Other Gases			
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Gas Cylinder Filling Plant DIN

1.0 Introduction

This DIN gives advice to those who inspect gas cylinder filling plants. It highlights areas where recent inspections by TD5 have revealed shortcomings that could lead to unsafe gas cylinders. This DIN does not look at COSHH, control of noise, guarding or welfare issues, which are adequately covered by other publications. Neither does this DIN seek to replicate the requirements detailed in standards.

This DIN should be read in conjunction with DINs TD5/038, TD5/044 and TD5/045, which deal with '*Incidents with gas cylinders used for beverage gases'*,' *Internal corrosion of gas cylinders'*, and '*Inspection of gas cylinder test houses'* respectively.

The British Standards covering the filling of gas cylinders are:

BSEN 1919:2000	Transportable gas cylinders. Cylinders for liquefied gases (excluding acetylene and LPG). Inspection at time of filling.
BSEN 1920:2000	Transportable gas cylinders. Cylinders for compressed gases (excluding acetylene). Inspection at time of filling.
BSEN 12754:2002	Transportable gas cylinders. Cylinders for dissolved acetylene. Inspection at time of filling.
BSEN 13365:2002	Transportable gas cylinders. Cylinder bundles for permanent and liquefied gases (excluding acetylene). Inspection at time of filling.
BSEN 13385:2002	Transportable gas cylinders. Battery vehicles for permanent and liquefied gases (excluding acetylene). Inspection at time of filling.
97/720071 DC	Transportable welded steel cylinders for Liquefied Petroleum Gas (LPG). Procedures for checking at time of filling. (ISO/DIS 10691) Draft for public comment.
DOT39(HSE)	Specification for welded steel non-refillable transportable pressure receptacles
BSEN 12205	Transportable gas cylinders – Non-refillable metallic gas cylinders

Further guidance is available from the European Industrial Gas Association (EIGA) publication IGC Doc 83/02/E '*Recommendations for safe filling of CO_2 cylinders and bundles*' which is available free at http://www.eiga.org/pdf/Doc%2083%2002%20E.pdf.org/

2.0 Cylinder filling Regulations

This DIN will only consider the requirements of Schedule 8 of the *Carriage of Dangerous Goods (Classification, Packaging and Labelling) and Use of Transportable Pressure Receptacles Regulations 1996* (CDGCPL2) *as amended* by the *Transportable Pressure Vessel Regulations 2001*(TPVR).

Paragraph 2 (2) of schedule 8 deals with the design and manufacture of cylinders that can be filled and paragraph 4 of schedule 8 deals with the filling.

3.0 Which cylinders can be filled?

The operator must *'check from the marks on the cylinder'*. If these marks cannot be seen, or if they have been tampered with in any way, the cylinder must not be filled. The important marks are those of the competent person who last inspected the cylinder and the date of his/her examination, the serial number, the tare weight, the fill pressure or weight, the intended gas and the design specification. A list of approved design specification to both CDGCPL2 and TPVR can be found at http://www.hse.gov.uk/a-z/t.htm#transportabe_pe.

One filling station visited by TD5 was filling cylinders that had the label required for transport positioned in such a way that it hid the markings on the shoulder of the cylinder. Therefore the operator could not read the markings. He had been trained to assume that every cylinder presented to him for filling was marked with standard information and could therefore be filled to the same pressure with the same gases. These are not safe assumptions as not all gas cylinders in circulation are made to the same pressure rating or do not have compatibility with all gases.

Many filling stations visited by TD5 were found to be filling cylinders that had strings of information removed by grinding. In another case the cylinders had been painted so thickly that all markings had been covered, see DIN No. TD5/038.

4.0 Pre-fill checks

It is important that each cylinder is carefully and fully inspected before being offered for filling. The person carrying out the inspection should look at all external surfaces – including the base, the markings, labelling and the valve and its protection.

