

SYSTEM DESCRIPTION MBN LIQUID FUEL SYSTEM	Respons. dept	Date	Reg.
	GPMA	2004-02-25	M DB 101
Prepared		YAMAMA CEMENT	
Markus Pernerros			

TABLE OF CONTENTS

Purpose of the system	2
General description of the system	2
Main components	3
Function	9
Start up	9
Continuous operation	9
Turbine stop	10
Stand still	10
Disturbances	10
Gas turbine trip	10
Generator breaker trip	10
Loss of power supply	10
System faults	10
Other faults	11
Technical specification	11
Design criteria and standard	11
Dimensioning data	11
Engineering data	11
Emergency power supply	11
Installation	11
Materials	11
Component data	12
Testing and service	12
Testing during normal operation	12
Accessibility during normal operation	12

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Purpose of the system

The purpose of the internal liquid fuel system is to supply fuel of correct quantity and pressure to the gas turbine burners.

That is:

- To supply the gas turbine with liquid fuel.
- To control the fuel flow at start-up and during operation and at normal 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 control the fuel supply at change over from liquid fuel to gas and vice versa.
- Drain surplus liquid fuel in the system and equipment for possibility to clean-blow the nozzles at shut down and at normal stop.
- To purge oil burners during gas operation.
- To purge some of the liquid fuel burners at low load of liquid fuel operation.
- Drain any liquid fuel in the system after shut down.

General description of the system

Also see P&ID 2046 025

The liquid fuel unit is located on a skid outside the gas turbine enclosure.

Fuel from the external fuel system is supplied via a filter to the liquid fuel tank. A float valve controls fuel level in the tank. The high pressure pump (internal gear type) with variable speed control the fuel through the shut-off valves to the fuel nozzles. The fuel injection thus is controlled through the pump and frequency converter.

The purge air system is used for purging the liquid fuel burners with gas fuel during operation on gas fuel and purging some of the liquid fuel burners with compressor air at low load of liquid fuel operation. The system is also used for clean-blowing the liquid fuel burners with instrument air after shut down of the gas turbine after liquid fuel operation.

The purging and clean-blowing will prevent the liquid fuel nozzles from carbonisation (coking).

The media is diesel oil or other type of fuels which fulfil liquid fuel specification GTI E242002 E.

Most fuel system components are located on the fuel unit.

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Main components

- Fuel isolation valve (spring closing type)
MBN10AA005
 The valve is located upstreams of liquid fuel unit. Purpose of valve is to isolate liquid fuel unit in case of fire, high level in liquid fuel tank or other reasons for isolating the liquid fuel unit. The valve is 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. Limit switches are indicating valve position.
- Filter (particle filter, duplex type)
MBN10AT005
 The filter is a duplex filter with 2 x 100% capacity with a continuous flow transfer valve and the filter purifies the fuel to the required level in order to avoid damage into the gas turbine burners. The filter cartridges are particle separating and are made of inorganic fibres bonded with resin. A differential pressure transmitter over the filter gives an alarm when maintenance is needed. The change-over between filters is made manually. Change of filter elements can be made during operation. The filter unit is also provided with an equalisation valve and this valve is used prior to change-over between filters, to enable filling of the standby filter in order to avoid a pressure drop in the system.
- Drainage shut off valves, fuel filter
MBN10AA220
MBN10AA225
 The shut off valves are used to drain the filter houses clean side during maintenance. The valves are in closed position during normal system operation.
- Ventilation shut off valves, fuel filter
MBN10AA235
MBN10AA240
 The shut off valves are used to vent the filter houses to avoid air pockets. The valves are in closed position during normal system operation.
- Differential pressure transmitter, fuel filter
MBN10CP005
 The transmitter is monitoring the differential pressure across the fuel filter, indicating need for filter change-over and maintenance.
 At high (H1) differential pressure, an alarm is initiated.
 The operator has to manoeuvre the change over valve and change the dirty filter element. It is recommended to change of the dirty filter element directly or soon after filter change-over.
- Flow meter
MBN10CF005

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The measuring principle of the screw-volumeter is positive-displacement. The measuring chambers are formed by two cycloidal spindels rotating in a casing. The fluid to be measured flows in axially and causes the spindles to rotate. The flow rate is a function of the defined volume of the measuring chambers.

