

5. Plant Shut Down

5.1. General

Although the plant has been designed as a continuous process, the plant or sections of the plant may be shut-down because:

- Routine maintenance of the plant is required.
- The periodic defrost of the cold equipment to remove the build-up of frozen contaminants which affect the safety, performance and efficiency of the cold box.
- Activation of an automatic shut-down device designed to protect a piece of equipment or the plant.
- A power supply failure.

If a plant shut-down is initiated by one of the automatic systems, the cause of the shut-down must be traced and rectified before restarting the plant.

In the event of a failure of a major piece of equipment or a routine shut-down for maintenance, the plant must if possible, complete a molecular sieve adsorber regeneration cycle before shut-down, so that a regenerated adsorber is available for the following start-up.

5.2. Shut Down and Defrost

5.2.1. Planned Shut Down

Ensure that the liquid disposal vaporiser is set up for liquid dumping. Close gaseous oxygen and nitrogen supplies from the cold box to the customer.

Reduce plant rates to minimum and shut down the plant:

- Adjust minimum air flow on the MAC, BAC and turbines.
- Activate the partial trip of the main air compressor: this will trigger the cold box trip and stop the front end equipment and put the BAC into idle operation.
- Stop the MAC and BAC.
- Make sure that the plant is in a safe position by checking each item on the check list for shut-downs.

5.2.2. Plant Check after Cold Box Trip

After a cold box trip the plant status has to be checked immediately to avoid damage to equipment by impermissible conditions. Most important is to make sure that the compressors and pumps have stopped, auxiliary oil systems are working and design pressures are not exceeded.

Step	Activity	Name	Item	Value
1	MAC	HS11001		off
		V11074		open
		oil system is running	HS11820	on
2	BAC	HS16001		off
		vent closed	V16071	closed
		recycles open	V16074	open
		discharge closed	K16073	closed
		oil system is running	HS16820	on
3	Front end	cooling water pump to DCAC	P13100/200	off
		chilled water pump	P14100/200	off
		refrigeration unit	HS12001	off
		DCAC liquid outlet	L13003	closed
		cooling water to DCAC	F13007	closed
		chilled water to DCAC	F13006	closed
		chilled water recycle	F12005	closed
		cooling water to chill tower	L14003	closed
		warm water to chill tower	T14010	closed
		MSA inlet closed and depressurised	K15011/21	closed
			K15018/28	closed
		regeneration gas flow stopped	K15044/45	closed
		air regeneration closed	P15037	closed
		cold box inlet closed	K20027/28	closed
		WN on pressure control	P15041	> 350 mb
4	To avoid accidentally over-filling the DCAC and risking to flood the MAC and/or MSA the isolation valves around the DCAC pumps must be closed manually	K13140/240		closed
		K13151/251		closed
5	Turbine	quick shut-off valves	K24101	closed
			K24201	closed
		oil systems running		
		Auxiliary pump and demister about 30 minutes)		
		seal gas running		

Step	Activity	Name	Item	Value
6	Cold Box	JT valve	T20008	open
		LIN reflux	F22013	closed
		liquid air to LP column	L21060	closed
		control GOX	F22043	closed
		LOX LGCC	L22030	closed
		LIN LGCC	V73001	closed
		HP column reflux	V21006	closed
		liquid air to HPC	V21014	closed
		sidearm gas flow	P40003	open
		crude argon inert gas vent	V40005	closed
		CLOX ex crude argon condenser	L40007	closed
		crude argon column reflux	F40011	closed
		CLOX to crude argon condenser	L21003	closed
		crude argon vent on pressure control	P40012	AUTO
		LOX product	L22001	closed
		LOX to dump	L23076	closed
		LIN product	F23013	closed
		LIN to dump	F23073	closed
		LAR product	L43023	closed
		LAR to dump	L43033	closed
7	Pure argon	column feed	F40014	closed
		reboiler feed	PD43021	closed
		condenser feed	L43027	closed
		LIN return	V43029	closed
		condenser gas outlet on pressure control	P43028	AUTO
		inert gas vent on pressure control	P43022	AUTO
8	Pumps	LOX pumps	P61100/200	off
		LOX pump suction	V61110/210	closed
		LOX pump recycle	P61170/270	open
		LOX pump production manual valves	V61152/252	closed
		LIN pumps	P71100/200	off
		LIN pump suction	V71110/210	closed
		LIN pump recycle	P71170/270	open
		LIN pump production manual valves	V71152/252	closed
		LAR pump	P40100	off
		LAR pump suction	V40110	closed
		LAR pump recycle	P40170	open
		LAR pump production manual valve	V40151	closed
9	Products	HP GOX product	F20011	closed
		HP GOX vent	F20012	closed
		HP GAN product	F20001	closed
		HP GAN vent	F20002	closed
		MP GAN product	F20005	closed
		MP GAN vent	F20006	closed

Step	Activity	Name	Item	Value
10	NIC	HS70001		off
	suction closed	K70001		closed
	vent closed	V70035		closed
	recycles open	V70074		open
	discharge closed	K70036		closed
	oil system is running	HS70820		on
		HS77001		off
	suction closed	K77001		closed
	vent closed	V77035		closed
	recycles open	V77074		open
	discharge closed	K77036		closed
	oil system is running	HS77820		on

Remarks:

It should be aimed for not to activate any safety devices due to cold box trip. In order to avoid lifting pressure relief valves the operator might need to intervene manually.