Cylinders should be placed in batches of:

- Like cylinders ready for filling,
- Cylinders requiring further inspection and
- Cylinders requiring periodic examination.

Cylinders batched for filling should be checked for residual pressure and weighed. Where differences are noted between the marked tare weight and the measured weight, which cannot be explained by any residual pressure, then the cylinder should be removed for further investigation.
In one recent cylinder explosion it was found that a beverage gas cylinder was half full of liquid before filling started. The empty cylinder weight of carbon dioxide was added to the liquid giving a 60% ratio of carbon dioxide instead of the required 30% and the cylinder was topped off with nitrogen to the 200 bar.g working pressure. As the nitrogen is pumped into the cylinder the cylinder warms and the operator compensates for this temperature by filling to above the 200 bar.g. Under the described circumstances the cylinder would have only needed a small nitrogen fill, thereby involving only a minor heat input. The cylinder would therefore have been in excess of its rated pressure of 200 bar.g at 15 ^{o}C. Carbon dioxide and nitrogen mixtures become unstable above 180 bar.g when mixed in 60/40 ratios with the carbon dioxide coming out of the mixture and forming a layer of supercharged carbon dioxide liquid floating on the liquid left in the cylinder. This attacked the cylinder internal surface, which failed by stress corrosion cracking.
DIN No.044/02 should be used as a guide for ensuring that the internal surfaces of a cylinder are not contaminated prior to any fill.

5.0 Calibration

The importance of pressure gauge calibration must be emphasised. Many filling stations have been inspected where pressure gauges are never calibrated. By not using calibrated gauges the filling station cannot be sure to what pressure any cylinder is being filled.
One successful calibration methodology is for the filling station to have an externally calibrated master pressure gauge, which is not used for routine cylinder filling. A suitably accredited test house should calibrate the master gauge annually and a certificate of calibration obtained. The master gauge should then be used weekly to check all other pressure gauges used in the filling station and a responsible person should keep records of each check. The Master Gauge should be kept in a clean and secure location.
A clear procedure is required to describe the actions to be taken if pressure gauges are found to be out of calibration on the weekly test. This could involve retesting each cylinder filled during the previous week or, if over pressure is suspected, a full venting and inspection of all cylinders.
When filling liquefied gases the weight of the cylinder and the gas added are very important factors. Again, the calibration of weighing scales forms a vital safety check.
One successful calibration methodology is for the filling station to have the weighing scales externally calibrated every six months and a certificate of calibration obtained. The scales should then be checked each shift by using a known weight and a responsible person should keep records of each check.
A clear procedure is required to describe the actions to be taken if weighing scales are found to be out of calibration during the daily check. This could involve reweighing each cylinder filled during the previous shift or, if over filling is suspected, a full venting and inspection of all cylinders.

6.0 Gauge/Scales units

One filling station visited was using a filling pressure gauge marked in units of ‘psi’. The cylinders being filled were stamped with units of ‘bar.g’ and the operator had a conversion table by the filling line. This clearly leads to an opportunity for operator error and it is recommended that pressure gauges and weighing scales display the same units as those stamped on the cylinder to be filled.
In other filling stations very small gauges were being used that made differentiation at the required fill pressure very difficult. It is recommended that the gauge face is at least 100mm in diameter with the fill pressure at between $^{1}/_{2}$ to $^{2}/_{3}$ and of fullscale deflection.

7.0 Methods of fill

Permanent gases can either be filled by weight or by pressure, whereas liquefied gases can only be filled by weight.
Mixtures of gases, mixing a liquefied gas to a permanent gas, often use a combination of the two methods but more accuracy of mix is achieved by carrying out the complete fill by weighing in the constituent parts. Where pressure filling is used temperature compensation will be required.

