Vacuum pumps safety guidance

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Safety and Health Services

Contents

1. Introduction

This document provides basic safety guidance for the use of vacuum pumps in laboratories and workshops.

The document identifies potential hazards which may arise and provides guidelines to minimize risks.

This document is intended to provide basic guidance which should be read by anyone who uses vacuum pumps.
This guidance must however be read in conjunction with:

- Any manuals or instructions supplied with the equipment by the supplier, and
- Any safety information or risk assessments relating to the specific activity which the pump will be used for.

Users of vacuum systems and those who are designing pumps may also need to refer to the Edwards Vacuum Pump and Vacuum Systems SAFETY MANUAL as it includes additional specialist considerations and guidance.

Where vacuum pumps are required for pumping flammable mixtures, you must seek approval prior to commencing activity. This includes consultation with your School or Service Safety Adviser to consider all possible sources of ignition.

2. Operation procedures and training

Safe operating of equipment requires proper training, clear and concise instructions and regular maintenance. It is important that all personnel who use vacuum equipment are properly trained, qualified and, where necessary, supervised.

Hazards can be caused during operation by equipment and component failure because of age, improper use or poor maintenance. We can reduce the probability of such hazards through provision of proper training in the use (and maintenance) of the equipment. Where necessary, refer to the instructions supplied by the manufacturer in the form of Instruction Manuals, training and after sales service.

Recommend the use of daily user checks for all vacuum pumps. A possible example checklist is listed below:

Daily user checks:

- Oil level – top up as required
- Overheating – if overheating cease use and seek advice
- Pipework – check connections and integrity of piping
- Electrical cables and plugs - check in good condition
- Valves or gauges – check in good condition and working if in use
- Exhaust extraction system – check operational and in good condition
- Check run time log for filters (where available)

3. Maintenance, servicing and repairs

All pumps should have a schedule for maintenance and servicing. Whilst this might vary given the range of vacuum pumps within UoB laboratories and workshops, it should be documented for each type or pump and the frequency should consider the type of work the pump is being used for.

To prevent personnel coming into contact with dangerous substances, special care must be exercised, and all safety precautions must be observed during maintenance of a system in which toxic, corrosive, flammable pyrophoric, asphyxiants or any other substances have been pumped or produced.

As per UoB guidance use the Contaminated item clearance permit to confirm safety for those maintaining, serving or repairing a pump.

3.1 In-house routine maintenance:

Where this is applicable details should be documented by the School or Service as part of normal local H&S management processes.

3.2 Annual servicing:

Servicing and repairs must be carried out by competent and qualified specialists in accordance with the manufacturer's guidelines, national and local safety requirements.

Please remember that most vacuum pumps could be considered as disposable items, with most repairs would not be economically viable. Users should therefore make suitable plans to budget for replacement equipment at reasonable periodicities.

Suggested contractor: Atlas Copco (cost varies between £200 and £650 per pump), annual servicing or as determined by risk assessment. As part of the service the following items are covered:

- Check electrical connections from motor to electrical panel
- Check electrical connections within started panel
- Check/ clean air passages on motor
- Check oil levels
- Top up oil level if required
- Check for leakage around Vacuum pump
- Check fixing bolts
- Check linkages
- Take temperatures and pressures as required

Other aspects that could need to be consider:

- Change of oil either at annual service or in line with manufacturer's recommendations
- Change exhaust filter at annual service or in line with manufacturer's recommendations

4. Decommissioning and disposal

Considerations should also be given to a planned maintenance program, and to the safe disposal of components which may be contaminated with dangerous substances. You must follow the maintenance advice given in the instruction manuals for all equipment to ensure safe and reliable operation.

As per UoB guidance use the Contaminated item clearance permit to confirm safety for those maintaining, serving or repairing a pump for any pumps that have been (or suspected to) exposed to toxic, corrosive or other hazardous substances.

5. The correct choice of equipment

To ensure that you choose the correct equipment for your application you must consider the limits within which you will require the system to operate.
Also consider if the chosen manufacturer has an agent or supplier within the UK for spare parts

The technical data for equipment is given in the equipment's Instruction Manual(s). When you design your vacuum system, take account of the relevant mechanical pump parameters, for example:

- Maximum static pressure (inlet and exhaust)
- Maximum operating inlet pressure
- Maximum operating exhaust pressure
- Conductance of the inlet and exhaust components

- Pressure specification of other components FITTED to the pump
- Pressure monitoring in case the exhaust line becomes blocked.

For oil-sealed rotary vane and piston pumps, you must also consider for example:
- Gas ballast flow rate
- Oil box purge flow rate
- Gases and vapours trapped in the oil box
- Gases and vapours absorbed into the oil in the oil box.

5.1 Pressure Relief

You may use bursting disks or pressure relief valves to relieve an over-pressure condition. The operating pressure of the device must be below the design pressure rating of the system. You must connect these devices with suitable pipelines to an area in which it is safe to vent your process gases, and which does not have vent restrictions. If your process produces solid by-products, the pressure relief devices must be inspected regularly to ensure that they are not blocked or restricted. The design of such protection devices should take into account the effect of pressure pulsations on the fatigue life of the bursting disk or the life of the valve.

