



SAFETY AUDIT ASSESSMENT TOOL – HYDROGEN COMPRESSION, PURIFICATION AND CYLINDER FILLING

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Amendments to Doc 102/03

All	Revision of Doc.102/03 Appendix C6
All	New format of Safety Audit / Assessment Tool

NOTE Technical changes from the previous edition are underlined

1 Introduction

Auditing is a proactive management tool for use by an organisation or activity as a part of its management responsibilities. It is used to proactively confirm compliance, detect potential issues and facilitate future improvement.

EIGA Doc 102, *Audit Guidelines*, provides an overview of audit and self-assessment processes, identifies different types of audits and lists the key points for ensuring success [1].¹

Sections 8.2 and 8.4 of Doc 102 refers to EIGA's audit tools document series that can be used in verification of findings and evidence collection and in action plans and follow up to audits [1].

This publication is part of that series.

2 Scope and purpose

2.1 Scope

This publication provides a checklist focusing on a specific area of safety, health and environment, management systems and technical practices within the industrial and medical gas industry.

This checklist does not incorporate all the requirements of local or national legislation. These should be taken into consideration when planning any audit or developing audit checklists.

The tool or combination of tools used can depend upon the type of audit and the organisation, location or site characteristics.

2.2 Purpose

Each Safety Audit / Assessment tool contains a list of questions that may be used by the auditor in the format shown in 3.1. Each question has a sequential reference number, the question itself and where relevant a reference to the EIGA publication or external publication that provides guidance on that specific topic.

These question sets may then be used at different stages of the audit process, by combining them with additional information columns in a manual or automated audit system, depending on company systems.

Section 3.2 shows the format of how the question set may be used for collection of evidence and development of findings.

¹ References are shown by bracketed numbers and are listed in order of appearance in the reference section.

Section 3.3 shows the format of how the question set may be used for management of actions arising from the audit.

Forms may be adapted or combined depending on audit and action monitoring systems used by a company.

The Auditor should not ask the questions on this list in isolation but should read them in conjunction with EIGA Doc 102, EIGA Doc 15, *Gaseous Hydrogen Stations* and EIGA Doc 102.03, *Safety Audit / Assessment Tool – Industrial Gas Cylinder Filling* [1, 2, 3].

3 Formats for Audit Checklists

3.1 Format for Audit / Assessment Tool Questions

Question reference	Question	Document Section Reference
<i>Use sequential numbering system within each section, for example 1.2, 1.3. Try to avoid multiple clustered questions under the same number but describe them as separate questions.</i>		<i>In EIGA reference document or external reference document</i>

3.2 Typical Format for collection of evidence and development of findings

Question reference	Question	Document Section Reference	Yes No N/A	Description of Evidence / Comments (Ref...)	Findings (Ref...)	Recommendations for improvement (Ref Doc xxx 8.2.6)	Action Required Yes/No
<i>Use sequential numbering system within each section, for example 1.2, 1.3. Try to avoid multiple clustered questions under the same number but word them as separate questions.</i>		<i>In EIGA reference document or external reference document</i>	<i>Answer is yes, no or question is not applicable</i>				

3.3 Typical format for management of actions arising from the audit

Question reference	Findings	Action(s)	By Whom	Dates	
				Target	Complete
<i>Use sequential numbering system within each section, for example 1.2, 1.3. Try to avoid multiple clustered questions under the same number but word them as separate questions.</i>					

4 Hydrogen compression, purification and cylinder filling – Question set

- 1 General
- 2 Hydrogen compressors
- 3 Hydrogen purification
- 4 Hydrogen filling racks
- 5 Maintenance
- 6 Emergency procedures

