BCGA GUIDANCE NOTE GN 19

Cryogenic Sample Storage Systems (Biostores)

Guidance on Design and Operation

2012

British Compressed Gases Association

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ISSN 0260 - 4809
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PREFACE

The British Compressed Gases Association (BCGA) was established in 1971, formed out of the British Acetylene Association, which existed since 1901. BCGA members include gas producers, suppliers of gas handling equipment and users operating in the compressed gas field.

The main objectives of the Association are to further technology, to enhance safe practice, and to prioritise environmental protection in the supply and use of industrial gases, and we produce a host of publications to this end. BCGA also provides advice and makes representations on behalf of its Members to regulatory bodies, including the UK Government.

Policy is determined by a Council elected from Member Companies, with detailed technical studies being undertaken by a Technical Committee and its specialist Sub-Committees appointed for this purpose.

BCGA makes strenuous efforts to ensure the accuracy and current relevance of its publications, which are intended for use by technically competent persons. However this does not remove the need for technical and managerial judgement in practical situations. Nor do they confer any immunity or exemption from relevant legal requirements, including by-laws.

For the assistance of users, references are given, either in the text or Appendices, to publications such as British, European and International Standards and Codes of Practice, and current legislation that may be applicable but no representation or warranty can be given that these references are complete or current.

BCGA publications are reviewed, and revised if necessary, at five-yearly intervals, or sooner where the need is recognised. Readers are advised to check the Association's website to ensure that the copy in their possession is the current version.

This document has been prepared by BCGA Technical Sub-Committee 1. It was approved for publication at BCGA Technical Committee 142. This document was first published on 11/04/2012. For comments on this document contact the Association via the website www.bcga.co.uk.

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1. Scope

This document covers the design, installation and operation of systems used for the storage of items at cryogenic temperatures, using liquid nitrogen as a sacrificial refrigerant. When used for biological materials the systems are commonly referred to as Biostores.

A typical system will comprise a cryogenic tank, pipeline and control system(s) that delivers the nitrogen to the storage equipment.

2. Definitions

Cryogenic tank: An assembly, complete with a piping system, of an inner vessel and an outer jacket containing insulation. The insulation space will normally be subject to a vacuum. This provides the supply of liquid nitrogen to the system and is the point of delivery for the gas company. A single cryogenic tank may supply multiple liquid nitrogen freezers in several storage rooms.

Pipework: The piping which links the cryogenic tank to the liquid nitrogen freezer. Piping may be un-insulated, conventionally insulated or vacuum insulated (SIVL). Pipework is considered to include all necessary valves, fittings and controls.

SIVL: An acronym for Super Insulated Vacuum Line. This is a type of piping which contains an inner pipe, and an outer jacket, separated from the inner with insulation. The insulation is held under vacuum. This type of piping is used for the conveyance of cryogenic liquid, maintaining the liquid at low temperature through minimization of heat in-leak.

Liquid nitrogen freezer: A non pressurised container in which items are stored at cryogenic temperatures. There are many different types of systems on the market ranging from simple manually controlled to fully instrumented automated systems. These may range in size from a few litres to several thousands litres volumetric capacity.

Storage room: A room in which a liquid nitrogen freezer or liquid nitrogen freezers are located.

Pressure relief device: A safety accessory as defined in the PER (5) designed and approved for protecting equipment from over pressure. This is normally a relief valve but can be a burst disc.

Note: It is not acceptable to use a back pressure regulator as a primary pressure relief device.

3. System design

The initial system design parameters such as capacity and number of liquid nitrogen freezers, flow rate of nitrogen and cryogenic tank capacity will be determined by the user's specific application.

All equipment selected shall meet national legislative and in-service inspection requirements. In particular the requirements of the PER (5) and the PSSR (6) will need to be addressed in addition to more general health and safety legislation such as, but not limited to, the HASAW Act (7) and the PUWER (8). The Medical Device Directive (9) may also apply to liquid nitrogen freezers that are being used to store human biological material, for example, blood and stem cells.

The overall system design should be undertaken only by a competent person familiar with the safe use and operation of liquid nitrogen freezers and the requirements of pressurised cryogenic liquid systems. The designer must ensure that the individual components of the system are mutually compatible such that they operate as a safe and functional whole.

All system design documentation, calculations, specifications, drawings and manufacturers literature shall be retained in a technical file as required by the PER(5). A typical process and instrumentation diagram is shown in appendix 1.

To minimise product flashing inside the liquid nitrogen freezer and to maintain the quality of product supplied, it is common practice to fit a device to maintain the supply tank at a low pressure below that of the lowest pressure relief valve setting.

