Piped compressed gas systems attached to gas cylinders and stand-alone compressed gas cylinder installations

Introduction

This document informs Schools/Departments of the key requirements for the safe operation and management of piped compressed gas systems attached to gas cylinders and stand-alone compressed gas cylinder installations.

Note: - The layout of gas distribution systems associated with cryogenic storage facilities are often comparable with those found on piped compressed gas systems attached to gas cylinders and so are included within the guidance. However, specific guidance on the cryogenic storage element of such installations can be found in the British Compressed Gas Association (CP36)

This document is not intended to replace the detailed; technical design guidance contained within documents published by organizations such as the British Compressed Gas Association (CP4); (CP 23); (GN2); (GN7). It is assumed that existing systems will have been installed and operated to these standards.

The requirements of this guidance apply to all piped compressed gas systems attached to pressure cylinders and stand-alone compressed gas cylinder installations operated by the University of Nottingham.

Due to the increased dangers associated with the use of standalone compressed gas cylinders located in buildings in the event of fire, the preferred method of providing compressed gasses within the University is via piped systems attached to gas cylinders securely housed outside the building.

The use of standalone cylinders within laboratories should only be sanctioned in the following circumstances.

- Building design or layout prevents the use of a piped gas system; and
- Fire risk assessment has been formally reviewed; and, where applicable
- Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002 assessment has been completed/reviewed.

Piped compressed gas systems attached to gas cylinders

Roles and responsibilities of Responsible Persons within Schools/Departments for piped compressed gas systems attached to gas cylinders

For the management of maintenance and inspection of piped compressed gas systems attached to pressure cylinders the Head of School/Department must appoint a Responsible Person usually the School Safety Officer/Department Safety Officer (SSO/DSO) for the coordination of this activity. Although these duties may of course be delegated to a competent nominated person within the school/department for day to day management, the responsibility to oversee this activity will remain with the SSO/DSO who will be the primary contact for their School/Department for University with regard to piped compressed gas systems attached to pressure cylinders.

Scope of guidance

In common with many pressure systems, elements of piped compressed gas systems attached to pressure cylinder installations fall within the scope of the Pressure Systems Safety Regulations 2000 (PSSR) (SI 2000/128), e.g. the requirement for a Written Scheme of Examination to be in place prior to the system being used.

Typically a Written Scheme will cover the examination of -

- All protective devices.
- All high pressure regulators.
- All high pressure hoses and pigtails.
- All pipe work, which, in the event of failure could give rise to danger.

In addition, there is a requirement for regular inspection / maintenance checks which technically fall outside the requirements of the Written Scheme of Examination and typically may include-

- Before use: Visual examination of the condition of the equipment.
- Regulator creep test.
- System low pressure leak test at normal operating pressures.
- Visual and functional check of all system components.
- Routine replacement of high pressure system components.

Competencies associated with the use, inspection, testing, maintenance and installation of piped compressed gas systems attached to gas cylinders

Level 1

- Before use checks, carried out by persons who have received sufficient instruction to operate the system safely.
    - Anticipated competency / training requirement – Successful completion of approved training course "**Compressed Gas Safety**"

