



SAFETY BULLETIN 22/20

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Safety Inspection Check List of Air Separation Units and Cryogenic Liquid Storages at plant site

Introduction:

Air Separation Units (ASUs) globally have maintained good safety performance over the years. This has happened due to the continuous efforts by the Industry to follow safe practices in design, operation and maintenance of the ASU facilities. But serious incidents occasionally still happened, mainly due to not following or ignoring well established safe procedures and best practices. Thus it is important that all responsible management ensure these safety procedures and practices are extensively communicated with people working for the industry, promote systematic and regular auditing of their ASU facilities to determine if safety procedures and practices are in place, and also take corrective measures to eliminate the gaps identified.

Purpose:

This safety inspection checklist has been prepared based on AIGA standards and member companies' practices, which focuses on the process and operational safety requirements of each unit operation in ASU facility and associated cryogenic liquid storage tanks.

This document gives general guidance information for the detection of unsafe conditions, prevention of hazards and incidents. This checklist is intended to help Gas Industry to facilitate periodic self-audit to identify any gaps in their safe operating practices.

It should be noted that this checklist does not incorporate all the requirements of local or national legislation, so users need to evaluate whether additional requirements need to be followed per the local legislation.

References:

- AIGA 056; Safe Practices Guide for Cryogenic Air Separation Plants
- AIGA 014; Safety Audit Guidelines
- AIGA 031; Bulk Liquid Oxygen, Nitrogen and Argon Storage Systems at Production Sites
- AIGA 035; Safe Operation of Reboilers/ Condensers in ASUs
- AIGA 079; Safe Design and Operation of Cryogenic Enclosures
- AIGA 032; Perlite Management

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PART 1: Industrial Gas and Liquid Plant

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- 8 Control room
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- 11 Expansion turbines
- 12 Expansion engines
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- 15 Cooling towers
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- 18 Argon purification plant
- 19 Hydrogen system
- 20 Product and disposal vaporisers for liquid nitrogen, oxygen and argon

NB This questionnaire is not exhaustive and may need to be complemented/adapted in order to cover all the procedures, plant and equipment on site.

SAFETY AUDIT QUESTIONNAIRE

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
1.0	General/Safety								
1.1	Is the standard of housekeeping adequate								
1.2	Is there safety reference literature available on site on the hazard material categories								
1.3	Is an approved procedure in use for authorising modifications of plant and process control circuits etc								
1.4	Are electrical personnel certificated/ authorised to carry out work related to high, medium and low voltage equipment								
1.5	Is a procedure in force for isolating, affixing warning boards and locking off process equipment prior to inspection, maintenance and other work								
1.6.1	Are numbered danger boards, spades and isolation register in use within the permit to work system								
1.6.2	Are permit to work procedures followed prior to isolating/ re-commissioning equipment								
1.7.1	Are operating procedures issued for all plant and equipment								
1.7.2	Are start/stop procedures posted adjacent to the starter/stop mechanism								
1.7.3	Are all operating procedures kept up-to-date								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
1.8.1	Are cleaning specifications and acceptance standards for production plants clearly defined								
1.8.2	Do these cleaning specifications differentiate between the requirements for: Gas phase air Liquid phase air/enriched air Oxygen clean etc								
1.9	Is an authorised material list available for oxygen service which is used when replacing joints, sealing rings and component parts								
1.10	Are pressure gauges for oxygen service clearly identified								
1.11	Is an operating procedure followed to establish the cause of cold box leaks				Ref Inspections and precautions during operation in AIGA 032				
1.12	Are there written emergency procedures relating to a large liquid spill from a tank, tanker or container				Ref AIGA 032 Section 9.				
1.13.1	Is a portable oxygen monitor available								
1.13.2	Is it calibrated at regular intervals								
1.14	Are proper instructions for start-up of main motor posted and do they cover frequency permitted, with time intervals etc								
1.15	Are maximum periods between air separation unit thawing operations/ maintenance laid down				Ref section 7.6.2 Deriming Frequency in AIGA 035				

