IN CONFIDENCE

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Objective

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

TESTS OF APPARATUS FOR DISPENSING PROPANE

by

E. H. Coleman

Summary

At the request of the Senior Chemical Inspector of Factories, Ministry of Labour and National Service - tests have been made of a device for decanting liquid propane from a large storage cylinder into small bottles, to determine the fire and explosion hazard in the vicinity of the apparatus due to escape of gas.

It has been shown that such a hazard exists, and is comparable with that from a kerbside petrol pump.

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Introduction

It is proposed to market, in Great Britain, a Swedish portable heating stove burning propane. The stove is fitted with small portable gas bottles which are recharged from large stock cylinders, which, it is suggested, would be operated at establishments such as garages.

The Senior Chemical Inspector, Ministry of Labour and National Service requested the Joint Fire Research Organization to examine the dispensing device so as to determine the likelihood of escape of gas, and the formation of flammable atmospheres in the vicinity of the apparatus while the bottles were being filled.

Description of Condrup Propane Decanting Valve

Messrs. Condrup Ltd., 67/73 Worship Street, London, E.C.2. supplied eighteen small bottles such as would be used on the stoves and also a stock cylinder of propane fitted with a special decanting valve. There was also a leaflet giving operating and installation instructions. (Appendix A).

The filling valve is shown in Figure 1.

The decanting valve is screwed by a coupling to the supply cylinder. The control is by a spring loaded lever, rotation of which through about 60° opens the valve fully and when the lever is released it returns to the closed position.

The small bottle is filled through a spring loaded valve operated by a small peg, depression of which opens the valve. Attaching the bottle to the outlet of the decanting valve depresses the peg and thus opens the bottle. A bleeder valve is fitted to the bottle and the open end, inside the bottle is fitted at a height to provide the correct ullage above the liquid level. The bleeder valve is opened one half-turn during filling, so that during the early stage of the filling process, it allows gas to discharge and when the bottle is filled to the level of the tube the discharge changes to liquid. The main decanting valve is then closed, and when the discharge from the bleeder valve reverts to gas, it too is closed. The content of propane is checked finally by weighing, excess propane being discharged through the bleeder valve. There is thus a continuous discharge of propane throughout the filling process. The report describes experiments made to measure the amounts of propane thus discharged, and the likelihood of an accumulation of explosive concentrations of propane around the filling point.

Experimental

Loss of propane during filling

Measurements of the loss of propane during filling were made with the apparatus installed in a compartment 6 ft x 6 ft x 6 ft (216 cu. ft) with one side open. The flammability of the atmosphere was measured with an explosimeter at 1 ft from the bleeder valve. The instrument had been calibrated with pentane and measured the concentration as a percentage of the lower flammable limit. It was known that the calibration would be substantially correct for propane (1).

Two series of experiments were made, with two operators who each filled three bottles. The weight of propane in the bottles was compared with the weight lost from the stock cylinder. The time for filling was also noted. The results are given in Table 1.

Table 1

Loss of propane during filling

Experiments in open side compartment 6 ft x 6 ft x 6 ft
Temperature 17°C. Relative humidity 67 per cent

Bottle No.	Time for filling sec.	Explosimeter reading per cent of lower flammable limit+	Weight of propane in bottle ø g	Difference from correct weight g	Total weight in bottles g	Total propane lost from cylinder g	Average loss per bottle during filling g	Average total loss Total g
Operator "A"*								
1	33	40	372	+32				
2	35	80	369	+29	1094	1303	70	94
3	34·5	95	353	+13				
Operator "B"*								
1	44	55	339	-1				
2	45	40	363	+23	1037	1247		70
3	45	60	335	-5				

+ The lower flammable limit of propane is 2·2 per cent by volume.
ø The weight of propane, as stamped on the bottle should be 340 gm.
* Operators A and B who were both skilled in laboratory techniques, used slightly different operating methods.
"A" shut the bleeder valve and decanting valve simultaneously, then removed the bottles for weighing, and excess liquid was discharged later.
"B" closed the decanting valve as soon as liquid discharge was observed, but did not close the bleeder valve until the discharge reverted to gas. The times given therefore include about 14 seconds after the decanting valve was closed and the actual filling times were about 30 seconds. This would probably be the more normal method of filling.

Loss of propane from the decanting valve

The instructions state that before connecting a small bottle for filling, the line should be cleared of air by momentarily opening the decanting valve. The valve was opened for 10 seconds with no bottle attached and 113·5 gm of propane was discharged.

Loss of propane from the bleeder valve

The bleeder valve is required to be open throughout the filling operation and thus propane is being discharged. Measurements were made of the rate of discharge of propane with the valve open at one half turn (as recommended in the instructions) and at one complete turn.

