KONGSBERG

# Oil & Gas Production Model

## Process Description

## K-Spice® Generic Training Simulator

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# 1 Oil & Gas Production Plant References

The main operational features of the Generic Oil and Gas Production Process are:

- Production of stabilised (dead) crude for export to Storage Tanks
- Compression and treatment of associated gas for export via pipeline
- Treatment of Produced Water prior to disposal as a supply for the Water Injection
- Treatment of Sea Water prior to Water Injection

## 1.1 Primary Hydrocarbon Process

Process design consists of a three-stage, three-phase separation train. The three-phase flow from the production wells is routed to the High Pressure (HP) or Test Separator, for the initial separation into water, gas and hydrocarbon liquids. The hydrocarbon liquids are further degassed in the Medium Pressure (MP) Separator and then heated before the final degassing is done in the Low Pressure (LP) Separator. Stabilised crude from the Low Pressure (LP) separator is routed to an Electrostatic Coalescer for final dewatering prior to export. Water removed in the Coalescer is pumped back to the inlet of the HP Separator.

The associated gas from the Medium Pressure (MP) and Low Pressure (LP) stages are recompressed to High Pressure (HP) stage pressure. This done prior to the total gas stream being cooled for heavy hydrocarbon removal and then dehydrated by intimate contact with lean Tri Ethylene Glycol in the TEG Contactor in order to meet export specifications. The dried gas is compressed and then cooled for delivery into the Gas Export Pipeline. The rich TEG is returned to the Regeneration System.

Produced Water leaving the HP and Test Separators is routed to their respective Hydrocyclones for de-oiling before final degassing in the Degassing Drum and onward pumping to the Water Injection System or disposal to sea.

A Test Separator, normally operating at the same pressure as the High Pressure Separator, caters for well testing.

To support the process operations a number of utility systems are provided. These utilities include:

- Cooling Medium
- Seawater
- Water Injection

## 1.2 Cooling Medium System

The Cooling Medium System is a closed circuit in which a mix of 35% TEG (Triethylene Glycol) and 65 % water is circulated via pumps. It is designed to remove 45.0 MW of heat from the process.

The Cooling Medium Expansion Vessel takes care of fluctuations in volume due to changes in the temperature of the Cooling Medium. This is placed on the highest location in the system and the pressure in the Expansion Vessel is held constant by using inert gas (Nitrogen).

2 off 100% capacity electric motor driven Cooling Medium Pumps provide the necessary flow.

The 2 off 50% capacity Cooling Medium Coolers are plate heat exchangers. Each cooler has a Cooling Medium Temperature control valve mounted on the outlet stream of the seawater.

## 1.3 Seawater System

The Seawater System is utilised for cooling the Cooling Medium System, Supplying the Water Injection System and production of fresh water.

The Seawater enters the Seawater System through an inlet from the sea. The Seawater is then routed through the Seawater Pumps. There are 2 off 100% capacity pumps. Both pumps have variable speed drives controlled by the outlet pressure of the pumps. Seawater Filters downstream of the Pumps remove 98% of particles larger than 1500 micron. After filtration, the Seawater is distributed to the various locations.

## 1.4 Water Injection System

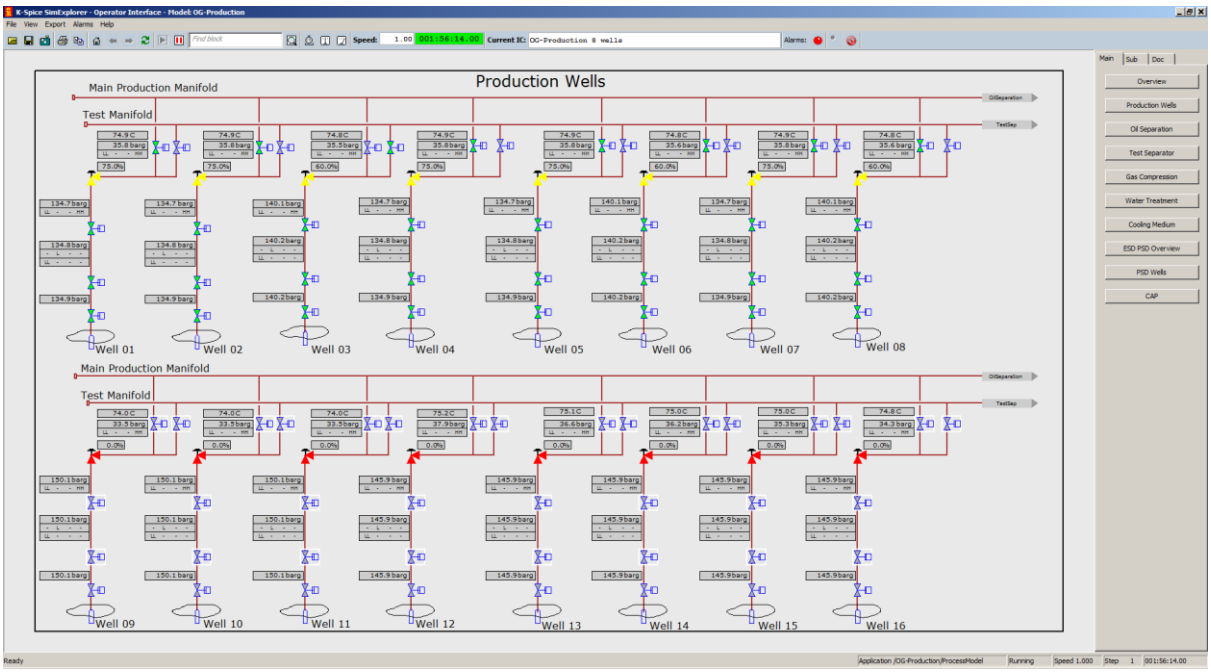
Warm seawater from the Seawater System (taken off downstream of the Cooling Medium Coolers) is further filtered before passing to the Seawater Deaerator. There, by means of the near vacuum maintained by the vacuum pumps, and the use of oxygen scavenger chemical, the dissolved oxygen is removed from the seawater, and the deaerated seawater exits the deaerator tower bottom. From there, it passes to the Booster pumps, and then the main Injection pumps. The Injection pumps discharge to the Water Injection Manifold and from there it can be routed to the 3 Water Injection Wells.

Produced Water from the Produced Water system can also be routed to the suction of the main Injection pumps to enable the Produced Water to be injected into the reservoir.

# 2 System 13 Details- Wells and Wellheads

The system is shown in P & I D's:

OGP-PID-1301 rev 0 Production Wells (Group 1)
OGP-PID-1302 rev 0 Production Wells (Group 2)
OGP-PID-1303 rev 0 Production Wells (Group 3)
OGP-PID-1304 rev 0 Production Wells (Group 4)
OGP-PID-5104 rev 0 Water Injection Manifold and Wells




The system for oil production comprises 16 wells, all connected to the Generic Oil & Gas Process Simulator by 8″ flowlines.

All trees have a 7″ production bore with 5″ wing outlet. Chokes are located on the trees for the producing wells and injection wells. Control of all Xmas Tree valves is by hydraulic fluid.

Design flow from each production well is 4,000 $m^3$/day.

The system for water injection comprises three injection wells, connected to the Generic Oil & Gas Process Simulator by 3 x 6″ flowlines.

Design flow to each water injection well is 160 $m^3$/day.

Control and monitoring of the production / injection system is by a multiplexed electro hydraulic control system also configured to operate downhole active control equipment and instrumentation.

Tubing head pressure and flowline pressure and temperatures are available for each well.

The opening of the valves associated with each well has to be done in the following order:

1. Sub Surface Safety Valve
2. Master Valve
3. Manifold valve (either Production or Test)
4. Wing Valve
5. Choke Valve

Safeguarding Instrumentation is provided by High and Low Pressure trip switches on each well.

Arrival temperature of the well fluids is between 70ºC and 90ºC and separator pressure is between 35.0 and 40.0 barg.

# 3 System 13 Details - Test and Production Manifolds.

The system is shown in P & I D's:

OGP-1305 rev 0 Production and Test Manifolds

The fluids from each production well can be routed to the Test manifold or the Production Manifold via a 6″ electric motor actuated on/off valve. Only one production well can be open to the Test Manifold at any time.

## 3.1 Test Manifold.

Each Production well can be routed to the 10″ Test Manifold using 6″ electric motor actuated on/off valves. The manifold itself has a 10″ hydraulically actuated shutdown valve 13XV2007 with a 2″ hydraulically actuated shutdown bypass valve 13XV2008.

**NOTE:** The pressurising valve must be opened until pressure is equalised before opening the main valve.

Electronic interlocks ensure that only one Production well can be connected to the Test Manifold at any time.

The Test Manifold can be depressurised to the HP Flare via a 2″ hydraulically operated blowdown valve 13BDV2005. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation.

Fluids from the Test Manifold are routed directly to the Test Separator.

No Safeguarding instrumentation is fitted to the Test Manifold.
Pressure and Temperature Indications are available for the Test Manifold.

## 3.2 Production Manifold

Each Production Well can be routed to the 18″ Production Manifold using 6″ electric motor actuated on/off valves. The manifold itself has an 18″ hydraulically actuated shutdown valve 13EV2003 with a 2″ hydraulically actuated shutdown bypass valve 13EV2004.

**NOTE:** The pressurising valve must be opened until pressure is equalised before opening the main valve.

The Production Manifold can be depressurised to the HP Flare via a 2″ hydraulically operated blowdown valve 13BDV2001. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation.

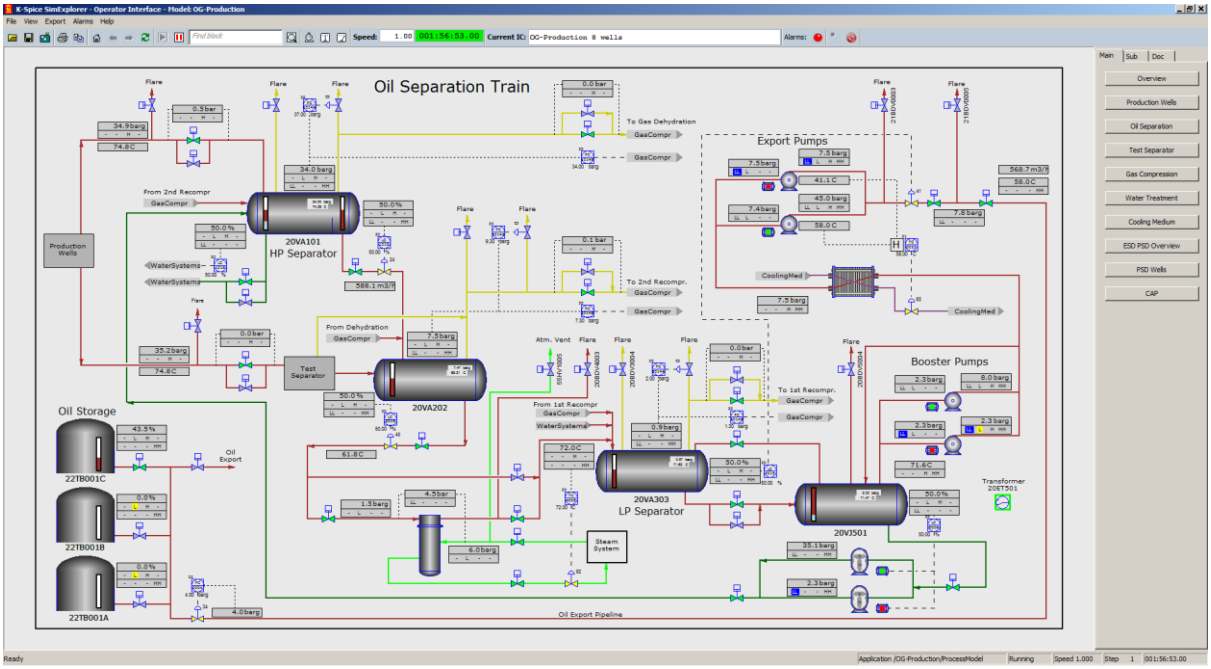
Fluids from the Production Manifold are routed directly to the HP Separator.
No Safeguarding instrumentation is fitted to the Production Manifold.
Pressure and Temperature Indications are available for the Production Manifold.

# 4 System 20 Details - Oil Separation

The system is shown in P & I D's:

OGP-PID-2002 rev 0 High Pressure Separator 20VA101
OGP-PID-2003 rev 0 Medium Pressure Separator 20VA202
OGP-PID-2004 rev 0 Crude Oil Heater 20HA401
OGP-PID-2005 rev 0 Low Pressure Separator 20VA303
OGP-PID-2006 rev 0 Coalescer 20VJ501
OGP-PID-2001 rev 0 Test Separator 20VA004




The oil/gas separation is a conventional three-stage process, at a sequentially reduced pressure in each stage. Produced water is separated at the High Pressure Separator 20VA101 whilst final dewatering of the crude to meet export BS & W specifications, takes place in an Electrostatic Coalescer 20VJ501. Crude specification is maintained by the use of Crude Oil Heater 20HA401, located between Medium Pressure Separator 20VA202 and Low Pressure Separator 20VA303. Test Separator 20VA004 is available to enable individual wells to be tested.

## 4.1 High Pressure Separator 20VA101

The High-Pressure (HP) separator 20VA101 is designed as conventional three-phase separator, and has a design pressure of 49.0 barg and a temperature of 100.0$^{o}$C. The vessel has an internal diameter of 3.600 metres with a length (tan-tan) of 14.000 metres.