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
1.16	Are plant pressure systems, condensate separators and carbon steel pipework adequately inspected (for corrosion/erosion etc) and proper records kept								
1.17	Is a control system in existence for additions, revisions or modifications to computer hardware/software								
1.18	Are rules established for inspection and pressure testing of relief valves								
1.19	Are consolidated rules laid down for inspection and maintenance of gas transmission lines (internal to factory and external to customers)								
1.20	Are adequate flow sheet/drawings available for all plant and ancillary services/equipment, e.g. instrument air, seal gas, cooling water etc								
1.21	Operation personnel can access the safety data sheet (MSDS) of hazardous materials handled in the site.								
2.0	Main Air Compressor & Surrounding Area								
2.1	Is the sign 'Asphyxiation Danger – Entry Permit Required' mounted on the air inlet duct inspection door/filter house door								
2.2	Are appropriate guards fitted over machine couplings								
2.3	Are noise warning signs posted in appropriate areas								
2.4	Is the sign 'Danger – Do Not Stand in Front of Cabinet While Motor is being Started' mounted on starter capacitor box								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
2.5	Is there adequate lighting around the compressor								
2.6	Is the emergency stop button functionally tested at regular intervals								
2.7	Are operating instructions posted nearby								
2.8	Are intercooler/aftercooler vents, drains and bursting discs piped to a safe location								
2.9	Are pressure/temperature gauges marked with alarm/trip levels								
2.10	Are temperature limits marked on lubricating oil indicators in use								
2.11	Is there a preventative maintenance system in use for regular inspection/calibration. of:								
2.12	Is technical data provided by compressor manufacturer available								
2.13	Does a daily log sheet record pressure, temperature and flow conditions as well as power consumption figures and are reference points shown on log sheets								
2.14	Does the supervisor carry out a daily check of all record data								
2.15	Does the supervisor record all unusual events								
2.16	Are pressure gauges installed on each compressor stage								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
2.17	Are maximum operating pressures marked on these gauges								
2.18	Is alarm/trip function provided on compressor discharge regularly tested								
2.19	Is the anti-surge protection of the turbo compressor regularly tested and calibrated				Ref to Section 8.3.1 Antisurge control in AIGA 056				
2.20	Are inter-cooler and after-cooler vessels internally inspected at regular intervals								
2.21	Are drain valves fitted to the bottom of each condenser and water separator operated at regular intervals								
2.22	Are alarm/trip functions provided on the guide vanes at the suction of the compressor checked at regular intervals								
2.23.1	Is pipework connecting main compressor to coolers inspected at regular intervals for presence of oil etc								
2.23.2	Are checks carried out at regular intervals so as to ensure that oil residues have not built up beyond the predetermined thickness								
2.24	Is the vibration monitor/shaft indicator in functional order								
2.25.1	Is the type of lubricating oil used in accordance with company recommendations								
2.25.2	Is the procedure for blowing oil separator drains being properly followed								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
2.25.3	Are oiling rates for all the compressors clearly identified and in use								
2.26	Are records of approach temperatures to coolers of compressors kept								
2.27	Are piston and ring clearances checked at regular intervals								
2.28	Are alarm/trip functions in working order on oil filter units								
2.29	Are individual compressor alarms/ trips operated by low cooling water flow conditions and/or high air temperatures in working order								
	Others				Ref to AIGA 045 Section 6.1 Plant surroundings)				
3.0	Air Refrigeration Equipment								
3.1	Freon								
3.1.1	Halogen gas detection equipment should be used to search for vapour leaks								
3.1.2	Does the permit to work form highlight the danger of phosgene gas formation when carrying out hot work on, or in the vicinity of, this equipment								
3.1.3	Are operating instructions posted adjacent to this equipment								
3.1.4	Are special procedures available identifying the means of isolating/ replenishing/re-commissioning the fern sections								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
3.1.5	Is the compressor oil properly stored to avoid ingress of humidity								
3.1.6	Have personnel been adequately trained and appreciate the hazards involved with this type of equipment								
3.2	Ammonia								
3.2.1	With ammonia cycles, are warning signs posted forbidding entry in the vent of leakage unless proper procedures have been followed (use of breathing equipment etc)								
3.2.2	Is there an emergency procedure for us in the vent of a major escape of ammonia								
3.2.3	Are operating instructions posted adjacent to this equipment								
3.2.4	Are special procedures available identifying the means of isolating/ replenishing/re-commissioning the ammonia sections								
4.0	Air Condensate Separators/ Molecular Sieves/Switch Valves								
4.1	Is the condensate separator drain valve checked regularly for proper operation								
4.2	For totally enclosed rooms: e.g. molecular sieve vessels and/or switch valves:								
4.2.1	Do all exit doors open outward								
4.2.2	Is powered ventilation with louvres in working order								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
4.2.3	Is visual alarm tied into oxygen monitor at entrance doors								
4.2.4	Does oxygen monitor give audible/ visible alarm in the event of increase/decrease in oxygen concentration								
4.2.5	Is a fail switch mounted in ventilation discharge duct which ties into the alarm circuit								
4.2.6	Are all nitrogen vent sources piped to a safe outside location								
4.3	Are guards installed over switch valve mechanisms								
4.4	Are lubricants applied to the switch valves oxygen compatible								
4.5	Do switch valve lubrication points have fittings to prevent the use of standard hydrocarbon grease								
4.6	Is CO2 analyser installed at outlet of the adsorption vessel (Molecular Sieves) in the ASU for oxygen production and calibrated regular?								
4.7	Monitor the temperature after TSA regeneration to avoid hot gas be sent to the downstream equipment potentially causing damage.				Ref to AIGA 056, Section 9.3				
4.8	For TSA regeneration heaters, ensure the high temperature and/or low flow protection can work to preserve the integrity of the heater and the rest of the system, especially in case of loss of reactivation gas flow.				Ref to AIGA 056, Section 9.3				
5.0	Caustic Scrubber (if in place)								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
5.1.1	Are air inlet and outlet connections to the scrubber checked at stipulated intervals for build-up of caustic								
5.1.2	Are the pipes to the safety valves checked at stipulated intervals for caustic build-up								
5.2	Is the pressure differential across the scrubber provided with an alarm/trip device and is it checked at stipulated periods								
5.3	Are operating procedures established for caustic systems								
5.4	Are loading/unloading procedures in place.								
6.0	Cold Box and Surrounding Area								
6.1	Are coloured caps fitted over the ends of protruding valve spindles								
6.2	Is cold box pressure regularly logged				Ref to AIGA 079 Section 6.1				
6.3	In the event of abnormal ice patches:				Ref to AIGA 079 Section 7.4 Cold Temperatures Ref to AIGA 079 Section 8 Troubleshooting Ref to AIGA 079 Section 8.2 Ice on External Enclosure or Piping				