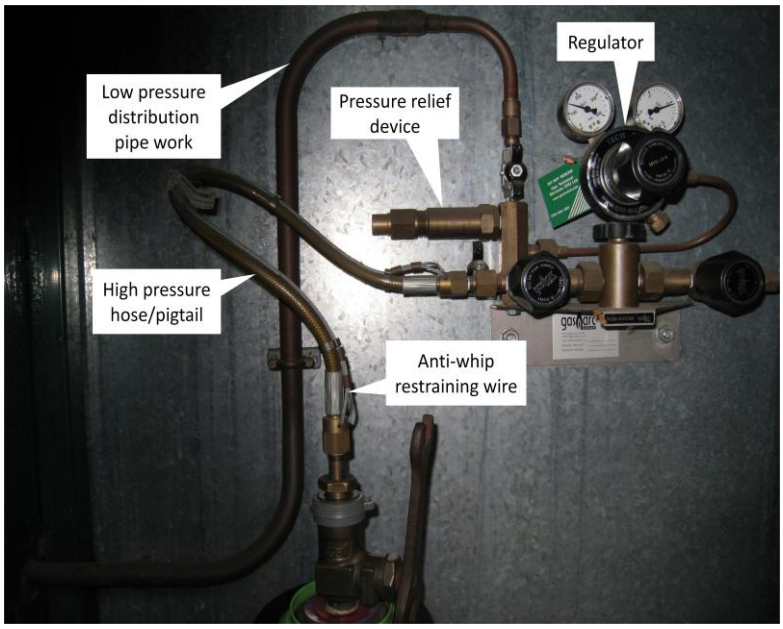
Level 2

- Annual checks, including, Regulator creep test; System low pressure leak test at normal operating pressures; Visual and functional check of all system components. If the department or school does not have staff available with these competencies then this work should be carried out by a competent third party service provider.
    - Anticipated competency /training requirement - Successful completion of approved training course "**Maintenance & inspection of Gas Systems**"

Level 3

- System design, installation, modification and component replacement should only be undertaken by a person who has undertaken relevant training by a suitably approved provider. Typically, a person undertaking this training should possess relevant engineering experience and should only be considered competent once a level of relevant practical experience in gas system design and installation has been gained. If the department or school does not have access to staff able to develop and maintain these competencies then this work should be carried out by a competent third party service provider.
    - Anticipated competency /training requirement – Successful completion of approved training course's "**Swagelok Installer**" & "**System design & installation Gas Safety Course**".
    - Where there is a requirement to carry out routine limited disassembly / re-assembly existing high pressure pipes within an existing system, the successful completion of the "**Swagelok Installer**" is advised.

Piped compressed gas systems attached to gas cylinders - typical system layout



Written Scheme of Examination for piped gas pressure systems attached to compressed gas cylinders

In common with other pressure systems, which fall within the scope of the Pressure Systems Safety Regulations 2000 (PSSR) (SI 2000/128) the University has engaged Allianz as the competent person to write / underwrite the Written Scheme of Examination for these systems. However, given the difficulty in carrying out a meaningful examination of key components of this type of system, the management of piped compressed gas systems attached to pressure vessels is based on routine inspection, testing and exchange of high pressure components.

Guidelines for the inspection and maintenance of high & low pressure components associated with piped compressed gas systems attached to compressed gas cylinders

Plant/equipment	Inspection Interval	Activity / Action	Inspection Interval	Activity / Action
Regulators – default 5 year programme.	1-year	a) Visual, external examination of condition. b) Check condition of threads and sealing surfaces, oil or grease contamination. c) Regulator creep test. d) Record all details of examination.	5-years	a) Replace with new or refurbished unit, or refurbish with approved spare parts kit and functionally check.

Note - the default 5 year programme should be applied in the following circumstances –

a) Standalone cylinder regulators in labs.
b) Piped system regulators where cylinders are housed in buildings, not in approved vented cabinets to BS EN 14470-2 and not provided with a vented secondary pressure relief valve.
c) Corrosive gas piped system regulators where cylinders are housed in buildings in approved vented cabinets to BS EN 14470-2.
d) Corrosive gas piped system regulators where cylinders are housed outside buildings.

Alternative 'risk based' programme may be applied to extend regulator exchange periods to 10 years in the following circumstances -

a) Non corrosive gas piped system regulators where cylinders are housed in buildings in approved vented cabinets to BS EN 14470-2.
b) Non corrosive gas piped systems where secondary pressure relief valve is provided and proven to be securely vented to a place of safety outside building.
c) Non corrosive gas piped system regulators where cylinders are housed outside buildings in appropriately designed cylinder store.
d) Low pressure (secondary) regulators.