Pressure Control of the vessel is via 20PC1014B to the speed controller of the Gas Export Compressor 27KA001 (or via 20PC1014A to the HP Flare if the Gas Export Compressor 27KA001 is not running).

Gas that is flashed from the fluids in this vessel is routed to the Inlet Cooler 26HB001 prior to being dehydrated.

Oil is released under control of 20LC1015 to the MP Separator.

**NOTE**: The level controller is pulsed to Manual Mode and 0% output when respective EV or XV valve is closed.

Produced Water is released under control of 20LC1018, located downstream of the HP Separator Hydrocyclone 44CE002, to the Produced Water Degassing Drum 44VD1001 and is metered by 44FT0002.

Safeguarding Instrumentation is provided by High and Low Pressure trip switch 20PST1013, High and Low Level trip switch (crude side) 20LST1016, Low Level trip switch (water side) 20LST1017.

Gas Blowby is prevented by 14" hydraulically operated shutdown valves 20EV1008 with 2" bypass 20EV1009 on the waterside and 14" 20EV1007 on the crude side.

On the Gas outlet to the Glycol Contactor, hydraulically operated shutdown valve 14" 20EV1001 is available to isolate the system.

Pressurisation of the downstream gas process is achieved using 2" hydraulically operated bypass valve 20EV1002 (fitted with restriction orifice).

The Separator can be depressurised to the HP Flare via a 3" hydraulically operated blowdown valve 20BDV1004. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation.

A connection to the Closed Drain System is available to drain the vessel once it has been depressurised.

### 4.2 Medium Pressure Separator 20VA202

The Medium Pressure (MP) separator 20VA202 is designed as conventional two-phase separator, and has a design pressure of 14.5 barg and a temperature of 120.0$^{o}$C. The vessel has an internal diameter of 3.350 metres with a length (tan-tan) of 11.000 metres.

Crude from the HP Separator and Test Separator is mixed on the inlet to the MP Separator along with condensate from the Glycol Contactor inlet Scrubber via 24EV1005.

Gas from the Test Separator (dependant on operating pressure) can also be routed to the gas outlet from the MP separator via hydraulically operated shutdown valve 20XV0001 (in parallel with 20XV0002).

**NOTE:** The pressurising valve must be opened until pressure is equalised before opening the main valve.

Pressure Control of the vessel is via 20PC2014B to the speed controller of the 2nd Stage Recompressor 23KA002 (or via 20PC2014A to the HP Flare if the 2nd Stage Recompressor 23KA002 is not running).

Oil is released under control of 20LC2015 to the Crude Heater 20HA401.

**NOTE**: The level controller is pulsed to Manual Mode and 0% output when respective EV or XV valve is closed.

Safeguarding Instrumentation is provided by High and Low-Pressure trip switch 20PST2013, High and Low Level trip switch 20LST2016.

Gas Blowby is prevented by 14" hydraulically operated shutdown valve 20XV2007.

On the Gas outlet to the 2nd Stage Recompressor 26KA001, hydraulically operated shutdown valve 10" 20XV2001 is available to isolate the system.

Pressurisation of the downstream gas process is achieved using 2" hydraulically operated bypass valve 20XV2002 (fitted with restriction orifice).

**NOTE:** The pressurising valve must be opened until pressure is equalised before opening the main valve.

The MP Separator can be depressurised to the HP Flare via a 2" hydraulically operated blowdown valve 20BDV2004. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation.
A connection to the Closed Drain System is available to drain the vessel once it has been depressurised.

### 4.3 Crude Heater 20HA401

Crude Heater 20HA401 is a shell and tube heat exchanger. Shell side design pressure and temperature is 13.5barg / 220.0°C and the tube side design pressure and temperature is 14.5barg / 130.0°C. Design heat duty of the exchanger is 8000 kW.

Crude from the MP Separator can be routed to the Low Pressure (LP) Separator via the Crude Heater 20HA401 or the heater can be by-passed totally.

Use of the Crude Heater is dependant on the arrival temperature of the crude, but when in use it will raise the temperature from around 65.0°C to 85.0°C to assist in the production of the correct specification crude.

Isolation of the crude inlet to and outlet from the heater is achieved with 16" hydraulically operated valves 20XV4001 and 20XV4002 respectively, with the by-pass facility provided via 16" 20XV4000.

The Crude Heater tube side can be depressurised to the HP Flare via a 2" hydraulically operated blowdown valve 20BDV4003. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation. Logic interlocks prevent blowdown valve 20BDV4003 from opening until crude inlet and outlet valves, 20XV4001 and 20XV4002 are closed.

LP Steam supply and Condensate return lines can be isolated by 10" hydraulically operated valve 55XV1001 and 3" hydraulically operated valve 55XV1002 respectively.

The Crude Heater shell side can be depressurised to the Atmospheric Vent system via a 2" electrically operated vent valve 55HV1005. A restriction orifice downstream of the vent valve limits the rate of depressurisation.

Interlocks are provided to ensure:

- Steam supply and Condensate return valves are closed when the Crude Heater is in By-pass mode.
- Crude oil flow is either through the heater or through the bypass

The temperature of the crude inlet to the heater is measured by 20TT4008 and the temperature control of the crude outlet is set by 20TC4008, on the liquid inlet to the LP Separator 20VA303, modulating the control valve on the condensate outlet from the Crude Heater.

**NOTE**: The temperature controller is pulsed to Manual Mode and 0% output when respective EV or XV valve is closed.

LP Steam supply pressure is monitored by 20PT4006B and the crude inlet pressure is measured by 20PT4006A.

Safeguarding Instrumentation is provided by Low Differential Pressure (LP Steam and Crude pressures) trip switch 55PDST1007 and Crude Outlet high temperature trip switch 20TST4007.

*Figure: Shell & Tube Heat Exchanger*

### 4.4 Low Pressure Separator 20VA303

The Low Pressure (LP) separator 20VA303 is designed as conventional two-phase separator, and has a design pressure of 14.5 barg and a temperature of 130.0$^{o}$C. The vessel has an internal diameter of 3.650 metres with a length (tan-tan) of 14.000 metres.

Crude from the Crude Heater (or directly from the MP Separator when the heater is in by-pass mode) is mixed on the inlet to the LP Separator with:

- Reject oil from the hydrocyclones via 44XV0001
- Condensate from the 1st Stage Recompressor Inlet Scrubber via 23XV1002

Pressure Control of the vessel is via 20PC3014B to the speed controller of the 1$^{st}$ Stage Recompressor 23KA001 (or via 20PC3014A to the HP Flare if the 1$^{st}$ Stage Recompressor 23KA002 is not running).

Oil is released to the Coalescer under control of 20LC3015 which modulates the speed of the Crude Oil Export Pumps and the control valve on their discharge via a split range system.

Safeguarding Instrumentation is provided by High and Low-Pressure trip switch 20PST3013, High and Low Level trip switch 20LST3016.

Gas Blowby is prevented by 12" hydraulically operated shutdown valve 20EV3007 in parallel with 2" hydraulically operated shutdown valve 20EV3008.

On the Gas outlet to the 1$^{st}$ Stage Recompressor 23KA001, hydraulically operated shutdown valve 14" 20XV3001 is available to isolate the system.

Pressurisation of the downstream gas process is achieved using hydraulically operated 2" bypass valve 20XV3002 (fitted with restriction orifice).

The LP Separator can be depressurised to the HP Flare via a 6" hydraulically operated blowdown valve 20BDV3004. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation.

A connection to the Closed Drain System is available to drain the vessel once it has been depressurised.

### 4.5 Coalescer 20VJ501

The electrostatic coalescer 20VJ501 is designed as a liquid/liquid separator and has a design pressure of 14.5 barg and a temperature of 130.0$^{o}$C. The vessel has an internal diameter of 3.100 metres with a length (tan-tan) of 9.000 metres. The vessel operates liquid full at all times.

Oil from the LP separator and any recycle from the Crude Oil Booster Pumps enters the vessel via a bottom entry. The oil leaves the vessel via a top entry nozzle. This arrangement ensures the vessel is always operated liquid full. The oil flows to the suction of the Crude Oil Booster Pumps.

The prime purpose of the vessel is to provide final dewatering of the crude oil before storage. The process is achieved using the principle of coalescing in which small water droplets are encouraged to coalesce into larger droplets. The large droplets will separate more readily from the oil due to gravitational effects. The migration of the water droplets towards each other is produced by the application of an electric potential between sets of plates immersed in the oil. The plates are energised to give a field potential, the power being supplied from a rectifying transformer unit 20ET501 located on top of the vessel. The unit is supplied at 440VAC, 60 Hz, 3-phase. The safety of the coalescer is dependent on ensuring that a gas cap does not exist whenever a current is flowing through the plates nor that the water level reaches the plates causing a short-circuit. The flow path through the unit guarantees this: i.e. bottom to top. However a low level detected by 20LT5010 will de-energise 20ET501.

Produced water accumulated in the coalescer is pumped to the HP Separator by Coalescer Water Return Pumps 20PG501A&B. The pumps are motor driven screw types each rated at 100% duty. The design flow rate is 75.0 m$^3$/hr at a differential pressure of 34.9 bar. Motor rating is 210 kW. Speed control of these pumps is by level controller 20LC5009 acting on the speed of the pumps and also a high or low level will start/stop the Standby Pump. Pump isolation is provided by 6" hydraulically operated shutdown valve 20XV5002 on the common suction and 4" hydraulically operated shutdown valve 20XV5003 on the common discharge.

A pressure balance line between the LP Separator and the coalescer is provided through 4" hydraulically operated valve 20EV5001.

The Coalescer can be depressurised to the HP Flare via a 2" hydraulically operated blowdown valve 20BDV5004. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation.

Manual block valves are available to isolate and bypass the Coalescer.

Due to the modelling solution for the balance line, the level transmitter 20LST5010 requires -300% calibration fault in order to reach the trip setting.

### 4.6 Test Separator 20VA004

The Test Separator 20VA004 is designed as conventional three-phase separator, and has a design pressure of 49.0 barg and a temperature of 120.0$^{o}$C. The vessel has an internal diameter of 3.000 metres with a length (tan-tan) of 6.000 metres.

Pressure Control of the vessel is variable as follows:

- Via 20PC0014B to a control valve on the line to the Gas Dehydration system or to the gas outlet of the MP Separator when the Test Separator is run at a lower pressure than the HP Separator
- Via 20PC0014A to the HP Flare.

Gas flow is metered by 20FT0019, irrespective of the gas flow routing.

Oil is released under control of 20LC0015 to the MP Separator and is metered by 20FT0020.

**NOTE**: The level controller is pulsed to Manual Mode and 0% output when respective EV or XV valve is closed.

Produced Water is released under control of 20LC0018 located downstream of the Test Separator Hydrocyclone 44CE003 to the Produced Water Degassing Drum 44VD101 and is metered by 20FT0021.

Safeguarding Instrumentation is provided by High and Low Pressure trip switch 20PST0013, High Level and Low trip switch (crude side) 20LST0016, Low Level trip switch (water side) 20LST0017.

Gas Blowby is prevented by 14" hydraulically operated shutdown valves 20EV0008 and 2" bypass 20EV0009 (water) and 20XV0007 (crude).

**NOTE:** The pressurising valve must be opened until pressure is equalised before opening the main valve.

On the Gas outlet to the Gas Dehydration System, hydraulically operated shutdown valve 10" 20EV0010 is available to isolate the system.

Pressurisation of the downstream gas process is achieved using 2" bypass 20EV0011 (fitted with restriction orifice).

**NOTE:** The pressurising valve must be opened until pressure is equalised before opening the main valve.

On the Gas outlet to the MP Separator, hydraulically operated shutdown valve 10" 20XV0001 is available to isolate the system.

Pressurisation of the downstream gas process is achieved using 2" bypass 20XV0002 (fitted with restriction orifice).

**NOTE:** The pressurising valve must be opened until pressure is equalised before opening the main valve.

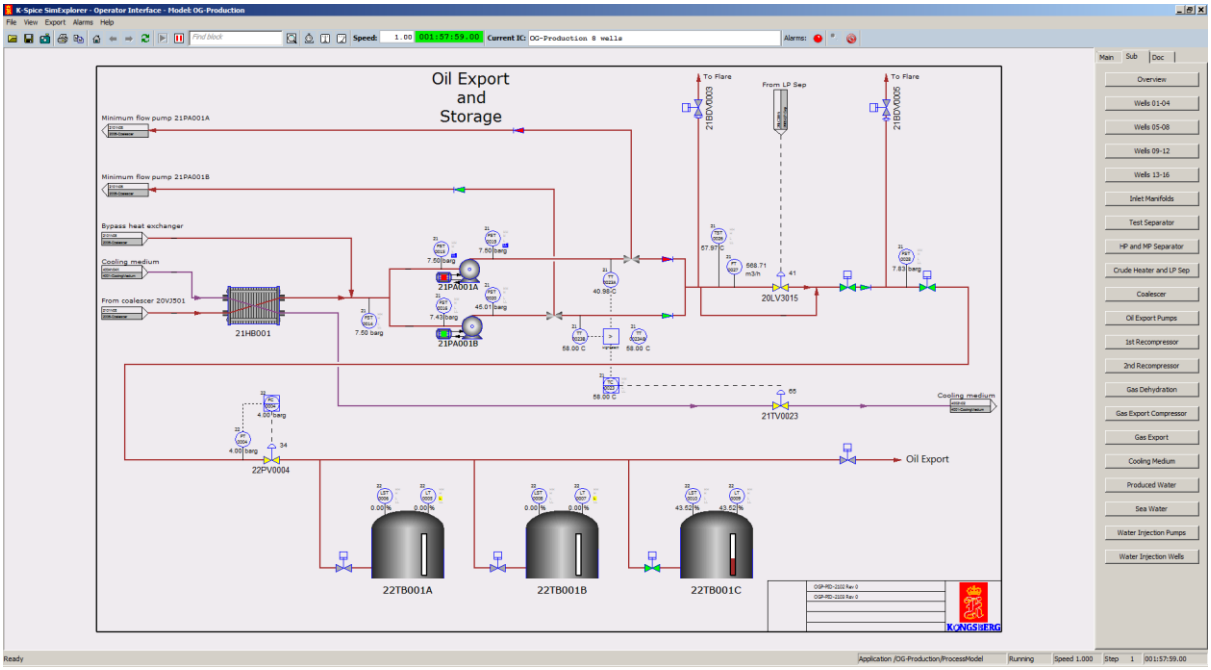
The Separator can be depressurised to the HP Flare via a 2" hydraulically operated blowdown valve 20BDV0004. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation.
A connection to the Closed Drain System is available to drain the vessel once it has been depressurised.