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
6.3.1	Are gas samples taken from frost spot areas and analysed				Ref to AIGA 079 Section 8.3. Purge Gas Sampling				
6.3.2	Is appropriate action taken								
6.3.3	Are cryogenic leaks reported to management and possible consequences evaluated				Ref AIGA 079 Section 8 Troubleshooting Ref to AIGA 079/18 Section 8.4 Purge gas flow and pressure changes				
6.4.1	Do safety valve exhausts vent to a safe place								
6.4.2	Are these vents free from obstruction								
6.5	Are cold box foundation temperatures checked at regular intervals								
6.6.1	Do liquid drain lines slop downhill into the disposal header								
6.6.2	Are there any low points where total evaporation of LOX could lead to a dangerous hydrocarbon concentration				Ref to AIGA 056 Section 16.6 Dead Legs				
6.7	Following deriming operations, are procedures followed (preferably logged) to ensure that all drain and instrument lines are clear and free from moisture				Ref to AIGA 035 Section 7.6.1 Procedure				
6.8	Are signs 'Possible Asphyxiation/ Enrichment of Atmosphere Beyond this Point' installed for walkways and platforms in the area of argon, nitrogen and oxygen vents								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
6.9.1	Is insulation material used on cold piping in good order and dry				Ref to AIGA 079 Section 4.4. Enclosure Materials of Construction Ref to AIGA 079 Section 7.3.4 Moisture				
6.9.2	If not, are atmospheric conditions leading to pipe corrosion								
6.10	Is there any evidence of valve spindles rubbing on the panel due to column movement caused by temperatures established during operating/thawing								
6.11	Is the area free of tripping/slipping hazards								
6.12	Do ladders, cages, safety gates, handrails and platforms comply with legal/company standards								
6.13.1	Is there the ability to monitor hydrogen levels in the top of the cold box in case of leaks				Ref to AIGA 079 Section 8.3 Purge gas sampling				
6.13.2	Is an alarm fitted				Ref to AIGA 079 Section 6.2.3.2 Pressures and flows to the DCS				
7.0	ASU								
7.1	Are adequate flow sheets and drawings of pipe routes available								
7.2	Are adequate operating instructions available								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
7.3	Do they include:								
7.3.1	Start-up procedures								
7.3.2	Normal operation								
7.3.3	Shut-down procedure								
7.3.4	Thawing procedure								
7.3.5	Emergency shut-down procedure								
7.3.6	Emergency liquid disposal procedure								
7.3.7	Are adequate flow sheets/drawings available for all plant and ancillary services/equipment, e.g. instrument air, seal gas, cooling water etc								
7.4	Is a daily log sheet record concerning pressure, temperature, liquid level and flow conditions, as well as power consumption figures, available								
7.5	Do management check data on log sheet regularly								
7.6	Are all unusual events recorded								
7.7.	Are all liquid level indicators, alarms/trips on columns or condensers checked and maintained at stipulated intervals				Ref to AIGA 035 Section 7.2.3 Level/flow instrumentation				
7.8	Are purity alarm/trip functions tested regularly – particularly with respect to oxygen content								
8.0	Control Room								
8.1	Do doors open outward								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
8.2.1	Are analysers vented to a common vent header and piped outside the building								
8.2.2	Is hydrogen vented through a separate header								
8.3	Are all chemicals used for analyses clearly identified								
8.4	Is oxygen monitor installed in the control room if there is potential hazard such as valve actuators being supplied with instrument nitrogen.								
8.5	Is the oxygen monitor tied in with an audible alarm								
8.6	Are all cylinders properly secured to prevent them falling								
8.7	Does the use and location of cylinders meet the requirements of company and national regulations								
8.8	Can the wind direction be identified from the control room								
8.9	Are non-smoking areas clearly defined								
8.10	Are suitable fire extinguishers available								
8.11	Are all instrument lines running into the control room limited on pressure								
8.12	Is the remote product storage tank gas pressure instrument gauge easily read								
9.0	Avoidance of Hydrocarbon Concentration								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
9.1	Are reactivation procedures established for hydrocarbon/ acetylene adsorbers				Ref to AIGA 056 Section 12.2 Cryogenic Adsorbers				
