

4. Start-up

4.1. General

It is important to notice that the start-up procedure differs depending on the plant state. One condition is the start-up from warm which applies for the initial start-up during commissioning, after plant thawing, repair works or similar actions. The other one is the cold condition after a short plant stop with liquids being kept inside the cold box. This procedure is detailed in the following lists.

The following sequences are not final. They may be changed when better procedures are found during operation of the plant. These changes should be noted in this manual. Always check and follow vendor operating manuals in addition to the listed procedures.

Nomenclature:

Y output of controller (e.g. valve position)

W set-point of controller

X actual value of controller (normally measurement)

auto automatic mode of controller

man manual mode of controller (output can be changed)

4.2. Preparations

Before starting the plant the following conditions have to be fulfilled:

- The plant is mechanically complete.
- Any temporary installation, construction, support etc. has been removed.
- The electricity supply is available.
- All measurements have been checked.
- All control system loop checks have been performed.
- All valves have been checked.
- A leak test of the entire plant has been done.
- A complete P&ID check has been carried out.
- Calibration gases for the analysers are available.
- Compressors, pumps and the cooling water system have been prepared.
- Instrument gas is available.

A list of controller positions (set-points and limits) eases the definition of a start setting. Before using any controller it has to be made sure that it is configured properly (parameters, etc.)

It is useful to record changes made and positions used during the start-up including the time. A form with plant measurements and settings should be prepared to record the start-up behaviour.



4.3. Cold Box Purge

To avoid air ingress into the cold boxes a constant positive nitrogen pressure is required inside the cold boxes. Attention must be paid not to increase the pressure too close to the pressure relief device setting.

| Step | Activity | Name | Item | Value |
|------|--|--|-----------------------|--|
| 1 | Adjust pressure controller: PCV87011 | P87012 | Х | 100 mbar |
| 2 | Adjust purge flow Set purge flows through: | | | |
| | V87020 V87021 V87060 V87061 V87062 V87063 V87064 | F87020 F87021 F87060 F87061 F87062 F87063 F87064 | X X X X X | 5 Nm ³ /h 5 Nm ³ /h |
| | The start-up of the box purge lines cannot be done simultaneously. Because they affect each other all pressures and flows must be checked regularly during start-up. | | | |

Remarks:

- 1. The given flows are estimates only and have to be adjusted to provide a positive pressure inside the cold boxes which is below the pressure relief device settings (approximately 1 mbar) and should not be high to prevent valves icing because of N2 blowing through leaks.
- 2. For the cold box purge only dry nitrogen with an oxygen content of less than 3% must be used to make sure that no oxygen will condense at the cold parts of the plant i.e. at the subcooler or the upper part of the low pressure column. The perlite, which is used as isolation material for the cold box has a capacity to store liquid and liquid oxygen inside the perlite room constitutes a hazard for the operation of the cold box. Thus the box atmosphere must be checked on a regular basis.



4.4. Instrument Air, Seal and Purge Gas

| Step | Activity | Name | Item | Value |
|------|--|---------|------|----------|
| 1 | Adjust N2 purge and seal gas back-up supply on PC81041 | PC81041 | W | 4 barg |
| 2 | Adjust N2 purge and seal gas supply on PC81040 | PC81040 | W | 4.5 barg |
| 3 | Adjust instrument air back-up supply on PC82020 | PC82020 | W | 3.5 barg |
| 4 | Adjust oxygen seal gas supply on PC81020 | PC81020 | W | 5 barg |
| 5 | Adjust nitrogen seal gas supply on PC7180 | PC71180 | W | 8 barg |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Remarks:

4.5. Cooling Water System

| Step | Activity | Name | Item | Value |
|------|----------------------------------|--------|------|---------------|
| 1 | Cooling water total flow to ASU9 | F80001 | | 1700 Nm³/h |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Remarks:

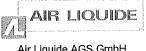
Cooling water is supplied from the existing cooling water system. Sufficient flow to each consumer has to be ensured.

4.6. Main Air Compressor

| Step | Activity | Name | Item | Value |
|------|---|--------------------------------------|------------------|--|
| 1 | Reset trip | | | |
| | main air compressor | HS11000 | | reset |
| | DCAC | HS13000 | | reset |
| 2 | Check oil system | | | |
| | oil pressure | P11854 | Χ | > 1.2 bar |
| | oil temperature | T11854 | Χ | 30 - 50 °C |
| 3 | Check cooling water is running | | | |
| 4 | Make sure that the inlet valves of the molecular sieve are closed | | | |
| | UK15011 closed UK15021 closed UK15018 closed | G15011 G15021 | | closed closed |
| | UK15028 closed | | | |
| 5 | Establish "ready to start" conditions (see "Start conditions" screen). | | | |
| 6 | Switch on air compressor | HS11001 | | ON |
| 7 | After running in steady conditions open inlet guide vane slowly to close manual controller of blow-off close blow-off slowly until outlet pressure is reached adjust pressure controller set-point and switch to automatic mode | F15035 H11074 H11074 P11041 | Y Y Y W | 35 % 0% decrease 4.8 barg AUTO |
| 8 | Check oil pump and heater have been switched off automatically Check oil and bearing temperatures Check vibrations Check cooling water outlet temperatures | | | |

Remarks:

Check vendor operating manual for start-up preparations and procedures.



Operating manual ASU No.9 Kosice – Master – Update from the 23/02/2007

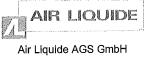
4.7. **DCAC**

| Step | Activity | Name | Item | Value |
|------|---|--------------------------------------|-------------|--|
| 1 | Reset trip DCAC Make sure the MAC is running on pressure control and delivering enough pressure | HS13000 P11041 | Х | reset >4 barg |
| 2 | Check inlet manual valve of the pump which will be started is open. Check that the outlet valve is closed (in order not to have air coming from the DCAC tower (which is at >4 barg) to the pump. Make sure there is no air in the pump by opening the drains and vents valves of the pump. | | | |
| 3 | Close FK13007 | F13007 | Υ | 0% |
| 4 | Set level controller | L13003 L13003 | W | 30% AUTO |
| 5 | Switch on water pump When pump is started and building pressure, open quickly outlet manual valve. | HS13100 or HS13200 | | ON |
| 6 | Open FK13007 until required flow is met and set to automatic | F13007 F13007 F13007 F13007 | Y X W | adjust 180 m³/h AUTO 210 m³/h |

Remarks:

Monitor the water level for proper controller function during level build-up.