4. Pressure relief devices

A pressure relief device must be fitted wherever thermal expansion of trapped liquid or gas can generate a pressure rise in excess of the design pressure of the local components.

Pressure relief devices must also be fitted downstream of pressure reducing devices such as pressure regulators, where failure of the pressure reducing device could give rise to a pressure exceeding the design pressure of the downstream equipment. Such pressure relief devices should be sized to exceed the maximum flow characteristics of the regulator.

The discharge points of all relief devices must be directed to a safe location. Discharge points should be directed away from plant, from where persons are likely to be standing or passing, and away from drains, trenches, building openings, confined space entries, etc.

Indoor relief devices should be piped-back into the liquid line or piped away, out of the room to a safe (freely ventilated) outdoor location.

Note: Where the outlet of the pressure relief valve is piped back the outlet pressure of the relief valve is not at atmospheric, therefore the set pressure is only ever 1 – 2 bar.

A calculation shall be conducted to ensure any pipe-away does not detract from the valve operability or required performance, e.g. due to pressure loss down the length of a pipe extension. The discharge outlet should be suitably designed to avoid accidental or deliberate obstruction or the accumulation of rain water or other debris, and shall be located as detailed above.

Only where neither of the above (pipe-back or pipe-out) is feasible should indoor discharge be considered. An appropriate risk assessment including a ventilation assessment will be needed if indoor discharge might occur.

It is crucial to the safe operation of the system that the relief valves operate with the correct discrimination, i.e. the hierarchical arrangement of the relief valve set pressures within the system. The correct rule to follow is to have the highest relief set point at the liquid nitrogen freezer cascading down to the lowest relief set pressure at the tank. Failure of the system to do this risks creating oxygen-depleted atmospheres and emptying of the tank through the relief device.

Correctly discriminating relief valve regimes ensure that optimum safety conditions are maintained. Discrimination is based on the principle of venting outdoors rather than indoors, and secondarily, venting gas rather than liquid.

Typical arrangements are illustrated at Diagram 1 in Appendix 1.

The usual hierarchy of safety relief valve settings is displayed in Table 1 and also shown in Diagram 1.

Hierarchy	**Category**	**Example**
First to vent	Gas – outdoor	Tank pressure control system
↓	Gas – outdoor	Tank Pressure relief valve
↓	Liquid – outdoor	Pipework thermal pressure relief valve
Last to vent	Liquid – indoor	Feed pipe to liquid nitrogen freezer thermal pressure relief valve

Table 1: Hierarchy of safety relief valve settings

5. Pipework

Any Pipework carrying liquid nitrogen shall be insulated and typically will be SIVL (Super Insulated Vacuum Line). Very short pipe runs may be left un-insulated provided that due consideration is given to the risk of cold burns to personnel, condensation, frost formation and water-ice accumulation. Design consideration should be given to the heat in-leak which may result from un-insulated pipe sections, and the detrimental impact which this may have on system performance.

Short runs may be defined typically as those of less than 2 m length.

6. Atmospheric monitoring and ventilation

Where liquid nitrogen freezers are installed, nitrogen gas will be released in to the local environment. This is a result of normal liquid nitrogen freezer operation, as the nitrogen sacrificially boils away. Nitrogen release may also arise from relief device operation, from system leaks or from equipment failure. These events should be considered by designers and operators as foreseeable and included in risk assessments.

Every storage room shall have a unique documented and formalised risk assessment to establish atmospheric monitoring and ventilation requirements. For guidance reference should be made to BCGA GN 11 (4).

Where the risk assessment identifies that there is insufficient existing ventilation or the possibility could arise for hazardous levels of oxygen depletion, the following should be considered as minimum recommendations:

i. Storage rooms should be equipped with oxygen depletion gas monitoring. This should activate an audio-visual alarm which consists of a flashing warning beacon and a siren. The beacon and siren shall be located inside the storage room such that any occupants are made aware of the alarm, and shall be repeated externally. Room occupants and potential occupants shall be trained on how to respond. The external beacon and siren should be located close to the room access door(s) to warn persons attempting to enter the storage room during alarm conditions. The use of an autodialer connected to the oxygen monitoring system, with a suitable emergency response procedure may also be considered. BCGA GN 11 (4) provides further guidance on this subject, but typically the alarm setting should be no lower than 19.5 % oxygen.