Copper and Copper alloy pigtail (For high-pressure gas cylinders)	1-year	a) Visual, external examination of condition. b) Anneal if work-hardened, or replace. c) Fit new seals where applicable. d) Record all details of examination.	N/A	
Hoses (Non-metallic lined for high-pressure gas cylinders)	1-year	a) Visual examination of condition. b) Restraining wire is in place. c) Record all details of examination.	5-years	a) Replace with new item. b) Record replacement.
Hoses Stainless steel (for high-pressure cylinders)	1-year	a) Visual examination of condition. b) Restraining wire is in place. c) Record all details of examination.	5-years	a) Replace with new item. b) Record replacement.
Hoses Other types and corrosive duties.	Some systems carrying toxic, or other harmful products, may require specific maintenance inspections to prevent danger. In these cases examination intervals should be determined by local operating conditions and manufacturer's recommendations.			
Pipe work – low pressure	1-year	a) Visual, external examination of condition. b) Pressure drop test. c) Record all details of examination.	N/A	
Hoses – low pressure	1-year	a) Hoses are compatible with gas in use; reactivity and pressure. b) Hoses in good condition e.g. no kinking twisting or cracking. c) Hoses are secured by non reusable 'O' type crimp clamps (note - worm type, clamps are not recommended)	N/A	
Process relief valves	1-year	a) Visual, external examination of condition. b) Lift test c) Record all details of	6-years	a) Replace valves with new or refurbished units.

		examination.		b) Record all details of replacement.
Busting discs	In clean non-corrosive service there is no need to replace or examine bursting discs. However, in corrosive service conditions there may be a need to replace on a frequency, which should be determined from the manufacturer's recommendations.			
Flame arrestors	1-year	a) Visual, external examination of condition. b) Record all details of examination.	5-years (Or supplier's recommendation)	a) Replace with new or refurbished unit. b) Record details of replacement.
		e)		
Isolation valves	1-year	a) Visual, external examination of condition. b) Functional test. c) Record all details of examination.	N/A	
Inspection (by the user)	Each time the equipment is used	a) Equipment is visually in good order. b) Valves shut off and open correctly. c) Hoses are compatible with gas in use; reactivity and pressure. d) Hoses in good condition e.g. no kinking twisting or cracking. e) Check hoses are secured by non reusable 'O' type crimp clamps (note - worm type, clamps are not recommended) f) No oil or grease contamination to hoses or fittings. g) System is operating normally.		

Keeping of records relating to piped compressed gas system attached to pressure cylinders

Maintenance & inspection records should be maintained by the school/department.

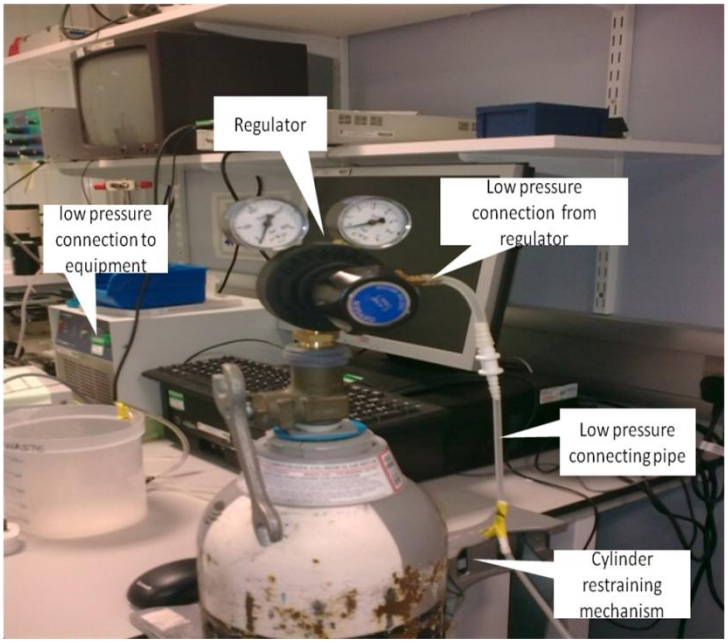
Stand-alone compressed gas cylinder installations

Competencies associated with the use, inspection, testing, and maintenance of stand-alone compressed gas cylinder installations

Level 1

- Before use checks, carried out by persons who have received sufficient instruction to operate the system safely.
    - Anticipated competency / training requirement – Successful completion of approved training course "**Compressed Gas Safety**"

Stand-alone compressed gas cylinder - typical system layout



Guidelines for the inspection and maintenance of high & low pressure components associated with standalone compressed gas cylinders

Written Scheme of Examination for standalone compressed gas cylinder installations

The HSE has advised owners and users of portable gas (oxy-acetylene or oxypropane) welding and cutting sets that Written Schemes of Examination are not required. However, it should be noted that such equipment can present a risk of fire or explosion if not assembled, operated and maintained correctly.