Switch DCAC pumps regularly.



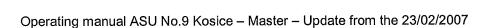
4.8. Chill Tower

| Step | Activity | Name | Item | Value |
|------|---|--------------------------------------|-------------|--------------------------------------|
| 1 | Reset trip | HS14000 | | reset |
| 2 | Check inlet and outlet manual valves of the pump which will be started are open. | | | |
| | Make sure there is no air in the pump by opening the drains and vents valves of the pump. | | | |
| 3 | Close FK13006 Close FV12005 | F13006 F12005 | Y Y | 0% 0% |
| 4 | Set level controller | L14003 L14003 | W | 50% AUTO |
| 5 | Switch on water pump | HS14100 or HS14200 | | ON |
| 6 | Open FK13005 until required flow is met and set to automatic | F13005 F13005 F13005 F13005 | Y X W | adjust 45 m³/h AUTO 45 m³/h |
| 7 | Open FK13006 until required flow is met and set to automatic | F13006 F13006 F13006 F13006 | Y X W | adjust 33 m³/h AUTO 33 m³/h |

Remarks:

Monitor the water level for proper controller function during level build-up.

Switch chill tower pumps regularly.



4.9. Refrigeration Unit

| Step | Activity | Name | Item | Value |
|------|---|---------------------------------------|-------------|---|
| 1 | Chilled water pumps are running at design conditions Chilled water is flowing in recycle to chill tower and to DCAC | P14100/200 F12005 F13006 | X X | ON 45 m³/h 33 m³/h |
| 2 | Cooling water to the unit is available Chilled water bypass is closed | | | |
| 3 | Reset trip refrigeration unit | HS12001Re s | | reset |
| 4 | Switch on refrigeration unit Make sure the chilled water temperature is high enough by either changing the flow to the DCAC or by injecting warm water into the chill tower | HS12001 T13026 F13006 T12003 | X W W | ACTIVE > 5°C increase increase |

Remarks:

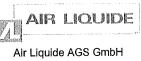
Check vendor operating manual for start-up preparations and procedures.

4.10. Molecular Sieve Adsorber (MSA)

| Step | Activity | potential service and the serv | Name | Item | Value |
|------|---|--|-------------------|------|--|
| 1 | Reset MSA trip: the molecular sieve will automatically star bed which is going on-stream (adsorption | | HS15000 | | reset |
| 2 | Wait till the pressurisation is finished and are in correct position. | check that the valves | | | |
| | When pressurisation is complete, switch (then put P15037 in auto | ON the sequence | HS15001 P15037 | W | ON 200 mbarg |
| 3 | Then switch ON Air Regeneration to get re | egeneration gas flow. | HS15006 | | ON |
| 4 | Make sure steam for the heater is availab manual valve K15042 is close. It is mand valve to avoid to withdraw cold gas at the main exchanger. | latory to close this | | | |
| | Adjust : regeneration gas flow | AUTO | F15041 | W | 19,000 Nm ³ /h for heating and 20,000 Nm3/h for cooling. |
| | regeneration gas temperature | AUTO | T15043 | W | 200°C |
| 5 | Later, when air flow is established through cold box and P15041 is in AUTO at opera valve K15042 must be reopened. Tempe end of exchanger must be checked closel operation. | ation value, manual erature of the warm | | | |

Remarks:

1. The large butterfly valves in the molecular sieve skid are of the three lever valve type. This means they are only closing tight in one direction (indicated by the P →) and that they cannot open against that direction if the pressure difference between in- and outlet of the valve is greater than about 0.3 bar.



4.11. Booster Air Compressor

| Step | Activity | Name | Item | Value |
|-------|--|--|-------------|---|
| 1 | Reset the trip BAC Make sure the molecular sieve is running | HS16000 | | reset |
| 2 | Check oil system | | | |
| | oil pressure | P16855 | Χ | > 2 bar |
| | oil temperature | T16854 | Χ | 45 - 50°C |
| 3 | Check cooling water is running | | | |
| 3 bis | Close cooling water on the oil cooler | | | |
| 4 | Check seal gas pressure is sufficient | P16751 | Χ | 70 mbarg |
| 5 | Close BAC discharge valves | HK16073 HV16071 | Υ | close 0% |
| | and cold box valves | UK20026 UK20027 | Υ | close 0% |
| 6 | Pressurise BAC slowly and open PK16007 at 100% when pressure is equal to the pressure in the mole sieve | PK16007 | Υ | open |
| 7 | Establish "ready to start" conditions | | | |
| 8 | Switch on booster air compressor | HS16001 | | ON |
| 9 | After running in steady conditions | | | |
| | Open cooling water on oil cooler open inlet guide vane slowly to close H16074 controller close recycle valve slowly until required pressure is reached adjust pressure controller set-point and switch to automatic mode | U16010 H16074 U16074 P16045_1 P16045_1 | Y Y Y | 15 % 0% decrease 56 barg AUTO |
| 10 | Check oil pump and heater have been switched off automatically Check oil and bearing temperatures Check vibrations Check cooling water outlet temperatures Check suction valve is fully open | PK16007 | Y | 100% |
| 11 | Set pressure protection controller set point and turn it to automatic mode | P16045_2 | W | 58 barg AUTO |

Remarks:

Check vendor operating manual for start-up preparations and procedures.



4.12. Cold Box Pressurisation and Set-up

Before pressurising the cold box all drain, vent, defrost, product and control valves in and around the cold box must be closed.