ii. The risk assessment shall identify the level of ventilation required for normal operation and also the level required in the event of equipment or system failure possibly leading to a large nitrogen release. For all but naturally well-ventilated storage rooms, forced ventilation should be provided for normal operation to prevent oxygen depletion and/or nuisance alarms arising from accumulations of nitrogen (small quantities discharged over a large time period). Whether the ventilation is achieved by natural or by forced means, the ventilation rate shall be no less than 5 times the expected nitrogen boil-off rate of all the liquid nitrogen freezers combined. This ventilation shall be arranged for permanent operation, i.e. shall be working at all times unless the installation is decommissioned with no opportunity for nitrogen introduction. For emergency situations two-stage ventilation may be considered either via a two-speed fan or via multiple fans. Emergency ventilation is an increased throughput designed for substantial emissions or leaks and should be triggered by the oxygen depletion monitoring system, or operated manually if necessary. Emergency ventilation should continue to operate for a further period (typically 20 minutes) after the alarm has re set. Note that the normal ventilation should remain effective even after the emergency ventilation ceases. For best-practice, if the oxygen concentration falls below the acceptable range during the run-on period, the alarm condition shall re-establish such that the emergency ventilation remains in operation until the depletion is corrected and a further run-on period successfully completed.

7. Emergency shut-down system

Emergency procedures shall be established to deal with foreseeable events which may require either a manual or automatic shut down. A manual system may be as simple as a clearly identified tank shut off valve. The risk assessment and operating considerations will determine if an automatic emergency shut-down system is required, triggered by the storage room oxygen depletion monitoring system. If so, the oxygen depletion monitoring system shall cause an automatically operated slam-shut valve to isolate the nitrogen bulk supply.

The slam-shut valve should include the following features:

i. It shall be in a well ventilated accessible location;
ii. It shall be positioned as close to the tank as is practicable;
iii. It shall be clearly labelled to enable identification by emergency services and other personnel who may not be familiar with site specifics;
iv. An ability to be manually overridden;
v. Arranged for fail-safe operation (close) in the event of power-failure or loss of actuation signal.

In addition to any automatically operated slam-shut valve, a separate manually-operated isolation valve shall be provided. This could be the tank liquid off-take valve. This valve function is to provide double-isolation of the nitrogen supply in emergency or maintenance circumstances. The valve shall be clearly labelled, mounted close to the tanks and in an accessible well ventilated location.

8. Pre-purge of liquid feed lines

A pre-purge (also known as a cool-down) facility may be provided to chill the service pipes prior to topping-up the liquid nitrogen freezers. This facility ensures that cold liquid is delivered rather than a mix of liquid and gas to the liquid nitrogen freezers. Such a facility is required on installations with significant pipe lengths, however, on very short pipe runs this provision may not be required i.e. sufficient cooling takes place during normal operation that pre-cooling is not required. The pre-purge shall operate in conjunction with a thermocouple which shall determine when sufficient cool-down has taken place and that it is acceptable to divert liquid to the liquid nitrogen freezer(s). Exhausted nitrogen from the pre-purge must pass to a well ventilated outdoor location and shall be discharged as set out in Section 4. Insulation of the vent pipeline shall be provided, except where alternative arrangements can be made for the safe management of condensate.

9. Installation

The specification, installation and location of the cryogenic tank shall comply with BCGA CP 36 (2).

The general principles as described in BCGA CP 4 (1) shall be used for the installation, testing and commissioning of pipework.

10. Documentation, handover and commissioning

Before the system is commissioned, the user shall ensure the following statutory obligations are fulfilled:

i. A Written Scheme of Examination covering the entire pressure system is in place in accordance with PSSR (6). Where equipment is leased, the owner of a pressure system may assume some of the duties of the user under Schedule 2 of PSSR (6).

   This may include:
   a. the preparation of the written scheme.
   b. the examination in accordance with the scheme.
   c. determination of the safe operating limits.
   d. maintenance requirements.

ii. An initial examination in accordance with PSSR (6) is completed by a competent person.

iii. The documentation specified in PSSR (6) has been supplied to the user.

iv. The persons operating the system have received sufficient information, instruction and training to allow the system to be operated safely, including establishing the safe operating limits and the actions to take in an emergency.

v. An appropriate Ageing Pressure Equipment Assessment is completed by a Competent Engineer prior to putting the system into service to ensure that the written scheme of examination takes into account any anticipated ageing mechanisms. See BCGA CP 39 (3).

vi. New equipment complies with the PER (5) or any other applicable regulation and shall have all appropriate documentation which will be retained for the life of the equipment (old equipment shall have the documentation as required by the regulations at the time of manufacture).

