6.   Operation and Controls

6.1.   Main Control Loops Front End and Cold Box

6.1.1.   Main air compressor

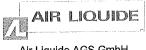| Controller	Output	
PIC11041	FK11074	Controls discharge pressure of the air compressor (mainly used during start up and to limit the discharge pressure during normal operation)
FIC11074	FK11074	Controls air flow vented after the air compressor if the surge limit of the compressor is reached

6.1.2.   Direct contact after cooler

Controller	Output	
LIC13003	LK13008	Controls the liquid level in the sump of the DCAC. The level must not exceed the air inlet nozzle. In this case the internals of the tower can be damaged
FIC13007	FK13007	Controls the cooling water flow ex pump P13100/200 to the DCAC
FIC13006	FK13006	Controls the chilled water flow to the top of the DCAC

6.1.3.   Refrigeration unit

Controller	Output	
FIC12005	FV12005	Controls the chilled water flow through the refrigeration unit by recycling to the chill tower
TIC12003	TV14010	Controls the chilled water temperature from the chill tower by injecting warm water from the DCAC

6.1.4.   Chill tower

Controller	Output	
LIC14003	LK14003	Controls the liquid level in the sump of the Chill tower. The level must not exceed the gas inlet nozzle. In this case the internals of the tower can be damaged.
PIC15041	PK15041	Controls the pressure of the waste gas. The column system should be held at constant pressure during operation

6.1.5. Molecular sieve adsorber

Controller	Output	
FIC15035	FV11010	Controls the air flow to the plant
PIC15037	PV15037	Controls the regeneration gas pressure for air regeneration
FIC15041	UK15044 UK15045	Controls the flow of regenerating gas during the different steps (cooling, heating and other steps)
TIC15043	TV15043	controls the temperature of the gas leaving the steam powered heater

6.1.6. Booster air compressor

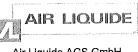| Controller	Output	
PIC16007	PK16007	Controls the suction pressure of the booster air compressor
PIC16045	FV16010 FV16074	Controls the discharge pressure of the booster air compressor via IGV and compressor recycle valve
FIC16074	FV16074	Opens the compressor bypass when the surge limit is reached. The actual value is calculated internally.

6.1.7. Expansion turbines

Controller	Output	
FIC24101	UK24105	Controls the flow through expander by changing the inlet guide opening.
FIC24201	UK24205	Controls the flow through expander by changing the inlet guide opening.

6.1.8. Main heat exchanger

Controller	Output	
TIC20008	TV20008	Controls the cold end temperature at the main heat exchanger by changing the JT valve opening.

6.1.9. Air separator

Controller	Output	
LIC21060	LV21060	Controls the liquid level in the air separator by varying the liquid air flow to the LP column.

6.1.10. LOX pumps

Controller	Output	
PIC61170	PV61170 UC61100	Controls the discharge pressure of the LOX process pump by adjusting the recycle flow to the LP column and the output of the frequency converter (split range control); the set-point of this controller is derived via a cascade from the pressure controller PIC20011 at the warm end of the main exchanger to ensure that the pressure ex cold box remains constant irrespective of changes in flow
PIC61270	PCV61270 UC61200	Controls the discharge pressure of the LOX process pump by adjusting the recycle flow to the LP column and the output of the frequency converter (split range control); the set-point of this controller is derived via a cascade from the pressure controller PIC20011 at the warm end of the main exchanger to ensure that the pressure ex cold box remains constant irrespective of changes in flow

6.1.11. LIN pumps

Controller	Output	
PIC71170	PV71170 UC71100	Controls the discharge pressure of the LIN process pump by adjusting the recycle flow to the HP column and the output of the frequency converter (split range control); the set-point of this controller is derived via a cascade from the pressure controller PIC20001 at the warm end of the main exchanger to ensure that the pressure ex cold box remains constant irrespective of changes in flow
PIC71270	PV71270 UC71200	Controls the discharge pressure of the LIN process pump by adjusting the recycle flow to the HP column and the output of the frequency converter (split range control); the set-point of this controller is derived via a cascade from the pressure controller PIC20001 at the warm end of the main exchanger to ensure that the pressure ex cold box remains constant irrespective of changes in flow

6.1.12. Argon reflux pump

Controller	Output	
LIC40053	PV40170 UC40100	Controls the level in the crude argon column adjusting the recycle flow to the crude argon column and the frequency converter for the pump motor

6.1.13. HP column

Controller	Output	
LIC21003	LV21003	Controls the liquid level in the HP column by varying the CLOX flow to the crude argon condenser. The level must not exceed the air inlet nozzle. In this case the column internals can be damaged.
HIC21006	HV21006	Controls the reflux to the HP Column. In normal operation the valve should be fully open.
HIC21014	HV21014	Controls the distribution of liquid air between HP column and LP column
HIC73001	HV73001	Controls the LIN LGCC flow to the HP column.