# 5 System 21 Details- Crude Oil Cooling and Export

The system is shown in P & I D's:

OGP-PID-2101 rev 0 Crude Oil Booster Pumps and Cooler
OGP-PID-2102 rev 0 Crude Oil Export Pumps
OGP-PID-2103 rev 0 Crude Oil Metering and Storage




## 5.1 Crude Oil Booster Pumps 21PA002A&B

Oil from the Coalescer supplies the suction of the Crude Oil Booster Pumps 21PA002A&B. The pumps are motor driven centrifugal type each rated at 100% duty. The design flow rate is 950.0 $m^3$/hr at a differential pressure of 5.1 bar. Motor rating is 150 kW.

Pump protection is provided by High Temperature switch 20TST5015 on the common suction, Low Pressure switch 20PST5016/02on the individual pump suction lines, and Low and High Pressure switch 21PST0010/24 on the individual pump discharge lines.
Minimum flow protection for the pumps is provided by automatic combined Minimum Flow/Non-return valves on the individual pump discharge lines, returning to the Coalescer.

## 5.2 Crude Oil Cooler 21HB001

Crude Oil Cooler 21HB001 is a plate type exchanger with a co-current flow pattern. Crude side design pressure and temperature is 14.5 barg / 110$^o$C and the cooling medium side design pressure and temperature is 16.0 barg / 110$^o$C. Design heat duty of the exchanger is 6291 kW.

The cooling medium is taken from the closed loop circulating system. Control of the oil exit temperature is by modulation of a temperature control valve on the cooling

medium return line, the temperature being measured on the discharge of the Crude Oil Export Pumps by 21TC0023 (see next section).

*Figure: Plate Heat Exchanger*

### 5.3 Crude Oil Export Pumps 21PA001A&B

Crude Oil Export Pumps 21PA001A&B take suction from the Crude Oil Cooler. The pumps are motor driven centrifugal type each rated at 100% duty. The design flow rate is 950.0 $m^3$/hr at a differential pressure of 37.1 bar. Motor rating is 1002 kW. Both pumps have variable speed motors controlled by the level in the LP Separator (70% - 100% of controller output is 55% - 100% of pump speed).
Minimum speed is 55% = 2000 rpm

Safeguarding Instrumentation is provided by High Pressure trip switch 21PST0014 on the common pump suction and High Temperature trip switch 21TST0026 on the common discharge line and also by Low Pressure trip switch 21PST0028 on the Export Pipeline.

Individual Pump protection is provided by Low Pressure trip switch 21PST0028/02 on the pump suctions and Low and High Pressure trip switch 21PST0019/4 on the discharge lines.

Temperature control is provided by 21TT0023A/B, which supply 21TC0023 via a high selector switch. The output of this selector then modulates the temperature control valve on the cooling medium outlet of the Crude Oil Cooler.

21FT0021/38 measure individual pump discharge flows respectively with the common export flow monitored by 21FT0027.

Minimum flow protection for the pumps is provided by automatic combined Minimum Flow/Non-return Valves on the individual pump discharge lines, returning to the inlet of the Crude Oil Cooler.

The Crude Oil Export Pumps can be depressurised to the HP Flare via a 2" hydraulically operated blowdown valve 21BDV0003. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation.

The Crude Oil Export Pumps can be isolated from the Export Pipeline by 14" hydraulically operated shutdown valves 21XV0001 and 21EV0002. High Pressure trip switch 21PST0014 on the Export Pump common pump suction will close 14" hydraulically operated shutdown valves 21XV0001. The pipework between the valves can be depressurised to the HP Flare via a 2" hydraulically operated blowdown valve 21BDV0005. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation.

### 5.4 Crude Oil Storage Tanks 22TB001A, B and C

The 18" pipeline from the Generic Oil & Gas Process Simulator is 50.0 km in length and terminates in 3 Storage Tanks each 30.0 metres high and 55.0 metres diameter with a capacity of 70,600 $M^3$.

22PC0004, located at the Tank Farm, achieves pressure control of the pipeline.

Level Indication and Alarm in each tank is provided by level indication 22LT0005, 22LT007 and 22LT009.

Each Storage Tank can be isolated from the pipeline by hydraulically operated valves 22HV0001, 22HV0002, and 22HV0003.

Safeguarding Instrumentation is provided by High-Level trip switches 22LST0006, 22LST0008 and 22LST0010 closing the respective tank inlet valve.

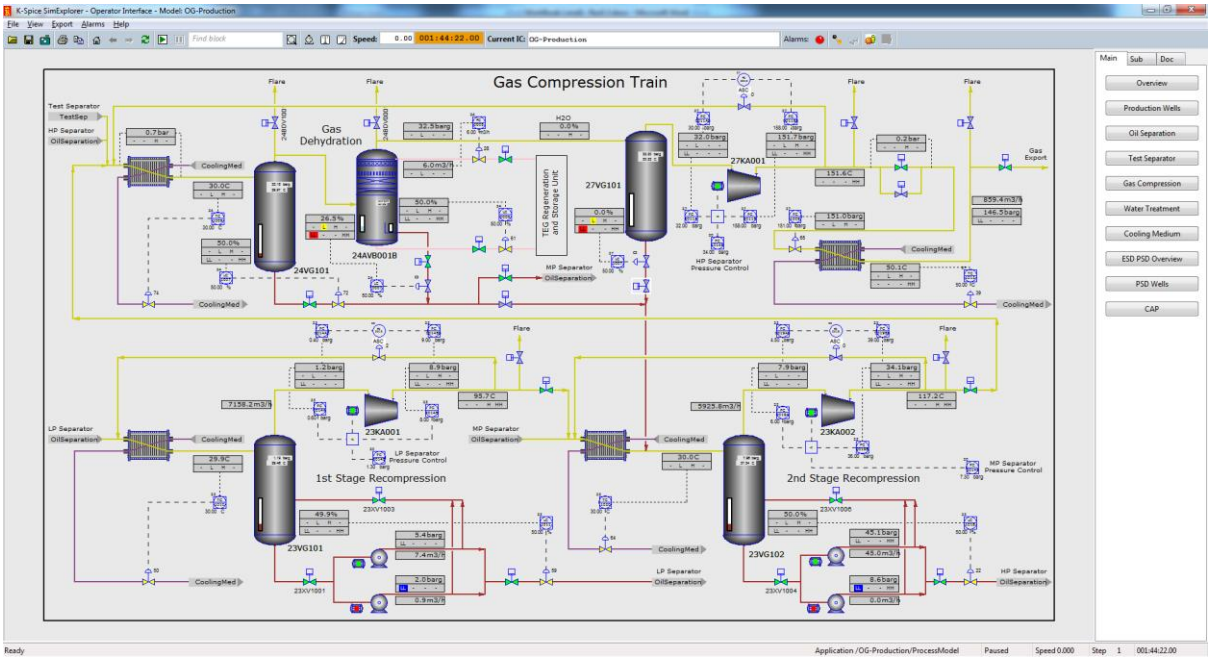
*Figure: Centrifugal Pump*

# 6 System 23 Details - Gas ReCompression

The system is shown in P & I D's:

OGP-PID-2301 rev 0 1st Stage Recompressor Cooler and Scrubber
OGP-PID-2302 rev 0 1st Stage Recompressor
OGP-PID-2303 rev 0 2nd Stage Recompressor Cooler and Scrubber
OGP-PID-2304 rev 0 2nd Stage Recompressor




A single gas processing train is provided for the Generic Oil & Gas Process Simulator's gas conditioning and export facilities. The train is designed to condition associated gas from the production separators at a maximum design rate of 130586.0 kg/hr. The gas process system provides compression and dehydration prior to export into the pipeline.

The train consists of 2 Recompression stages, 23KA001 & 23KA002 and an Export Compressor together with associated equipment.

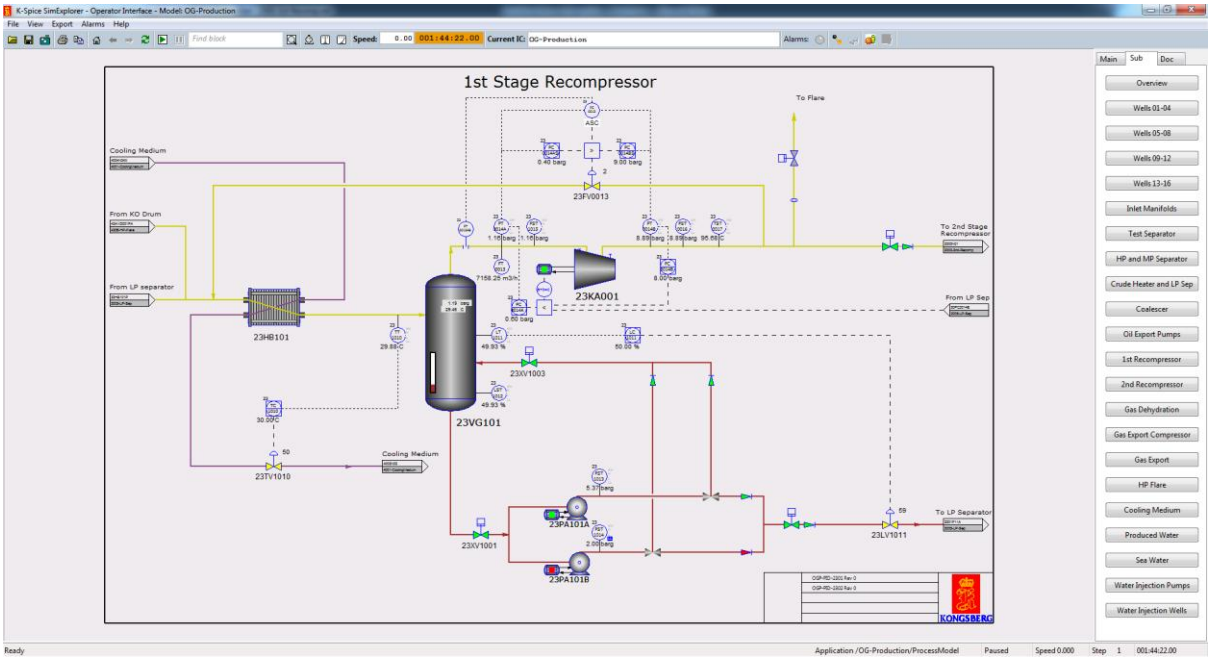
## 6.1 1st Stage Recompression System

The 1st Stage Recompressor 23KA001 is a multi-wheeled centrifugal compressor which compresses associated gas from the LP Separator and from the HP Flare Drum at LP separator pressure up to the operating pressure of the MP separator. The compressor is driven by a variable speed electric motor. A suction gas cooler 23HB101 and suction scrubber 23VG101 are provided. The compressed gas is combined with associated gas leaving the MP separator (and the Test Separator if it is running at this pressure) before being routed to the 2nd Stage Recompressor 23KA002.

The 1st Stage Recompressor is designed to handle an inlet mass flow of 31,216 kg/hr at 0.6 barg and 28.0°C with a duty of 1086 kW.

The 1st Stage Recompressor stage consists of the following major equipment:

- 1st Stage Suction Cooler 23HB101
- 1st Stage Suction Scrubber 23VG101
- 1st Stage Condensate Return Pumps 23PA101A/B
- 1st Stage Recompressor 23KA001




### 6.1.1 1st Stage Suction Cooler 23HB101

Suction Cooler 23HB101 is a plate type exchanger with a counter-current flow pattern. Gas side design pressure and temperature is 14.5 barg / 130.0°C and the cooling medium side design pressure and temperature is 16.0 barg / 130.0°C. Design heat duty of the exchanger is 2238kW.

The cooling medium is taken from the closed loop circulating system. Control of the gas exit temperature is by modulation of a temperature control valve on the cooling

medium return line, the temperature being measured on the inlet to the Suction Scrubber 23VG101 by 23TC1010.

Associated gas from the LP separator 20VA303 at between 1.0 and 1.5 barg and 66 - 76.0$^{o}$C and recovered gas from the HP Flare Drum 43VD001 is routed to the Suction Cooler 23HB101 where it is cooled to 30.0$^{o}$C.

Gas then enters the Suction Scrubber 23VG101 where any entrained liquid is removed.

### 6.1.2 1st Stage Suction Scrubber 23VG101

Suction Scrubber 23VG101 is a vertical gas/liquid separator with a design pressure of 14.5 barg and a temperature of 130.0$^{o}$C. The vessel has an internal diameter of 1.020 metres with a height (tan-tan) of 3.260 metres.