| Step | Activity | Name | Item | Value |
|------|--|--|-------------|--|
| 1 | Check all front end equipment is running properly and reset cold box trip. Make sure that the turbines have seal and purge gas and their oil pumps and demister fans are running. | US2000 | | reset |
| 2 | Check all process and product valves beyond MSA and BAC are closed. In particular make sure that the turbine and pump inlets are shut. | UK24101 UK24201 HV61110 HV61210 HV71110 HV71210 | | closed closed closed closed closed closed |
| | | HV40110 | | ciosed |
| | Make sure that all automatic valves between HP and LP system are closed to isolate the HP-column. | | | |
| | Open all manual valves of turbines. Open all manual valves of pumps except production valves. Open side arm gas valve to CrAr column Adjust crude argon pressure controller and switch to automatic. | PK40003 P40003 P40003 | Y W | 100% 500 mbarg AUTO |
| 3 | Adjust LP column pressure controller and switch to automatic | P15041 P15041 | W | 500 mbarg AUTO |
| 4 | Open cold box pressurisation valve stepwise and monitor HP and LP column pressure After pressure equalisation open cold box inlet valve | UK20027 UK20026 | Υ | 100% open |
| 5 | Increase flow to LP system by slowly opening LIN reflux valve LAIR reflux valve CLOX to CrAr condenser valve CLOX to LP column valve gradually to a maximum of 70% open gas lifts 2 turns | F22013 L21060 L21003 L40007 V21017 V22015 | Y Y Y | increase increase increase increase |
| | Observe LP column pressure is kept at approx. | V40010 P22001 | Х | 500 mbarg |
| 6 | Slowly pressures pure argon column and put pressure controller into automatic | F40014 P43022 P43022 | Y W | increase 400 mbarg AUTO |
| 7 | Slowly pressurise pure argon column condenser and put pressure controller into automatic | PD43021 P43028 P43028 | Y W | increase 1.5 barg AUTO |
| 8 | Slowly pressurise the high pressure air system. The JT valve is closed during pressurisation. After pressure equalisation open BAC discharge and gradually establish flow through the JT-valve | HK16073 T20008 HK16073 T20008 | Y Y Y | increase 0% 100% 50% |

Operating manual ASU No.9 Kosice - Master - Update from the 23/02/2007

page 56

| Step | Activity | Name | Item | Value |
|------|---|--------------------------------|-------------|------------------------|
| 9 | Slowly pressurise LOX pump via recycle line and start flow through the main exchanger. The product valve is closed. | P61170/270 F20012 F20011 | Y Y Y | 100% increase 0% |
| 10 | Slowly pressurise LIN pump via recycle line and start flow through the main exchanger. The product valve is closed. | P71170/270 F20002 F20001 | Y Y Y | 100% increase 0% |
| 11 | Slowly start LP GAN flow through the main exchanger. The product valve is closed. | F20006 F20005 | Y | increase 0% |
| 12 | Slowly pressurise LAR pump via recycle line | P40170 | Υ | 100% |

Remarks:

This procedure covers pressurisation when the plant is warm. The pressure in the LP-column is kept at the indicated high level to facilitate being able to put a significant amount of gas through the GOX - passages of the main heat exchanger.

4.13. Blow through

Purpose of the cold box blow through is to remove particles from the air separation unit which have been accumulated during fabrication and assembly of the equipment and piping. The following points give guidance for performing the blow through. Locations which cannot be blown through must be cleaned by other methods like sweeping, flashing, wiping etc.

- After a period of 15 20 minutes steady blow through at high velocity (30 40 m/s) sufficient cleaning of the respective circuit can be assumed.
- The blow through should be conducted with dry and clean air from the MSA.
- In general the blow through should be performed in such a manner that particles are not blown into equipment like heat exchangers, columns or machines.
- Special care has to be taken at the cold box inlets. These pipes are normally made of carbon steel and therefore prone to corrosion. The cold box inlet flange is spread and some sort of barrier such as a wooden board is placed over the cold box inlet to prevent particles from entering the cold box pipe.
- Bursting disks are used to conduct a blow through when a valve is not available. A piece of cardboard or plastic is used to cover the open section of the piping to be blown. A blind flange with a centre circle cut out covers the cardboard or plastic. The piping is pressurised until the bursting disk ruptures. Sometimes the cardboard has to be slightly scored to help it burst. Depressurise the piping before scoring the disk. Clamps can be put on the flange to help prevent leaks around the disk. The procedure is repeated until the line is clear of debris. If this cannot be determined visually a target made of cardboard or gasket material can be used.
- The turbine and all pumps have to be protected against uncontrolled spinning by suitable valve opening sequences, by disconnecting attached piping or spin protection devices.
- Flexible hoses at pump flanges should be disconnected and used for venting.
- Instrument piping must only be blown through and dried after all other equipment has been cleaned.
- The pressure in each circuit has to be controlled such that lifting of safety valves is avoided.
- All filters and strainers must be cleaned after the blow through is completed.

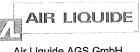
- To conduct the blow through in a systematic manner mark up the P&ID showing the flow circuits and the valve positions.
- After liquid levels have been build for the first time all liquid have to be drained from the plant to remove collected particles. Subsequently all filters must be cleaned.

4.14. Cold Box Drying

Drying of the equipment is required to remove traces of moisture and CO₂ from all cold box equipment, i.e. heat exchangers, columns, piping and other vessels, before it is cooled down to cryogenic temperatures. The following general points should be noted.

- Drying should be conducted with dry and clean air from the MSA.
- Drying is completed when the moisture content of all vented streams is below 3 vppm, equivalent to -70°C dew point temperature. This can be measured by a mobile moisture analyser, a Dräger moisture test tube or equivalent.
- The pressure in each circuit has to be controlled such that lifting of safety valves is avoided.
- The plant has to be dried in sequential steps. It must be made sure that already dried circuits are not subsequently exposed to wet air.
- Under any circumstances it must be avoided to feed wet air into the regeneration piping to the MSA. Hence the manual valve in this line is to be closed until the cold box is dry.
- In case of an interruption of the drying process all connections to ambient must be closed.
- Where no dry air flow can be forced through equipment, e.g. condensers, the surrounding vessel should be repeatedly pressurised and depressurised to purge the passages concerned.

To conduct the drying in a systematic manner mark up the P&ID showing the flow circuits and the valve positions.



4.15. Gas Expansion Turbines

The start-up is described for a single turbine. The second identical unit is to be handled accordingly.

| Step | Activity | Name | Item | Value |
|------|--|--------------------------------------|--------|----------------------------|
| 1 | Make sure that the starting conditions are fulfilled and trip reset Check that generator switch is engaged | HS24100 | | reset |
| 2 | Close inlet nozzles Make sure that the oil pump is running, seal gas is available, manual isolation valves are open | F24101 H24105 K24110 K24102 | Y Y | 0 % 0 % open open |
| | and defrost, purge and drain lines are closed. | | | |
| 3 | Open quick shut-off valve | HS24101 | | on |
| 4 | Open FV24101 to 20% in on shot (MIN selector) Then slowly open inlet nozzles to speed up the turbine Minimum speed 500 rpm must be achieved within the defined | F24101 | Υ | increase |
| | time (30 seconds). The generator will automatically switch on at operating speed Increase load until generator power is positive (trip if < 5 kW for 30s). | S24124 | Х | 36,000 rpm |
| 5 | Adjust turbine flow to the required cold production | F24101 | Υ | adjust |
| 6 | Make sure that the turbine is not operated at too low inlet temperature to keep away from liquid creating at the discharge. To avoid liquid formation adjust the JT-valve to increase the inlet temperature. If an increase in inlet temperature is followed by an increase in discharge temperature there is no liquid at the turbine outlet. | | | |

Remarks:

Check vendor operating manual for start-up preparations and procedures.