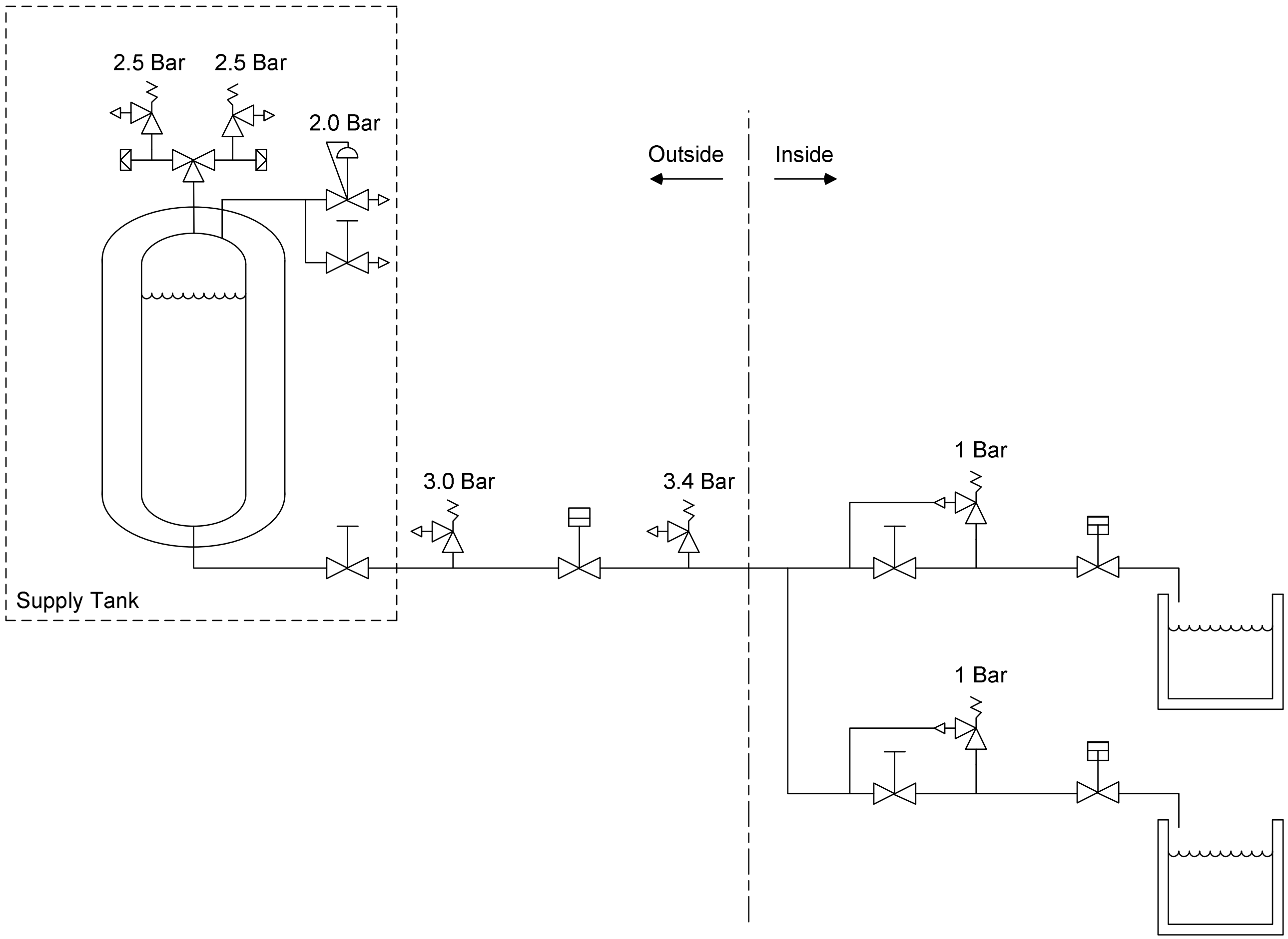
Having satisfied the above points, commissioning may commence. Commissioning shall be carried out by competent persons, preferably with direct experience of similar systems. All safety systems must be functionally verified.

Once the system is commissioned it shall be maintained in accordance with a documented maintenance programme.

11. References

1	BCGA Code of Practice 04	Industrial gas cylinder manifolds and gas distribution pipework (excluding acetylene).
2	BCGA Code of Practice 36	Cryogenic liquid storage at users premises
3	BCGA Code of Practice 39	In-service requirements of pressure equipment installed at user premises
4	BCGA Guidance Note 11	Reduced oxygen atmospheres. The management of risk associated with reduced oxygen atmospheres resulting from the use of gases in the workplace
5	SI 1999 No. 2001	The Pressure Equipment Regulations (PER)
6	SI 2000 No. 128	The Pressure Systems Safety Regulations (PSSR)
7		Health and Safety at Work etc Act 1974
8	SI 1998 No. 2306	The Provision and Use of Work Equipment Regulations 1998 (PUWER)
9	Council Directive 93/42/EEC	The Medical Devices Directive.

Diagram 1. Typical P&ID diagram of a cryogenic sample storage supply system showing the discriminating relief valve regime.



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