Liquids that are disengaged are pumped back to the inlet of the LP Separator 20VA303 by either of the Condensate Return pumps 23PA101A/B.

The gas is routed to the suction of the 1$^{st}$ Stage Recompressor 23KA001.

Safeguarding Instrumentation is provided by High and Low Level trip switch 23LST1012.

Gas Blowby is prevented by 3" hydraulically operated shutdown valve 23XV1001 located on the pump common suction line and by 23XV1002 on the pump common discharge line.

Liquid level control is by 23LC1011 modulating a level control valve on the common discharge line from the Condensate Return pumps 23PA101A/B.

**NOTE**: The level controller is pulsed to Manual Mode and 0% output when respective EV or XV valve is closed.

Vapour from the Suction Scrubber is routed to the suction of the 1$^{st}$ Stage Recompressor 23KA001.

### 6.1.3 1st Stage Condensate Return Pumps 23PA101A/B

Condensate Return pumps 23PA101A/B are motor driven centrifugal type each rated at 100% duty. The design flow rate is 9.7 m$^{3}$/hr at a differential pressure of 3.3 bar. Motor rating is 2.3 kW.

Pump protection is provided by Low Pressure switch 23PST1013/14 on the individual pump discharge lines.

Minimum flow protection for the pumps is provided by automatic combined Minimum Flow/Non-return valves on the individual pump discharge lines, returning to the Suction Scrubber.

Pump isolation is provided by 2" hydraulically operated shutdown valve 23XV1002 on the pump discharge and 2" hydraulically operated shutdown valve 23XV1003 on the common minimum flow line.

### 6.1.4 1st Stage Recompressor 23KA001

Vapour from the Suction Scrubber 23VG101 is routed to the suction of the 1st Stage Recompressor 23KA001 where it is compressed from 0.6 barg at 30.0 $^{o}$C to 7.0 barg at 96.0$^{o}$C. The discharge gas is combined with gas released from the MP separator 20VA202 prior to entering the 2nd Stage Recompressor Suction Cooler 23HB102.

Varying the compressor speed controls its performance. Pressure controllers on the suction (23PC0014A) and discharge (23PC0014B) together with pressure controller 20PC3014B on the LP Separator are compared in a Low selector and the lowest pressure controls the speed of the machine.

The compressor is provided with an anti-surge control (ASC) system to ensure that the compressor capacity (i.e. suction nozzle flow) is always above a specified minimum and that the machine operates at a sufficient margin from its surge limit under all steady state and dynamic conditions. The compressor is supplied with a recycle line that recirculates gas from compressor discharge to suction via the 1st Stage suction cooler 23HB101. The recycle flow is regulated by a recycle valve which itself is modulated by the compressor's anti-surge control system.

The actual operating point of the machine on its head/flow curve is calculated by the control system from input signals provided by suction pressure transmitter 23PT0014A, suction flow transmitter 23FT0013 and discharge pressure transmitter 23PT0014B. All the time that the operating point is further from the surge limit than the safety margin the recycle valve remains closed. The recycle valve opens when the operating point is equal to or less than the safety margin. On opening the recycle valve, hot discharge gas is routed to the inlet of the suction scrubber, via the 1st Stage suction cooler 23HB101. The gas is cooled to remove the unwanted heat of compression and protect the machine from excessive temperatures, especially during full recycle.

The actual position of the recycle valve is available via 23FZT0013 and the valve actuator is fitted with a quick opening solenoid.

Safeguarding Instrumentation is provided by Low Pressure trip switch 23PST0015 on the suction of the machine with High Temperature trip switch 23TST0017 and High/Low Pressure trip switch 23PST0016 on the discharge.

Isolation of the suction side of the machine is provided by:

14" hydraulically operated shutdown valve 20XV3001 on the gas outlet from the LP Separator (with a 2" hydraulically operated pressurisation bypass valve 20XV3002 in parallel)

3" hydraulically operated shutdown valve 43EV0001 on the gas stream from the HP Flare Drum

**NOTE:** The pressurising valve must be opened until pressure is equalised before opening the main valve.

Isolation on the discharge side of the machine is provided by 10" hydraulically operated shutdown valve 23XV0001.

The Compressor can be depressurised to the HP Flare via a 2" hydraulically operated blowdown valve 23BDV0003. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation.

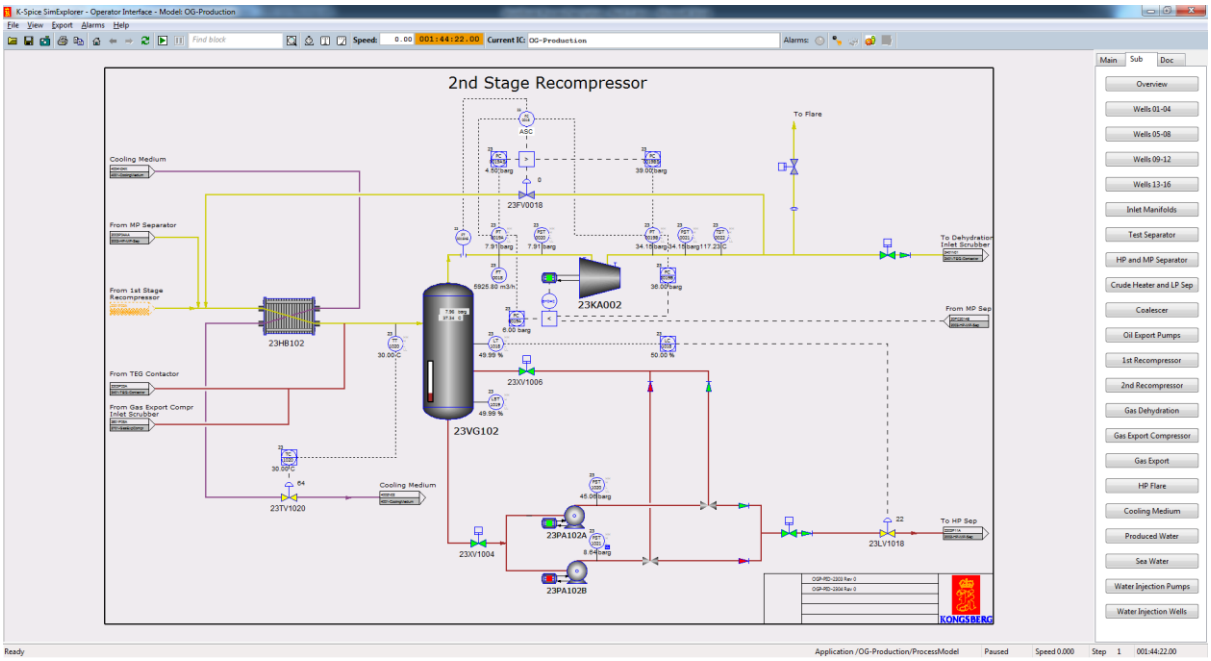
## 6.2 2nd Stage Recompression System

The 2nd Stage Recompressor 23KA002 is a multi-wheeled centrifugal compressor which compresses associated gas at MP separator pressure up to the operating pressure of the HP separator. The compressor is driven by a variable speed electric motor. A suction gas cooler 23HB102 and suction scrubber 23VG102 are provided. The compressed gas is combined with associated gas leaving the HP separator before being routed to the Gas Dehydration System.

The 2nd Stage Recompressor is designed to handle an inlet mass flow of 53,870.0 kg/hr at 7.3 barg and 30.0°C with a duty of 3,600 kW.

The 2nd Stage Recompressor stage consists of the following major equipment:

- 2nd Stage Suction Cooler 23HB102
- 2nd Stage Suction Scrubber 23VG102
- 2nd Stage Condensate Return Pumps 23PA102A/B
- 2nd Stage Recompressor 23KA002



### 6.2.1 2nd Stage Suction Cooler 23HB102

Suction Cooler 23HB102 is a plate type exchanger. Gas side design pressure and temperature is 16.5 barg / 130.0$^{o}$C and the cooling medium side design pressure and temperature is 16.0 barg / 130.0$^{o}$C. Design heat duty of the exchanger is 2910 kW.

The cooling medium is taken from the closed loop circulating system Control of the gas exit temperature is by modulation of a temperature control valve on the cooling medium return line, the temperature being measured on the inlet to the Suction Scrubber 23VG102 by 23TC1017.

Associated gas from the MP separator 20VA202 at between 7.5 and 8.5 barg and 66.0 - 76.0 $^{o}$C, gas from the Test Separator (if running at this same pressure) and gas from the 1$^{st}$ Stage Recompressor 23KA001 is routed to the Suction Cooler 23HB102 where it is cooled to 30.0$^{o}$C.

On the outlet of Suction Cooler 23HB102 condensed liquids from the Glycol Contactor Inlet Scrubber 24VG101, Glycol Contactor 24VB001 (via 4" hydraulically operated shutdown valve 24EV1010) and Gas Export Suction Scrubber 26VG101 are introduced.

This combined stream then enters the Suction Scrubber 23VG102 where any entrained liquid is removed.

### 6.2.2 2nd Stage Suction Scrubber 23VG102

Suction Scrubber 23VG102 is a vertical gas/liquid separator with a design pressure of 16.5 barg and a temperature of 130.0$^{o}$C. The vessel has an internal diameter of 1.100 metres with a height (tan-tan) of 5.000 metres.

Liquids that are disengaged are pumped back to the inlet of the HP Separator 20VA101 by either of the Condensate Return pumps 23PA102A/B.

The gas is routed to the suction of the 2$^{nd}$ Stage Recompressor 23KA002.

Safeguarding Instrumentation is provided by High and Low Level trip switch 23LST1019.

Gas Blowby is prevented by 6" hydraulically operated shutdown valve 23XV1004 located on the pump common suction line and by 23EV1005 on the pump common discharge line.

Liquid level control is by 23LC1018 modulating a level control valve on the common discharge line from the Condensate Return pumps 23PA102A/B.

**NOTE**: The level controller is pulsed to Manual Mode and 0% output when respective EV or XV valve is closed.

Vapour from the Suction Scrubber is routed to the suction of the 2nd Stage Recompressor 23KA002.

### 6.2.3 2nd Stage Condensate Return Pumps 23PA102A/B

Condensate Return pumps 23PA102A/B are motor driven centrifugal type each rated at 100% duty. The design flow rate is 57.4 $m^3$/hr at a differential pressure of 31.1 bar. Motor rating is 88.9 kW.

Pump protection is provided by High and Low Pressure switch 23PST1020/9 on the individual pump discharge lines.

Minimum flow protection for the pumps is provided by automatic combined Minimum Flow/Non-return valves on the individual pump discharge lines, returning to the Suction Scrubber.

Pump isolation is provided by 3" hydraulically operated shutdown valve 23EV1020 on the pump discharge and 2" hydraulically operated shutdown valve 23XV1006 on the common minimum flow line.

### 6.2.4 2nd Stage Recompressor 23KA002.

Vapour from the Suction Scrubber 23VG102 is routed to the suction of the 2nd Stage Recompressor 23KA002 where it is compressed from 6.0 barg at 30.0 $^oC$ to 35.5 barg at 125.0$^oC$. The discharge gas is combined with gas released from the HP separator 20VA101 and gas released from the Test Separator 20VA004 prior to entering the Glycol Contactor Inlet Cooler.

Varying the compressor speed controls its performance. Pressure controllers on the suction (23PC0019A) and discharge (23PC0019B) together with pressure controller 20PC2014B on the MP Separator are compared in a Low selector and the lowest controls the speed of the machine.

The compressor is provided with an anti-surge control (ASC) system to ensure that the compressor capacity (i.e. suction nozzle flow) is always above a specified minimum and that the machine operates at a sufficient margin from its surge limit under all steady state and dynamic conditions. The compressor is supplied with a recycle line that recirculates gas from compressor discharge to suction via the 2nd Stage suction cooler 23HB102. The recycle flow is regulated by a recycle valve which itself is modulated by the compressor's anti-surge control system.

The actual operating point of the machine on its head/flow curve is calculated by the control system from input signals provided by suction pressure transmitter 23PT0019A, suction flow transmitter 23FT0018 and discharge pressure transmitter 23PT0019B. All the time that the operating point is further from the surge limit than the safety margin the recycle valve remains closed. The recycle valve opens when the operating point is equal to or less than the safety margin. On opening the recycle valve, hot discharge gas is routed to the inlet of the suction scrubber, via the 2nd Stage suction cooler 23HB102. The gas is cooled to remove the unwanted heat

of compression and protect the machine from excessive temperatures, especially during full recycle.

The actual position of the recycle valve is available via 23FZT0018 and the valve actuator is fitted with a quick opening solenoid.

Safeguarding Instrumentation is provided by Low Pressure trip switch 23PST0020 on the suction of the machine with High Temperature trip switch 23TST0022 and High/Low Pressure trip switch 23PST0021 on the discharge.

Isolation of the suction side of the machine is provided by:

- 10" hydraulically operated shutdown valve 20XV2001 on the gas outlet from the MP Separator (with 2" hydraulically operated pressurisation bypass valve 20XV2002 in parallel)
- 10" hydraulically operated shutdown valve 23XV0001 on the gas stream from the 1st Stage Recompressor discharge
- 4" hydraulically operated shutdown valve 24EV1010 on the inlet from Gas Dehydration
- 3" hydraulically operated shutdown valve 27XV1002 on the line from the gas Export Suction Scrubber

Isolation on the discharge side of the machine is provided by 10" hydraulically operated shutdown valve 23EV0002.

The Compressor can be depressurised to the HP Flare via a 3" hydraulically operated blowdown valve 23BDV0006. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation.