The valve was opened for 30 seconds and the loss of weight measured, and the procedure repeated until the propane was discharged. The discharge cooled the valve and bottles, and frost and ice were formed, therefore, the bottles were not weighed until this frost had thawed. With one cylinder, 22 gm of frost formed after three discharges each of 30 seconds. This may be important as the operator is instructed to check the contents by weighing.

The discharge experiments were made in the open air with a wind of less than 5 m.p.h. and explosimeter readings were taken at distances of between 1½ and 2 ft from the bleeder valve.

The results are given in Table 2.

Table 2

Loss of propane from Bleeder Valve

Experiments made in open air
Temperature 16·4°C. Relative Humidity 60 per cent. Wind < 5 m.p.h.

Total time of discharge min.	Loss of weight gm			
	Bottle numbers 1	2	3	Average
Valve open one half turn				
½	88	52	67	70
Valve open one complete turn				
½	123	63	93	80

Discussion of results

Loss of propane during filling

The figures in Table 1 show that each time a bottle is filled about 70 gm of propane are discharged into the atmosphere. From Table 2 and Figure 1 it appears that most of this is discharged through the bleeder valve during filling. With slower operation of the valves the bottles are over filled and discharge of the excess propane will increase the hazard to some extent.

Flammability of the atmosphere

Explosimeter readings taken during the filling operation varied between 0 and 100 per cent and the readings in Table 1 are averages. When filling three bottles the total quantity of propane discharged was 210 gm which would occupy 107 litres. In the compartment of 6100 litres (216 cu. ft) this is 1·7 per cent by volume or 77 per cent of the lower flammable limit of 2·2 per cent. Thus, filling a succession of bottles in a small compartment can produce a hazardous concentration of propane gas. It should be noted however that the manufacturer's instructions state that filling should be in the open air.

During the experiments on rate of loss of propane explosimeter readings were taken at about 18 in. distance, down wind, and in the same horizontal plane as the bleeder valve. In the open air and with a wind of less than 5 m.p.h., concentrations varied from 20 to 95 per cent of the lower limit, higher readings were obtained when the sampling tube was in the stream of gas issuing from the valve. It may be assumed therefore that the atmosphere within a radius of two feet from the bleeder valve would be hazardous. In a closed space the danger radius would be greater.

L. Katan [2] examined the flammability of the atmosphere in the vicinity of the openings of aircraft petrol tanks during refuelling, and calculated safe distances for different rates of filling and different wind speeds. While this is not strictly applicable to other conditions it would appear probable that the hazard of refilling propane bottles in the open air is of the same order as that of refuelling a car from a kerbside pump delivering petrol at 12 g.p.m. as assessed by Katan's formulae [2].

Other observations

Smell

The propane contained a stenching agent and this was noticeable at concentrations much lower than those giving a just perceptible reading of the explosimeter. It was not possible to work continuously in the open sided compartment as the operators could not tolerate the smell for more than 10 to 15 minutes.

Operation of the valve

The rapid discharge of gas through the bleeder valve during filling produces a coating of frost round it. A suitable tool should be provided so that the valve can be manipulated without danger of freezing the operator's fingers. The threads of the coupling on the bottle should also be arranged so that the valve is always accessible, and also, the stream of cold gas from the valve does not play on the operators fingers. Any decrease of the time taken to operate the valve reduces the amount of propane discharged into the atmosphere.

Check weighing

During discharge from the bleeder valve and also during filling, frost collects round the valve. The contents are required to be checked by weighing, and to obtain a correct weight the bottle should be allowed to thaw. However, since immediate weighing means that the contents will be less than those indicated this does provide an additional safeguard against over filling.

CONCLUSIONS

The experiments have shown that there is a hazard from formation of flammable atmospheres when filling propane bottles with the Condrup decanting valve from a storage tank. The hazard is increased if the filling is done in a small compartment and not in the open air as recommended in the instructions.

In the open air the danger would probably be comparable with that from a kerbside petrol pump refuelling a car at 12 g.p.m.

The design of the bottle should be such that the valves are located more conveniently.

The stenching agent is an adequate warning of the presence of the gas.

References

(1) E. H. Coleman and M. D. Perry. The Performance of Explosimeters Part 1. F.R. Note 214/1955. September, 1955.

(2) L. Katan. The Fire Hazard of Fuelling Aircraft in the Open. Fire Research Technical Paper No. 1. H.M.S.O. 1951.

PC.