9.2	Is there a constant monitoring of hydrocarbons within the LP column sump/reboiler condenser				Ref to AIGA 035 Section 7.4 Contaminant analysis (AIGA 035/13) Ref to AIGA 035 Section 7.5.2 Plant shutdown and cold standby				
9.3.1	Are hydrocarbon levels above maximum permitted, immediately reported to management				Ref to AIGA 035 Section 7.5.2 Plant shutdown and cold standby.				
9.3.2	Are procedures established and followed in case of a significant increase in hydrocarbon level being detected				Ref to AIGA 035 Section 7.4 Contaminant analysis				
9.4	Are acetylene checks within LOX reboilers regularly carried out								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
9.5.1	Is minimum liquid level in oxygen condenser bath always maintained at a safe operating level				<p>Ref to AIGA 035 Section 7.2.1 Bath-type reboilers</p> <p>Ref to AIGA 035 Section 7.2.3 Level/flow instrumentation</p> <p>Ref to AIGA 035 Section 7.3.1.1 Thermosyphon-driven oxygen guard adsorbers circuits</p> <p>Ref to AIGA 035 Section 7.5.3 Plant restart</p>				
9.5.2	Is a LOX purge being maintained from oxygen/enriched bottom column that is sufficient to ensure hydrocarbon concentration does not exceed safe levels				<p>Ref to AIGA 035 Section 7.7.4 Cleaning reboilers and column sumps</p> <p>Ref to AIGA 035 Section 7.3.2 Purging</p>				
9.6	Are LOX batch samples taken from column for full analysis periodically								
9.7	Is the adsorber material condition checked at stipulated intervals and replaced as necessary								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
	Others				Ref to AIGA 035 Section 7.6.1 Deriming Procedure Ref to AIGA 035 Section 7.6.2 Deriming Frequency				
10.0	Oxygen Pumps								
10.1	Are operating instructions posted nearby								
10.2	Is control equipment for seal gas checked and maintained regularly, e.g. regulators, valves etc								
10.3	Is there a preventive maintenance system for inspection/calibration of:								
10.3.1	Vibration monitoring devices								
10.3.2	Mechanical pump components (labyrinth, filters etc)								
10.3.3	Alarm/trip functions								
10.3.4	Safety devices, e.g. under-current/ over-current etc								
10.3.5	Electric motors								
10.3.6	Electrical systems								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
10.4	Is there a special maintenance procedure available for overhauling the pump in accordance with oxygen cleanliness standards				Refer to AIGA 056 Section 11.5 Special considerations for oxygen service Details of considerations for oxygen service are given in AIGA 055 [62].				
10.5	Are the manufacturers' and company regulations regarding lubrication of pumps and motors strictly observed								
10.6	Are pump suction filters checked and cleaned at regular intervals								
10.7	Are centrifugal pumps free from materials non-compatible with LOX				(From AIGA member company practice: e.g. aluminium alloy – see AIGA 055)				
10.8	Is centrifugal pump cavitation protection maintained in good condition, e.g. pressure switches, low current trip								
10.9	If pumps are installed in confined spaces, are ventilation openings free from obstruction								
10.10	Is the area around the pumps free from combustible material, e.g. oil, grease, tar etc								
11.0	Expansion Turbines				Refer to AIGA 056, Sec 10 Expanders				
11.1	Is manufacturer's data on these machines available								
11.2	Are operating instructions posted nearby								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
11.3.1	Are all applicable pressure, temperatures and power figures being monitored and logged								
11.3.2	Are pressure and temperature conditions at the turbine exhaust controlled so as to avoid any possibility of liquid formation in turbines				Refer to AIGA056, Sec 10.3 Abnormally low temperatures				
11.3.3	Are all the indicators appropriately marked with the limits, e.g. pressure, temperature, power, speed								
11.4.1	Are the alarm/trip functions of the brake generator tested at regular intervals								
11.4.2	Is alarm/trip system of the vibration monitor regularly tested				Refer to AIGA056, Sec .7 Abnormal vibration				
11.4.3	Are alarm/trip functions provided for oil temperature, oil pressure and oil tank level tested regularly				Refer to AIGA056, Sec .5 Loss of lubrication				
11.4.4	Are anti-surge controller of brake blower tested and maintained regularly?								
11.5	Are alarm/trip functions for seal gas pressure tested regularly				Refer to AIGA056, Sec .10.2.1 Turboexpanders				
11.6	Is the overspeed trip device tested regularly				Refer to AIGA056, Sec .10.1 Loss of loading and overspeed				