- Level control valve (float type)

MBN10AA010

The valve is a float valve, and is used to maintain level in the fuel tank BB005. The float body is fixed at the lever. The float can be adjusted in horizontal direction at the lever arm. There is also the possibility to achieve a higher or lower regulation of the fluid level, by means of adjusting the lever arm at the mounting bolt.

- Fuel tank

MBN10BB005

The liquid fuel tank, with its float valve controlled level, serves as a reservoir for the high pressure fuel pump. Fuel from clean blowing sequence, circulation during start up, drain from pump and safety valve returns in the tank.

The tank has a volume which correspond with operation times on GT in the range from 3 minutes up to 15 minutes depending on GT load. The volume is enough for transition over from gas to distillate and distillate to gas.

- Level switch

MBN10CL005

Fuel level in the tank is monitored by a level switch that gives alarm at high or low level.

High level (H1) will cause closing of the fuel isolation valve to prevent overfilling of the tank in case of float valve failure. The fuel isolation valve opens 5 seconds after high level (H1) switch is released.

Low level (L1) and low level (L2) initiates alarm.

Low level (L1) in the tank will initiate fuel change over to gas operation.

Low level (L1) in the tank interlocks the tank heater.

Low level (L2) prevents fuel change over from gas to liquid fuel.

Low level (L2) initiates unloaded shutdown (30 sec). Pump is not allowed to run dry because of hazardous media.

- Temperature transmitter, fuel tank

MBN10CT005

The Pt100, installed in the tank, is continuously monitoring the fuel temperature in the tank. The transmitter is used for correction of fuel amount (to correct for density) and pump curves (to correct for internal leakage in the pump). The Pt100 element is also used to supervise the tank temperature i.e. heater MBN10AH005.

- Fuel heater, electrical

MBN10AH005-R01

The heater is installed in the liquid fuel tank cover. For applications with high viscosity fuels, the electrical heater keeps the fuel in the tank at optimum viscosity for the burners at start up. +5°C is the lowest allowed temperature for the liquid fuel.

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The fuel heater is controlled internally by a thermostat.

- Overheating protection switch
MBN10AH005-K01
 The switch is integrated in the heater **MBN10AH005**.
 High temperature automatically disconnects the power in order to prevent overheating of the heater element. The switch has to be manually reset after activation.
- Tank ventilation filter
MBN10AT015
 The filter prevents particles from surrounding air from entering the tank during ventilation
- Electrical heat tracing
MBN10AH010
 Electrical cable is winded round the pipes from the t-piece close the second shut off valve **MBN10AA030** up to and including the manifold. The aim is to keep the pipes warm at start up.
- Shut off valve, fuel oil tank drain (manually operated)
MBN10AA205
 The valve is located in the lowest point of the liquid fuel tank to ensure complete emptying.
- Strainer
MBN10AT010
 The strainer is located in the entry of the suction line to the fuel pump to prevent foreign objects to enter the fuel pump and the nozzles.
- Fuel pump (internal gear type)
MBN10AP005
 The high pressure fuel pump is a displacement pump of internal gear type driven by an AC motor and frequency converter (SFC). The pump is installed horizontally beside the tank with coupling and motor connected. The pump can only be operated in automatic mode. The pump gives the required amount of fuel to the burners using the frequency converter which is controlled by the turbine governor. The pump will decrease the fuel flow quickly at turbine trip, thus serving as a back up for the shut-off valves.
 A thermistor in the motor winding is connected to the SFC. At high winding temperature, the thermistor breaks operation order to the SFC and the pump will stop. High winding temperature can occur when operating the motor continuously at low speed.
 The motor has a built in anti condensation heating element to protect from condensate. The anti condensate heater is operating when the motor is shut-off.
- Safety valve
MBN10AA215
 The valve is a safety function for the system. The valve limits the pressure in the system and starts to open at a pressure of 60 bar. The valve is located close to the pump.