In the case of other equipment covered by this guidance, most stand-alone pressure cylinder installations systems will consist only of a cylinder, regulator & low pressure flexible hose feeding the output of the regulator to the process equipment and is not required to have a Written Scheme of Examination. However, in such cases, a documented assessment of the potential risk should be undertaken, and where this results in recognition that injury could result from a failure of the system, then a Written Scheme of Examination is required to be drawn up.

Guidelines for the inspection and maintenance of high & low pressure components associated stand-alone compressed gas cylinder installations

Plant/equipment	Inspection Interval	Activity / Action	Inspection Interval	Activity / Action
Regulators and their integral protective devices	1-year	a) Visual, external examination of condition. b) Check condition of threads and sealing surfaces, oil or grease contamination. c) Regulator creep test. d) Record all details of examination.	5-year	a) Replace with new or refurbished unit, or refurbish with approved spare parts kit and functionally check.
Flash back arrestors and their integral cut off valves	1-year	a) Check condition of threads and sealing surfaces, oil or grease contamination. b) Leak test all joints at working pressure. c) Check unit for flow restriction. d) Reverse flow to ensure correct operation of non-return valves. e) Where pressure sensitive cut off valves are fitted, they must operate at a pressure of no greater than 1.2 bar. f) If of a pressure sensitive type check shut off in the tripped condition in the direction of flow.	5-year	a) Replace with new or refurbished unit, or refurbish with approved spare parts kit and functionally check.
Low pressure hose assemblies (including non return valves)	1-year	a) Check threads and sealing surfaces. b) Reverse hose to ensure the correct operation of non-return valve where fitted. c) Leak test of all joints at working pressure. d) Check hoses are secured by non reusable 'O' type crimp clamps (Note - worm type, clamps are not recommended).	N/A	
Inspection (by the user)	Each time the equipment is set up or used	a) Equipment is visually in good order. b) Regulator has been in service for less than 5 years. c) Valves shut off and open correctly. d) Hoses are compatible with gas in use; reactivity and pressure. e) Hoses in good condition e.g. no kinking twisting or cracking. f) Hoses are secured by non reusable 'O' type crimp clamps (Note - worm type, clamps are not recommended). g) No oil or grease contamination to hoses or fittings.		

		h) Bottle support is secure. i) System is operating normally.

Keeping of records relating to stand-alone compressed gas cylinder installations

Where a documented assessment of the potential risk has resulted in recognition that injury could result from a failure of the system and a Written Scheme of Examination drawn up, Allianz Engineering will maintain electronic records of examination schedules, examination reports and written schemes of examination on behalf of the University.

Maintenance & inspection records should be maintained by the school/department.

Low pressure hoses used in association with piped compressed gas systems attached to pressure cylinders

The condition of the hose is of vital importance to safety. Correct hose connections, properly fitted and tested and retained by suitable non reusable clips or ferrules, are also essential. Re-usable worm-drive clamps (e.g. Jubilee clips) should not be used.

Low pressure hoses shall be -

- Capable of safely handling gas pressure applied.
- Made of a material which has been proved to be compatible with the gas used.
- Protected from excess heat.
- Kept as short as possible.
- Not allowed to become contaminated with grease or other materials.
- Fastened with appropriate fastenings.
- Where multiple low pressure hoses are used in close proximity, a unique marker to include the gas name should be used to identify each end of each hose.
- A fire in a coiled hose is difficult to extinguish; oxygen or fuel gas hoses should not be coiled around the cylinders, regulators or cylinder trolley during operation.
- Discarded when worn or damaged.

Hoses and hose assemblies shall conform to the following standards -

- BS EN 1327 Thermoplastic hoses.
- BS EN 559 Rubber hoses.
- BS EN ISO 14113 Rubber and plastic hose assemblies (450 bar).
- Hoses to BS EN 559 shall be assembled and tested in accordance with BS EN 1256.
- Hose connections shall conform to BS EN 560.
- Quick action couplings shall conform to BS EN 561.