4.16. Cool Down

Before cooling the plant down to cryogenic temperatures moisture and CO₂ must be removed from the equipment. Otherwise some passages in heat exchangers, columns or piping can get blocked by solid H₂O or CO₂.

Make sure that as much air as possible is guided through the cold box. To achieve this set up the main valves to the LP column to manual with a maximum opening of 70%. The pressure in the LP column should be kept at about 0.5 barg to encourage flow through the IC GOX passages. Make sure that the outlet and recycle valves of the LOX and LIN process pumps are fully open and that the pressure controller is able to maintain the desired pressure in the LP column. The turbine air flow must be manually controlled to avoid cooling down the plant too quickly. The ASU must not be cooled down any quicker than 30 K per hour. Adjust the JT-valve to control the inlet temperature to the turbine. In the beginning only a limited air flow can be fed to the plant. The flow can be increased as the plant is cooled down.

During the cool down temperature differences within equipment have to be kept to a minimum. For plate fin heat exchangers a limit of 30 °C applies within a cross section. Another limit is the cool down rate which must not exceed 30 °C/h. Particular care must be taken where no flow can be forced through equipment, e.g. condensers. In order to slow down the cooling process either take back turbine flow or open a vent in the vicinity of the part of the plant that is cooling down too quickly.

While cooling down adjust the various reflux, bypass and drain lines suitably to ensure that the equipment cools down as uniformly as possible. Continuously monitor the heat exchanger and column temperature indicators to check the progress. As the plant cools down it will be necessary to load the main air compressor further in order to maintain the pressures.

Monitor the temperature and pressure at the turbine inlet. From there outlet conditions can be calculated. The formation of liquid at the turbine outlet must be avoided under any circumstances.

The cooling speed is essentially controlled by the temperature gradient of the HP LOX passage, since this has the smallest cross section. For accelerating the cooling procedure the dump valves behind the LOX IC pumps and the LOX product to dump can be opened. This is to increase the flow rate through the low pressure column. Keeping the pressure in low pressure column high also supports the cool down speed. The control GOX should be fully open to encourage flow towards the sump of the low pressure column.

Cool down is completed after the dew point temperature has been achieved at the cold end of the main heat exchanger and liquid levels begin to build up.

At the end of the cool down all piping opened only for cooling the equipment down to cryogenic temperatures, e.g. all vents, must be closed.



4.17. Establish Liquid Levels

Once the first liquid levels appear start to decrease the pressure in the LP and CAR column to eventually reach the normal set-point. When liquid temperatures are reached level will start to build in the HP column. This is directly transferred to the LP column sump. Build up the level in the main condenser until it is fully submerged. Keep the HP column reflux valve HV21006 closed during the liquid build-up.

Once level is established at the main condenser, start building up liquid in the HP column by slightly opening the HPC reflux valve HV21006 (5%) and closing in on the CLOX valve LV21003. The increasing pressure drop in the HP column indicates the build-up of liquid inventory on the trays. Once the pressure drop has stabilised the HPC HV21006 reflux valve can be opened further. This procedure is repeated until the reflux valve is fully open. Make sure that the level in the main condenser does not drop below 90% while filling the high pressure column. Once the normal level is reached in the HP column sump, set the level controller to AUTO and start to build up level in the condenser of the crude argon column. While increasing the level in the crude argon condenser throttle LV40007 and keep the reflux to the CAR column FV40011 closed.

The levels in the main condenser and in the crude argon condenser should be build up as quickly as possible to avoid dry boiling in the heat exchangers.

The level in the air separator is established by reducing the liquid air flow to the HP column (HV21014) to approximately 30% and setting the level controller LV21060 to automatic mode.

Open the vents at the condensers for a few minutes to release the non - condensable gases.

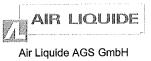
Monitor the pressure levels during the entire process and try to keep the conditions constant. Also keep an eye on the main air compressor and booster air compressor to avoid operating at the surge limit. During the cool down the air flow to the cold box will increase continuously. The MAC inlet guide vanes have to be adjusted accordingly. For an even distribution in the main heat exchanger adjust the GAN flow to keep the GAN/WN flow ratio constant. The air flow should be limited to about 70% of the design air flow.

To assist the process LIN can be injected from the tank. LIN inject must only be used after liquid level has been build in the main condenser. Otherwise high temperature differences may lead to excessive tensions in the equipment. After cooling down the LIN assist piping liquid nitrogen is fed to the top of the HP column.

4.18. Cold Box Operation

| Step | Activity | Name | Item | Value |
|------|---|-----------------------------|-------------|---------------------------|
| 1 | After building the liquid inventory, the levels in the HP column, main condenser, air separator and crude argon condenser are | L21003 L22001 L21060 | X X X | 30% 102% 60% |
| | brought to normal operating values | L21060 L40007 | X | 102% |
| | Afterwards set all level controllers to AUTO The HP column reflux valve is open | | | |
| 2 | Gradually reduce WN pressure controller and start MSA regeneration with WN | P15041 HS15006 K15042 | W | 140 mbar OFF open |
| | Set MAC flow and switch to automatic mode | F11070 F11070 | W | 75,000 Nm³/h AUTO |
| 3 | HP column | 10404044 | | 000/ |
| | Open liquid air to HP column Adjust LIN reflux to achieve HP column purity | HV21014 F22013 Q21002 | Y W X | 30% adjust < 10 ppm |
| | and set to automatic mode | F22013 | | AUTO |
| 4 | Set Joule-Thomson valve | T20008 T20008 T20008 | X W | adjust -168°C AUTO |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Remarks:



4.19. HP GOX production

The start-up is described for a single pump. The second identical unit is to be handled accordingly.

