PRESSURE AND VACUUM SYSTEMS

Sudden equipment failure can cause similar consequences in high pressure systems and in vacuum systems. Both the bursting of high pressure systems and the collapse or implosion of vacuum systems can cause glass or metal fragments to be projected with explosive violence in all directions and may release chemical and other (mercury from pumps, manometers) contents.

High Pressure Systems

High pressure systems present the greater hazard because of their higher potential energy and are subject to statutory requirements – see [http://www.hsu.bham.ac.uk/univ/hspolicy/10ps.pdf].

Design

Design considerations should assume there will be an explosion, thus:

- include pressure relief valves or bursting discs, and route their discharge via suitable ducting to a safe location;
- size pressure relief devices so as to prevent an excess pressure greater than 10% of the maximum allowable working pressure;
- include in calculations of relief capacity all internal pressure possibilities and also external heat from an adjacent fire;
- size the vessel and/or the quantity of material used in it so as to avoid liquid expansion on heating filling the vessel and generating hydraulic pressure.

NB Pressure vessels designed to contain high pressure are of very substantial construction and therefore of high thermal capacity so that they are liable to be slow to cool. In the event of an unplanned and sudden temperature rise, cooling would not check an accelerating reaction.

Shielding

Glass equipment under pressure should be shielded, first with mesh or tape and also with a suitable armour shield:

- Steel shields are 4 times as effective as polymethylmethacrylate, but neither should be used at a thickness of less than 6.5mm;
- autoclaves, bombs, etc., should be shielded with steel;
- portable shields can only give adequate protection if anchored securely;
- shielding should be so arranged as to protect against ricochets along deflected missile paths at 45°;
- personal protection for an operator should include an impact grade visor.

In order to ensure safety it may be necessary for equipment to be over engineered and, if necessary and if pressure is likely to exceed 200bar, for the equipment to be confined to an isolation cell.

Testing

High pressure vessels must be tested before use:

- the whole assembly should be vacuum tested for leaks at joints; and then
- hydraulically tested to 150% of the maximum allowable working pressure.

Vacuum Systems

Whilst vacuum systems are liable to implosion, the effects are as for an explosion, i.e., flying debris, chemical release, etc.

For all vacuum systems the pressure difference from ambient cannot be greater than one atmosphere. Furthermore, so far as safety is concerned, a poor or low vacuum, as for example from a water aspirator giving 10 torr (10 mmHg), is at similar level below ambient atmospheric pressure as a high vacuum at 10-5 torr. (The difference from ambient is 750 and 759.99999mmHg, respectively.)
Guarding

Thus precautions must be taken with any evacuated chamber, at least by guarding with tape or plastic mesh. An explosion shield and personal impact grade visor are also needed to guard against chemical release.

Inerting

Fire and explosion may result from the inward leakage of air or a sudden inrush of air into a system containing hot organic material. If air cannot be excluded until the material has cooled, an inert gas such as nitrogen should be admitted to the system.

Traps

Traps are employed to:

- prevent a sudden movement from one part of a system to another due to a sudden pressure change (one way valves may also help);
- to guard vacuum distillation pumps to prevent oil or water from being sucked back into the apparatus on cooling;
- when cooled, to protect pumps from contamination by chemical vapours.

NB If liquid nitrogen is used for a cool trap great care must be taken to avoid the accumulation of condensed liquid oxygen in open vessels. Traps open to the atmosphere should not be cooled by liquid nitrogen.

Pump Exhausts

Despite the use of protective traps it may still be possible for highly toxic or reactive chemicals to escape through a pump.

The effluent from such pumps and also mercury diffusion pumps should therefore be exhausted through a fume cupboard or direct to the outside air.

Mercury Hammer

A sudden release of vacuum can cause mercury to flow through a system and to strike bends and surfaces with hammer-like violence. The use of constricting capillaries in manometers, etc., can avoid mercury hammer shock.

Mercury Contamination of the Atmosphere

Open containers and spills of mercury can seriously contaminate the atmosphere with mercury vapour and cause excessive exposure. Mercury reservoirs should be surrounded by unbreakable spill containers and exposed mercury surfaces covered with silicone oil.

Glass-blowing Hazard

Organic solvents should not be used for cleaning vacuum glassware since pockets of residual vapour can cause explosions or the release of toxic fumes during glass-blowing.