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
11.7	When carrying out maintenance of turbines, are cleanliness standards strictly observed				Refer to AIGA 056, Sec 10.12 Operating and maintenance procedure Refer to AIGA 056, Sec 10.10 Fouling of expander with ice or carbon dioxide				
12.0	Expansion Engines								
12.1	Is the overspeed trip tested regularly								
12.2	Is oil lubrication properly controlled when applicable								
12.3	Is the oil separator of an oil lubricated engine blown at regular intervals								
12.4	Are the oil filters and adsorber regularly inspected and maintained								
12.5	Are temperature and pressure conditions at expansion engine exhaust controlled so as to avoid any possibility of liquid formation in expansion engine				Refer to AIGA 056, Sec 10.3 Abnormally low temperatures				
12.6	Are all expansion engine component parts purchased to approved specifications								
13.0	Argon & Nitrogen Compressors				Refer to AIGA 056, Sec 8 Compressors				
13.1	For machinery enclosures:								
13.1.1	Do all exit doors open outward								
13.1.2	Is powered ventilation with louvres provided								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
13.1.3	Is visual alarm tied into oxygen monitor at entrance doors								
13.1.4	Does oxygen monitor give an audible/visual alarm in the event of reduced oxygen concentration								
13.1.5	Is a sail switch mounted in the ventilation discharge duct which ties into the alarm circuit								
13.1.6	Are danger signs posted outside all entrances to this enclosure: 'Caution Oxygen Deficiency Possible'								
13.1.7	Are all argon and nitrogen vents piped to a safe outside location								
13.2	Is the grating around the compressor area securely mounted								
13.3	Is sign 'Danger – do not Stand in Front of Cabinet While Motor is being Started' mounted on starter capacitor box								
13.4	Are bursting disc and relief valve discharges piped to a safe area								
13.5	Is emergency stop button functionally tested at regular intervals								
13.6	Are operating instructions posted nearby								
13.7	Is hot piping/intercoolers guarded such that personnel cannot come into contact with it								
13.8	Are pressure/temperature gauges marked with alarm/trip levels								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
13.9	Are temperature limits marked for lubrication oil in use								
13.10	Is compressor manufacturer's technical data available								
13.11	Is a daily log sheet record concerning pressure, temperature and flow conditions, as well as power consumption figures available, and are reference points shown on the log sheet								
13.12	Does the supervisor carry out a daily check of all recorded data								
13.13	Does the supervisor record all unusual events								
13.14	Are pressure gauges installed on each stage of compressors								
13.15	Are maximum operating pressures marked on these gauges								
13.16	Are suction pressure alarm/trip functions available								
13.17	Is alarm/trip system provided on compressor discharge tested regularly								
13.18	Is the anti-surge protection of the turbo compressor regularly tested and calibrated				Refer to AIGA 056, Sec 8.3.1 Antisurge control				
13.19	Are cooler purging procedures posted near to the compressor								
13.20	Are alarm/trip functions on oil filter units in working order								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
13.21	Are individual compressors fitted with alarm/trips operated by low cooling water flow conditions and/or high gas temperature in working order								
13.22	In the event of compressors being capable of being run on either oxygen or nitrogen service, are detailed operating procedures posted adjacent to the compressor								
13.23	Are the compressors being regularly maintained in accordance with the preventative maintenance system								
14.0	Oxygen Compressors See AIGA 071/13 & 048/18				Refer to AIGA 071 Centrifugal compressors for oxygen service Refer to AIGA 048 Reciprocating compressors for Oxygen Service				
14.1.1	Is entry to an oxygen compressor machinery space forbidden whilst the compressor is in oxygen service				Refer to AIGA 048, Sec 11.2 Enclosure of the hazard area by a safety barrier Safety barrier shall be installed when the discharge pressure is greater than 2 MPa for reciprocating Oxygen compressors.				
14.1.2	Can all necessary instrument readings be taken from a safe place								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
14.1.3	Can these readings be taken without entering a restricted area during normal operation								
14.2	Do entrance and exits to restricted areas have appropriate warning signs								
14.3	Are specific operating procedures available and fully understood by all authorised personnel								
14.4.1	Are local and remote emergency stop buttons available				Refer to AIGA 048, Sec 11.4.2 Equipment outside the hazard area				
14.4.2	Are they tested at regular intervals on a rota basis								
14.5.1	Are all vent, drain and relief valves etc piped to external safe locations								
14.5.2	Is the position of the oil vapour vent at a safe distance from all the above oxygen vents								
14.6	Is the sign 'Danger – Do not Stand in Front of Cabinet while Motor is being Started' mounted on starter capacitor box								
14.7	Does the immediate area around the compressor conform with company standards								
14.8	Is the area frequently checked for oil spillage and cleanliness								
14.9	Is the piston rod checked regularly for any sign of oil contamination (e.g. ultra violet light)								
14.10	Are operating procedures (normal and emergency) posted nearby								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
14.11	Are alarm and trip values clearly marked on all pressure gauges/ temperature indicators								
14.12	Is compressor manufacturer's technical data available								
14.13	Is a daily log sheet record concerning pressure, temperature and flow conditions, as well as power consumption figures, available and are reference points shown on the log sheet								
14.14	Does the supervisor carry out a daily check of all recorded data								
14.15	Does the supervisor record all unusual events								
14.16	If a machine is shut down under abnormal conditions, is management permission needed before machine re-start								
14.17	Have procedures been established for the inspection and maintenance of oxygen machinery and do they cover:								
14.17 .1	Compressor isolation/purging								
14.17 .2	The use of oxygen compatible materials				Refer to AIGA 035, Sec 7.7.3 Foreign material due to plant maintenance				
14.17 .3	Oxygen cleanliness standards and ultra violet light inspection				Refer to AIGA 048, Sec 12.1.1 Responsibility Refer to AIGA 071, Sec 6.1.1 Responsibility				

