

SYSTEM DESCRIPTION MBP GAS FUEL SYSTEM	Respons. dept GPMA	Date 031204	Reg. MDB 101
	Prepared Anders Samuelsson		Yamama Cement

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Purpose of the system

The purpose of the gas fuel system is to supply gas fuel of correct flow to the gas turbine burners during turbine start and operation.

That is:

- To supply the gas turbine with gas fuel.
- To control the fuel flow at start-up, during operation and stop.
- Activate a fast shut-off of the fuel supply in case of a turbine trip in order to prevent damage to the machinery.
- To check tightness of fuel shut-off valves.
- To control the fuel supply at change over from liquid fuel to gas and vice versa
- To purge the liquid fuel nozzles with gas during operation on gaseous fuel.

General description of the system

Refer to P&ID 2046026.

Fuel from the external gas fuel system flows through isolating valves, two coalescer filter lines, shut-off valve no.1 and 2 and gas control valves before flowing through the fuel nozzles.

The position of the control valves determines the fuel volume flow injected to the combustion chamber.

Ventilation valves are used to ventilate remaining gas after a shutdown.

The gas fuel system comprise two units, the gas fuel unit 1 which is located outside the GT enclosure and the gas fuel unit 2 which is installed in the frame of the gas turbine.

Main components

- Isolation valve (manually operated)
MBP05AA005
The valve isolates the gas fuel unit 1&2 from the external gas fuel system. The valve is closed during maintenance of the system, as a precaution before opening the gas fuel system. The valve is manually operated.
- Ventilation valve (manually operated)
MBP05AA205,
The valve is opened to ventilate trapped gas between MBP05AA005 and MBP05AA015 when they are closed. The valve is manually operated.

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- Fuel isolation valve (spring closing type)
MBP05AA015
The isolation valve prevents gas access inside the gas turbine enclosure during standstill. The valve is pneumatically operated and of spring closing type. If the open order or instrument air for any reason disappears, the valve returns to its safe closed position. The valve can only be operated automatically and is also closed via the lock out trip relays. There are two limit switches indicating "opened" and "closed" incorporated with the valve if the valve is in wrong position an alarm is given and, at start-up, the start is aborted.

- Electrical heat-tracing and insulation
MBP05AH010
The piping and components in contact with the natural gas are heat-traced to prevent temperature losses and condensation of natural gas/water in the gas fuel system.

- Isolation valves (manually operated)
MBP05AA020
MBP05AA025
The valves isolate one part of gas fuel unit 1 from the external gas fuel system. The valves are closed during maintenance of the system, when the filter elements are being exchanged and when the other gas filter line is used. The valves are manually operated.

- Ventilation valve (manually operated)
MBP05AA225
The ventilation valve is manually operated and used to ventilate trapped gas between MBP05AA020 and MBP05AA025.

- Pressure tap
MBP05CP003
The pressure tap makes it possible to measure the pressure upstream the coalescer filter MBP05AT015.

- Pressure indicator
MBP05CP010
The pressure indicator shows the pressure in one of the two filter lines in the gas fuel line. The indicator is used for checking that the system is not pressurised before opening for maintenance.

- Differential pressure transmitter
MBP05CP005
The differential pressure transmitter gives an alarm when the filter elements have to be exchanged. At alarm, it is time to switch from coalescer filter MBP05AT015 to coalescer filter MBP05AT025 or vice verse.

- Nitrogen purging valve
MBP05AA305
The valve is opened to purge the gas system with nitrogen before opening the system for maintenance.