8.0 Fill temperature compensation

When filling cylinders by pressure they will heat up to a temperature significantly above the ambient temperature. Gas cylinders in use in the UK are rated at a fill temperature of 15 ^{o}C. On a cold day this rated fill temperature may not be achieved meaning that a cylinder filled to its rated pressure below 15 ^{o}C would exceed its rated pressure at 15 ^{o}C. Conversely on a warm day a cylinder would need to be filled in excess of its rated pressure so that when it cooled to 15 ^{o}C it would be at its rated pressure.
Many filling stations visited by TD5 fill to the same pressure all year round and have no methods for checking cylinders against their rated pressure or any form of calibration chart or temperature monitoring that would assist in setting fill pressures.
It is recommended that each filling station monitors the temperature of all cylinders filled by pressure and has a method of calibrating the fill pressure to ensure that the gas cylinder rated pressure at 15 ^{o}C is not exceeded.

9.0 Fill monitoring

TD5 visited filling stations that relied on one operator monitoring fill pressure and being on hand to stop the compressor once the required fill pressure was reached. In these particular

instances there was no back up system if the operator was incapacitated in some way. Where manual systems are used, TD5 recommends that an automatic cut off should be fitted to the fill line to stop the fill operation once the predetermined fill pressure is reached.

10.0 Venting

Occasionally a cylinder will accidentally be overfilled either by over pressurisation or by exceeding the filling ratio for liquefied gases.

Where gross over filling has occurred the cylinder should be completely vented and sent to the test house for examination by a competent person. When overfilling is marginal the excess contents can be vented.

Venting of the cylinder should be carried out at the filling position; the cylinders should not be moved outside or to a venting area because, whilst overfilled, the cylinder is in a dangerous condition. It is recommended that a venting line is fitted to each filling line so that an overfilled cylinder can be vented to a safe place without having to disconnect it from the filling line or move it in any way.

11.0 Non-refillable gas cylinders

Non-refillable gas cylinders up to 1.4 litre water capacity and above 5 litres water capacity are exempt from the requirements of the Regulations. Non- refillable cylinders in the range 1.4 to 5 litres water capacity must be made to standards or specifications approved by the Executive.

The only approved standards for non-refillable gas cylinders are DOT39 (HSE), *Specification for welded steel non-refillable transportable pressure receptacles,* that covers welded steel cylinders in the range 1.4 to 4.55 litres water capacity, and BSEN12205, *Transportable gas cylinders – Non-refillable metallic gas cylinders,* which covers all metallic non refillable gas cylinders with the following limitations:

- The maximum operating pressure not to exceed 250 bar.
- The product of pressure and volume not to exceed 1000 bar.litres.
- Where pressure exceeds 35 bar, volume limited to 5 litres.
- Where contents are toxic, volume limited to 2 litres.

Non-refillable gas cylinders are either supplied into the UK already filled with gas or they are filled once in the UK. The same Regulations apply in either case.

Non-refillable gas cylinders must never be refilled.

It has been noted by TD5 that the labelling on some non-refillable gas cylinders is not clear and the instruction not to refill the cylinder is small and hidden in amongst other text. The approved design standards require, in DOT 39(HSE) for the lettering to be 3mm high and in BSEN 12205 for the lettering to be a least 6mm high.

12.0 Conclusions

Pre-fill checks are extremely important and must not only include a look at the outside of the cylinder but must also scrutinise markings and labelling.

Calibration of pressure gauges and weighing scales must be carried out on a regular basis if confidence in actual filling conditions is to be achieved.

Gauges and scales need to be in the same units as those marked on each cylinder to be filled and display sizes should be sufficient to prevent misinterpretation.

Temperature compensation is required when filling any cylinder by pressurisation. This compensation is not required when filling by weight.

An automatic cut off should be fitted in the fill line to stop the fill operation once the pre-determined fill pressure or weight is achieved.

Cylinders that have been overfilled should be safely vented from the filling position, they should never be moved if overfull.

There are a limited number of approved design specifications for non-refillable gas cylinders in the range 1.4 to 5 litres. The warning labels on non-refillable gas cylinders are generally of poor quality and should meet the minimum requirements of the approved design specifications.