| Step | Activity | Name | Item | Value |
|------|---|--------------------|------|------------------|
| 1 | GOX vent valve is closed. | FV20012 FV20011 | Y | 0% 0% |
| | GOX product valve is closed. Manual production valves at LOX IC pumps are closed. | V61152 | ' | Closed |
| | Manual recycle valves at LOX IC pumps are open. | V61171 | | Open |
| | Drain and defrost valves are closed. BAC is operating at design pressure. Establish start conditions. | VOTITI | | Ороп |
| 2 | Cool down LOX pump. Make sure the outlet temperature falls below maximum | HS61101 | | ON |
| | value for a period of time before attempting to start the pump. | T61130 | Х | < -150°C |
| 3 | Adjust pump discharge pressure. | P61170 | Υ | 28,3 barg |
| | Start pump after permission is given. | HS61101_S | | ON |
| | !!! Do not run pump against a closed valve as a minimum throughput is required!!! | | | |
| 4 | Check JT valve is in automatic mode. | T20008 | | AUTO |
| 5 | Slowly open manual production valve of the pump to pressurize GOX pipe. | V61152 | | open |
| | Open GOX vent valve slowly. Check JT valve controls works properly. Check conditions around gas turbines are to design. | F20012 | Y | increase |
| 6 | Increase GOX flow to | F20012 | X | 14,000 |
| | and when steady switch JT-valve and | T20008 | W | Nm³/h |
| | GOX flow to automatic mode. | F20012 | | -168°C AUTO |
| 7 | Start supply to customer once purity is steady. | F20011 | Υ | increase |
| | After reaching steady conditions switch controller to | F20011 | W | 14,000 Nm³/h |
| | automatic mode. | F20011 F20012 | W | AUTO |
| | | F20012 | ** | < F20011 AUTO |

Remarks:

Check vendor operating manual for start-up preparations and procedures.

For details about the split range controller please refer to the attachment.



4.20. HP GAN production

The start-up is described for a single pump. The second identical unit is to be handled accordingly.

| HPGAN vent valve is closed. HPGAN product valve is closed. | FV20002 | Υ | 0% |
|---|--|---|---|
| | FV20001 | Υ | 0% |
| Manual production valves at LIN IC pumps are closed. | V71152 | ' | Closed |
| Manual recycle valves at LIN IC pumps are open. | V71171 | | Open |
| Drain and defrost valves are closed. BAC is operating at design pressure. Establish start conditions. | | | · |
| Cool down LIN pump Make sure the outlet temperature falls below maximum | HS71101 | | ON |
| value for a period of time before attempting to start the pump. | T71130 | Χ | < -160°C |
| Adjust pump discharge pressure. | | W | 21 barg |
| Start pump after permission is given. | HS71101_S | | ON |
| !!! Do not run pump against a closed valve as a minimum throughput is required!!! | | | |
| Check JT valve is in automatic mode. | T20008 | | AUTO |
| Open slowly manual production valve to pressurize HP GAN | V71152 | V | open |
| Open HP GAN vent valve slowly. Check conditions around JT-valve and gas turbines are to design and HP column purity is to specification. | F20002 | Y | increase |
| Increase HP GAN flow to and when steady switch GAN flow to automatic mode. | F20002 F20002 | X W | 2,500 Nm³/h AUTO |
| Start supply to customer once purity is steady After reaching steady conditions switch controller to | F20001 F20001 | Y W | increase 2,500 Nm³/h AUTO |
| automatic mode. | F20002 F20002 | W | < F20001 AUTO |
| | BAC is operating at design pressure. Establish start conditions. Cool down LIN pump Make sure the outlet temperature falls below maximum value for a period of time before attempting to start the pump. Adjust pump discharge pressure. Start pump after permission is given. I!! Do not run pump against a closed valve as a minimum throughput is required!!! Check JT valve is in automatic mode. Open slowly manual production valve to pressurize HP GAN pipe. Open HP GAN vent valve slowly. Check conditions around JT-valve and gas turbines are to design and HP column purity is to specification. Increase HP GAN flow to and when steady switch GAN flow to automatic mode. Start supply to customer once purity is steady | BAC is operating at design pressure. Establish start conditions. Cool down LIN pump Make sure the outlet temperature falls below maximum value for a period of time before attempting to start the pump. Adjust pump discharge pressure. Start pump after permission is given. III Do not run pump against a closed valve as a minimum throughput is required!!! Check JT valve is in automatic mode. Open slowly manual production valve to pressurize HP GAN pipe. Open HP GAN vent valve slowly. Check conditions around JT-valve and gas turbines are to design and HP column purity is to specification. Increase HP GAN flow to automatic mode. Start supply to customer once purity is steady After reaching steady conditions switch controller to automatic mode. F20001 F20001 F20001 | BAC is operating at design pressure. Establish start conditions. Cool down LIN pump Make sure the outlet temperature falls below maximum value for a period of time before attempting to start the pump. Adjust pump discharge pressure. Start pump after permission is given. WHS71101_S III Do not run pump against a closed valve as a minimum throughput is required!!! Check JT valve is in automatic mode. Open slowly manual production valve to pressurize HP GAN V71152 pipe. Open HP GAN vent valve slowly. Check conditions around JT-valve and gas turbines are to design and HP column purity is to specification. Increase HP GAN flow to F20002 X and when steady switch GAN flow to automatic mode. Start supply to customer once purity is steady After reaching steady conditions switch controller to F20001 W automatic mode. F20001 F20001 F20001 |

Remarks:

Check vendor operating manual for start-up preparations and procedures.

For details about the split range controller please refer to the attachment.