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- Coalescer Filter
MBP05AT015
The filter is a coalescer filter and is to be considered as a “last chance” filter to protect the system and the gas turbine. Exchange of filter elements can be done during operation on gaseous fuel if the other gas line in the gas fuel unit is in operation and the line with this filter is closed off.
- Sight glass
MBP05CL020
The sight glass indicates if liquid has been separated out in the coalescer filter
- Isolation valve (manually operated)
MBP05AA255
MBP05AA265
The isolation valves are manually operated, MBP05AA255 is open and MBP05AA265 is closed during operation of the gas turbine. When draining liquids that has been collected in the sight glass the valve MBP05AA255 is closed and MBP05AA265 is opened. When the liquid has been drained the valve MBP05AA265 is closed and MBP05AA255 is opened.
- Isolation valves (manually operated)
MBP05AA030
MBP05AA035
The valves isolate one part of gas fuel unit 1 from gas fuel unit 2. The valves are closed during maintenance of the system and when the filter elements are being exchanged. The valves are manually operated.
- Ventilation valve (manually operated)
MBP05AA230
The ventilation valve is manually operated and used to ventilate trapped gas between MBP05AA030 and MBP05AA035.
- Ventilation valve (manually operated)
MBP05AA235
The ventilation valve is manually operated and used to ventilate trapped gas when MBP05AA230 or MBP05AA225 are opened.
- Isolation valves (manually operated)
MBP05AA040
MBP05AA045
The valves isolate one part of gas fuel unit 1 from the external gas fuel system. The valves are closed during maintenance of the system, when the filter elements are being exchanged and when the other gas filter line is used. The valves are manually operated.
- Ventilation valve (manually operated)
MBP05AA240
The ventilation valve is manually operated and used to ventilate trapped gas between MBP05AA040 and MBP05AA045.
- Pressure tap

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MBP05CP008

The pressure tap makes it possible to measure the pressure upstream the coalescer filter MBP05AT025.

- Pressure indicator

MBP05CP025

The pressure indicator shows the pressure in one of the two filter lines in the gas fuel line. The indicator is used for checking that the system is not pressurised before opening for maintenance.

- Nitrogen purging valve

MBP05AA310

The valve is opened to purge the gas system with nitrogen before opening the system for maintenance.

- Coalescer Filter

MBP05AT025

The filter is a coalescer filter and is to be considered as a “last chance” filter to protect the system and the gas turbine. Exchange of filter elements can be done during operation on gaseous fuel if the other gas line in the gas fuel unit is in operation and the line with this filter is closed off.

- Sight glass

MBP05CL025

The sight glass indicates if liquid has been separated out in the coalescer filter.

- Isolation valve (manually operated)

MBP05AA270

MBP05AA280

The isolation valves are manually operated, MBP05AA270 is open and MBP05AA280 is closed during operation of the gas turbine. When draining liquids that has been collected in the sight glass the valve MBP05AA270 is closed and MBP05AA280 is opened. When the liquid has been drained the valve MBP05AA280 is closed and MBP05AA270 is opened.

- Isolation valves (manually operated)

MBP05AA050

MBP05AA055

The valves isolate one part of gas fuel unit 1 from gas fuel unit 2. The valves are closed during maintenance of the system and when the filter elements are being exchanged. The valves are manually operated.

- Ventilation valve (manually operated)

MBP05AA245

The ventilation valve is manually operated and used to ventilate trapped gas between MBP05AA050 and MBP05AA055.

- Ventilation valve (manually operated)

MBP05AA250

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The ventilation valve is manually operated and used to ventilate trapped gas when MBP05AA245 or MBP05AA240 are opened.

- Flow meter
MBP05CF005
The flow meter

- Ventilation valve (spring opening type)
MBP10AA205

The valve ventilates the remaining gas trapped between the fuel isolation valve and the quick shut-off valve no.1 in case of fire, gas detection, and ventilation failure or manual emergency shutdown. The valve is pneumatically operated and of spring opening type, if the close order or operating air for any reason disappears, the valve returns to its safe open position. The valve is operated automatically, but manual operation is needed when exchanging gas fuel filter elements. There are two limit switches indicating "opened" and "closed" incorporated with the valve. If the valve is detected to be in wrong position an alarm is given and, at start-up, the start is aborted.

