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SAFETY ASSESSMENT FEDERATION

Guidelines

Pressure Systems

Guidelines for Users and Competent Persons- Refrigeration Systems

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CONTENTS

1. Introduction

The purpose of these Guidelines is to provide guidance to Competent Persons when creating Written Schemes of Examination (WSE) for refrigeration systems and carrying out subsequent examinations to those schemes in accordance with the Pressure Systems Safety Regulations (PSSR).

They are intended to assist when assessing the system for inclusion of all appropriate pressure vessels, protective devices and pipework as applicable in the written scheme.

These Guidelines assume the reader has a basic understanding of the vapour compression refrigeration cycle and the common components of a plant.

2. Scope

These Guidelines address the Pressure Equipment Directive, Pressure Systems Safety Regulations, damage mechanisms, types of examination, protective devices and reporting of examinations for refrigeration plant (encompassing chillers and air conditioning plant).

Note: Equipment installed on sites which come within the Control of Major Accident Hazards Regulations may require additional considerations.

Absorption chillers generally do not contain a relevant fluid and operate under vacuum conditions so are not within the scope of the document. When fitted with a low pressure steam heat exchanger, these would need consideration under the PSSR.

3. Legislation

3.1. Pressure Equipment Directive (PED).

Several SAFed documents address the requirements of the Pressure Equipment Directive (PED), for example PEC04 and PSG16. This document addresses one key issue relating to the interaction of the PED with refrigeration plant, namely:

For new installations, safety valves may be issued with batch test certificates rather than individual certification.

Certification supplied may only cover the leak test of the individual valve, with accumulation and lift test being carried out on sample valves in a batch. This is because some manufacturers cannot guarantee the valve will be leak tight after lifting.

3.2. Pressure Systems Safety Regulations (PSSR)

The following excerpts from PSSR are particularly relevant to refrigeration systems. Their implications must be fully understood and addressed by the Competent Person and User / Owner of the system when operating the system, drawing up the WSE, or conducting an examination.

- **Regulation 2**. Interpretation (Pressure System) — "a system comprising one or more pressure vessels of rigid construction, any associated pipework and protective devices".

This will include refrigeration systems that contain vessels such as liquid receivers, shell / tube evaporators and condensers.

- **Regulation 7.** Safe Operating Limits, specifically ACoP para. 85 "e.g. Minimum and maximum temperatures and pressures" and Guidance para. 92 "The safe operating limits for refrigeration plant will be expressed as min and max temperatures."

This should be viewed as a reminder to the Competent Person to not just be aware of the maximum pressure for the system, they should record and assess the system as being suitable against the full range of pressure and temperatures provided by the Safe Operating Limit, as identified on the system data plate.

Note: Whilst the Regulations refer to fluorocarbon refrigerants these are generally superseded by alternative refrigerants.

- **ACoP L122 para. 103 (b)** "all protective devices should be included, even if they are on a part of the system which is not included". (See Clause 6.1)

When drawing up WSE's all protective devices should be included within the scope.

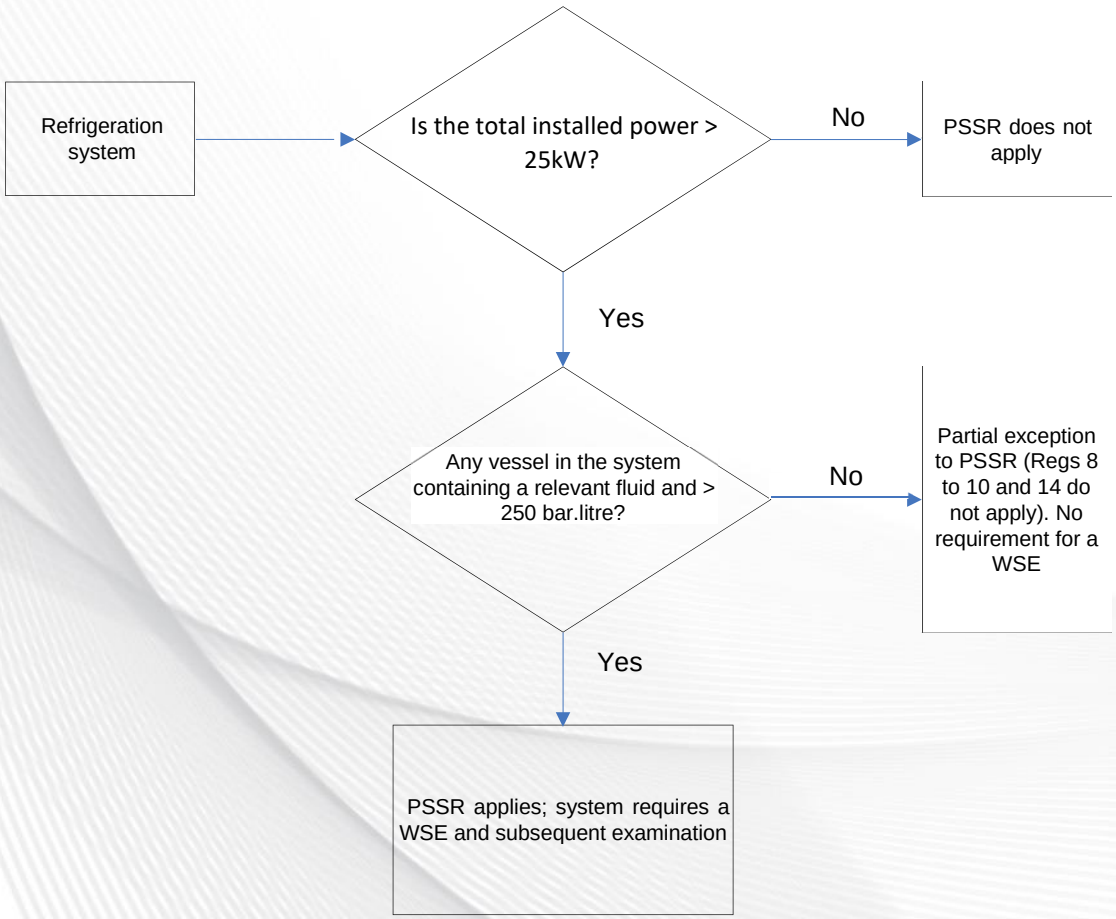
- **Schedule 1 Part I**, Pressure systems excepted from all Regulation, No 18. “Any vapour compression refrigeration system incorporating compressor drive motors, including standby compressor motors, having a total installed power not exceeding 25kW”.