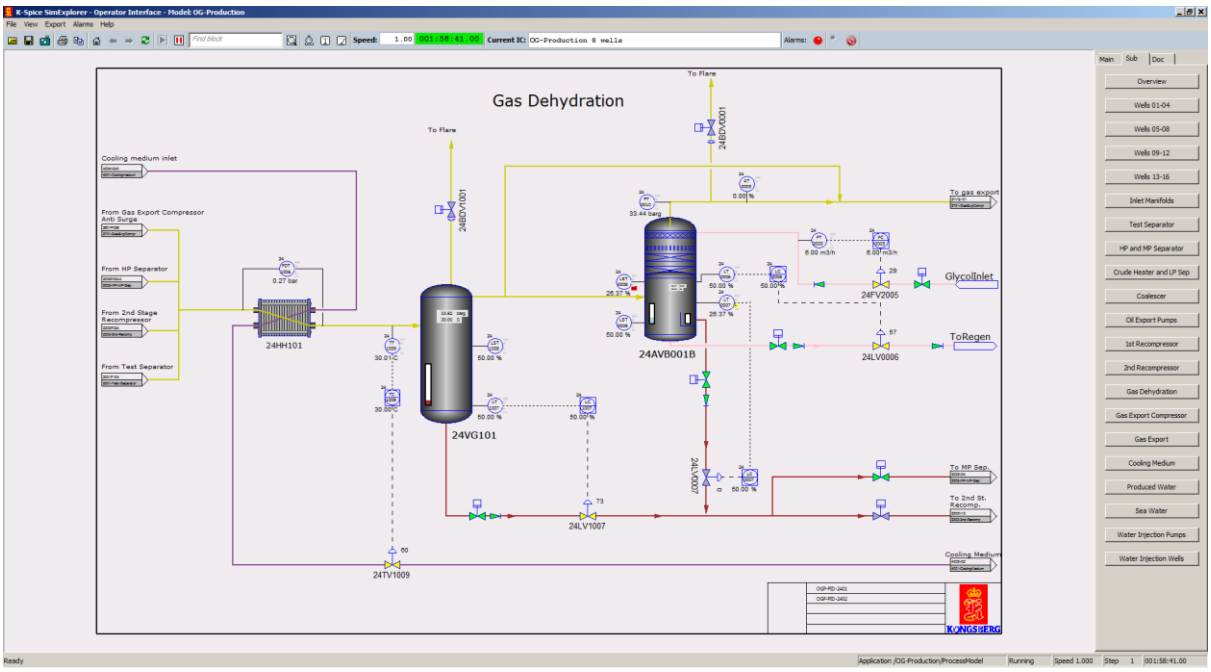
# 7 System 24 Details - Gas Dehydration

The system is shown in P & I D's:

OGP-PID-2401 rev 0 Glycol Contactor Inlet Cooler and Scrubber
OGP-PID-2402 rev 0 Glycol Contactor

The Gas Dehydration consists of the following major equipment:

- Glycol Contactor Inlet Cooler 24HH001
- Glycol Contactor Inlet Scrubber 24VG101
- Glycol Contactor 24VB001




To satisfy the export pipeline specification, the export gas needs to be dried to water specification of 15 kg $H_2O$/million $Sm^3$ of gas. The gas drying process is achieved by the flowing of lean Triethylene Glycol against the wet gas stream, as the gas passes up through the Glycol Contactor 24VB001.

Gas from the discharge of the 2nd Stage Recompressor 23KA002, together with gas from the Test Separator 20VA004, gas from the HP Separator 20VA101, and gas from the anti-surge system of the Export Compressor 26KA001 are mixed upstream of Inlet Cooler 24HH001.

The gas is then cooled and any associated liquids are dropped out in Inlet Scrubber 24VG101. The cooled gas then enters the Glycol Contactor 24VB001 where it flows upwards through a packed bed section where it is contacted with lean glycol. This action absorbs moisture from the gas stream.

Condensate from the Inlet Scrubber 24VG101 and the condensate section in the base of the Glycol Contactor 24VB001 are returned to the inlet of MP Separator 20VA202 via 24EV1005 or to the 2nd Stage Recompressor 23KA002 via 24EV1010.

### 7.1 Glycol Contactor Inlet Cooler 24HH001

Suction Cooler 23HB102 is a compact type exchanger. Gas side design pressure and temperature is 50.5 barg / 155.0°C and the cooling medium side design pressure and temperature is 16.0 barg / 155.0°C. Design heat duty of the exchanger is 9749 kW.

The cooling medium is taken from the closed loop circulating system. Control of the gas exit temperature is by modulation of a temperature control valve on the cooling medium return line, the temperature being measured on the inlet to the Inlet Scrubber 24VG101 by 24TC1009.

Gas is mixed upstream of Inlet Cooler 24HH001 that has originated from:

The discharge of the 2nd Stage Recompressor 23KA002 via 23EV0002
The Test Separator 20VA004 via 20EV0010 (with 20EV0011 in parallel)
The HP Separator 20VA101 via 20EV1001 (with 20EV1002 in parallel)
The anti-surge system of the Export Compressor 26KA001

**NOTE:** There are no specific Isolation Valves for the Dehydration System as closing all of the above valves isolates the system.

24PDT1006 measure the differential pressure across the gas side of the cooler.

Methanol injection upstream of the Inlet Cooler is provided for the prevention of Hydrate formation. A 2" electrically operated valve, 42HV0001, controls the flow.

Gas then enters the Inlet Scrubber 24VG101 where any entrained liquid is removed.

### 7.2 Inlet Scrubber 24VG101

Contactor Inlet Scrubber 24VG101 is a vertical gas/liquid separator with a design pressure of 50.5 barg and a temperature of 155.0°C. The vessel has an internal diameter of 0.990 metres with a height (tan-tan) of 5.560 metres.

Liquids which are disengaged are returned, under control of 24LC1007 modulating a level control valve to either the inlet of the MP Separator 20VA202 via 4" hydraulically operated shutdown valve 24EV1005 or to the 2nd Stage Recompressor via 4" hydraulically operated shutdown valve 24EV1010. 4" hydraulically operated shutdown valve 24EV1005 will open automatically on 2nd Stage Recompressor trip.

**NOTE**: The level controller is pulsed to Manual Mode and 0% output when respective EV or XV valve is closed.

The gas is then routed to the inlet of the Glycol Contactor 24VB001 or it can be routed through a 14" Contactor Bypass line. The manual valves on this line are interlocked to prevent the isolation valves being closed if the bypass valve is closed.

Safeguarding Instrumentation is provided by High and Low Level trip switch 24LST1008.

The Inlet Scrubber can be depressurised to the HP Flare via a 3" hydraulically operated blowdown valve 24BDV1001. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation.

### 7.3 Glycol Contactor 24VB001

Glycol Contactor 24VB001 is a vertical vessel with a design pressure of 50.5 barg and a temperature of 155.0$^{o}$C. The vessel has an internal diameter of 1.670 metres with a height (tan-tan) of 10.760 metres.

A separate compartment in the base of the vessel collects any condensate and returns it, under the control of 24LC0007 modulating a control valve, to either:

- The inlet of the MP Separator 20VA202 via 4" hydraulically operated shutdown valve 24EV1005 or to
- The 2nd Stage Recompressor via 4" hydraulically operated shutdown valve 24EV1010.

**NOTE**: The level controller is pulsed to Manual Mode and 0% output when respective EV or XV valve is closed.

The gas rises through the packed bed where it has intimate contact with the lean glycol from the regeneration unit supplied via 2" hydraulically operated shutdown valve 24XV2003 located on the dry glycol inlet line. The glycol absorbs any water from the gas and the, now wet, glycol is returned under the control of 24LC0006 modulating a control valve, to the inlet of the Glycol Regeneration System.

**NOTE**: The level controller is pulsed to Manual Mode and 0% output when respective EV or XV valve is closed.

The dry gas exits the top of the contactor where it is monitored by dewpoint analyser 24AT0010. A slipstream from this vapour line is taken to supply the Glycol Regeneration System with make-up and stripping gas via 2" hydraulically operated shutdown valve 24XV2001. The main vapour route continues to the inlet of the Gas Export System.

Safeguarding Instrumentation is provided by Low Level trip switch 24LST0009 on the condensate side and by High and Low Level trip switch 24LST0008 on the wet glycol side.

Gas Blowby is prevented by 2" hydraulically operated shutdown valve 24XV0005 located on the condensate outlet line and by 2" hydraulically operated shutdown valve 24XV0004 located on the wet glycol outlet line.

The Glycol Contactor can be depressurised to the HP Flare via a 2" hydraulically operated blowdown valve 24BDV0001. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation.

A 14" Contactor Bypass line is available. The manual valves on this line are interlocked to prevent the isolation valves being closed if the bypass valve is closed.

The lean, dry gas then passes to the suction side of the Gas Export Compressor 27KA001.

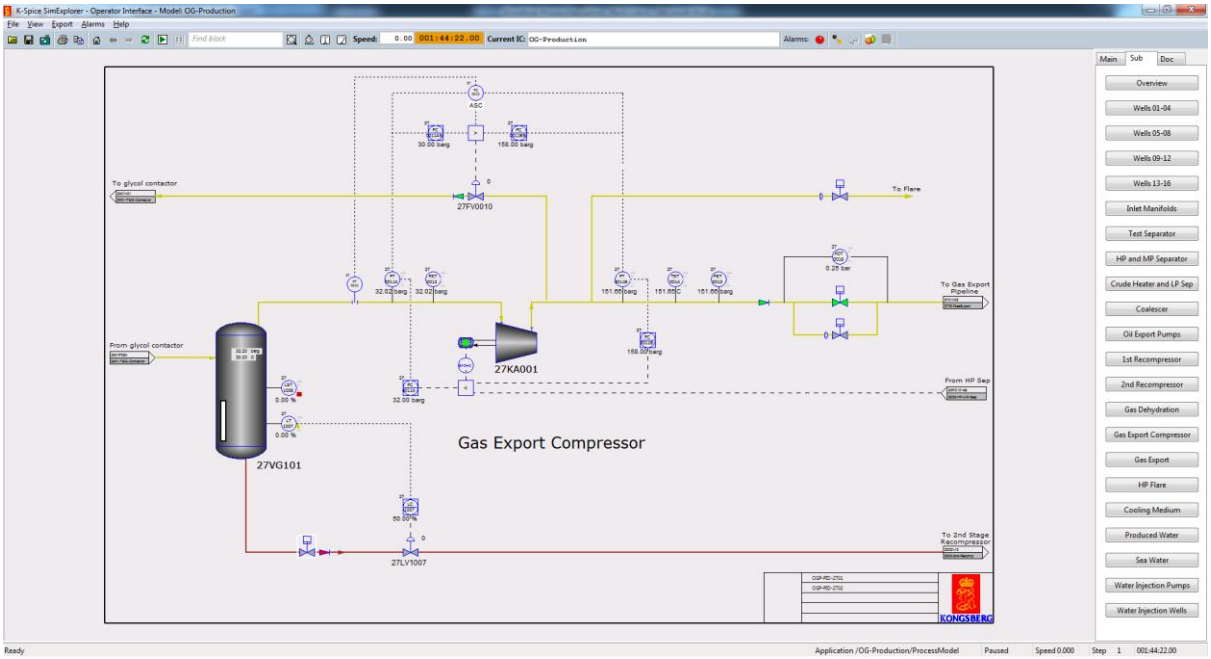
*Figure: Glycol Contactor*

# 8 System 27 Details - Gas Export System

The system is shown in P & I D's:

OGP-PID-2701 rev 0 Export Gas Suction Scrubber 27VG101
OGP-PID-2702 rev 0 Export Gas Compressor 27KA001
OGP-PID-2703 rev 0Export Gas Cooler 27HH101




The Export Gas Compressor 27KA001 is a multi-wheeled centrifugal compressor which compresses associated gas at HP separator pressure up to the operating pressure of the Gas Export Pipeline. A suction scrubber 27VG101 and an export gas cooler 27HH101 are provided.

The Export Gas Compressor is designed to handle an inlet mass flow of 130,556.0 kg/hr at 34.5 barg and 30.0$^{o}$C with a duty of 8,202 kW.

The Export Gas stage consists of the following major equipment:

- Export Gas Compressor Suction Scrubber 27VG101
- Export Gas Compressor 27KA001
- Export Gas Cooler 27HH101

## 8.1 Gas Export Compressor Inlet Scrubber 27VG101

Suction Scrubber 27VG101 is a vertical gas/liquid separator with a design pressure of 50.5 barg and a temperature of 155.0$^{o}$C. The vessel has an internal diameter of 0.630 metres with a height (tan-tan) of 2.150 metres.

Gas from the Dehydration System is fed to the inlet of the Suction Scrubber 27VG101 without any further cooling. The scrubber should normally run with no liquid level unless there has been carryover of Glycol from the Contactor.

Any liquids that are disengaged are returned back to the inlet of the 2nd Stage Suction Scrubber 23VG102 under the control of 27LC1007 modulating a level control valve.

**NOTE**: The level controller is pulsed to Manual Mode and 0% output when respective EV or XV valve is closed.

Safeguarding Instrumentation is provided by High and Low Level trip switch 27LST1008.

Gas Blowby is prevented by 3" hydraulically operated shutdown valve 27XV1002 located on the liquid outlet line.

Vapour from the Suction Scrubber is routed to the suction of the Gas Export Compressor 27KA001.

### 8.2 Gas Export Compressor 27KA001

Vapour from the Suction Scrubber 27VG101 is routed to the suction of the Gas Export Compressor 27KA001 where it is compressed from 32.0 barg at 30.0 $^{o}$C to 151.5 barg at 152.0$^{o}$C.