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
14.17 .4	Purchase of oxygen spares to written cleanliness specifications				Refer to AIGA 035, Sec 7.7.3 Foreign material due to plant maintenance				
14.17 .5	Maintaining spare parts in this clean condition until used				Refer to AIGA 035, Sec 7.7.3 Foreign material due to plant maintenance				
14.17 .6	The wearing of white, lint-free gloves conforming to company standards, when handling oxygen clean parts								
14.17 .7	The wearing of clean overalls conforming to company standards								
14.17 .8	Carrying out pre-filter and non- return valve inspection whenever compressor inspections are done								
14.17 .9	In the event of repairs to the compressor (e.g. valve repair), is a laid down procedures followed to establish all parts have been located and removed before re-start of compressor								
14.17 .10	Do these procedures cover the need to account for all tools and materials at start and completion of the work on the internals of the compressor								
14.18	Are non-return valves installed in oxygen compressor discharge pipelines								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
14.19	Is start up of turbo compressor linked to the availability of a 'failsafe' seal gas control system				Refer to AIGA 071, Sec 4.6 Seal gas system				
14.20	Are safety signs and fire fighting equipment installed in accordance with the site emergency plan				Refer to AIGA 048, Sec 18.8 Fire protection and precautions Refer to AIGA 071, Sec 2.4 Fire protection and precautions				
14.21 .1	Are personnel provided with protective clothing and equipment for their full range of activities								
14.21 .2	Is it used								
14.22	Is there a planned preventive maintenance system in existence for the frequent inspection/ calibration of pressure gauges, temperature indicators, vibration monitoring equipment, major machine components, all instrumentation, filters, valves, relief valves, alarms, trips, electric motors, electrical systems, safety devices including seal gas equipment								
14.23	Has consideration been given to the fitting of temperature monitoring of all valves on the compressor (rather than one per stage) in order to assist in the early detection of faults								
14.24	In the event of a trip, is a 'first flag' indication available to simplify fault diagnosis								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
14.25	Are individual compressors fitted with alarms/trips operated by low cooling water flow conditions and/or high gas temperatures				Refer to AIGA 048, Sec 9.3 High Oxygen temperature protection Refer to AIGA 071, Sec 4.7.4 High Oxygen temperature protection				
14.26	In the event of compressors being capable of being run on either oxygen or nitrogen service, are detailed operating procedures posted adjacent to the compressor								
15.0	Cooling Towers & Pumps				Refer to AIGA 056, Sec 15 Cooling systems				
15.1	Are there guards installed over motor shaft couplings								
15.2	Is the necessary lifting tackle etc available for removal of filter screens before the pump suction								
15.3	Is there adequate protection to prevent personnel falling into cooling tower ponds								
15.4	Is the cooling tower pond fitted with a low level alarm								
15.5	Is the cooling tower deck equipped with kick-boards and non-slip surfaces								
15.6	Are handrails and ladders smooth and free of splinters on wooden towers and free of sharp edges on metal towers								
15.7.1	When working on gearboxes, vee-belt drives etc on cooling towers, is a 'safe system of work' established for normal operation, inspection and maintenance								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
15.7.2	Does this take account of the need to secure the fan blade whilst carrying out maintenance in this area								
15.8	Is a failsafe sprinkler system installed on wooden towers (being connected to the circulating water pumps such that shutdown, or trip, automatically starts the system)								
15.9.1	Are fire extinguishers available on the top deck								
15.9.2	Is an escape route from the top deck available and free from obstruction								
15.10	Are there emergency stop buttons located on top of the tower								
15.11	Notwithstanding the use of Permit to Work system when carrying out maintenance, in the event of burning/hot work, then are precautions taken to prevent any sparks/hot metal coming into contact with wooden/combustible materials of construction								