4.21. MP GAN production

The start-up is described for a single compressor. The second identical unit is to be handled accordingly.

| Step | Activity | Name | Item | Value |
|------|---|---|-------------|---|
| 1 | LP GAN product valve is closed Increase LP GAN flow by opening vent valve and set to automatic control | FK20005 FK20006 F20006 F20006 | Y Y W | 0% increase 20,000 Nm³/h AUTO |
| 2 | Open GAN product valve slowly, adjust set point and switch to automatic mode | FK20005 F20005 F20005 F20006 F20006 | Y W W | 100% 20,000 Nm³/h AUTO < F20001 AUTO |
| 3 | Reset trip GAN compressor | HS70000 | | reset |
| 4 | Check oil system | | | |
| | oil pressure | P70854 | X | > bar |
| | oil temperature | T70854 | X | °C |
| 5 | Check cooling water is running | | | |
| 6 | Open suction valve | HK70001 | Υ | open |
| | Close discharge valve | HK70036 HV70035 | Y Y | close close |
| 7 | and vent valve Establish "ready to start" conditions | 11070033 | , | 0.030 |
| 7 | _ | HS70001 | | ON |
| 8 | Switch on compressor | 11070001 | | 011 |
| 9 | After running in steady conditions adjust setpoint of P70007 | P70007 | W | 0,95 bara |
| | and switch it to automatic | P70007 | | AUTO |
| | open inlet guide vane slowly to | U70010 | Υ | % |
| | close recycle valve slowly until outlet pressure is | U70074 | Υ | decrease |
| | reached adjust pressure controller set-point | P70035 | W | 6 barg |
| 10 | and switch to automatic mode Check oil pump and heater have been switched off automatically Check oil and bearing temperatures Check vibrations Check cooling water outlet temperatures | P70035 | | AUTO |
| 11 | Open vent valve until purity is to specification | HV70035 Q70035 | Y X | increase < 10 ppm O ₂ |
| 12 | Start supply to customer by opening discharge valve and product valve | HK70036 HK77041 | Y Y | increase increase |

Remarks:

Check vendor operating manual for start-up preparations and procedures.

Operating manual ASU No.9 Kosice – Master – Update from the 23/02/2007

page 65

4.22. LOX production

Applicable when plant is running producing LOX.

| Step | Activity | Name | Item | Value |
|------|--|--------------------|--------|------------------|
| 1 | Product valve is closed LP Tank inlet valve is closed | L22001 HV62051 | Y | 0% 0% |
| | LOX LGCC valves are closed | LV22030 HV63034 | Ý | 0% closed |
| | LP tank is ready for operation LOX IC pump is running Plant is producing LOX to dump | | | •••• |
| 2 | Once purity has been achieved open product valves and | L22001 HV62052 | Υ | 10% open |
| | adjust dump valve to provide enough purge flow | HV62051 L23076 | Υ | open decrease |
| 4 | When line to tank is cooled down, slowly open tank inlet and stop flow to dump vaporiser | L22001 L23076 | Y Y | increase 0% |
| 5 | When product flow and LP column are steady switch on level controller | L22001 L22001 | W | 100% AUTO |
| | | | | |
| | | | | |

Remarks:

4.23. LIN production

Applicable when plant is running producing LIN.

| Step | Activity | Name | Item | Value |
|------|--|------------------------------|-------------|----------------|
| 1 | Product valve is closed LP Tank inlet valve is closed | F23013 HV72051 LV73001 | Y Y Y | 0% 0% 0% |
| | LIN LGCC valves are closed | HV72053 | ' | closed |
| | LP tank is ready for operation | | | |
| 2 | Once purity has been achieved open product valve and | F23013 HV72051 | Y Y | 10% open |
| | adjust dump valve to provide enough purge flow | F23073 | Υ | decrease |
| 4 | When line is cooled down, slowly increase production valve and stop flow to dump vaporiser | F23013 F23073 | Υ | 0% |
| 5 | When product flow is steady choose set point and switch on flow controller | F23013 F23013 | W | Nm³/h AUTO |
| | | | | |
| | | | | |

Remarks:

4.24. LOX LGCC

| + | Activity | Name | Item | Value |
|---|---|-------------------------------|--------|----------------------------------|
| | Product valve is closed Manual isolation valve is open LP Tank inlet valves are closed | L22001 V22002 H62051&52 | Y Y | 0% open closed |
| | LOX LGCC pump discharge valve is closed LGCC valve to LP column is closed | HV63034 L22002 | Y | closed closed |
| 2 | Cool down LOX LGCC pump Make sure the outlet temperature falls below maximum value | HS63001 | | ON |
| | for a period of time before attempting to start the pump. | T63001 | X | < -150°C |
| | Start pump after permission is given Adjust pump discharge pressure and switch to automatic pressure control | HS63001_S P63033 P63033 | X W | ON increase 4 barg AUTO |
| | !!! Do not run pump against a closed valve as a minimum throughput is required!!! | | | |
| 4 | Open LOX LGCC pump discharge (be carefull with the pump discharge pressure!) | HV63034 | | open |
| | carefully cool down and purge product pipe | V61108 | | increase |
| 5 | After sufficient purging close manual purge valve and slowly open LOX LGCC ASU inlet and adjust to stabilise main condenser level | V61108 L22002 | Y | close increase |
| 6 | When system is steady switch on level controller | L22002 L22002 | W | 100% AUTO |

Remarks:

A sufficient amount of liquid storage has to be available before commencing the LGCC operation.

To satisfy the oxygen balance the GOX product flow has to be adjusted in proportion to the amount of LOX LGCC and air flow to the cold box. At the same time the additional refrigeration introduced by LOX LGCC has to be balanced with the turbine power and the LIN product flow.

Operating manual ASU No.9 Kosice - Master - Update from the 23/02/2007

page 68

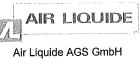
4.25. LIN LGCC

| Step | Activity | Name | Item | Value |
|------|--|-----------------------------|------|--------------------------|
| 1 | Product valve is closed Isolation valve is open | F23013 V23014 | Υ | 0% open |
| | LP Tank inlet valve is closed LIN LGCC valve is closed | HV72051 HV73001 | Y | 0% 0% |
| 4 | Open LIN LGCC isolation valves carefully cool down and purge product pipe | V73011 HV72053 V73081 | Υ | open open increase |
| 5 | After sufficient purging close manual purge valve and slowly open LIN LGCC ASU inlet | V73081 HV73001 | Y | close increase |
| | | | | |

Remarks:

A sufficient amount of liquid storage has to be available before commencing the LGCC operation.

The additional refrigeration introduced by LIN LGCC has to be balanced with the turbine power and the LOX product flow. Simultaneously the oxygen balance has to be satisfied by adjusting the HP GOX product flow, the LOX product flow and the air flow to the cold box.