Varying the speed of the driver controls performance of the compressor. Pressure controllers on the suction (27PC0011A) and discharge (27PC0011B) together with pressure controller 20PC1014B on the HP Separator are compared in a Low selector and the lowest controls the speed of driver.

The compressor is provided with an anti-surge control (ASC) system to ensure that the compressor capacity (i.e. suction nozzle flow) is always above a specified minimum and that the machine operates at a sufficient margin from its surge limit under all steady state and dynamic conditions. The compressor is supplied with a recycle line that recirculates gas from compressor discharge to the inlet of the Glycol Inlet Cooler 24HH101. The recycle flow is regulated by a recycle valve which itself is modulated by the compressor's anti-surge control system.

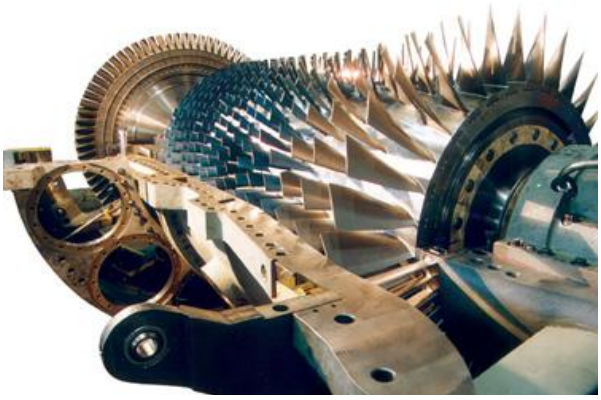


*Figure: Compressor Blades*

The actual operating point of the machine on its head/flow curve is calculated by the control system from input signals provided by suction pressure transmitter 27PT0011A, suction flow transmitter 27FT0010 and discharge pressure transmitter 27PT0011B. All the time that the operating point is further from the surge limit than the safety margin the recycle valve remains closed. The recycle valve opens when the operating point is equal to or less than the safety margin. On opening the recycle valve, hot discharge gas is routed to the inlet of the suction scrubber, via Glycol Inlet Cooler 24HH101. The gas is cooled to remove the unwanted heat of compression and protect the machine from excessive temperatures, especially during full recycle.

The actual position of the recycle valve is available via 27FZT0010 and the valve actuator is fitted with a quick opening solenoid.

Safeguarding Instrumentation is provided by Low Pressure trip switch 27PST0012 on the suction of the machine with High Temperature trip switch 27TST0014 and High/Low Pressure trip switch 27PST0013 on the discharge.

Isolation of the suction side of the machine is only possible using the same isolation valves as for the Gas Dehydration System. Isolation on the discharge side of the machine is provided as follows:

- Gas Export: 8" hydraulically operated shutdown valve 27XV1001 (with 2" hydraulically operated pressurisation valve 27XV1002 in parallel)

The Compressor can be depressurised to the HP Flare via a 2" hydraulically operated blowdown valve 27BDV0007. A restriction orifice downstream of the blowdown valve limits the rate of depressurisation.

### 8.3 Export Gas Cooler 27HH101

Export Gas Cooler 27HH101 is a compact type exchanger. Gas side design pressure and temperature is 174.0 barg / 185.0$^{o}$C and the cooling medium side design pressure and temperature is 16.0 barg / 185.0$^{o}$C. Design heat duty of the exchanger is 11538 kW.

The cooling medium is taken from the closed loop circulating system. Control of the gas exit temperature is by modulation of a temperature control valve on the cooling medium return line, the temperature being measured on the gas outlet to the Export Line by 27TC1012.

Gas from the discharge of the Gas Export Compressor 27KA001 is pressure controlled by 27PC1009 / 26PC0011C (see previous section).

27FT1014 measures gas flow on the gas outlet from the cooler.

The Export Gas Pipework can be depressurised to the HP Flare via a 2" hydraulically operated blowdown valve 27BDV1003. A restriction orifice downstream of the

blowdown valve limits the rate of depressurisation. Temperature of gas during a pipeline blowdown is measured by 27TT1016, located upstream of blowdown valve 27BDV1003.

Safeguarding Instrumentation is provided on the gas outlet of the cooler by High Temperature trip switch 27TST1013 and Low Pressure trip switch 27PST1015.

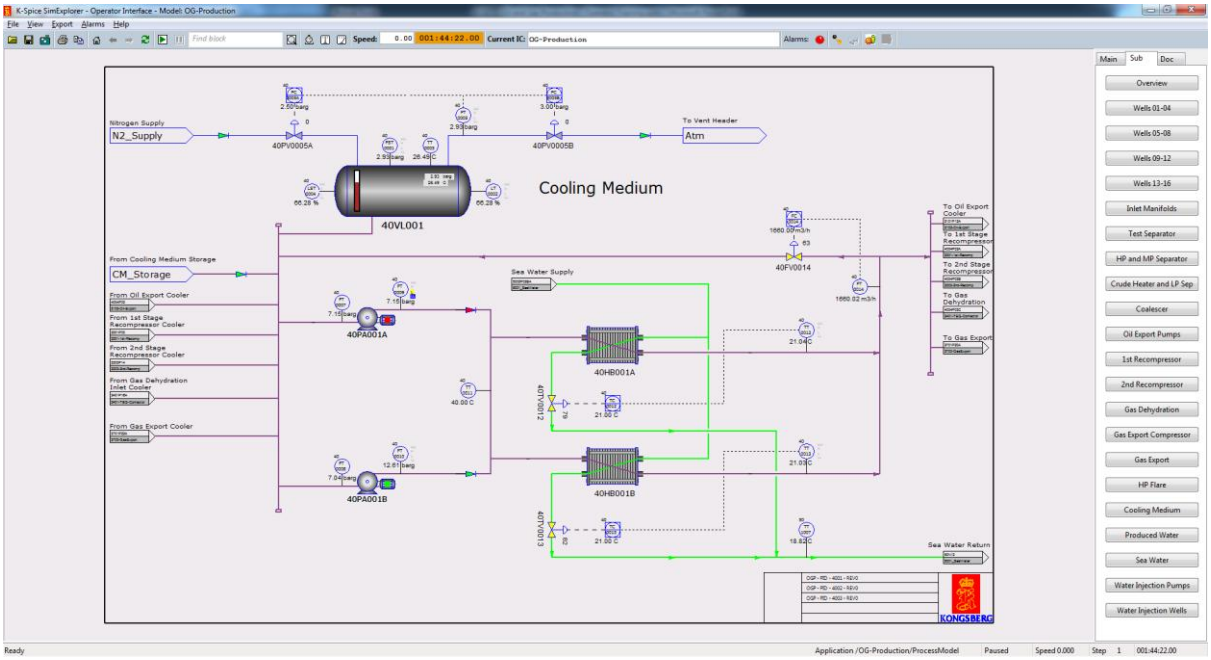
Isolation from the pipeline is provided by 8" hydraulically operated shutdown valve 27EV1001.

# 9 System 40 Details - Cooling Medium System

The system is shown in P & I D's:

OGP-PID-4001 rev 0 Cooling Medium Expansion Vessel 40VL001
OGP-PID-4002 rev 0 Cooling Medium Pumps 40PA001 A/B
OGP-PID-4003 rev 0 Cooling Medium Coolers 40HB001 A/B
OGP-PID-4004 rev 0 Cooling Medium Distribution




The Cooling Medium System is a closed loop system, using a 35% (by volume) Triethylene Glycol solution in fresh water, consisting of a Cooling Medium Expansion Vessel 40VL001 2 × 100 % Cooling Medium Pumps 40PA001 A/B and 2 × 100 % Cooling Medium Coolers 40HB001 A/B. The cooling medium is used principally for gas compression cooling duty, TEG regeneration, Glycol Contactor Inlet Cooler and Crude Oil Coolers. Warm cooling medium returned from users is in turn cooled against seawater.

## 9.1 Cooling Medium Expansion Vessel 40VL001

The Cooling Medium Expansion Vessel 40VL001, located at the highest point of the system, is connected to the return header by a 6" branch. This provides expansion capacity, surge volume, and reservoir for small cooling medium losses.

The vessel has an internal diameter of 1.400 metres with a length (tan-tan) of 3.600 metres. It has a design pressure of 16.0 barg and a temperature of 80.0$^{o}$C.

Pressure controller 40PC0005A ensures that pressure (provided by Nitrogen Supply via 40PV0005A) does not fall below 2.5 barg. Pressure controller 40PC0005B modulates control valve 40PV0005B on the line to vent, to ensure pressure does not exceed 3.0 barg. This maintains the pressure for the whole cooling medium system.

Analyser 40AT0006 monitors hydrocarbon content of the vapours in the vessel. This device would give the first indication of a leak in one of the exchangers.

Safeguarding Instrumentation is provided by High Pressure trip switch 40PST0001, High and Low Level trip switch 40LST0004.

40TT0003 and 40LT0002 monitor temperature and level in the vessel respectively.

## 9.2 Cooling Medium Pumps 40PA001 A/B

The Cooling Medium Pumps 40PA001 A/B are motor driven centrifugal type each rated at 100% duty. The design flow rate is 1660.0 $m^3$/hr at a differential pressure of 6.0 bar. Motor rating is 331.0 kW. Spent cooling medium from the 18" return header at 50.0°C flows to a common pump suction header. Pumps discharge at 13.0 barg. Pump discharge pipes tie into to a 16" common discharge header.

The pumps operate on an Auto / Standby basis.

Suction Pressure transmitters 40PT0007/09 and Discharge Pressure transmitters 40PT0009/11 monitor pump conditions with the discharge temperature monitored by 40TT0011. A High High or Low Low pressure as measured by 40PT0009/11 will Stop / Start the respective pump.

Flow controller 40FC0014, located downstream of the Cooling Medium Coolers provides 40HB001 A/B, provides minimum flow protection for the pumps 40HB001 A/B, with the stream returning to the 18" Cooling Medium return header.

## 9.3 Cooling Medium Coolers 40HB001 A/B

Cooling medium is pumped to the Cooling Medium Coolers 40HB001 A/B. These are plate type exchangers with a counter-current flow pattern with seawater as the cooling supply. Cooling Medium side design pressure and temperature is 20.0 barg / 80.0$^o$C and the cooling medium side design pressure and temperature is 20.0 barg / 80.0$^o$C. Design heat duty of the exchanger is 22510.0 kW.

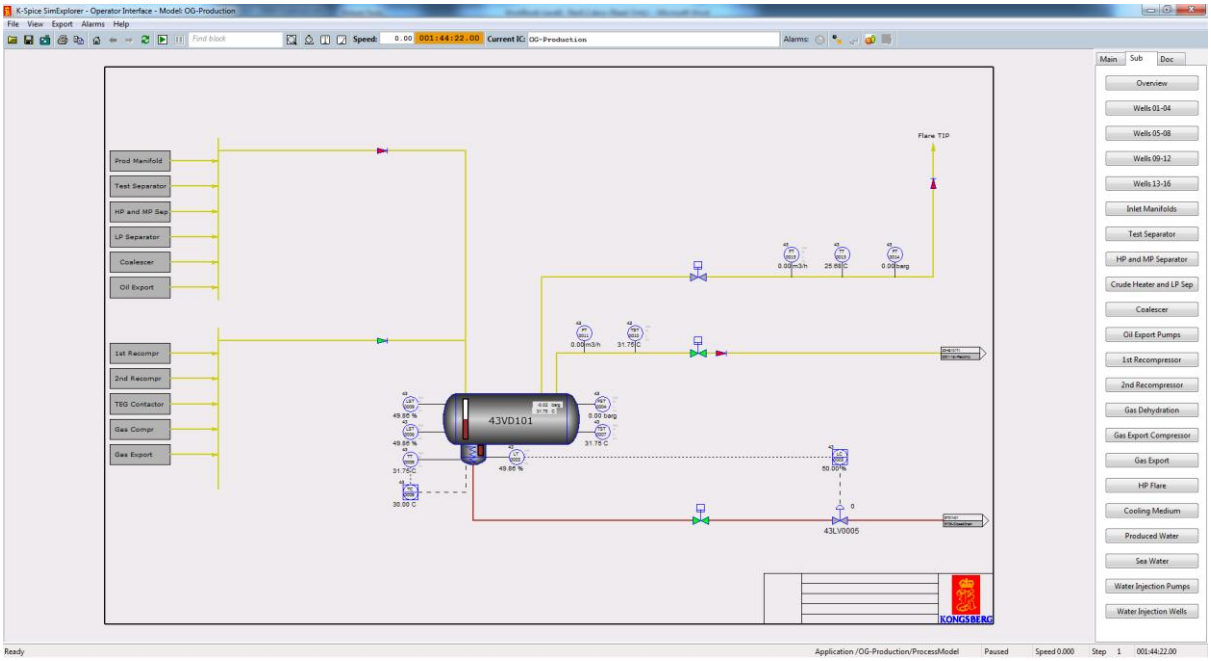
The seawater used in cooling is taken from the Sea Water Syste. Control of the Cooling Medium exit temperature is by modulation of a temperature control valve on the seawater return line, the temperature being measured on the Cooling Medium outlet of each cooler by 40TC0012/05 respectively. The cooled Cooling Medium is supplied to the users via a 16" supply header. The return from the users combines together as an 18" return header back to the pump suction. The warmed seawater from the exchanger outlet is used as the supply of seawater to the Water Injection System.