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

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
1.0	General								
1.1	Are personnel <u>trained on</u> properties of hydrogen, for example flammability range, explosion limits, low energy requirement for ignition, heating effect of expansion								
1.2.1	Is a purging procedure issued for all major equipment								
1.2.2	Is it strictly followed								
1.3	Is the nitrogen purge distribution system in good working condition								
1.4.1	Is the plant regularly monitored for hydrogen leaks								
1.4.2	In the event of a leak being found, is immediate action taken								
1.4.3	<u>Are personnel trained on actions to take if a leak is found</u>								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
1.5	Have all sources of ignition been eliminated								
1.6.1	Is there an adequate <u>means of escape</u>								
1.6.2	Do all doors open outwards								
1.6.3	Are escape routes adequately signed <u>and free from obstruction</u>								
1.7.1	Are personnel provided with the necessary protective clothing and equipment, for example anti-static <u>clothing and conductive</u> footwear								
1.7.2	Is the protective clothing / equipment used								
1.8.1	Are personnel aware of the need to use approved tools when working on hydrogen equipment								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
1.8.2	<u>Are non-sparking tools provided where necessary</u>								
1.9	Is the installation and operation of electrical systems in accordance with the regulations, standards and codes of practice								
1.10.1	Are lightning conductors provided, <u>where necessary</u>								
1.10.2	<u>Where fitted</u> , are they checked at the stipulated intervals by a competent person								
1.11.1	Are all systems bonded and effectively earthed to give protection against hazards of stray electrical currents and static electricity in accordance with national codes / regulations								
1.11.2	Are they checked at stipulated intervals								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
1.12	Are personnel <u>trained on</u> the danger of using portable electrical equipment (<u>including mobile phones</u>) in <u>hazard zones</u>								
1.13	Are the <u>hazard</u> zones indicated by permanent notices / <u>markings</u> where they can be entered								
1.14	Are notices posted at appropriate locations 'Hydrogen – Flammable Gas – No Smoking – No Naked Flames'								
1.15	Is all work other than <u>normal</u> operation covered by a 'safety work permit' system								
1.16.1	Is natural / forced draught ventilation free from obstruction and in good working condition								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
1.16.2	Do hydrogen monitors give an audible / visual alarm outdoors in the event of hydrogen enrichment in the building								
1.16.3	Are hydrogen monitors tested and calibrated at stipulated intervals								
1.17.1	Is there adequate lighting in the hydrogen plant area								
1.17.2	Is there also adequate emergency lighting available								
1.17.3	Is the emergency lighting checked at regular intervals								
1.18.1	Are plant and machinery functions checked / monitored								
1.18.2	Is this information reviewed by the appropriate supervisor on a <u>periodic</u> basis								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
1.19.1	Are all vents, drains and <u>safety valve exhaust lines</u> free from obstruction								
1.19.2	Are all vents, drains and <u>safety valve exhaust lines routed to a safe location, away from personnel and combustible materials</u>								
1.20	Are pressure indicators tested / calibrated regularly								
1.21	Is all analysing equipment tested / calibrated at regular intervals								
1.22	Are all safety valves tested / reset at stipulated intervals								
1.23	<u>Are all critical safety circuits tested at regular intervals</u>								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
1.24	Are all hazardous chemicals (for example drier / purifier /de-oxo) disposed of according with a company approved procedure respecting all regulations								
2.0	Hydrogen compressors								
2.1.1	Are operating instructions for the compressor <u>readily available</u>								
2.1.2	Are they up to date and <u>accessible</u>								
2.2.1	Is a flowsheet of the system <u>readily available</u>								
2.2.2	Is it up to date								
2.3	Are compressor main shut-off valves maintained regularly								
2.4	Are regular checks made to ensure hydrogen cannot leak back into the nitrogen purge system								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
2.5	Are the high and low pressure alarm and trip settings of the compressor tested at stipulated intervals								
2.6	<u>Does the sample point for the oxygen analyser give an appropriate response time such that the hazardous mixtures can be detected before reaching the compressor</u>								
2.7	Are alarm / trip functions at pre-set oxygen levels tested at stipulated intervals								
2.8.1	Are temperature limits for each stage clearly identified								
2.8.2	Are temperature indicators / recorders tested regularly								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
2.8.3	Are high temperature alarms / trips at the discharge of compressor stages tested regularly								
2.9	Are pressure limits for each stage clearly identified								
2.10.1	Are the compressor remote emergency stop buttons tested at regular intervals								
2.10.2	<u>Are positions emergency stop buttons clearly evident (for example, signs, labelling, colour coding) and outside hazard zone</u>								
2.11	Are the automatic drain valves of the condensate drain vessels checked and maintained at regular intervals								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
2.12	Are the high and low level alarms / trips of the condensate level gauges checked at regular intervals								
2.13	Are water drain lines kept free from obstruction								
2.14	Are all compressor safety valves tested / reset at stipulated intervals								
2.15	Are the alarm / trip functions of individual compressors for water temperature and pressure, oil pressure and motor overload checked on a regular basis								
2.16	Are inlet temperatures of compressor inter and after coolers checked regularly								
2.17.1	Are safety devices fitted to water side of all coolers checked at stipulated intervals								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
2.17.2	Are vents leading from safety devices to a safe area checked regularly to ensure they are free from obstruction								
2.18.1	Is the safety valve of the compressor crankcase (pressurised by hydrogen or nitrogen) checked and maintained at stipulated intervals								
2.18.2	Are the alarm and trip functions on the crankcase purge gas for low pressure / flow conditions checked regularly								
2.18.3	Is the sample valve at the purging line downstream of the compressor crankcase checked and maintained as necessary								