Appendix 1

Test procedures

Creep test

Regulator creep is a phenomenon in which delivery pressure rises above the set point. Creep can occur in two ways. The first is due to inconsistencies in the motion of the regulator springs when gas flow is stopped. When flow has stopped, the springs should move to a new position of equilibrium, if this does not happen correctly, it can cause a slight increase in delivery pressure. The second cause of regulator creep is debris entering the regulator, impeding its normal operation.

To carry out a creep test -

1. Isolate the downstream side of the gas regulator by closing the regulator outlet valve, instrument valve or process isolation valve.

2. Close the regulator until it reaches stop or rotates freely.

3. Slowly turn on the gas supply, when the regulator inlet gauge registers full cylinder delivery pressure, shut off the gas supply.

4. Turn the regulator adjusting knob clockwise until delivery pressure gauge reads approximately half of scale (i.e. 50 psi on a 100 psi gauge).

5. Close the gas regulator by turning the adjustment knob counter clockwise until it rotates freely or reaches the stop. Note the reading on delivery pressure gauge.

6. Wait 15 minutes and recheck the setting on delivery pressure gauge.

7. If any rise in delivery pressure is detected during this time, the regulator is defective and should be replaced.

8. Return system to normal operating status.

9. Record & file results of test.

Drop test (Gas Tightness Test)

To carry out a drop test –

1. Isolate all gas consuming equipment from the low pressure gas distribution system and ensure that all distribution valves are open.

2. Isolate the downstream side of the gas regulator by closing the regulator outlet valve, instrument valve or process isolation valve.

3. Close the regulator by turning the adjustment knob counter clockwise until it reaches stop or rotates freely.

4. Slowly turn on the gas supply until the regulator inlet gauge registers full cylinder delivery pressure.

5. Turn the regulator adjusting knob clockwise until delivery pressure gauge reads normal system operating pressure.

6. Switch off gas supply. Note the reading on delivery pressure gauge.

7. Wait 15 minutes and recheck the setting on delivery pressure gauge. If any drop in delivery pressure is detected during this time, the low pressure delivery pipe work should be tested for leaks using an approved leak detecting solution and any leaks repaired as required.

8. Return system to normal operating status.

9. Record & file results of test.

Appendix 2

External gas cylinder store minimum design and operation requirements

a) Cylinder stores should be located where they are not vulnerable to impact, e.g. from vehicles such as fork-lift trucks or overhead lifting activities, and should afford good, smooth, level access for cylinder movements.

b) Where possible stores should be located away from pedestrian routes, where this is not possible, cylinder stores should be constructed from perforated steel sheet in preference to mesh.
c) Method of construction offering some degree of weather protection is recommended.
d) Cylinder stores should be securely padlocked.
e) Bottle support brackets to restrain cylinders should be provided unless specifically designed to be free standing.
f) Stores should be located as to protect gas cylinders from external heat sources that may adversely affect their mechanical integrity.
g) Cylinders stores should be stored away from sources of ignition and other flammable materials.
h) Empty cylinders should be stored separately.
i) Avoid storing gas cylinders so that they stand or lie in water.
j) Gas cylinders must be clearly marked to show what they contain and the hazards associated with their contents.
k) Area around cylinder stores should be kept free from debris such as litter; leaves etc.

References

- Pressure Systems Safety Regulations 2000.
- British Compressed Gas Association (CP4) Industrial gas cylinder manifolds and gas distribution pipe work: excluding acetylene.
- British Compressed Gas Association (CP23) Industrial & medical pressure systems installed at user premises.
- British Compressed Gas Association (CP36) Bulk cryogenic liquid storage.
- British Compressed Gas Association (GN7) The Safe Use of Oxy-Fuel Gas Equipment (Individual Portable or Mobile Cylinder Supply).
- British Compressed Gas Association (GN2) Guidance for the Storage of Gas Cylinders in the Workplace.
- British Compressed Gas Association (GN7) The Safe Use of Oxy-Fuel Gas Equipment.
- University guidance document (Statutory requirements for the management of pressure systems, lifting equipment & power presses).