This makes it clear that some refrigeration plant will not be subject to any requirements from PSSR.

- **Schedule 2, part II**, Pressure systems excepted from certain Regulations, para 2. (1) “Subject to sub-paragraph (2), regulations 5(4), 8 to 10 and 14 shall not apply to a pressure system containing a relevant fluid (other than steam) if the product of the pressure in bar and the volume in litres of its pressure vessels is in each case less than 250 bar litres”.

This allows the exclusion from certain Regulations of PSSR for vessels with low stored energy. The Competent Person should exercise caution when considering this partial exclusion, noting that it does not apply to vessels containing steam (absorption chillers) and can only be applied if ALL vessels are below 250 bar litre. All remaining Regulations within PSSR (e.g. installation, operation, maintenance etc.) still apply.

The following decision tree can be applied as guidance when assessing refrigeration plant for potential inclusion in a Written Scheme of Examination and subsequent examination in accordance with that scheme.



4. Damage Mechanisms.

4.1. Typical Damage Mechanisms

Table 1: Typical Damage mechanisms

Damage Mechanism	Inspection Technique
Fatigue: • Pressure and temperature cycling • Pipework vibration • Mechanical loading Note – Fatigue failures are rare on steadily operated processes.	External visual inspection, supplemented with surface NDT flaw detection of suspect areas.
Corrosion — Refrigerants are normally non-corrosive and internal corrosion is not generally an issue. External corrosion can occur in some environments.	External visual inspection, supplemented with thickness measurements (detailed testing may be required for extensive damage). This may require insulation removal (see below).
Corrosion Under Insulation (CUI) Occurs at temperature transition points of limits of insulation. It will also occur where the moisture is not frozen below the insulation. Systems which cycle around freezing point can be particularly susceptible to CUI in the secondary system (this may not contain a relevant fluid).	Removal of damaged insulation, external visual inspection, supplemented with thickness measurements (detailed testing may be required for extensive damage).
Stress Corrosion Cracking (SSC) (Ammonia systems), on un-insulated vessels operating at or above -5 °C.	External visual inspection, supplemented with a suitable NDT technique capable of detecting SCC on the internal surface. This would typically be on the main welded seams but it can also occur in the parent material.
Over pressurisation — Failure of pressure limiting devices.	Proving and / or certification of protective devices.
Impact damage (vessels and support structures)	External visual inspection for signs of damage or deterioration of insulation.
Fouling of heat exchange surfaces.	Where there are concerns then operating temperatures should be checked and if required examination of heat exchange surfaces.

4.2. Other Issues

- On systems where the cooled medium can freeze the low temperature trips should be included as a protective device. Failure of the trip may lead to the crushing of evaporator tubes causing a release of the primary refrigerant.
- Where the secondary circuit is a sealed system containing non relevant fluid, then failure of an evaporator tube may release high pressure gas into the secondary circuit. It is recommended that a safety valve is fitted to the secondary circuit and this should be included in the written scheme of examination.
- Where copper pipework is fitted then it can be susceptible to work hardening and potential premature failure due to flexing. During the examination any excessive movement of copper pipework should be reported for remedial action.

