Health & Safety Executive OC 449/7

Field Operations Division

To

Factory Inspectors

FCG Specialist Inspectors (Process Safety)

Offshore Safety Division Inspectors

PREVENTION OR CREATION OF LIQUID SLUGS IN FLARELINES

This OC summarises a number of recent potentially serious incidents involving flareline systems in refineries and recommends measures to prevent their reoccurrence.

Introduction

1 Several problems connected with the operation of flare systems at refineries have come to light. They are concerned with the dangers of liquid accumulations in such systems, or simultaneous vapour and liquid releases resulting in the propulsion of liquid slugs along the flareline. A summary of incidents is given in Appendix 1.

Discussion

2 Flarelines are installed for the safe disposal of routine and emergency gaseous emissions from process plant. However, under some circumstances, they have to be designed with restraints to cope with liquid. This can arise from a number of sources:

(1) condensed hydrocarbon gases and steam which have been fed to the flare;

(2) liquid carried over from high pressure plant when rapid acting emergency depressurisation valves are opened; and

(3) dense phase mist flows due to two-phase flashing relief flow where only large liquid droplets are separated by the knock out pot, or where simultaneous vapour and liquid releases can occur and the vapour entrains small droplets before entering the main flareline.

3 It is generally considered impractical to design the supports and restraints of flareline systems to cope with the large mechanical reaction forces which arise when liquid slugs of possibly several pipe diameters in length are driven into bends at vapour release velocities. It is therefore vital that no gross liquid slugs enter flarelines. The knock out pot facilities should therefore be designed, instrumented, and operated so that they can never become full of liquid if there is a possibility of vapour flow occurring which might scoop up slugs of liquid. Plant instructions should prohibit start-up or other significant changes unless the full knock out pot capacity is available, and the knock out pot should be run at the minimum level to give the operator the maximum amount of time to respond if it does start to fill.

4 The conventional, and preferred design, is to slope the flareline down to a knock out pot before the flare stack. This is not always possible and local knock out pots should be provided when suitable slopes cannot be incorporated. It should be noted that such pots are likely to be needed to handle liquid carryover during emergency depressurisation. If they are not fitted occupiers must demonstrate that liquid carryover from the process plant is not possible, or that its potential effects can be accommodated by the plant.

5 If carryover is not possible then simpler drainage arrangements may be acceptable. In these circumstances the following principles should be adhered to:

(1) drainage pots and lines should be designed so that the chances of blockage are minimised. Large diameter lines (200mm diameter or over) and lines connected to the side of sumps might be appropriate;

(2) an easily operated and effective means of checking that drain lines are free should be provided. Bleed valves are a simple way of achieving this, although it is important to be aware that small bore bleed valves can become blocked. It may be possible to fit a second valve plus a pressure gauge, together if necessary with an inert gas supply to the inter valve space, so as to be able to test the line for freedom from blockage; and

(3) inspection of drain lines should be routinely undertaken and the results formally recorded.

Design codes

6 The potential for liquid to accumulate in flarelines is well recognised. It is addressed in the 2 main design codes- the Institute of Petroleum's, *Refining safety code (Part 3 of the Model Code of Safe Practice)* [file 449] and the American Petroleum Institute's, *Recommended Practice 521, Guide for pressure relieving and depressurising systems*, a copy of which is held in Bootle St Hugh's Information Centre. Scale, rust and sludge are always likely to be present in the flareline. The HSE report into the BP Grangemouth flareline fire, *The fires and explosion at BP Oil (Grangemouth) Refinery Ltd, [file* 254] draws attention to this and highlights the problem of the blocking of small bore pipework on refinery flare systems.

7 The design codes state that it is not necessary to assume the simultaneous occurrence of 2 or more unrelated events. Additionally it may have been assumed in the design that only one relief valve would lift, but the dynamics of process upset may be such that 2 relief valves lift in close succession. The interpretation of "unrelated" needs careful consideration. A "relation" may not, for instance, be due to the process characteristics or to a common utility failure, but may instead be caused by operator overload when the plant is in a very upset condition.

ACTION BY INSPECTORS

8 Flare systems are provided as a last line of defence against a major accident. Adequate design and maintenance, particularly where low points exist, is an important topic which it may be appropriate for inspectors to select for inspection.

9 Prevention of liquid accumulation is central to safe operation. The following should be regarded as matters of serious concern:

(1) The lack of knock out pots without detailed justification;

(2) The presence of small bore drains. In particular those less than 75mm diameter should be regarded as suspect.

(3) The lack of regular formal checks on drainage arrangements.

10 It is vital that no gross liquid slugs enter flarelines. Managers should be able to demonstrate that credible near simultaneous vapour/liquid releases have been assessed.

11 It is important that the knock out pot facilities are designed, instrumented, and operated so that they can never become full of liquid if there is a possibility of vapour flow occurring which might scoop up slugs of liquid. Plant instructions should prohibit start-up unless the full knock out pot capacity is available.

12 Managers of sites with flarelines should be asked to take account of these factors when carrying out risk assessments and deciding on the appropriateness of their control measures.

13 FCG assistance may be required particularly where knock out pots are not provided. The Chemical Manufacturing NIG, Area 17, should be informed of any problems Inspectors come across when pursuing such issues.

26 November 1993

(FOD/1438/1993)

Disc No: FODA1.ED/J047/11.93/DH

NEW REF: J:\EDITORS\CA1\OCFILES\449_7.SAM

ASI headings

Flarelines: gas(es): process plant: pollution: refineries: vapour.

APPENDIX 1

(para 1)

INCIDENTS

1 Sections of flarelines at refineries have been partially or fully displaced from their mountings. Incidents of this type have the potential to result in major accidents. These occurred:

(1) During emergency depressurisation of a depropaniser column due to liquid accumulation at a low point in the flareline which led to a liquid hammer effect when the pressure front from the depropaniser hit the liquid. The drain pot had blocked with solid debris because its drainage line was a narrow diameter (37mm) and the design precluded routine checks to ensure that it was free. Liquid had accumulated in the flareline until it was nearly liquid full. Subsequent checks on other flare systems identified 2 low points, one had no apparent means of draining liquid and the other had similar drainage pot problems.

(2) The tripped interlocks of the outlet valves on a vessel were not reset prior to plant start-up. This resulted in the over full vessel venting liquid via its relief valve to the knock out pot. The upset conditions created during the plant restart resulted in operation of a high pressure vapour relief valve, leading to the liquid in the full knock out pot being propelled down the flareline.

2 In another refinery flareline incident liquid hydrocarbon was blown out of the flare stack, ignited at the stack and fell to the ground where further hydrocarbons were ignited. Important factors leading to the incident were:

(1) The knock out pot designed to disengage liquid entrained in a gaseous flow had excessive liquid in it due to a blocked filter on the off-take pump. Further the automatic level control system on the knock out pot had been disabled and the high level alarm was being used to initiate manual operation of the pump.

(2) The downstream seal pot had a continuous flow water seal in order to maintain a seal and prevent flashback. It was fitted with a separate skimmer line to drain off any residual liquid hydrocarbon. The liquid from the knock out pot was carried over to the seal pot and was held there because the skimming drain line was blocked with waxy deposits from previous emissions from the process plant.