# 10 System 43 Details - Flare System

The system is shown in P & I D's:

OGP-PID-4306 rev 0 HP Flare Knockout Drum 43VD001




The flare system is designed to safely dispose of hydrocarbon and toxic gases released from the processing facilities during normal operation and emergency situations.

The flare system consists of dedicated HP piping collection headers where relief flows, blowdown and operational venting of hydrocarbons are collected. The headers are piped to the HP Flare Knockout Drum, 43VD001, for liquid removal before flaring via the HP Flare Tip. Liquids are returned to the Reclaimed Oil Tank. The Flare Tip is mounted on the top of a vertical flare tower for combustion of gases.

## 10.1 HP Flare Knockout Drum 43VD001

The HP Flare Knockout Drum 43VD001 is designed as horizontal separator with a boot for liquid collection, and has a design pressure of 9.0 barg and a temperature of 115.0$^{o}$C. The vessel has an internal diameter of 3.400 metres with a length (tan-tan) of 10.000 metres.

The liquid collection boot is equipped with an electrical heater 43FE001 (duty 25.0 kW) controlled by 43TT0008, with any liquids returned to the Reclaimed Oil Sump under the control of 43LC0005 modulating a level control valve in the liquid outlet line.

**NOTE**: The level controller is pulsed to Manual Mode and 0% output when respective EV or XV valve is closed.

Vapours from the Flare Drum are normally routed to the suction of the 1st Stage Recompressor via 4" hydraulically operated shutdown valve 43EV0001. This valve will trip closed if the Flare Drum pressure exceeds 2.5 barg (as measured by 43PST0004). If the 1st Stage Recompressor is not available then vapours are routed to the Flare Tip via 43XV0002A (which also opens when 43EV0013 closes on high pressure).

43FT0015 measures the flow to the Flare Tip with the pressure measured by 43PT0014, the temperature by 43TT0013, and the flow to the 1st Stage Recompressor by 43FT0011.

Safeguarding protection is provided by High level trip switch 43LST0009 (this causes an ESD 2.1) High and Low level trip switch 43LST0006, High Pressure trip switch 43PST0004, High and Low temperature trip switches 43TST0007, and Low temperature trip switch 43TST0010 on the outlet to the 1st Stage Recompressor.

Gas Blowby is prevented by 6" hydraulically operated shutdown valve 43XV0003 on the Boot liquid outlet that closes if Flare Drum temperature falls below -10.0°C (as measured by 43TST0007).

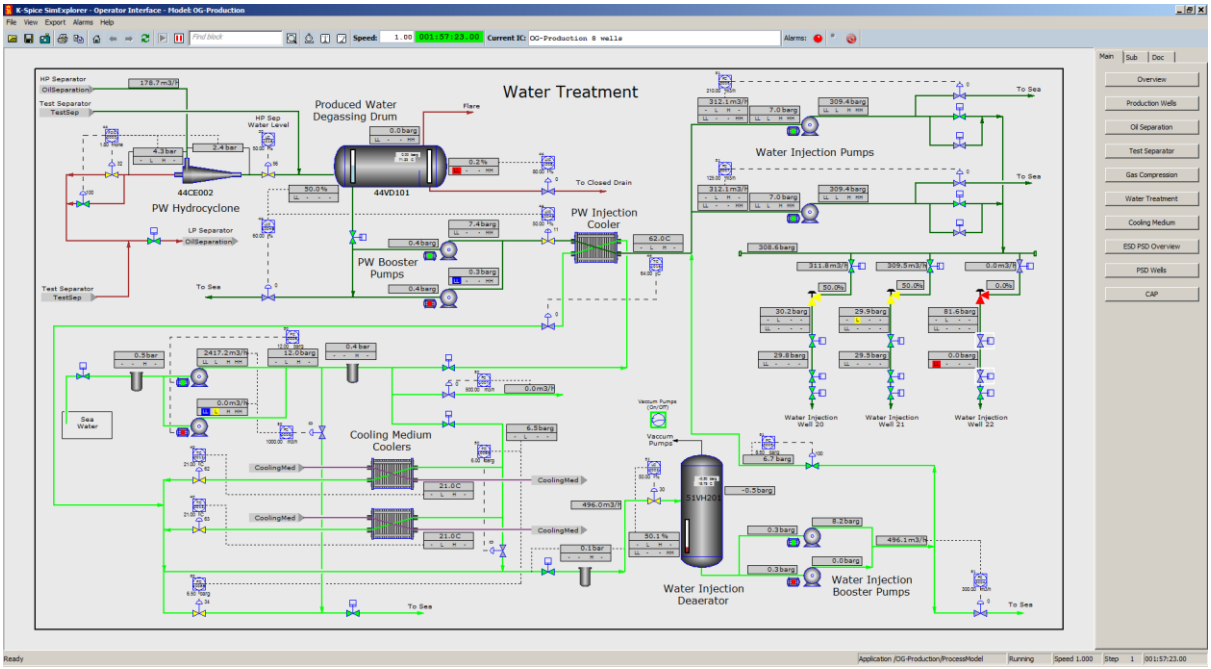
*Figure: Flare Tip*

# 11 System 44 Details- Produced Water System

The system is shown in P & I D's:

OGP-PID-4401 rev 0 Produced Water Hydrocyclones
OGP-PID-4402 rev 0 Produced Water Degassing Drum
OGP-PID-4403 rev 0 Produced Water Booster Pumps
OGP-PID-4404 rev 0 Produced Water Injection Filter & Cooler




## 11.1 HP Separator Hydrocyclone 44CE002

The HP Hydrocyclone 44CE002 is designed for a throughput of 646.0 $m^3$/hr at a design pressure and temperature of 49.0 barg and 100.0$^oC$

Produced water accumulated in the HP Separator is released on interfacial level control to dedicated hydrocyclone 44CE002.

Hydrocyclones are extremely efficient wastewater treatment devices. The primary variable which dictates performance and separation efficiency is inlet flow rate, since high velocity is required to generate the very high g-forces needed to create the oil and water separation.

The resultant clean water leaving the individual hydrocyclones flows to a common Degassing Drum 44VD101, where it is degassed.

The reject oil streams from the hydrocyclones are released on pressure differential ratio control and returned to the LP separator via 3" hydraulically operated shutdown valve 44XV0001. These streams contain essentially all of the oil separated, which is approximately 10% vol. of a stream.

Control of the ratio of the pressure differentials between oily water inlet and the two product streams is used to control separation efficiency of the hydrocyclones.

Pressure differential measurement is used as an inferential method of determining flow rates. The efficiency of the separation is based on what is known as the reject ratio, which is defined as the ratio of the reject stream to inlet flow. Below a critical minimum ratio the hydrocyclones will not function. The pressure differential ratio **(PDR)** is defined as:

**PDR = PD (in - reject): PD (in - clean)**

The actual PDR is generally of the order of 2.6.

The measured differential pressures are fed to a pressure differential ratio controller. The output of the controller is used to modulate a set of split range parallel valves in the reject line downstream of the hydrocyclones.

Controllers for the HP hydrocyclone are as follows:

- Clean = 44PDT0003A, Reject = 44PDT0003B, Ratio = 44PDC0003

The load on the hydrocyclones is indicated by the position of the clean water control valve 20LV1018, located downstream of the hydrocyclone. The HP Separator interface level controller 20LC1018 positions this valve, hence as the water-cut increases, so does the load on the hydrocyclones.

The flow of the oily water is measured on the inlet to the hydrocyclone by 44FT0002.

The HP Hydrocyclone is isolated from the HP Separator by 14" hydraulically operated shutdown valve 20EV1008 with 2" bypass 20EV1009.

### 11.2 Test Separator Hydrocyclone 44CE003

The Test Separator Hydrocyclone 44CE002 is designed for a throughput of 646.0 $m^3$/hr at a design pressure and temperature of 49.0 barg and 100.0$^oC$. This ensures that it can be used as a spare for the HP Hydrocyclone, however normal throughput when used with the Test Separator is 30 - 155.0 $m^3$/hr.

The produced water accumulated in the Test separator is released on interfacial level control to hydrocyclone 44CE003

The operation of the Test Hydrocyclone is identical to the HP Hydrocyclone with the controllers numbered as follows:

- Clean = 44PDT0004A, Reject = 44PDT0004B, Ratio = 44PDC0004

The load on the hydrocyclones is indicated by the position of the clean water control valve downstream of the set, 20LV0018. The Test Separator interface level

controller 20LC0018 positions this valve, hence as the water-cut increases, so does the load on the hydrocyclones.

The Test Hydrocyclone is isolated from the Test Separator by 14" hydraulically operated shutdown valve 20EV0008 with 2" bypass 20EV0009.

*Figure: Hydrocyclone*

### 11.3 Degassing Vessel 44VD101

The vessel has a design capacity of 544.0 tonne/hr. The vessel is designed as a three-phase separator and has a design pressure of 14.5 barg and a temperature of 120.0$^{o}$C. The vessel has an internal diameter of 2.400 metres with a length (tan-tan) of 7.000 metres.

The separator interface level control valves 20LV1018 and 20LV0018 are located in the clean water inlet lines upstream of common manifold to the degassing drum.
Clean water is released from the degassing drum on interfacial level control by 44LC1004A to the suction of the Produced Water Booster Pumps 21PA002A/B, with the level control valve 44LV1004A located downstream of the pump's common discharge on the line to the Produced Water Injection Cooler 44HB101.

**NOTE**: The level controller is pulsed to Manual Mode and 0% output when respective EV or XV valve is closed.

An internal weir, being used to skim any oil that accumulates on the surface of the clean water, forms the interface. If the Water Injection system cannot handle all the Produced Water (or it is not running) then it can be routed to sea via 44LC1004B with the valve located on the disposal line to sea.

**NOTE**: The level controller is pulsed to Manual Mode and 0% output when respective EV or XV valve is closed.

44FT1015 monitors the amount of water disposed of to sea.

The slops oil which accumulates on the opposite side of the weir is released to the Closed Drains System by 44LC1008 modulating a level control valve 44LV1008 on the slops liquid outlet line.

**NOTE**: The level controller is pulsed to Manual Mode and 0% output when respective EV or XV valve is closed.

Safeguarding Instrumentation is provided by High and Low Pressure trip switch 44PST1006, Low Level trip switch (water side) 44LST1005, High and Low Level trip switch (slops side) 44LST1007.

Gas Blowby is prevented by 14" hydraulically operated shutdown valve 44XV1001 on the produced water outlet and 2" hydraulically operated shutdown valve 44XV1002 on the slops outlet.

### 11.4 Produced Water Booster Pumps 44PA101A/B

Produced Water Booster Pumps 44PA101A/B take suction from the Degassing Vessel 44VD101 and are motor driven centrifugal type each rated at 100% duty. The design flow rate is 646.0 $m^3$/hr at a differential pressure of 8.4 bar. Motor rating is 196.0 kW.

Minimum flow protection for the pumps is provided by automatic combined Minimum Flow/Non-return valves on the individual pump discharge lines, returning to the inlet of Degassing Vessel 44VD101.

44PT1009/10 provide individual pump suction pressures respectively.

Individual Pump protection is provided by Low and High-Pressure trip switches 44PST1011/1012 on the discharge lines.

The level control valve 44LV1004A for the Degassing Vessel 44VD1001 is located downstream of the pumps common discharge manifold and is modulated by 44LC1004A mounted on the Degassing Vessel. From the control valve the water flows to the Produced Water Injection Cooler 44HB101.

### 11.5 Produced Water Injection Cooler 44HB101

Produced Water Injection Cooler 44HB101 is a plate type exchanger with a counter-current flow pattern. Produced Water side design pressure and temperature is 16.0 barg / 120.0$^{o}$C and the Seawater side design pressure and temperature is also 16.0 barg / 120.0$^{o}$C. Design heat duty of the exchanger is 15736.0 kW.

The cooling medium is taken from the Sea Water system. Control of the Produced Water exit temperature is by modulation of a temperature control valve on the Seawater return line, the temperature being measured on the Produced Water outlet of the cooler by 44TC1016.

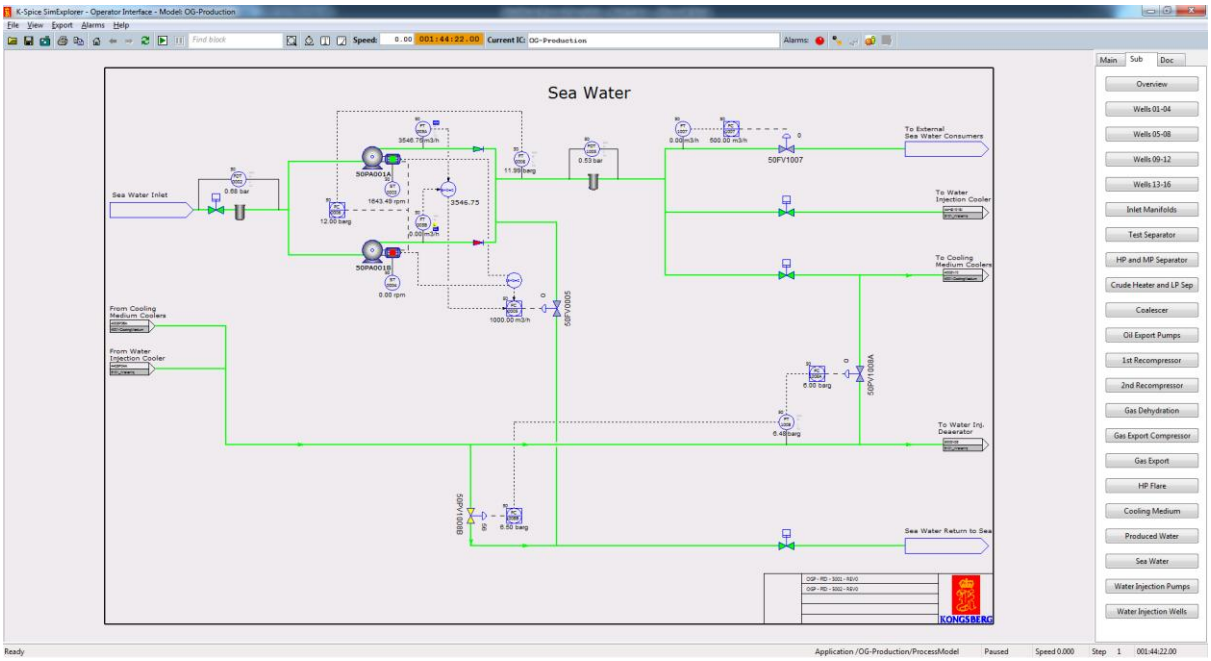
Cooled, filtered Produced Water then enters the suction of the Water Injection Pumps where it is supplemented by deaerated seawater.