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- Fuel test valve
MBN10AA405
The fuel test valve is used when taking fuel samples.
- Liquid fuel shut-off valve (spring closing type)
MBN10AA025
The fuel shut-off valve is used to shut off the fuel supply when stopping the turbine by using a pneumatic quick closing actuator. The valve is of spring closing type. If the open order or instrument air for any reason disappears it will return to its safe closed position. Limit switches are indicating valve position. When indicating not fully closed valve before start, an alarm is given and the start is interlocked. The valve can be operated only in automatic mode.
- Pressure measuring point
MBN10CP020
Pressure point upstream second liquid fuel shut off valve.
- Liquid fuel shut-off valve 2 (spring closing type)
MBN10AA030
The fuel shut off valve is used to shut off the fuel supply when stopping the turbine by using a pneumatic quick closing actuator. The valve is of spring closing type. If the open order or instrument air for any reason disappears it will return to its safe closed position. Limit switches are indicating valve position. When indicating not fully closed valve before start, an alarm is given and the start is interlocked. The valve can only be operated in automatic mode
- Drain valve (manually operated)
MBN10AA406
The fuel drain valve is used when system is drained for service.
- Drain valve (manually operated)
MBN10AA407
The fuel drain valve is used when system is drained for service.
- Delta pressure transmitter
MBN10CP035
The transmitter is monitoring the differential pressure down stream second shut off valve before manifold and compressor discharge pressure. Used during start up. Used during change of fuel to oil to indicate burning on oil.
- Liquid fuel drain valve (spring open type)
MBN10AA040
The liquid fuel drain valve is used when flushing the liquid fuel system during start up and during clean-blowing sequence by using a pneumatic actuator. The valve is of spring opening type. If the open order or instrument air for any reason disappears it will return to its safe open position. The valve can only be operated in automatic mode.

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- Cleaning air valve 1
MBN30AA005
 The cleaning air valve supplies instrument air for clean blowing of the fuel system during the clean blowing sequence. The valve prevents liquid fuel and gas to enter instrument air system during operation. The valve can only be operated automatically.
- Pressure between cleaning air valves 1 and 2.
MBN30CP005
 Pressure between cleaning air valves is supervised by a pressure transmitter. High pressure indicates possible gas or/and fuel leakage through cleaning air valve MBN30AA010. High pressure H1 will initiate alarm.
- Cleaning air valve 2
MBN30AA010
 The cleaning air valve supplies instrument air for clean blowing of the fuel system during the clean blowing sequence. The valve prevents liquid fuel and gas fuel to enter instrument air system during operation. The valve can only be operated automatically.
- Purge gas valve
MBN30AA015
 The purge gas valve is only open during operation on main gas fuel, to purge and cool the liquid fuel burners with small amount of gas. Prevents leakage of liquid fuel into gas system.
 The valve can only be operated automatically.
- Purge gas valve
MBN30AA030
 The purge gas valve is only open during operation on main gas fuel, to purge and cool the liquid fuel burners with small amount of gas. The valve opens one minute before valve MBN30AA015 to avoid to fast injection of liquid fuel from fuel manifold and pipe down stream MBN30AA025 (together with MBN30BP005). MBN30AA030 closing at the same time as MBN30AA015.
 The valve can only be operated automatically.
- Purge gas orifice
MBN30BP005
 The purge gas orifice creates a flow restriction to achieve slow injection of liquid fuel when purge gas operation is starting.
- Pressure between purging air valves
MBN30CP010
 Pressure between purge gas valves is supervised by a pressure transmitter. High pressure indicates possible liquid fuel leakage through valve AA025. High pressure H1 will initiate alarm.
- Purge gas / Cleaning air valve
MBN30AA025
 The valve is open during operation on gas fuel, to purge and cool the liquid fuel burners with small amount of purge gas and it is open to supply instrument air for clean blowing of the fuel system

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during the clean blowing sequence, to prevent carbonisation in the fuel nozzles. Prevents leakage of liquid fuel into purge gas system and instrument air system.
The valve can only be operated automatically.