APPENDIX A

Instructions for filling (from instruction leaflet)

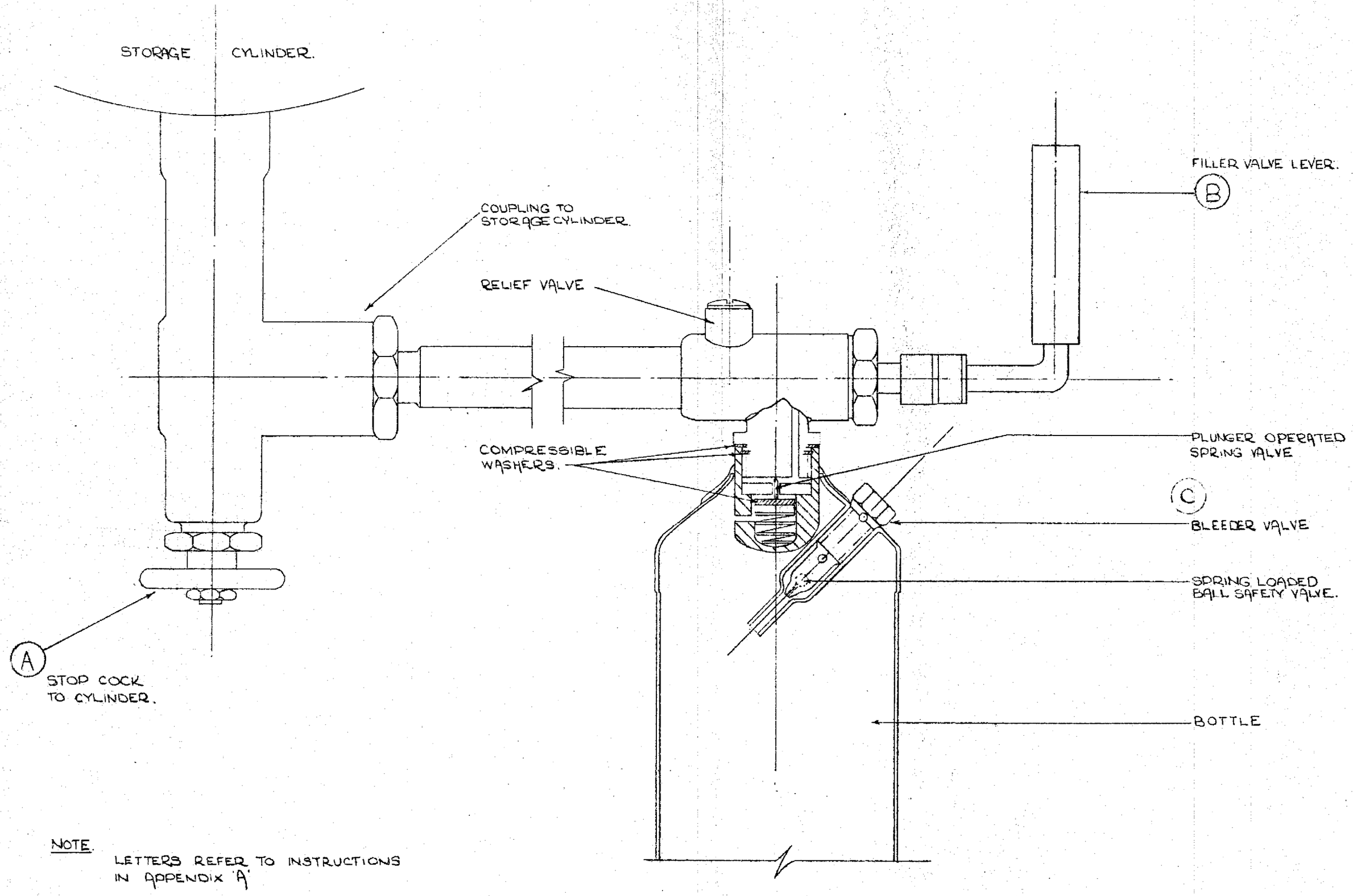
1. Place the storage cylinder in the filling stand (valve down).
2. Connect the bottle to the storage cylinder with the filler coupling.
3. Back out the bleeder valve screw (C) $\frac{1}{2}$ turn.
4. Open valve A on the storage cylinder.
5. Turn lever B clockwise; this opens the filler valve.
6. As soon as the gas coming out of the bleeder valve changes to liquid, release lever B to close the filler valve.
7. Close the bleeder valve (C) as soon as the flow of liquid changes to gas again.
8. Close valve A.
9. Disconnect the bottle from the filler coupling.
10. Weigh the bottle and adjust the weight if necessary. The correct weight is the tare of the bottle plus the weight of the maximum permissible quantity of propane. This information is stamped on a ring at the neck of the bottle.

CAUTION

Propane gas comes out through the bleeder valve while the bottle is being filled, and also at the fitting when it is being disconnected. Propane is inflammable, and when mixed with air it may be explosive. Bottles should be filled outdoors. There must be no open flame, sparks, or the like near the filling site.

A copy of these instructions should be posted at the filling site.

Before filling any bottles, notify the local authorities and have them inspect and approve the site and the filling arrangements.



NOTE.

LETTERS REFER TO INSTRUCTIONS IN APPENDIX 'A'

FIG. 1. SKETCH OF CONDRUP PROPANE DECANTING VALVE