15.12	Are protective devices fitted to the fan and gearbox to protect against excessive vibration and temperature respectively								
16.0	Cooling Water Treatment								
16.1	Are operating procedures established for use of sulphuric acid/caustic/chlorine/other chemicals								
16.2	Is an unloading procedure posted								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
16.3	Is individual protection made available and wear on site helmet faceshield neoprene gloves boots protective clothing								
16.4	Are warning signs properly posted								
16.5	Are there emergency showers and eye-wash stations located within the appropriate safety zones								
16.6	Are dosing pumps equipped with plexiglass shields								
16.7	Are cylinders/drums located in safe areas								
16.8. 1	Are employees aware of the hazardous nature of all materials used in chemical water treatment								
16.8. 2	Have adequate facilities/equipment been provided to deal with emergencies relating to use of these chemicals								
16.9	Do testing procedures ensure that damage to plant cannot occur due to excessive deviations of water quality								
16.10	Is there a procedure for checking the state of effluent so as to ensure disposal of same meets the requirements of local/national regulations								
17.0	Emergency Equipment/ Procedures								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
17.1.1	Are the breathing gas cylinders regularly checked for content								
17.1.2	Are the breathing gas cylinders full								
17.1.3	Are all component parts of the breathing equipment in good condition								
17.2	Is the inspection of equipment logged								
17.3	Is the equipment regularly tested								
17.4	Are cylinders still within approved test period								
17.5	Stretchers/fire fighting suits/ fire blankets: is all the equipment regularly inspected/logged								
17.6	Eye washers/showers: is all the equipment regularly inspected/ logged								
17.7	Emergency lighting: is all equipment regularly tested/logged								
17.8	Portable analysers: is all equipment regularly tested/logged								
17.9	First aid kits: is there a check system to ensure the kits are stocked with the necessary items								
17.10	Are emergency procedures available and up-to-date for shutting down all items of plant								
18.0	Argon Purification Plant								
18.1	Are there heat protective shields around de-oxo units								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
18.2	Is the automatic protection device on high oxygen content in the feed to the de-oxo unit regularly checked								
18.3	Is the high temperature protection device, installed in the de-oxo unit bed, regularly checked								
18.4	Are hydrogen/hydrocarbon analysers sensing the cold box for leaks of flammable gases, checked at regular intervals								
18.5	Is the forced draft ventilation in analyser rooms checked at regular intervals								
18.6	Is the permanent hydrogen gas monitoring device calibrated/logged at stipulated intervals								
18.7	Are condensate traps on condensate separators checked against blowing hydrogen and are they regularly inspected								
18.8	Are the low flow shutdown devices on all process heaters checked/ maintained at regular intervals								
19.0	Hydrogen System								
19.1	Are vent lines and safety device outlets free from obstruction and piped to a safe height								
19.2	Are hydrogen trailers properly earthed prior to connecting								
19.3	Are all operating personnel trained on properties of hydrogen gas								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
19.4	Are all operating personnel trained in handling hydrogen fires								
19.5	Are operating procedures posted nearby and kept legible								
19.6	Are transfer hoses replaced at regular intervals								
19.7	Are anti-towaway procedures for hydrogen trailers/bundles in force								
19.8	Are maintenance procedures established to allow for purging of the system so that air cannot enter the storage system before commencing repair work								
20.0	Product & Disposal Vaporisers for Liquid Nitrogen, Oxygen & Argon								
20.1	Are low temperature trip devices on product outlets regularly checked								
20.2	Are all alarm/trip devices regularly submitted to functional test								
20.3	Is warm water/steam ejection from vaporiser discharged to a safe location in case of coil rupture								