- Gas Fuel quick shut-off valve 1 (spring closing type)
MBP10AA025

The fuel shut-off valve is used for shutting off the fuel supply when stopping the turbine. The fuel shut-off valve consists of a ball valve using a pneumatic, quick-closing actuator. The valve is of spring closing type. If the open order or operating air for any reason disappears it will return to its safe closed position. The quick-shut off valve have two solenoid valves incorporated in the function of the valves. When opening the valve both solenoids are activated and the two-way solenoid -Y02 mounted on the short end of the actuator is closed. The three-way solenoid valve -Y01 mounted on the long side of the actuator is opened and the instrument air flows into/fills the actuator. When closing the valve both solenoids are deactivated and the two-way solenoid valve-Y02 is opened and evacuates the air in the actuator fast for quick closing. The three-way solenoid valve -Y01 closes the port to the instrument air and the port for venting the air in the actuator is opened. Both solenoid valves are incorporated in the closing of the valve but the main one for the quick closing is -Y02. The main function of the -Y01 is supplying instrument air to the actuator.

There are two limit switches indicating "opened" and "closed" incorporated with the valve. If the valve is detected to be in wrong position an alarm is given and, at start-up, the start is aborted.

An automatic valve leakage test sequence is performed at start-up. The valve can only be operated in automatic mode and is also closed via the lock out trip relays.

- Pressure reducing valve
MBP10AA040

This valve keeps a constant instrument air pressure to the quick shut-off valves MBP10AA025.

- Pressure indicator
MBP10CP030

The pressure indicator shows the instrument air pressure to the quick shut-off valves.

- Pressure reducing valve
MBP10AA045

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This valve keeps a constant instrument air pressure to the quick shut-off valves MBP10AA030.

- Pressure indicator

MBP10CP035

The pressure indicator shows the instrument air pressure to the quick shut-off valves.

- Pressure transmitter

MBP10CP015

The pressure transmitter monitors the pressure upstream the control valves. During start up of the gas fuel system the transmitter gives alarm and start interlock at high or low pressure. The transmitter also measures the pressure during the leakage test of the quick shut-off valves. During operation on gas fuel, the transmitter gives alarm at high or low pressure and an unloading turbine trip at low pressure.

High-pressure (H2) gives:

- Alarm

High-pressure (H1) gives:

- Alarm

Low pressure (L1) gives:

- Alarm

Low pressure (L2) gives:

- Unloading turbine trip

- Temperature transmitter

MBP10CT005

Gas fuel temperature upstream the control valve is continuously measured.

The temperature transmitter monitors the gas temperature versus the dew point of the gas and the design temperature of the system.

High gas temperature (H1) gives an alarm.

Low gas temperature (L1) gives an alarm.

Low gas temperature (L2) gives an alarm.

Low gas temperature (L3) initiates an unloading turbine trip.

- Gas Fuel quick shut-off valve 2(spring closing type)

MBP10AA030

The fuel shut-off valve is used for shutting off the fuel supply when stopping the turbine. The fuel shut-off valve consists of a ball valve using a pneumatic, quick-closing actuator. The valve is of spring closing type. If the open order or operating air for any reason disappears it will return to its safe closed position. The quick-shut off valve have two solenoid valves incorporated in the function of the valves. When opening the valve both solenoids are activated and the two-way solenoid -Y02 mounted on the short end of the actuator is closed. The three-way solenoid valve -Y01 mounted on the long side of the actuator is opened and the instrument air flows into/fills the actuator. When closing the valve both solenoids are deactivated and the two-way solenoid valve-Y02 is opened and evacuates the air in the actuator fast for quick closing. The three-way solenoid valve -Y01 closes the port to the instrument air and the port for venting the air in the actuator is opened. Both solenoid valves are incorporated in the

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closing of the valve but the main one for the quick closing is -Y02. The main function of the -Y01 is supplying instrument air to the actuator.
 There are two limit switches indicating "open" and "closed" incorporated with the valve. If the valve is detected to be in wrong position an alarm is given and, at start-up, the start is aborted.
 An automatic valve leakage test sequence is performed at start-up.
 The valve can only be operated in automatic mode and is also closed via the lock out trip relays.

- Ventilation valve (spring opening type)

MBP10AA230

The valve ventilates the remaining gas trapped between the two quick shut-off valves and is always opened when the turbine is stopped. The valve is of spring opening type. If the close order or operating air for any reason disappears, the valve returns to its safe open position. The valve can only be operated automatically. There are two limit switches indicating "opened" and "closed" incorporated with the valve. If the valve is detected to be in wrong position an alarm is given and, at start-up, the start is aborted.