2.18.4	Are gas samples taken at purging outlets from compressor crankcase before allowing maintenance to commence								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
2.19.1	Are working procedures available for compressor start-up following erection or maintenance work								
2.19.2	Do these procedures include the use of a nitrogen purge								
2.19.3	Do these procedures include analysis of the nitrogen purge (including inter-stage bypass lines etc) to ensure the compressor internals are full of inert gas prior to start-up								
2.19.4	Are restart and shut-down procedures of compressor available								
2.20	Are all suction drum and inter-stage separators internally checked, cleaned and tested at stipulated intervals								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
2.21	Are wall thicknesses regularly checked at fixed points in pipework / condensate pot systems so as to determine the corrosion rate								
2.22	Are appropriate guards fitted, for example over couplings and flywheels etc								
3.0	Hydrogen purification								
3.1	Are detailed operating instructions of the purification system available								
3.2.1	Are all valves and control equipment numbered								
3.2.2	Is a flowsheet <u>readily available</u> clearly identifies valves and control equipment								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
3.3	Are the isolating valves between the HP and LP part of the purifier secured against <u>incorrect</u> operation								
3.4	Are valve operating instructions posted to ensure slow valve movements								
3.5	Are oil / water separators, filter and pressure vessels internally checked and tested at stipulated intervals								
3.6	Are the dust filters inspected and cleaned regularly								
3.7.1	Are all temperature control devices in the purification system tested / calibrated at regular intervals								
3.7.2	Are the alarm / trip functions of these temperature controllers checked at regular intervals								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
3.7.3	Is the analysing equipment monitoring the purified gas calibrated at regular intervals								
3.7.4	Are purifier / drier / deoxidiser materials checked at regular intervals and replaced as necessary								
3.8	Is the back pressure valve fitted to avoid fluidisation checked and tested at regular intervals								
3.9.1	Are working procedures for purifier start-up / shutdown available								
3.9.2	Do these procedures also cover start-up / shutdown at the time of carrying out maintenance work								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
3.10	Are vessels and pipeline nitrogen purging procedures applied before and after maintenance shutdown, prior to re-connection to the live system								
3.11	Are the automatic quick-acting hydrogen shutoff valves before inlet purifier unit tested and maintained regularly								
3.12	Is the adjustment of the purge outlet valve controlled by high pressure and high temperature at the mole sieve section tested and calibrated regularly								
4.0	Hydrogen filling racks				See also EIGA Doc 102.03 [3]				
4.1	Is the automatic emergency stop valve before the main feeder system checked and maintained at stipulated intervals								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
4.2	Are the remote emergency stop buttons placed on each filling rack tested regularly								
4.3	Are filling rack blowdown / purge valves independently purged at plant start-up								
4.4	Is each manifold and fill connection shutoff valve opened slowly								
<u>4.5.1</u>	Are manifolds earth bonded								
<u>4.5.2</u>	<u>Are</u> cylinders / bundles / trailers earthed while being filled								
<u>4.6.1</u>	Are cylinder connections leak tested at connection to filling rack whilst filling								
<u>4.6.2</u>	Are cylinder / bundles / trailer valves leak tested at valve spindle / gland								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
<u>4.6.3</u>	Are cylinder / bundles / trailer valves checked for leaks after filling								
<u>4.6.4</u>	Are mechanical joints on the filling system and cylinders / trailers leak tested regularly								
<u>4.7</u>	<u>Are filling connectors in good condition (threads / pins not damaged and fully functioning)</u>								
<u>4.8.1</u>	<u>Are adaptors used for filling</u>								
<u>4.8.2</u>	<u>Is the use of adaptors controlled (for example access by authorised personnel only)</u>								
<u>4.8.3</u>	<u>Are adaptors in good condition (correct and undamaged threads)</u>								
<u>4.9</u>	Are analytical instruments and systems for hydrogen service checked and maintained at stipulated intervals								
5.0	Maintenance								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
5.1	Are maintenance procedures for hydrogen systems available								
5.2.1	Are personnel instructed that prior to slowly depressurising and purging hydrogen systems, or undertaking work on them, a safety work permit <u>shall</u> be issued								
5.2.2	Does the safety work permit require that a final sample analysis <u>is</u> taken before reconnection of any equipment to a live system								
5.3	Is all portable hydrogen monitoring equipment tested and calibrated at stipulated intervals								
5.4	Are maintenance personnel who work on hydrogen systems adequately trained and aware of the particular safety precautions associated with this type of plant								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
5.5	Are personnel instructed to use approved tools in hydrogen safety zone								
6.0	Emergency procedures								
6.1	Are adequate instructions available for shutting down plant in emergency situations: Electrical isolation Equipment isolation Nitrogen purging								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
6.2	Are personnel aware of the action to be taken in the event of fire, for example: Actuate the emergency stop button Raise the alarm Summon help and fire fighting services Close valves to cut off the sources of hydrogen supply Evacuate all persons from the danger area except those necessary to deal with the emergency Always approach any fire from the windward direction								
6.3	Are personnel aware that hydrogen flames are very difficult to see in daylight								
6.4	Are operators instructed to wear gloves when they manipulate valves / control systems etc in the course of their work								

	Question	Yes	No	N/A	Comment	Agreed Action	By Whom	Dates	
								Target	Compl
6.5	Is approved flameproof <u>lighting</u> (torches) readily available for use in emergency situations								
6.6.1	Is remote controlled emergency inert gas supply in good working order								
6.6.2	Is it checked at regular intervals								

5 References

- [1] EIGA Doc 102, *Audit Guidelines*, www.eiga.eu.
- [2] EIGA Doc 15, *Gaseous Hydrogen Stations*, www.eiga.eu.
- [3] EIGA Doc 102.03, *Safety Audit / Assessment Tool – Industrial Gas Cylinder Filling*, www.eiga.eu.