# 12 System 50 Details - Seawater System

The system is shown in P & I D's:

OGP-PID-5001 rev 0 Seawater Supply Pumps
OGP-PID-5002 rev 0 Seawater Filter & Distribution




The supply of seawater is provided by one 30" line from sea, with a 30" hydraulically operated isolation valve 50HV0001. A strainer, complete with differential pressure indication 50PDT0002 is fitted in the line. The line then forms a 30" manifold and this supplies the 20" suction lines to each of the two Seawater Lift Pumps 50PA001 A/B. A minimum flow control valve returns seawater from the discharge manifold to the sea, the set point of this flow controller depends on the number of pumps running. Seawater from this common discharge manifold is then filtered in Seawater Filter 50CA101. Filter design ensures that particles larger than 1500 micron are removed from the seawater. Filtered seawater is now sent to the various users. Hydraulically operated valves, to enable only the essential users to be supplied in an emergency, can isolate non-essential users.

The pressure of the Seawater System is controlled by 50PC1008A on the outlet of the Cooling Medium Coolers 40HB001 A/B controlling a valve on the bypass of the coolers and by 50PC1008B controlling a valve in the return line to sea.

All excess warm return water is returned to sea.

## 12.1 Seawater Lift Pumps 50PA001 A/B

The Seawater Lift Pumps 50PA001 A/B are motor driven variable speed centrifugal type each rated at 100% duty. Motor rating is 1360.0 kW. The design flow rate for each pump is 3350.0 $m^3$/hr at a differential pressure of 11.0 bar. Pump discharge pipes tie into a 30" common discharge header. The flow of each pump is monitored

on their discharge by 50FT0005A/B respectively and the process values of these controllers are added before being sent to flow controller 50FC0005. The Set Point for 50FC0005 will be adjusted between 1100.0 $m^3$/hr and 2200.0 $m^3$/hr depending on the number of pumps running. Pressure controller 50PC0006, acting on the speed of the pump drivers, controls the pressure in the discharge manifold. High High pressure or Low Low pressure detected on the discharge of the pump will stop that pump.

From the discharge manifold seawater supplies the Seawater Filter 50CA101.

*Figure: Sea Water Pumps*

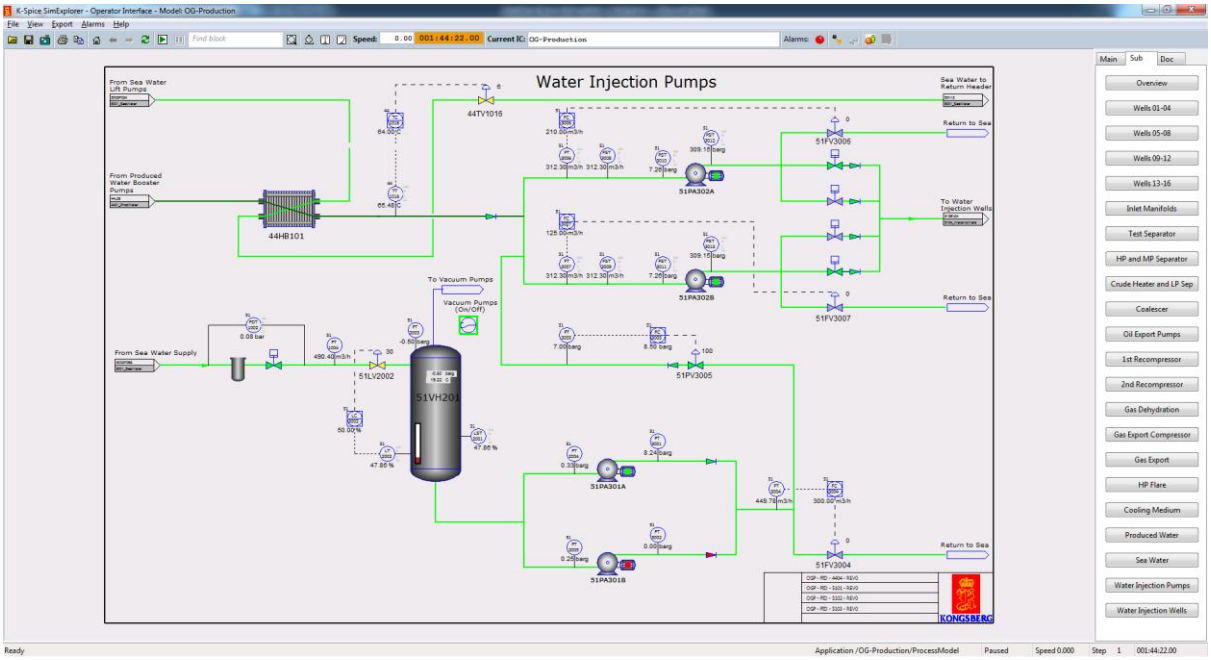
### 12.2 Sea Water Filter 50CA101

Seawater Filter 50CA101 removes all particles greater than 1500 microns. 50PDT1005 monitors the differential pressure across the filter. From this filter the seawater is routed to the major consumers, and in an emergency they can be isolated by hydraulically operated valves 50HV1001/9/10. One of the major consumers is the Cooling Medium Coolers. 50TT1006/07 measure the temperature of the seawater upstream and downstream of the Cooling Medium Coolers respectively. The warm sea water from the Cooling Medium Coolers is routed to the inlet of the Sea Water Injection system, with the system pressures controlled by 50PC1008A on the bypass of the coolers and by 50PC1008B on the return line to sea. Local Controller 50FC1007, modulating a control valve, determines the demand of the other users.

# 13 System 51 Details - Water Injection System

The system is shown in P & I D's:

OGP-PID-5101 rev 0 Water Injection Deaerator 51VH201
OGP-PID-5102 rev 0 Water Injection Booster Pumps 51PA301A/B
OGP-PID-5103 rev 0 Water Injection Pumps 51PA302A/B
OGP-PID-5104 rev 0 Water Injection Manifold and Wells




The water injection system is installed on the Generic Oil & Gas Process Simulator to inject into the reservoir via 3 Water Injection wells to maintain reservoir pressure.

The water injection system comprises:

- Seawater Injection Filter 51CZ101
- Water Injection Deaerator 51VH201
- Water Injection Booster Pumps 51PA301A/B
- Water Injection Pumps 51PA302A/B
- Water Injection Manifold
- Water Injection Wells

Warm filtered seawater is supplied from the seawater return header, immediately downstream of the Cooling Medium Coolers. Seawater is taken for the injection system from downstream of the process cooling for two reasons:

(a) seawater lift pump capacity is smaller than if the water injection take-off was parallel to process cooling, and

(b) warming the seawater reduces its oxygen carrying capacity which therefore aids the deaeration process.

The seawater supply flows to the Deaerator Tower 51VH201 via the Seawater Injection Filter 51CZ101. There, by means of the near vacuum maintained by the vacuum pumps, (boundary condition set by Instructor) and the use of oxygen scavenger chemical, the dissolved oxygen is removed from the seawater, and the deaerated seawater exits the deaerator tower bottom. From there, it passes through the booster pumps 51PA301A/B, and then the main injection pumps 51PA302A/B. The injection pump discharges to the Water Injection manifold and from there to the individual Water Injection Wells

### 13.1 Seawater Injection Filter 51CZ101

This filter has a design flow rate of 1046.0 $m^3$/hr. It ensures that particles no larger than 750 micron are allowed to the Injection System. 51PDT1002 monitors differential pressure across the filter.

### 13.2 Water Injection Deaerator 51VH201

The Water Injection Deaerator 51VH201 is a 3 stage packed bed tower with tan-tan height of 16.250 metres, and internal diameter 3.250 metres. The packing is arranged in three separate and sealed stages.

Hand Valve 51HV1001 on the seawater supply line from the Injection Filter 51CA101 is used to provide isolation of the Water Injection System when required.

Seawater measured by 51FT1004 enters at the top of the tower, and passes through a flow distributor that ensures an even spread of seawater flow at the top of the first packed section. Vacuum in the tower is maintained by the vacuum pump package.

Thus, water passes through the three stages, where the bulk of the oxygen is removed. Deaerated seawater falls from the third stage of packing into the liquid hold-up section of the tower. Normally, oxygen content will have been reduced to 20.0 ppb in the packed stages. Above the liquid section is a distributor, which sprays a solution of oxygen scavenger chemical mixed with a flow of water from the Water Injection Booster Pumps 51PA301A/B into the falling water and the liquid section. The oxygen scavenger reduces oxygen content to the required outlet specification of 10.0 ppb.
The vacuum in the tower is indicated by 51PT2003 and is controlled by a boundary condition set by the Instructor.

Level control in the Deaerator is provided by level controller 51LC2002 modulating a control valve located on the seawater inlet to the top of the Deaerator.

**NOTE**: The level controller is pulsed to Manual Mode and 0% output when respective inlet valve 51HV1001 is closed.

Level Indication and Alarm is provided by 51LST2001 with a High High level alarm closing the inlet valve 51HV1001 and a Low Low level alarm stopping Booster pumps.

Deaerated water then exits the tower at the bottom of the tower and flows to the Water Injection Booster Pumps 51PA301A/B

### 13.3 Water Injection Booster Pumps 51PA301A/B

Water Injection Booster Pumps 51PA301A/B take suction from the Water Injection Deaerator 51VH201. Pressure at the liquid outlet is less than atmospheric pressure, and so the booster pump is designed to operate with very low suction pressure, and very low N.P.S.H. The pumps are motor driven centrifugal type each rated at 50% duty. The design flow rate is 523.0 $m^3$/hr at a differential pressure of 11.5 bar. Motor rating is 280.0 kW.

A line from the discharge of the pumps returns to the Deaerator 51VH201 and is used to dilute the Oxygen Scavenge chemical and carry it to the bottom of the Deaerator where it reduces any remaining oxygen to less than 10.0 ppb.

Pump suction and discharge pressures are available via 51PT2005/2004 on the suctions and 51PT3001/3002 on the discharge lines. High High pressure or Low Low pressure detected on the discharge of the pump will stop that pump.

Flow controller 51FC3004, located on the common discharge, modulates a control valve on the return line to sea to provide minimum flow protection for the pumps. The set point of this controller has to be adjusted dependant on the number of Booster Pumps running.
The discharge pressure of the pumps (and hence the suction pressure of the Water Injection Pumps 51PA302A/B is controlled by downstream pressure controller 51PC3005 set at 8.0 barg where it is combined with water from the Produced Water System.

### 13.4 Water Injection Pumps 51PA302A/B

Water Injection Pumps 51PA302A/B take suction from the Water Injection Booster Pumps 51PA301A/B via downstream pressure controller 51PC3005 set at 8.0 barg and the discharge from the Produced Water Booster Pumps 44PA101A/B. The pumps are motor driven centrifugal type each rated at 50% duty. The design flow rate is 523.0 $m^3$/hr at a differential pressure of 266 bar. Motor rating is 4982.0 kW.

Pump Protection Instrumentation is provided by High and Low Pressure trip switches 51PST3010/3011 and by High and Low Flow trip switches 51FST3008/3009 on the pump suctions and High and Low Pressure trip switches 51PST3012/3013 on the pump discharge lines.

Minimum flow protection for the pumps is provided by flow controllers 51FC3007 & 51FC3007, located on the suction of each pump, modulating a control valve on the discharge of each pump on a return line to sea. The flow controller must be in Manual Mode with the output at 65% before starting the pump. To prevent spurious trips High and Low Flow trip switches 51FST3008/3009 on the pump suctions are fitted with a 5 second time delay.

10" Hydraulically operated valves 51HV3014/3015 (with 2" Hydraulically operated bypasses 51HV3016/3017) are available on the pump discharges to isolate the pumps from the Water Injection Manifold and assist in starting the pumps.

**NOTE:** The pressurising valve must be opened until pressure is equalised before opening the main valve.

### 13.5 Water Injection Manifold

The Water Injection Manifold is a 14" header that supplies the requirements of the 3 Water Injection Wells.

17PT0026 measures the pressure of the manifold.

Each well has the following:

- 8" electrically operated isolation valve with a manual pressurising bypass valve
- Flow Measurement
- Choke valve
- Low Pressure Trip Switch downstream of Injection Wing Valve
- Low Pressure Trip Switch downstream of Injection Master Gate Valve
- A Manual depressurising valve fitted between choke valve and Wing Valve.

The opening of the valves associated with each well has to be done in the following order:

1. Sub Surface Safety Valve
2. Master Valve
3. Wing Valve
4. Choke Valve.