5.2 Pressure Regulators

There are two main types of pressure regulators: venting and non-venting.
- Venting regulators
  - Vent gas to atmosphere or to a separate vent line to maintain a constant outlet pressure under no-flow conditions
  - Are generally used where pipeline integrity is of paramount importance.

- Non-venting regulators
- Can only maintain a constant outlet pressure under flow conditions

Under no-flow conditions the outlet pressure of some regulators can rise to the level of the supply pressure. The rate of rise is dependent on the characteristics of the regulator and the volume to which its outlet is connected. The rise can take from a few minutes to several months.

Pressure regulators are not designed to be shut-off valves and must be used in combination with a suitable isolator device (such as a solenoid valve) when isolation is required. Alternatively, you must take measures to safely vent excess pressures.

5.3 Exhaust extraction systems

It is important that you use the correct type of exhaust extraction system for your pump. For instance, if you are using an oil-based pump, you must ensure that the exhaust is suitably extracted or use a filter to prevent hazardous releases to atmosphere.
Any exhaust systems should be checked regularly, and filters changed as required.
Recommend the installation of a run time/calendar time and base filter changes of this data based on filter manufacture information.

6. Potential Hazards

Unexpected events are invariably caused by deviation from manufacturers safety guidelines.

Common causes are ignition of flammable materials, or the blockage or restriction of the pump exhaust. To avoid hazards, you should pay attention to the following to help ensure the safe operation of your vacuum pumps and systems.

- Unless your system has been designed for pumping material at concentrations where it could be ignited in the vacuum pump, you must ensure that mixtures of flammables and oxidants are kept outside the flammable range. The use of inert purge is one way of achieving this.

- Ensure that exhaust blockages cannot occur during operation either because of mechanical components (for example, valves or blanks) or because of process materials or by-products depositing in pipelines, filters and other exhaust components, unless your system has been designed to cope with it.

6.1 Chemical hazards

You must carefully consider all possible chemical reactions which in normal use, misuse and failure conditions may occur at any point within your vacuum system. In particular you must carefully consider reactions which involve gases and vapours which can lead to explosions. Experience has shown that explosions have occurred in which there were materials involved which were not originally considered by the system designer, and in which the failure mode of such equipment had not been taken into account.

Summary - chemical sources of hazards

- Consider all possible chemical reactions within your system.
- Make allowance for abnormal chemical reactions, including those which could occur under fault conditions.
- Refer to Material Safety Data Sheets when you assess the potential hazards associated with your process materials.
- Use dilution techniques to minimize reactions with oxidants and flammable materials.
- Where a flammable zone has been specified you must use a suitable certified ATEX vacuum pump.
- Use the correct type of lubricant in your pump when you pump oxidants and consider the use of a dry pump.
- Do not use heavy metals in the gas path of your process system if your process uses or produces sodium azide.
- Take specific care when handling toxic, corrosive or unstable materials.

6.2 Physical sources of hazards

- When you perform safety calculations ensure that the safe working pressures for all components in the system are taken into account.
- Ensure that the pump exhaust cannot become blocked or restricted.
- If there is a risk of high pressures in excess of the pressure rating of any part of your vacuum system occurring, we recommend that your system incorporates suitably positioned pressure measuring equipment. This must be connected to your control system to put your system into a safe state, if an over-pressure condition is detected.
- Take account of abnormal and fault conditions when you assess the required pressure rating of the vacuum system and pump components.
- Ensure that you incorporate the correct type of pressure relief device and that it is suitably rated for your application.
- Ensure that compressed gas supplies are properly regulated and monitored. Switch off these supplies if the pump is switched off.
- Where possible, ensure the supply pressure to any regulated purges is lower than the

maximum allowable static pressure of the system. Alternatively ensure that pressure relief is possible in the event of component failure.

7. Fire protection

Laboratories and workshops where vacuum pumps are operating and/or are being maintained/serviced must have:

- Smoke head detectors fitted (as opposed to heat only); this provides maximum sensitivity and ensures the fire alarm is triggered/activated at the earliest opportunity in the event of smoke generation and or fire.
- Reasonable fire protection (compartmentation); the door must close fully meaning that escape routes are protected.
- Staff must be aware of the nearest fire extinguishers and should consider whether extinguishing media is appropriate.
- Debris and any combustible material must be cleared and particular attention paid to the space above and adjacent to where the pumps will be positioned.
- A regular fire watch must be employed during testing and servicing; the periodicity of checks should be based on a risk assessment of the likelihood of fire (which may vary during different stages of the testing period). Wherever practicable pumps should not be left unattended and if the risk of fire is considered likely then a continual fire watch alongside appropriate access to firefighting equipment.
- A metal plate should be positioned on any wooden benching where pumps will be positioned for testing, PPM, etc.