6.1.14. LP column

Controller	Output	
LIC22001	LV22001	Controls the liquid level of the LP column by adjusting the LOX product flow to storage
LIC22002	LV22030	Controls the liquid level of the LP column by adjusting the LOX LGCC flow to the low pressure column
FIC22043	FV22043	Controls the GOX flow
FIC22013	FV22013	Controls the LIN flow to the LP column

6.1.15. Crude argon column

Controller	Output	
QIC40011	FIC22043	Controls the quality of the vapour feed to the crude argon column by adjusting Control GOX flow to waste.
QIC40011_2	FIC20011	Controls the quality of the vapour feed to the crude argon column by adjusting Control GOX flo to production.
FIC40011	FV40011	Controls the vapour feed flow to the crude argon column.
LIC40007	LV40007	Controls the level in the crude argon column condenser
PIC40003	PK40003 HK40012	Controls the pressure at the top of the crude argon column during normal operation and the pressure in the LP system in shutdown periods
FIC40014	FV40014	Controls the liquid argon flow to the pure argon column
QIC21004	FIC40014	Control the O2 content in CrAr column bottom with the flow to Pure Ar column.
HIC40005	HV40005	Vents the non-condensable gases from the crude argon column condenser

6.1.16. Pure argon column

Controller	Output	
LIC43023	LV43023	Controls the sump level in the pure argon column by argon product flow to storage
LIC43033	LV43033	Controls the sump level in the pure argon column by argon product flow to dump
LIC43027	LV43027	Controls the level in overhead condenser vessel by adding LIN from the LIN separator or by withdrawing LIN from the pure argon column reboiler
PDIC43021	PV43021	Controls the vapour flow in the pure argon column by adjusting the flow of the reboiler heating stream
PIC43022	PV43022	Controls the column pressure by venting non-condensable gases from the pure argon column
PIC43028	PV43028	Controls the pressure in the overhead condenser vessel

6.1.17. Gaseous products

Controller	Output	
FIC20001 FIC20002	FV20001 FV20002	Controls the HP GAN product flow from the ASU
PIC20001	PIC71170 PIC71270	Controls the GAN product pressure by adjusting the set-point of the LIN pump pressure controller.
FIC20005 FIC20006	FK20005 FK20006	Controls the LP GAN product flow from the ASU
FIC20011 FIC20012	FV20011 FV20012	Controls the GOX product flow from the ASU
PIC20011	PIC61170 PIC61270	Controls the GOX product pressure by adjusting the set-point of the LOX pump pressure controller.

6.1.18. Liquid products

Controller	Output	
FIC23013	FV23013	Controls the liquid nitrogen product flow to storage
FIC23073	FV23073	Controls the liquid nitrogen product flow to dump
LIC23076	LV23076	Controls the liquid level of the LP column by adjusting the LOX product flow to dump

6.1.19. Cold box purge

Controller	Output	
PC87011	PCV87011	Controls the purge gas pressure from the back-up system
FI87021 etc.		Adjusts the purge gas flow to the cold box and heat exchanger box

6.1.20. Nitrogen compressors

Description is made for compressor n°1. The same applied to compressor n°2.

Controller	Output	
PIC70035	P70010	Controls the discharge pressure of the nitrogen compressor via IGV.
PIC70007	P70010	Protect the suction pressure from trip value acting on IGV.
FIC70074	FV70074	Opens the compressor bypass when the surge limit is reached. The actual value is calculated internally.