5. Maintenance

The owner/user of the refrigeration system is responsible for ensuring that it is maintained. In addition to the examination the user/owner needs to confirm that suitable maintenance regimes are in place. The maintenance documents should be made available to the Competent Person at the time of the examination.

6. Type and frequency of examination

For the majority of systems, the examinations will be limited to a visual external examination for evidence of damage or deterioration and that the plant is being correctly maintained. The Competent Person must ensure that the safety valves and/or other primary overpressure protection will function correctly.

The guidance contained in the Institute of Refrigeration Safety Codes of Practice suggest a frequency of five years for examination in accordance with the written scheme, although previous guidance suggested a four year frequency. Unless there are specific inspection related problems with a refrigeration system, it is recommended that the five year thorough examination frequency should be followed.

Note: existing schemes giving a shorter interval would need be amended at a formal review.

Where the examination involves functional testing of protective devices, controls and trips, satisfactory documentary evidence should be presented to the Competent Person, for verification or the service company will be required to attend to complete these tests for the Competent Person to witness.

Where a midterm examination is required, it may be sufficient for the Competent Person to review recent maintenance logs to establish at what pressure the unit high and low pressure trips activated. If the Competent Person is not satisfied with the quality or content of the maintenance records, they may ask for service company assistance to functionally test the protective devices.

6.1. Protective device types

The following list of items should be considered as protective devices and included within the WSE; further guidance for the testing of such devices can be obtained later in this section:

- The High pressure trip
- Safety valves (including those fitted to the low pressure circuit)
- Bursting discs
- Fusible plugs

Systems built in accordance with BS EN 378-2 can have various configurations of protective devices based on their design and construction, and not all refrigeration plant will have all the above protective devices. Systems may also be fitted with additional control devices such as low pressure trips.

Where there is doubt over which protective devices that should be included within the WSE, the Competent Person should discuss with the owner/user and refer to manufacturer's documentation to ascertain the design of the overpressure protection arrangement.

6.2. Refrigeration plants with no safety relief valves fitted for overpressure protection.

It is permissible for smaller refrigeration plant build in accordance with BS EN 378-2 not to have any safety relief valves fitted for operational overpressure protection.

Note: These refrigeration plants may have relief valves fitted for Fire Engulfment Protection and Section 6.5 refers.

The requirement for a safety valve for overpressure protection is determined by the flowchart (fig1) in clause 6.2.6 "Application of protection devices" of BS EN 378-2.

If there is no evidence of a relief valve for overpressure protection, then the protection arrangement will need to be verified from manufacturer's documentation. In this case the HP trips will be the Primary protective device and should be tested as part of a PSSR examination.

The HP trip must be a type approved pressure limiter, which is defined as a safety-switching device for limiting the pressure according to BS EN 12263 that automatically resets.

6.3. Testing.

6.3.1. Trips

Where a system trip is fitted and is considered to be a protective device then it should be included within the WSE and functionally tested to ensure it operates correctly.

The pressure trips provided should be suitable to prevent the safe operating limit from being exceeded. When witnessing the functional testing of pressure trips the Competent Person should ensure that the test is carried out using a calibrated pressure gauge as a reference.

6.4. Safety valves

Safety valves should be replaced or overhauled and reset at the interval required by the written scheme.

It is good practice that replaced safety valves are tested in the as removed condition to establish whether they would still provide adequate protection. This is to confirm that the examination frequency in the WSE remains suitable.

- The valve must be set no higher than safe operating limit(s) of the asset it is protecting.
- There is no 10% rule on the set point! (This 10% is to allow a momentary rise in pressure to lift the valve seat to its full height).

6.5. Safety valves for Fire Engulfment

Some packaged type refrigeration systems are fitted with safety valves which do not provide protection from operational overpressure. These safety valves are installed as a precaution in the case of fire engulfment.

The safety valve can be set above the normal safe operating limit and the set limit will be specified by the manufacturer.

The issue for the Competent Person is that there is no way of knowing, by looking at the plant, if the safety valve is fitted as a protective device as defined in PSSR or as fire engulfment protection which is considered to be outside the scope of the PSSR.

To confirm the purpose of the valve it may be necessary to ask, or it may be referenced in the manufacturer's documentation. Where the function of the valve cannot be determined it should be treated as a protective device under PSSR until information is received to dismiss it.

Safety valves fitted solely for fire engulfment protection should not be added to a written scheme, though where possible, it would be beneficial to add a comment regarding the valve's function so that there is no confusion in the future.

6.6. Bursting discs

Bursting Discs – Should be changed in line with the periodicity set out in the written scheme.

6.7. Fusible plugs

Fusible plugs, where fitted, should be visually examined for condition or leakage, and replaced in any case of doubt.