- Electrical heat-tracing and insulation

MBP10AH005

The piping and components in contact with the natural gas are heat-traced to prevent temperature losses and condensation of natural gas/water in the gas fuel system.

- Main Control valve

MBP10AA035

The control valve controls the main gas flow to the combustion chambers. The turbine governor via the AC servo motor drive unit controls the valve position. A position transducer gives the valve position feedback to the control system. Limit switches indicate ignition, minimum and maximum valve position. The ignition position is monitored during system start and if it is exceeded, the start will be aborted. The maximum and minimum position limit switches indicate that the valve is outside its operating range. This will block the servo motor drive unit preventing further movement in respective direction. The maximum and minimum position limit switches are adjusted so that the mechanical stop at respective end position is not reached before the servomotor has reduced speed. This will prevent damage to the valve if the control system fails. The power supply to the AC servo motor drive unit is monitored and an alarm is given if it should fail. The valve control is blocked when the turbine is shut down by disconnection of the AC servo motor drive unit power supply.

At system start up a stroke test is performed on the control valve where the control valve first is opened, then closed and then set to ignition position. The deviation between control signal and valve position is monitored during the test and should it be too large the start is aborted.

The control valve will decrease the fuel flow quickly at turbine load loss detection, thus preventing over-speed trip.

The control valve is only operated in automatic mode, but can be operated manually for testing.

- Pressure transmitter

MBP10CP050

The pressure transmitter measures pressure downstream the main control valve.

- Primary Control valve

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MBP20AA005

The control valve controls the primary gas flow to the combustion chambers. The turbine governor via the AC servo motor drive unit controls the valve position. A position transducer gives the valve position feed back to the control system. Limit switches indicate ignition, minimum and maximum valve position. The ignition position is monitored during system start and if it is exceeded the start will be aborted. The maximum and minimum position limit switches indicate that the valve is outside its operating range. This will block the servo motor drive unit preventing further movement in respective direction. The maximum and minimum position limit switches are adjusted so that the mechanical stop at respective end position is not reached before the servomotor has reduced speed. This will prevent damage to the valve if the control system fails. The power supply to the AC servo motor drive unit is monitored and an alarm is given if it should fail. The valve control is blocked when the turbine is shut down by disconnection of the AC servo motor drive unit power supply.

At turbine start up, a stroke test is performed on the control valve where the control valve first is opened, then closed and then set to ignition position. The deviation between control signal and valve position is monitored during the test and should it be too large the start is aborted.

The control valve will decrease the fuel flow quickly at turbine load loss detection, thus preventing over speed trip.

The control valve is only operated in automatic mode, but can be operated manually for testing.

- Pressure transmitter

MBP20CP005

The pressure transmitter measures pressure downstream the primary control valve.

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Function

Operation of the system is fully automatic.

Start up

The gas fuel system is automatically started by the gas turbine start sequence. The ventilation and lubricating oil systems shall be in operation. The external gas supply system shall not indicate “gas fuel supply failure” (please refer to section ”Other faults”) and the lock out trip relays shall be in reset position.

Start of the gas fuel system includes the following steps:

The fuel isolation valve opens.

Stroke test of the gas fuel control valves is also performed.

Leakage test of the gas fuel quick shut-off valves and the intermediate ventilation valve is automatically performed.

Leakage test of MBP10AA025

The pressure downstream MBP10AA025 shall be low when the test is started. The ventilation valve MBP10AA230 closes and the fuel isolation valve opens and pressurise the first downstream quick shut-off valve. If the pressure downstream MBP10AA025 increases above a set value within a specified time, the start will be blocked/aborted.

Leakage test of MBP10AA030 and MBP10AA230

The first quick shut-off valve opens during some seconds and pressurises MBP10AA030 and MBP10AA230. The valve closes again, thus trapping a gas volume between the shut-off valves. If the pressure downstream MBP10AA025 decreases more than a set value within a specified time, the start will be blocked/aborted.