- Purge air shut-off valve
MBN30AA035
 The purge air shut-off valve is automatically open at low load on diesel fuel at operation below 4 MW to purge and cool the liquid fuel burners with small amount of air from the compressor. Above 4 MW MBN30AA035 will be automatically closed due to closing of MBN40AA035.

MBN30AA035 is automatically opened / closed when opening / closing valve MBN40AA035.
- Burner shut-off valves (stage valves)
MBN40AA005, AA010, AA015, AA020, AA025 and AA030
 The shut-off valves located on six of totally eighteen of the liquid fuel burners are used to shut off supply in order to keep up velocity in remaining burners at low turbine load. The valves are of three-way type and connect to liquid fuel manifold, burner and purge air manifold. Unloaded the valve is spring opening to connections liquid fuel manifold to burner. If the open order or instrument air for any reason disappears they will return to safe open position. The valves can only be operated in automatic mode.
- Instrument air shut-off valves
MBN40AA035, MBN40AA040
 The two instrument air shut-off valves are used to supply air to the actuators to the six burner liquid fuel shut-off valves by using two solenoid valves. The valves can only be operated in automatic mode.
- Instrument air orifice
MBN40BP005
 The instrument air orifice creates a flow restriction to achieve slow opening/closing of burner shut off valves.
- Instrument air orifice
MBN40BP010
 The instrument air orifice creates a flow restriction to achieve slow opening/closing of burner shut off valves.

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Function

Operation of the system is fully automatic.

Start up

Leakage test of the instrument air and purge gas fuel shut-off valves is automatically performed during start up.

Before start, the fuel heater has heated the fuel in the tank to start up temperature. At start the isolation valve opens. The level control valve adjusts the level in the liquid fuel tank. The shut-off valve 1 and the drain valve opens. The high-pressure fuel pump starts to flush the system. At the same time gas from the ignition gas system is ignited. The flame detection system checks the ignition of the flame. The second shut-off valve opens and the liquid fuel injects into start up burners and the fuel system is in operation.

Shut-off valve in wrong position, pump speed, or flame detector indicating flame before fuel injection interlocks or aborts start.

Continuous operation

During continuous operation the fuel pump gives the required amount of fuel to the burners using the frequency converter which is controlled by the turbine governor. The safety valve limits the fuel pressure.

Loss of flame initiates turbine trip.

Burner shut-off valves

At low load operation on liquid fuel, below 2 MW, all of the valves are closed for liquid fuel (open for purge air). Between 2 and 4MW three of the valves (MBN40AA005, 015, 025) are open for liquid fuel (closed for purge air) and three of the valves (MBN10AA010, 020, 030) are closed for liquid fuel (open for purge air). Above 4 MW all the valves are open only for liquid fuel (closed for purge air).

Gas fuel running

When operating on gas fuel, a small portion of gas fuel flow downstream the control valve enters the fuel oil nozzles for purging. Change over between fuels can be initiated automatically or manually.

Burner shut-off valves

All valves in closed position (closed for liquid fuel to burner) to ensure purging with gas. In this closed position the valve is open for flow of gas to the burners.

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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

Change-over from main fuel to backup fuel can be initiated automatically or manually.
 Change-over from backup fuel to main fuel shall be initiated manually.

Turbine stop

During turbine stop the load of the power turbine is ramped down. When the load has reached a pre-set minimum value, the fuel shut of valves are ordered to close and the pump is stopped.

During the shut down sequence the second shut off valve (AA030) and the liquid fuel drain valve (AA040) are open for a short period to drain surplus fuel from liquid fuel piping back to the tank by means of combustion chamber pressure.

After closing the fuel shut off valves a second time, the cleaning air shut off valves open and the manifold and nozzles are purged by blowing instrument air through the system to prevent carbonisation in the fuel nozzles.

Stand still

After shut down the system is not in operation. The liquid fuel FG is off. The shut off valves, the drain valve, the clean-blowing valves and the isolation valve are closed. The fuel pump is stopped.

Disturbances

Gas turbine trip

The fuel shut off valves are ordered to close and the pump is stopped.

Generator breaker trip

The pump control will react to sustain zero load.

