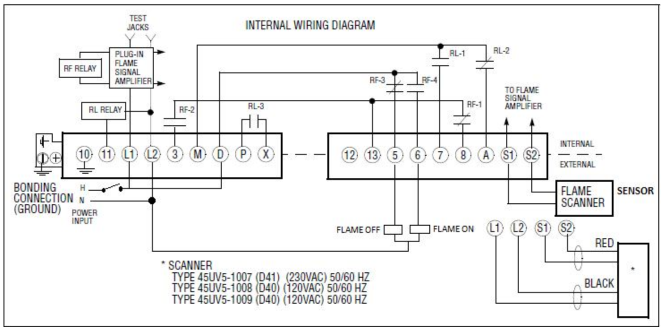


Figure 15: Wiring Diagram of Burner Management

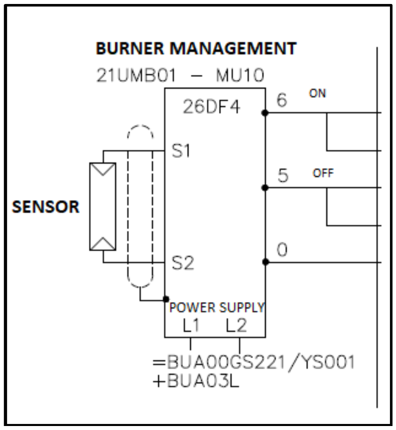


Figure 16: Wiring Sensor to Burner Management

In wiring burner management, a sensor connected with pin S1 and S2. S1 pin and S2 pin serves as a pin that can connect to the flame signal amplifier. Then from a flame signal amplifier is connected with L1 and L2 power supply. The voltage needed for burner management was 220 VAC. When the sensor detects a fire, pin 6 on burner management will be active and transmit the signal "Flame on". If there is no flame, then pin 5 on burner management and transmit the signal "Flame off". Pin 0 on Burner Management works for common.

A flame detector serves to detect or not fire in the combustion chamber and signal to the controllers used. The signal that is sent is the designation that the flame is on HMI. In the combustion chamber, there are three flame detectors located on the right, left and front of the drum combustor. Mounting the flame detector on the combustor must have a tilt of 120°. Figure 17 showed the mounting flame detector on the combustor. Table 5 showed description of combustor details.

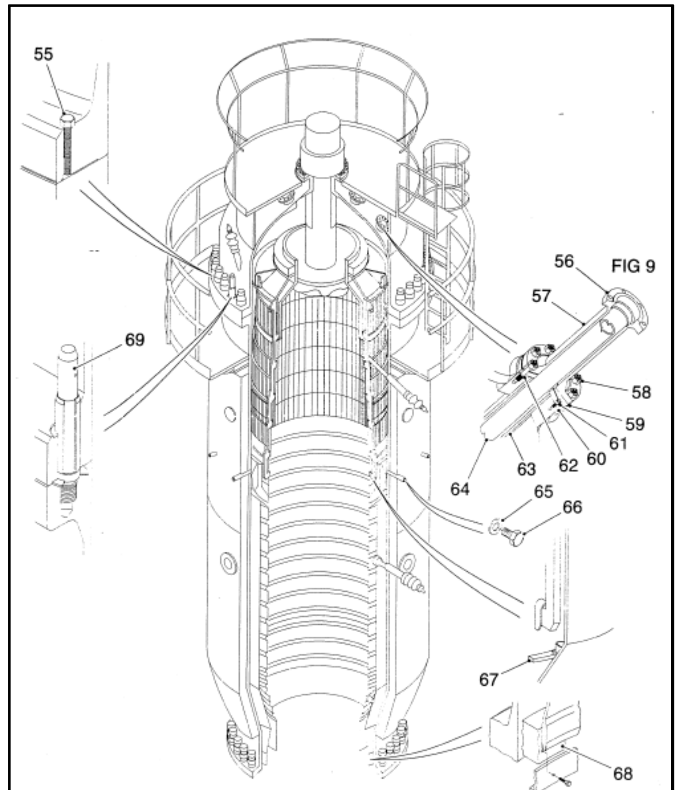


Figure 17: Combustor Details

Table 5: Description of Combustor Details

Drw-Pos	Order-Pos	Designation	Qty
55	55	Hex head screw,F85 M24 x 180	4
56	56	Flame monitor support	3
57	57	Sight glass arrangement	1
58	58	Hex nut 0.8D M20	24
59	59	Gasket	3
60	60	Gasket	3
61	61	Socket head cap screw, M10 x 20	6
62	62	Expansion bolt, M20 x 100	24
63	63	Protection tube	3
64	64	Swivel tube	3
65	65	Gasket 47/33 x 1cu	12
66	66	Hex head blanking screw	12
67	67	Ring	1
68	68	Support	2
69	69	Guide bolt, M64 x 500	2

Figure 18: Flame Detector onCombustor Details

The flame detector (Figure 18) in the combustion chamber is used as a detector that there is fire used in combustion processes. The fire detection process begins when the combustion starts when the combustion lasts until the fire off.

Gas Turbine operates at a rotation speed of 3,000 rpm in order to produce a power of 130 MW. When the rpm reaches more than 700 rpm, the flame fires. After Flame is flame, the sensor will detect the fire and transmit a signal to burner management. If the third flame detector is on and the flame detector will signal the burner management connected to the Pluto PLC B46 U10 for Channel 1 and U20 for Channel 2. Channel 1 and Channel 2 are used as protection systems, in the event of interference or damage, indirect damage of all parts thereof. The output from Pluto, sign into the DCS P-14. The Output of the DCS P-14 will notify the HMI if the flame detector has detected the presence of fire and has been combustion in the combustion chamber. If two flame detectors are turned off (Not on) and do not detect the presence of fire in the combustion chamber, then the flame 2/3 output will be off which means gas turbine will trip due to protection system.

4. CONCLUSION

In summary, maintenance was conducted in Gas and Steam Power Plant:

a. Many methods of maintaining instrumentation and control equipment exist, including PM, CM, CD, OH, etc. that have been scheduled with the aim of reliability of each equipment to support the overall system.

b. Maintenance of instrument and control equipment will be effective and optimal if it knows the workings and functions of the equipment.

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