The sudden expansion of the BAC using the recycle valve can lead to excessive pressure on the BAC suction piping. This can be prevented by opening the discharge vent until the pressure has dropped to a safe level. The same principle applies to both nitrogen product compressors.

The pressure in the BAC discharge line is released into the HP column by opening the Joule-Thomson valve. To limit the pressure rise in the HP column open a reflux valve to the LP column system, e.g. F22013, L21060, L21003. After the pressure is released from the BAC discharge line reset the valves to the original position.

5.2.3. Defrost

When pressure must be released from lines within the cold box while the cold box is still cold care must be taken not to pass any cold stream to the warm side of the main heat exchanger. As a consequence the exchanger might be damaged when starting up again because warm air from the molecular sieve would be fed to a cold heat exchanger block. The thermal stresses are likely to break the exchanger.

Before commencing the defrost drain all liquids from the columns using the dump valves provided. Monitor disposal vaporiser temperatures to maximise the dumping rate taking care not to overload the system.

Defrost the turbines as instructed in the vendor's manual and in the related chapter.

When the systems have been fully drained of liquid close the dump valves previously opened.

The procedure for warming the plant is essentially the same as for the cold box blow through, except that valves opened briefly in that section must be now left cracked open for the duration of the warm-up. This is to ensure that the whole unit warms up evenly. The pure argon column can be defrosted independently of the remaining cold box equipment.

Allow the plant temperatures to rise at a maximum rate of 30 K/h by adjusting the quantity of gas venting out of valves at the cold end of the main heat exchanger and column system.

Continue to defrost until all air separation unit temperatures indicate above freezing and all vents are free of ice. At this point blow out and systematically open all minor vents, drains and instrument lines until each shows no signs of frosting.

Take care to keep the HP circuit at sufficient pressure to have a reasonable driving force in the LP column. Adjust the product vents to suit.

When all the plant vents are blowing warm, the defrosting is complete.

Stop all machines. Close all control valves in manual. Close dump and defrost valves.

To keep the cold box dry it may be continuously purged with dry gas. It must be ensured that no inadmissible pressure is built in any part of the plant.

5.2.4. Gas Turbine Defrost

Defrosting is described for a single turbine. The second identical unit is to be handled accordingly.

Step	Activity	Name	Item	Value
1	Isolate the turbine by closing the manual inlet and outlet valves	K24110		close
		K24102		close
2	Release the pressure from the inlet and outlet Outlet pressure must be below limit value	V24180		open
		V34183		open
		P24102	X	< 2 barg
3	Establish defrost start conditions oil pump is running seal gas is available generator is engaged defrost gas is available	HS24163		ON
		PD24141		> min
		P24144		> min
				ready
		EL24110		
4	Switch on defrost mode opens the quick shutoff valve	HS24106		ON
		UK24101		open
5	Open the inlet nozzles slightly	H24105	Y	50%
6	Start to sent defrost air through the turbine by carefully opening defrost inlet Be careful not to spin the turbine and not to exceed the maximum permissible pressure	V34182	Y	increase
		S24124	X	< 500 rpm
		P24102	X	< 2 barg
7	Defrosting is completed if the turbine inlet temperature is close to ambient	T24101	X	≈ ambient

Remarks:

Check vendor operating manual for defrosting preparations and procedures.

5.3. Cold Shut Down

A cold plant shut-down may be necessary if short term maintenance of warm equipment is required or if an automatic shut down device is activated. This involves shutting down the warm and cold equipment but maintaining the liquid levels and cold temperatures in the cold box.

By maintaining the plant in a cold condition, the time required for restart can be reduced.

Proceed as described for a planned shut-down. Liquids within the columns will drain into the sumps and level indications may read out of range. Before attempting to re-start the unit, these levels must be drained to give a working level indication and to avoid damage to column internals. Before disposal liquids can also be distributed between sumps if feasible.

Monitor the HP and LP column pressures for build-up due to heat ingress causing boil-off. Vent excess pressure using vents at the cold end of the plant. This will avoid exposing the carbon steel piping of the warm end to low temperatures.

During the shut down monitor the hydrocarbon levels of the LP column sump and in the argon condenser. If excess hydrocarbon content is detected during this period, refer to standing instructions on whether it is necessary to dispose off the complete liquid inventory before restarting the plant.

5.4. Emergency Shut Down

An emergency shut down can be caused by fire, mechanical failure, the partial or complete failure of an essential service or by the operator.

The operator must be fully aware of the shut down system design philosophy and trip strategy, as laid out in the above chapters.

In all cases emergencies action should be taken as quickly as possible to make the plant safe.

Depending on the reason for the shut-down and its anticipated duration, the plant may be held cold isolated as above or drained of liquid and defrosted. The respective actions have to be taken.