6.1.21. Instrument, purge and seal gas

Controller	Output	
PC87011	PV87011	Controls the backup purge gas pressure to the cold box
PC81040	PV81040	Controls the normal seal and purge gas pressure
PC81041	PV81041	Controls the back-up seal and purge gas pressure
PC82020	PV82020	Controls the instrument air back-up pressure
PC81020	PV81020	Controls the GOX seal gas pressure
PC71180	PV71180	Controls the HP GAN seal gas pressure

6.1.22. Dump vaporiser

Controller	Output	
TIC90008	TV90004	Controls the gas temperature in the dump vaporiser by adjusting the steam flow

6.2. Main Control Loops Tank farm and back-up

6.2.1. Oxygen

Controller	Output	
PIC63033	PV63033	Controls the LOX LGCC pump discharge pressure by adjusting the recycle valve to the LP LOX tank

6.2.2. Argon

Controller	Output	
PIC44105	PV44105	Controls the maximum LP LAR tank pressure by venting gas to atmosphere.
PC44106	PV44106	Controls the minimum LP LAR tank pressure by vaporising gas in the pressure build-up loop.
PIC44205	PV44205	Controls the maximum LP LAR tank pressure by venting gas to atmosphere.
PC44206	PV44206	Controls the minimum LP LAR tank pressure by vaporising gas in the pressure build-up loop.
PC44073	PV44073	Controls the purge gas flow to the argon truck filling pump
HIC48070	HV48070	Controls the LAR back-up pump discharge pressure by adjusting the recycle flow to the LP argon tank
PC48080	PV48080	Controls the purge gas flow to the LAR back-up pump
PIC48005	PV48005	Controls the maximum HP LAR tank pressure by venting gas to atmosphere.
PIC48027	PV48027	Controls the HP LAR tank pressure by distributing liquid feed between top and bottom inlet
PC48006	PV48006	Controls the minimum LP LAR tank pressure by vaporising gas in the pressure build-up loop.
TIC49020	PV49020	Limits the vaporiser throughput depending on outlet temperature
PIC49020	PV49020	Controls the back-up pressure by adjusting the flow rate

6.3. Operating range

The main purpose of the plant is to produce gaseous oxygen, nitrogen and argon to supply the customer. As the plant usually produces more nitrogen than required the air flow to the cold box is controlled by the oxygen production.

- In the normal design case the plant produces 20.000 Nm^3/h of oxygen, 3.500 Nm^3/h of high pressure nitrogen and 29.500 Nm^3/h of medium pressure nitrogen. This is the best efficiency operating point.

- For the maximum liquid production both expansion turbines are running providing sufficient refrigeration for either 3.500 Nm^3/h LOX or LIN.

- For maximum oxygen gas production the plant is equipped with a LOX LGCC facility which allows the injection of up to 5.000 Nm^3/h LOX. This additional oxygen is available as GOX product from the ASU.

- At low GOX demand the flow can be reduced to 11.000 Nm^3/h. The remaining oxygen is stored as liquid.

More details are given in the attached process flow diagram and stream table. The plant can be operated across the complete range between the maximum and minimum operating point.

In case of an expander failure the plant can be operated with liquid inject from storage.

The plant has been designed for automatic control during normal operation.

6.4. Measurement range and limit value list

To ensure safe operation and stable product purity and quantity alarm and trip points are defined within the DCS. In case of abnormal conditions violating the set limits the operator will be warned or the plant or parts of it will be automatically shut down. The attached list contains detailed information about each measurement. Identified by the TAG number and location the following data are given:

- measurement range

- alarm and trip values

- controller settings

6.5. Level measurements

The attached level transmitter data sheets provide information about the geometry and operation values of the level measurements.

For vessels the operating range is usually set from 0 - 100%. 0% is always defined by the lower tap position. 100% is normally defined at the upper tap, except where the nozzle is placed in a connecting pipe. In this case the upper edge of the vessel is used to specify the 100% level.

For reboilers/condensers the level is defined relative to the heat exchanger. 0% is always defined at the lower edge of the heat exchanger, 100% is defined at the upper edge of the unit. Therefore the level can be below 0% and above 100%. 100% level indicates a just fully submerged reboiler/condenser.

Please note that a reading below range minimum means that the level is at the lower tap or below. The same principle applies to a reading of range maximum which is also indicated if the level is above the upper level tap.

For heat exchangers standing in liquid baths the submergence level is of utmost importance. Keeping the specified levels ensures a safe and stable operation.