PART 2: Cryogenic Bulk Storage at Production Sites

- 1 Tanks
- 2 Cryogenic fill points

NB This questionnaire is not exhaustive and may need to be complemented/adapted in order to cover all the procedures, plant and equipment on site.

SAFETY AUDIT QUESTIONNAIRE

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
1.0	Tanks See AIGA 031/13								
1.1	Is there a flow sheet in place.								
1.2.1	Have checks been carried out to ensure that all safety devices on the tank can relieve vapours created by tanker flash-off in the worst possible condition				Refer to Section 9.3.3 Pressure relief devices of AIGA 031				
1.2.2	Are procedures for transfer of liquid into low pressure bulk storage tanks in place.								
1.3	Are the safety valves provided checked and maintained at stipulated intervals				Refer to Section 9.3.3 Pressure relief devices of AIGA 031				
1.4	When changeover valves upstream of safety valves are provided, are they adjusted to the middle position so that both safety valves are in their operating condition								
1.5	Are the exhaust pipes from safety valves and vent valves kept free from any obstruction such as foreign material, ice etc				Refer to Sections 7.3.6; 8.2.3.2; 7.3.4 of AIGA 031				
1.6	Are there established procedures for the inspection and overhaul of tank safety devices								
1.7	Is the seal gas flow in the annular space of the tank maintained at a certain rate								
1.8	Is the manually operated vent valve of the tank easily accessible, if installed.				Ref to Section 7.1 General of AIGA 031				

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
1.9	Are all alarm functions provided such as: minimum pressure maximum pressure high level etc checked regularly.				Ref to Section 5.4.1 of AIGA 031				
1.10	Is the liquid level indicator provided checked and calibrated at regular intervals				Ref to Section 5.4.7 of AIGA 031				
1.11	Is all valve identification maintained in good condition and kept legible								
1.12.1	Is the automatic tank pressure build-up control system checked and maintained regularly				Ref to Section 5.2.5.1 of AIGA 021				
1.12.2	Is the anti-vacuum system on the tank checked and maintained regularly				Ref to Sections 5.4.4; 5.4.6 of AIGA 031				
1.13	Is the instrument air control system inspected and maintained regularly				Ref to Section 8.2.3.3 of AIGA 031				
1.14	Is the dew point of the instrument air in stationary lead lines to vital equipment sufficiently low to avoid blockage								
1.15	Are an adequate number of product identification and safety signs posted, e.g. 'No Smoking', 'Safety Glasses' etc				Ref to Section 8.2.3.4 Signage of AIGA 031				
1.16	Are operators trained to deal with the dispersal of large vapour clouds				Ref to Section 10.3 Training of personnel of AIGA 031				

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
1.17	Are warning signs posted at ducts and valve pits pointing out that permit to work procedures are to be followed prior to entering the pit				Ref to Section 10.1 & 2 Work permit of AIGA 031				
1.18	Is the liquid level controller/ recorder of the tank calibrated and checked				Ref to Sections 9.3.4; 5.4.7; 7.3.5;5.6.1 of AIGA 031				
2.0	Cryogenic Fill Points								
2.1	Is tank gas pressure gauge in view of fill point checked and maintained regularly								
2.2	Are pressure gauges on suction and discharge of transfer pump checked and maintained regularly								
2.3	Are the pump safety valves inspected and overhauled at regular intervals								
2.4	Are filling procedures for road and rail tankers in place.								
2.5	Is a flow sheet of the fill point in place.								
2.6	Are identification signs of fill point valves legible								
2.7	Are safety distances clearly identified and observed								
2.8	Are the filling hoses pressure tested/inspected and maintained at regular intervals								
2.9	Are filling hose supports in good working condition								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Completion
2.10	Are filling hoses kept free from any dirt or other foreign materials								
2.11	Are precautions taken not to kink filling hoses								
2.12	Is the tanker loading area at LOX fill points made of concrete and free from oil, grease and any organic compounds e.g. tar, bitumen etc				Ref to Section 6.4.3 Construction of floor of AIGA 031				
2.13	Are warning signs and/or tow-away devices used to avoid tanker tow-aways								
2.14	Is each fill point clearly identified								
2.15	Do the filling procedures clearly identify the responsibility of operating personnel and tanker drivers								
2.16	Are personal safety protection signs posted at each filling point, e.g. safety glasses safety shoes safety gloves								
2.17	Is there a procedure to report and remedy cryogenic leaks at the fill point								
2.18	Is there an emergency shower provided near oxygen tank and kept in good working condition.								