4.26. LAR production

| Step | Activity | Name | Item | Value |
|------|---|------------------------------|-------------|----------------------------------|
| 1 | HP column and LP column are operating steady with sidearm gas purity at about Vent, product, reflux valves are closed | Q40011 HK40012 HV40005 | X Y Y | ≈ 95% O ₂ 0% 0% |
| | | F40014 F40011 P40003 | Y Y Y | 0% 0% 0% 100% |
| | Feed throttle valve is open | | | |
| 2 | Crude argon condenser is filled operating in automatic mode | L40007 L40007 | W | 102% AUTO |
| 3 | Start vapour flow to crude argon column Partially open vent to release non-condensable gases Adjust GOX production to control sidearm gas purity As the condenser starts working the vapour flow and the differential pressure across the crude argon column increases. If the effect is too strong (flow > 5,000 Nm³/h) close the reflux valve completely. After the system has settled start again. | F40011 HK40012 | Y | increase 10% |
| 4 | When level builds up in the crude argon column | | | |
| | Open LAR pump manual recycle valve | V40171 | | |
| | Close manual outlet valve | V40151 | Х | |
| | Cool down reflux pump Make sure the outlet temperature falls below maximum value for a period of time before attempting to start the pump. | HS40101 T40130 | ^ | ON < -120°C |
| 5 | Start pump after permission is given Cool-down line 100-OL-40101 to LP column by opening carefully manual outlet valve | HS40101_S V40151 | | ON |
| | Adjust recycle valve to control sump level and switch to automatic level control | HS40100 L40053 L40053 | W | adjust 55% AUTO |
| | !!! Do not run pump against a closed valve as a minimum throughput is required!!! | | | |
| 6 | Increase sidearm gas flow and | F40011 | X | adjust |
| | reduce sidearm gas purity gradually to design conditions | Q40011 F40011 | X W | adjust 20,000 Nm |
| | Activate side arm gas flow controller and | F40011 | VV | AUTO |
| | top pressure controller and | P40003 | W | 160 mbar |
| | top pressure controller and | P40003 | | AUTO |
| | sidearm gas purity controller on GOX production | Q40011_2 Q40011_2 | W | 90% AUTO |
| 7 | Dump vaporiser is ready for operation After the crude argon column is on oxygen purity start the pure argon | L43023 | Y | 0% |
| | column Product and dump valves are closed | L43033 | Υ | 0% |
| 8 | Fill condenser and | L43027 | Y Y | open |
| | open vapour outlet to control pressure and set pressure controller to automatic mode | P43028 P43028 P43028 | W | open 1.5 barg AUTO |
| | Activate column pressure controller | P43022 P43022 | W | 0.5 barg AUTO |
| 9 | Open liquid feed to pure argon column and start reboiler operation once the condenser is working and column pressure is dropping | F40014 PD43021 | Y Y | open open |
| 10 | Purge pure argon column to dump to control the level and set to automatic | L43033 L43033 | Y W | open 80% |



Operating manual ASU No.9 Kosice - Master - Update from the 23/02/2007

page 70

| Step | Activity | Name | Item | Value |
|------|--|---------|------|-----------|
| | | L43033 | | AUTO |
| 11 | Once column system is running stable put controllers in automatic | F40014 | | AUTO |
| ' ' | mode | L43027 | W | 90% |
| | | L43027 | | AUTO |
| | | PD43021 | W | 15 mbar |
| | | PD43021 | | AUTO |
| | | Q21004 | W | 1,9%-2,0% |
| | | Q21004 | | AUTO |
| 12 | Argon tank is ready for operation | | | |
| | After product is on purity open product valve and | L43023 | Υ | increase |
| | close dump valve and | L43033 | Υ | decrease |
| | set both to automatic mode | L43023 | W | 80% |
| | Cool down and purge product line carefully before sending argon into | L43023 | 144 | AUTO |
| | the tank | L43033 | W | 90% |
| | | L43033 | | AUTO |
| | | | | |
| | | | | |
| | | | | |

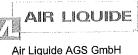
Remarks:

If the level in the crude argon column sump is above 65% the pump may be started before sending gas to the column. The sump level must be kept below 78% to avoid mechanical damage to the column.

Should the pure argon condenser start working during the filling process thus reducing the column pressure it is advised to start the reboiler operation at the same time.

For details about the split range controller please refer to the attachment.

Revision 2 February 2007 JJ / IV.Z



4.27. Start up from Cold Conditions

When starting up from cold conditions the operator has to pass through different stages each of which requires attention to different areas of the plant. Cold condition means that the plant has been stopped for a short period of time and liquid inventory has been kept. Steps not explained in detail are described in above chapters.

- In order to avoid freezing of the waste nitrogen line going to the molesieve unit, it is compulsory to close the valve HK15042 before starting molesieve sequence. This valve must be re-opened as soon as a steady flow of air is established through the main exchangers W20010/20/30/40. As soon as the cold box is cold, operators must monitor closely the temperature at warm ends of this exchanger during transitional phase.
- To begin with, the process pumps for LOX, LIN and LAR need to be cooled down so that at least one unit is ready to be started when needed later on.
- Pressurisation

P40003 should be in automatic mode acting on HK40012. Adjust P40003 so that the pressure P22001 in the LP column reaches a level above its normal operating value.

Furthermore decrease the level in the sump of the pure argon column to values below 0% to ensure that no gas is drawn from the HP column during pressurisation.

The air compressor should be in automatic mode with a suitable guide vane position and a discharge pressure set-point of 4.8 barg;

The molecular sieve adsorber sequence should not be switched on during pressurisation;

The booster air compressor should be running at about 56 barg discharge pressure; HK16073 should be fully open and the quick shut-off valves before the turbines and the Joule Thompson valve (JT-valve) should be closed.

All connections between high pressure column and the low pressure circuit should be closed.

When all these settings are stable open the valve UK20027; monitor the pressures in the cold box; one should aim to keep the time required for pressure built up to a minimum – if the pressure in the high pressure column does not rise any more open the JT-valve to let more air into the HP-column; make sure that there are no leaks on the warm side of the exchanger: air must flow into but no product should leave the main exchanger during pressurisation.

Once the pressure in the high pressure column is established, UK20026 can be opened.

Open P15041 in manual mode to bring the pressure of the low pressure column down to its
normal operating level and set to automatic mode; open F20002, F20006 and F20012 slightly
to allow flow through the oxygen and nitrogen passages of the main exchanger; monitor the
cold end temperature difference: one cannot avoid increasing the cold end temperature
difference when pressurising the HP column – but one should only allow small flow rates
through the exchanger as long as the temperature differences are still high.