Loss of power supply

Loss of AC power supply stops the fuel pump, causing a loss of flame and a gas turbine shut-down.

System faults

The faults which are supervised by alarms and/or shutdown procedures are listed in the alarm and trip document.

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Other faults

Fault in connecting systems:

- External fuel system

External fuel system faults may result in to small amount of fuel oil in the liquid fuel tank. Low level in tank will cause alarm and eventually trip of the turbine.

- Fuel additive dosage system

To much additive in the fuel may result in deposits on the turbine blading. None or too little additive may result in high temperature corrosion in the turbine.

- Instrument air system

Lost or reduced instrument air pressure will result in an alarm and a start interlock of the turbine.

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

Isolation valve (Unpressurised position = closed position)

Drain valve (Unpressurised position = closed position)

Quick shut off valves (Unpressurised position = closed position)

Purge gas and clean air valves (Unpressurised position = closed position)

Clean blowing sequence.

Technical specification

Design criteria and standard

Liquid fuel specification according to GTI E242002 E

Dimensioning data

Fuel flow required 140 l/min

Engineering data

Design pressure: 100 Bar(e)

Design temperature: 90 °C

Emergency power supply

The solenoids operating the shut off valves are powered from 24 V DC battery back up system.

Installation

The liquid fuel unit is installed outside the gas turbine enclosure.

Materials

Fuel tank and piping after duplex filter is made of stainless steel.

Filter casing is made of carbon steel.

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Component data

[See the system lists](#)

Testing and service

Testing during normal operation

No function test is possible during normal operation.

Accessibility during normal operation

Filter in liquid fuel system is of duplex type 2 x 100% . Contaminated filter element can be changed during normal operation.

Parts of the system are available for maintenance during operation on gas fuel. Further details may be found in the maintenance manual.

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M		MBN10 AT015	
		Tank ventilation filter	5
		MBN10 BB005	
		Fuel tank	4
MBN10 AA005		MBN10 CF005	
Fuel isolation valve	3	Flow meter	3
MBN10 AA010		MBN10 CL005	
Level control valve	4	Level switch	4
MBN10 AA025		MBN10 CP005	
Liquid fuel shut-off valve (spring closing type)	6	Differential pressure transmitter	3
MBN10 AA030		MBN10 CP020	
Liquid fuel shut-off valve 2 (spring closing type)	6	Pressure measuring point	6
MBN10 AA040		MBN10 CP035	
Liquid fuel drain valve	6	Pressure transmitter	6
MBN10 AA205		MBN10 CT005	
Shut off valve, fuel oil tank drain	5	Temperature transmitter (fuel tank)	4
MBN10 AA215		MBN30 AA005	
Safety valve	5	Cleaning air valve 1	7
MBN10 AA220		MBN30 AA010	
Drainage shut off valve	3	Cleaning air valve 2	7
MBN10 AA225		MBN30 AA015	
Drainage shut off valve	3	Purge gas valve	7
MBN10 AA235		MBN30 AA025	
Ventilation shut off valve	3	Purge gas / Cleaning air valve	7
MBN10 AA240		MBN30 AA030	
Ventilation shut off valve	3	Purge gas valve	7
MBN10 AA405		MBN30 AA035	
Fuel test valve	6	Purge air shut-off valve	8
MBN10 AA406		MBN30 BP005	
Drain valve	6	Purge gas orifice	7
MBN10 AA407		MBN30 CP005	
Drain valve	6	Pressure between cleaning air valves 1 and 2	7
MBN10 AH005-K01		MBN30 CP010	
Overheating protection switch	5	Pressure between purging air valves	7
MBN10 AH005-R01		MBN40 AA005, AA010, AA015, AA020, AA025 and AA030	
Fuel heater	4	Burner shut-off valves	8
MBN10 AH010		MBN40 AA035, AA040	
Electrical heat tracing	5	Pressure between purging air valves	8
MBN10 AP005		MBN40 BP005	
Fuel pump	5	Instrument air orifice	8
MBN10 AT005		MBN40 BP010	
Particle filter	3	Instrument air orifice	8
MBN10 AT010			
Strainer	5		

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