6.8. Pressure/Temperature indicators

Pressure/Temperature indicators used to verify the protective devices should have current calibration certification.

6.9. Review against PSG 05

Pipework should be considered against guideline PSG 05 (In service examination of pressure systems pipework) before being excluded. The examination frequency should be in line with other parts of the system. Removal of lagging should only need to be carried out if corrosion as identified in Table 1 is likely to be present.

7. Reporting

After completion of the examination the report should be issued on the required forms. Where the examination has referred to other documentation, safety valve certificates, maintenance documents etc. then they should be referenced on the report of examination.

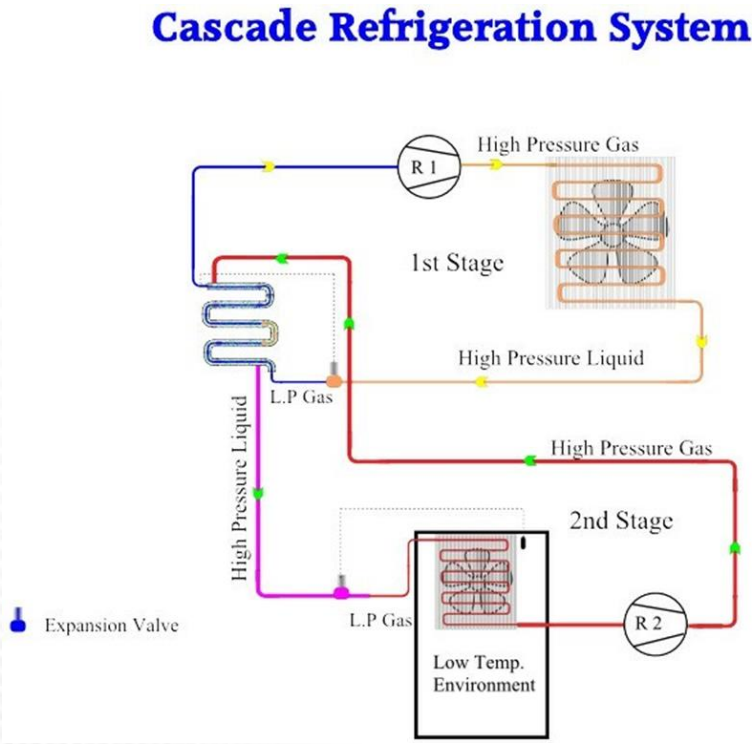
Each examination report should clearly state the WSE that the examination has been carried out in accordance with, including its issue number (or where no issue number is given the date of the WSE). Each report must carry a statement as to the suitability of the WSE, in respect of the plant item(s) on the report. Where a change is required then details of the changes should be given.

Where the Competent Person is to issue a report certifying the plant item for a shorter period than quoted in the WSE, a clear explanation should be given on the examination report.

8. Refrigeration Systems — Special Considerations

8.1. Carbon Dioxide Systems.

(R744) The vapour pressure from CO_2 is considerably higher than most other refrigerant systems and the consequences of failure could be more significant. This refrigerant is commonly used cascade refrigeration systems as the secondary refrigerant. A primary refrigerant such as R404a cools the carbon dioxide.



8.2. Ammonia Systems. (R717).

Ammonia is regaining popularity as a refrigerant as it is not classed as a greenhouse gas. Therefore, it is becoming increasingly likely that this type of system will be encountered.

Materials not to be used on ammonia contacting parts include, copper, zinc, and their alloys. Additionally, ammonia has been known to cause stress corrosion cracking in carbon steels used in some refrigeration plants. SAFed's experience is that stress relieved vessels do not experience this ammonia induced stress corrosion. Where vessels are installed without post weld stress relief, consideration should be given to carrying out testing for the defect. This is normally associated where parts of the circuit are operating above -5 °C. Note internal access is usually not possible and any testing will need to be completed from the outside.

It should be noted that ammonia is toxic, and these systems have suffered a number of incidents of leakage leading to harm to employees. Hence users should consider including all of the ammonia pipework system within a system of examination by a competent person.

8.3. LPG (Butane R600/Propane R290):

The systems are normally charged with odorless gas (Butane and Propane normally have a stenching agent added to the gas), therefore leakage cannot be detected by smell.

8.4. All pressure relieving devices should have discharge pipes terminating in a safe place.

9. References

- Institute of Refrigeration Guidance — Safety Codes of Practice for refrigerating systems.
- BSEN378 2008 — Refrigeration Systems and Heat Pumps.
- PSG05 — SAFed — In-service examination of pressure systems pipework.
- PSG01 — SAFed — Periodicity of Examinations.
- PM81 — HSE — (Withdrawn) Safe Management of Ammonia Refrigeration Systems.
- IMG01 — SAFed — The Mechanical Integrity of Plant Containing Hazardous Substances.