The gas fuel shut-off valves open when purging of the gas turbine is ready, the ignition flame is detected, the gas fuel control valves are in the ignition position and rotor speed is correct for ignition.

The ignition timers are started (for monitoring of “limitation time”) and the primary control valve controls fuel injection.

The main flame is ignited and the gas turbine is accelerated.

Flame detectors monitor ignition of the flame.

Leakage of shut-off valves, shut-off valves in wrong position, control valve in wrong position or incorrect gas fuel pressure abort start. Start will also be aborted if the turbine rotor speed is incorrect for ignition, if the control valves exceed the ignition position before flame is detected or if the fuel doesn't ignite within the “limitation time”.

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Continuous operation

During continuous operation the fuel flow through the nozzles is governed by the gas fuel control valves, which are controlled by the turbine governor.

- Main fuel-the fuel that is pre-defined for the gas turbine plant to be the main operating fuel.
- Backup fuel- the fuel that is pre-defined for the gas turbine plant to be the backup fuel.
- Auto control-the fuel that the operator has selected to be the operating fuel.
- Standby control-the fuel that the operator has selected to be the standby fuel.

Turbine stop

During turbine stop, the load/speed is ramped down.
 When the load/speed has reached a pre-set value, the turbine is tripped. Thereby the fuel shut-off valves close and the control valves are set to minimum position. Simultaneously the isolation valve will close the ventilation valve MBP10AA230 opens and ventilates the trapped gas between the shut-off valves.

Stand still

The shut-off valves and the isolation valve are closed. The ventilation valve MBP10AA230 is open.
 The control valves are in minimum position

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Disturbances

Gas turbine trip

The two redundant fuel quick shut-off valves and the fuel isolation valve are connected via the lock out trip relays and will close at turbine trip.

Loss of power supply

Loss of gas turbine power supply will not directly affect the system, since power supply to the solenoids is taken from battery and power supply to the control valve AC servo motor drives are taken from UPS.

System faults

Actions for the operators to take during alarm/trip conditions are listed in the alarm and trip list.

Other faults

Fault in connecting systems:

- External fuel system

External fuel system faults may result in difficulties to control the fuel flow to the burners. Gas supply temperature below the dew point may result in condensation inside the fuel system and damage to the combustion chambers.

The external fuel supply system shall be monitored that the pressure is within the operating limits and the temperature isn't too low. A signal "gas supply system failure" shall be sent to the gas turbine indicating that conditions are not met. (The signal may also include other conditions, which should stop operation on gas fuel.)

If the signal is present when the system is ordered on an alarm is given and if the turbine will start the start will be aborted. Fuel change to liquid is initiated and fuel change to gas will be aborted/blocked.

- Instrument air system

Reduced instrument air pressure will result in malfunctioning of following objects.

- | | |
|--------------------|--|
| Isolation valves | (Unpressurised position = closed position) |
| Shut-off valves | (Unpressurised position = closed position) |
| Ventilation valves | (Unpressurised position = opened position) |

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Technical specification

Design criteria and standards

Gas fuel specification according to GTI J241003E.

Dimensioning data

Approximate 1.7 kg/s (Turbine operating at full load)

Engineering data

Design pressure: 30bar(g)
Design temperature: -15°C --150°C

Emergency power supply

The solenoids operating the shut-off valves are powered from the 24 VDC system. The 24VDC system is powered from the 230VAC UPS system.

Power supply to control valve AC servo motor drive is taken from the 230 VAC UPS system.

Installation

The gas fuel unit 2 is installed in the frame under the gas turbine. The isolation valve and the filter are included in the gas fuel unit 1, which is installed outside the GT enclosure.

Materials

Valves and piping downstream filter are made of stainless steel.
Valves and piping upstream filter are made of carbon steel.
Filter casing is made of carbon steel.

Component data

See the aggregate, instrument, setting and electric load lists

Testing and service

Testing during normal operation

No function test is possible during normal operation.

Accessibility during normal operation

Coalescer filter elements can be exchanged during operation of the turbine in the not active (stand-by) filter line.

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