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# Gas and Chemical Process Safety Unit

# Internal corrosion of gas cylinders

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## 1.0 Introduction

The *'Carriage of Dangerous Goods (Classification, Packaging and Labelling) and Use of Transportable Pressure Receptacles Regulations 1996'* (CDGCPL2) as amended, requires in Schedule 8, paragraph 5 (2) that the gas cylinder filler '*makes all other appropriate safety checks'*.

This DIN looks at the avoidance and detection of corrosion on internal walls of a gas cylinder and recommends that the Guidance Note GN6 '*Avoidance and Detection of Internal Corrosion of Gas Cylinders'* issued by the BCGA is followed by all fillers of gas cylinders where a corrosive atmosphere is a possibility.

## 2.0 Background.

There have been ten explosions of gas cylinders used for carbon dioxide gas or mixtures of carbon dioxide with nitrogen over a period of 18 months and in each case corrosion was present on the internal wall of the cylinder. In seven of the eight cases the corrosion led directly to stress corrosion cracking which in turn tore the cylinders apart. In the other case, gross corrosion was present which led directly to the formation of a hole in the side of the cylinder and the release of the contents.

Carbon dioxide gas is not corrosive within a steel gas cylinder unless moisture is present. If moisture is present corrosion rates are extremely high with literature showing average corrosion rates of 1mm/month. A standard carbon dioxide gas cylinder may be in the region of 5 mm thick and can possibly survive a 3 mm reduction in thickness before the pressure overcomes the steel's ability to remain intact. This indicates that a gas cylinder is very tolerant of wall thickness reductions . However, it also shows that the cylinder's life is very limited once moisture ingress has occurred unless the cylinder is dried out quickly.

Inspections and Investigations have shown that many fillers are unaware that cylinders do corrode internally, do not know how to prevent the corrosion and as a result are not carrying out the required safety checks.

## 3.0 Available guidance.

The BCGA published a guidance note in 1998 'GN6 *Avoidance and Detection of Internal Corrosion of Gas Cylinders'*. This guidance clearly sets out the following ;

- Sources of moisture contamination,
- Avoidance of cylinder corrosion, and
- Detection methods.

3.1 Moisture contamination.
All of the sources of moisture contamination discussed in GN6 have been found during recent investigations, with liquid backfeed during use and rainwater being the most common occurrences.
3.2 Hierarchy of corrosion avoidance in GN6.
The avoidance of cylinder corrosion is set out, and should be used as, a hierarchy of inherently safer approaches as follows;
i) Step 1 is to eliminate the risk of corrosion by using corrosion resistant materials. For carbon dioxide, aluminium has been shown to have good corrosive resistance in most cases with the noted exception of the ingress of coca cola extract.
ii) Step 2 is to prevent moisture ingress with the top of the hierarchy pointing towards the use of residual pressure valves (RPVs). These are essentially non-return valves which prevent any backfeed of liquids into the cylinder. If RPVs are not fitted the hierarchy moves down to-
iii) Step 3 - control of the process design and its operating procedures. Controlling the operating procedures and methods are not always available to the gas cylinder owner, however procedural control methods are relevant to the user as it is often they who leave the cylinder out in the rain with the valve open.
3.3 Detection methods.
This is to ensure that moisture is detected prior to the cylinder being filled. Again there is a hierarchy in the methods of detection to be used, at the top of which is a check to make sure that residual pressure remains in the cylinder. (Use of the RPV aids this process). Next is a weigh check designed to detect over about 10g of moisture. It has been shown that a teaspoonful of water is enough to destroy a gas cylinder so this check is not really sensitive enough as a teaspoonful of water weighs 5g. The check also relies on the weighing scales working correctly and it is expected that weighing scales are independently calibrated at least on an annual basis and routinely checked on a weekly basis with records of all calibrations and checks maintained.
The moisture detection hierarchy continues with an internal visual inspection. This requires the removal of the cylinder valve which must be replaced using the correct tools and torque settings. By-products of this procedure include increased wear on the valve threads and increases in the risk of moisture ingress whilst the valve is removed. This method also relies on the person carrying out the inspection being capable of detecting small quantities of moisture, so he/she must have attested eyesight and a good source of lighting the inside of the cylinder.
The forth level is moisture detection and the guidance clearly sets out the limitations of its use. Moisture detection may be appropriate for on line monitoring of the gas going into the cylinder but would be a poor method of detecting moisture already present inside the cylinder from either rainwater or liquid backfeed.
Cylinder evacuation by use of a vacuum pump is a very reliable method of detecting free moisture within a cylinder but this method was not seen in any of the smaller filling stations visited by HSE. This would be the preferred method of moisture detection after the fitting of RPVs.
The installation of a dip tube could be effective in ensuring that there is no puddle of moisture in the bottom of a cylinder but again this method would not detect very small quantities. The method also relies on residual pressure in the cylinder so may require a partial fill of a dangerous cylinder before moisture could be detected. There are also dangers to the system being supplied with gas from the cylinder which may not be designed to cope with liquid phase. This is particularly true in pub cellars where liquid carbon dioxide could cause pipework to burst. It is therefore not recommended.
The final level is cylinder inversion with the valve open and a look for drips of moisture. This method would detect large volumes of free liquid but is unlikely to find small quantities as the moisture would wet the cylinder wall as it was inverted and would not necessarily reach the valve.
**4.0 Recommendations.**
Gas cylinder fillers should be asked to follow the guidance on the avoidance of internal corrosion given in the BCGA publication GN6 and this DIN.

Gas cylinder fillers should be made aware that the avoidance measures given in the BCGA guidance note GN6 are an hierarchy.
For cylinders in beverage gas service, owners of gas cylinders should be asked to fit RPVs at the next periodic examination.
For cylinders in beverage gas service not fitted with an RPV the filler must have a procedure that uses a combination of the corrosion avoidance and moisture detection methods discussed above to ensure that no cylinder that contains moisture is filled with gas.