- Once pressure built up is finished stable flow conditions through the plant must be established and the liquid levels built up again. Start with establishing flow from the high pressure column to the low pressure circuit and open:
 - o V21006, reflux to the high pressure column
 - o F22013, LIN to LP column
 - o L21003, CLOX to crude argon condenser
 - o L40007, CLOX ex crude argon condenser
 - o V21060, LAIR to the LP column;

Bring the pressure controller P15041 down to its normal operating pressure; adjust the set point of P40012 accordingly; activate the molecular sieve adsorber sequence and manually increase the regeneration gas flow to the molecular sieve adsorber when the steps heating or cooling are active;

Start the turbine/s when the plant is running stable at an air flow of more than 30,000 Nm³/h.
 Activate JT-valve to control the cold end temperature at the main heat exchanger.

Start the oxygen pump (product and vent valves are initially closed) as soon as a normal level is reached in the main condenser and adjust the flow to vent at F20012.

Start the nitrogen pump (product and vent valves are initially closed) and adjust flow at F20001.

Adjust the LP GAN flow to design.

- Built up liquid levels to design conditions; priorities are:
 - o First adjust the main condenser level L22001 to 100%; to do this one might have to lower the level in the sump of the high pressure column L21003; make sure that the crude argon system is not drawing gas i.e. by closing the reflux valve F40011 and by lowering the level in the crude argon condenser.
 - o Then fill up the crude argon condenser and start to draw gas into the crude argon column.
- Built up purities in the columns

4.28. Plant Preparation after Cold Box Trip

| Step | Activity | Name | Item | Value |
|------|---|---|----------------------------|--|
| 1 | Check dump vaporiser availability | HV90013 HV90014 HV90015 | X X X | open open open |
| 2 | Liquid levels DCAC chill tower HP column LP column Crude argon column Pure argon column | L13003 L14003 L21003 L22001 L40053 L43023 | X X X X X | 20 - 95% 15 - 75% < 80% < 160% < 78% < 131% |
| 3 | To avoid cooling down the main heat exchanger at the warm end during shutdown all vapour generated must be vented on the cold side of the main heat exchanger. LP system crude argon vent on pressure control WN to chill tower on pressure control Check crude argon vent has sufficient capacity to control the pressure; if necessary open additional cold vents HP system normally not required | P40003 P15041 | W W | 300 mbarg 500 mbarg |
| 4 | Ensure all product outlets at the warm end of the main heat exchanger are closed, e.g. product valves, vents. This is to prevent flow through the main heat exchanger which would lead to severe damages of the unit | PK15041 UK15044 UK15045 FV20001 FV20002 FK20005 FK20006 FV20011 FV20012 | Y Y Y Y Y Y | 0% 0% 0% 0% 0% 0% 0% 0% |
| 5 | Close gas lifts | V22015 V21017 V40010 | X X X | close close close |

Remarks:

If necessary liquid inventory must be disposed (refer to section 3).



4.29. Argon Storage and Back-up

4.29.1. LP Argon Tanks

- The tanks are filled via valve V44101 and V44201 respectively.
- The level is shown locally at L44107 and L44207. Level switches protect the vessels against too high and too low levels.
- The operation pressure of the inner vessel is about 500 mbarg. This pressure is monitored at P44105/P44205. The maximum pressure is controlled by vent valve P44105/P44205, the minimum pressure by pressure build up controller P44106/P44206.

4.29.2. Argon Back-up Pump

- Make sure that sufficient purge gas is available before operating the pump.
- It is mandatory to cool down cryogenic centrifugal pumps to their working temperature. A pump which is not cooled down sufficiently will not convey any fluid. This may have severe influence on the lifetime of the pump.
 - o The cooling down starts with opening the tank withdrawal lines V44136 and V44236, which should be kept open at all times. Afterwards pump suction valve HV48010 is opened. Recycle valve HV48070 is set to approximately 50% and increased in small steps up to 100%.
 - o The temperature of the pump is monitored by T48050. If the pump has reached its working temperature it is ready for operation . Close recycle valve down to 50% and start by switching on HS48001. Discharge pressure is controlled by recycling to the LP tanks.

4.29.3. HP Argon Tank

- The tank is filled by opening HV48050. Manual valves V48038, V48028 and V48010 at the tank should be always open. PV48027 regulates the tank pressure by distributing the feed between the bottom and top of the vessel.
- The level is shown locally at L48020. A level switch protects the vessel against too high and too low levels.
- The operation pressure of the inner vessel is ca. 21 barg. This pressure is monitored at P48005. The maximum pressure is controlled by vent valve P48005, the minimum pressure by pressure build up controller P48006.

Operating manual ASU No.9 Kosice - Master - Update from the 23/02/2007

page 75

JJ / IV.Z

4.29.4. Argon Vaporiser

- The product is sent to the ambient air heated vaporisers by opening V48011. The vaporisers possess 100% of the required capacity each. Open inlet and outlet valves, e.g. V48101 and V48102 of the operational unit, whereas the inlet to the standby unit is kept closed (outlet open).
- The vaporisers are designed to be in operation for approximately eight hours. The actual maximum online duration depends on the present ambient conditions and the product demand. If the outlet temperature from the vaporiser falls too low the units have to be switched by opening the inlet to the standby vaporiser and closing the inlet to the other one.
- The vaporiser flow is determined by the product valve PV4020, controlling the pressure on the customer side. To protect the equipment the pressure controller is disabled if the temperature falls too low or the tank level is insufficient.

4.29.5. Road Tanker Filling

• Make sure that sufficient purge gas is available before operating the pump.

It is mandatory to cool down cryogenic centrifugal pumps to their working temperature. The cooling down starts with opening the feed in the suction line HV44210, opening the recycle valve V44004 approximately 50% and increasing opening in small steps up to 100%. After approximately 30 min, we can consider that the pump is cool-down (as there is no temperature probe for checking).

When the pump is properly cool-down, follow the here under procedure to start the pump:

- 1. In Control Room, switch HS44013 to have it from BLOCKED to ENABLE status.
- 2. On field, press START FILLING button.
- In Control Room, when START FILLING button is pressed on field, the pump gets READY in DCS.
- 4. On field, press the DEAD MAN HANDLE and keep it pressed to run the pump.
- 5. On site, every 30 seconds, a horn and a flash will show up: stop pressing the DEAD MAN HANDLE for 1 second and after keep it pressed to carry on with the pump running.
- 6. To stop the pump, leave the DEAD MAN HANDLE: after 10 seconds, the pump will stop.