Report to Procurator Fiscal

ICL Expert Evidence

Factual Report on Guidance

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Date: 27th November 2006

Revised September 2008

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Qualifications and experience of the author

1. I am Penny Taylor, a Chartered Chemical Engineer since 1995. I was awarded a Bachelor of Engineering with Honours from the University of Bradford in 1991 and a Post Graduate Certificate in Occupational Health and Safety from Aston University in 2000.

2. I have 8 years experience in the chemical industry, predominantly as a process engineer where my duties included process design and safety evaluation of new or modified equipment and systems. I later held the position of safety engineer where my responsibilities included engineering safety assessment of designs and procedures (including advising on risk assessments), investigation of incidents, emergency response to major site incidents and oversight of a major plant shutdown.

3. I joined the Health and Safety Executive (HSE) in 1998 as a Specialist Inspector of Process Safety working in what is now known as the Process, Materials and Systems Safety Corporate Topic Group, currently based in HSE's Corporate Specialist Division. I took over the role of LPG process safety technical topic lead in 2002 and continued to fulfil some of those functions until July 2008. My remit included providing technical guidance and advice to others in HSE and to external parties such as employers and trade associations. I became a Principal Specialist Inspector of Process Safety in May 2005 with responsibility for pressure systems, which includes containment of hazardous substances. Since July 2008 I have been on attachment to HSE's Planning, Finance and Procurement Division as a project manager.

4. In May 2004, at the time of the ICL explosion, I was a Specialist Inspector of Process Safety in the Process Safety CTG. My role included the HSE process safety technical lead on LPG and its remit included providing technical guidance and advice to others in HSE and to external parties such as employers and trade associations. I became LPG technical topic lead in 2002 and fulfilled some of those functions until July 2008.

5. My role as technical lead for LPG included providing and disseminating technical advice on operational policy decisions and interpretation of legislation and guidance to Process Safety Specialists; Specialist Inspectors of other disciplines; and colleagues in Safety Unit, Utilities Sectors and Policy Directorate. This required discussion with specialist colleagues of other disciplines to ensure the advice or guidance provided did not adversely impact on other disciplines. My role was also to obtain information on the practical aspects of applying the guidance and to identify emerging issues: This was done through discussions with Process Safety Specialist Inspectors in the operational directorates and reviews of centrally collected information. Part of my role of providing guidance to HSE colleagues and external stakeholders included working closely with the LP Gas Association (LPGA) to review and revise their Codes of Practice.

1. Introduction and scope

6. The report summarises the main points of external guidance relating to LPG from 1959 to 2004, with particular reference to the specifications for installation and subsequent maintenance and inspection requirements for underground pipework. Comment has been given where possible regarding the scope of the guidance and its intended audience.

7. HSE's involvement with LP Gas Association and the LPGA Codes of Practice is briefly discussed.

2. External guidance 1959 to 2004

2.1 Summary of guidance

8. LPG specific guidance has not been identified before 1961. Since 1959 there has been guidance, published by the Institution of Gas Engineers (IGE), on the laying of steel gas service pipes . Though it is primarily aimed at the mains gas industry it is referenced in some of the later LPG guidance.

9. The main LPG industry guidance was the Code of Practice published, reprinted and revised on several occasions to date by the main LPG trade association the Liquefied Petroleum Gas Industry Technical Committee (LPGITC), later called the Liquefied Petroleum Gas Industry Technical Association (LPGITA) and LP Gas Association (LPGA). Additional guidance has been produced through various central Government bodies (Ministry of Labour, Home Office and HSE) as well as other industry bodies (the Institution of Gas Engineers, the Institute of Petroleum, Fire Protection Association, European Liquefied Gas Association (AEGLP) and the US National Fire Protection Association (NFPA)).

10. This section of the report summarises the main points of the guidance, with particular reference to underground pipe work; the specifications for installation and the subsequent maintenance and inspection requirements. Comment has been given where possible regarding the scope of the guidance and its intended audience.

11. The later guidance should be considered within the context of the relevant health and safety legislation in force at the time of each milestone event. Details of relevant legislation are covered in the evidence of others. HSG34, and later versions of those LPGA Codes of Practice endorsed by HSE are identified as demonstrating good practice and as one way of achieving an acceptable standard of safety. However, they should not be regarded as an authoritative interpretation of the law. HSE's foreword is only contained in those LPGA Codes of Practice covering topics previously included in HSG34.

2.1.1 Installation standards

12. In 1969 when the LPG system was initially installed at ICL there were six guidance documents of relevance, five of which were LPG specific. The most

detailed was IGE Communication No. 563 and although aimed at mains gas it may have been used by the LPG industry prior to LPG specific guidance being produced.

13. The guidance produced by IGE in 1959 (Communication No. 563) presented a standard for gas pipe installation which identified the hazard of corrosion to steel service pipes. It addressed that hazard by requiring corrosion protection by coating or wrapping the pipework where it was below ground and extending that wrapping by at least 2 ft above ground level. It identified the trench and backfill requirements to reduce the likelihood of damage to underground pipes, required sleeves at walls to prevent damage to the pipe and sealing of the sleeve annuli to prevent leaking gas entering the building. Much of this detail emerges in later revisions of the LPGITC guidance.

14. The LPGITC guidance initially only dealt with the installation up to the first stage regulator and hence did not give detailed information on the requirements for underground pipework or its corrosion protection. Although the April 1969 revision discussed corrosion protection of underground vessels it only required the pipework to be resistant to the actions of LPG. This revision allowed for a medium weight steel pipe whereas the IGE Communication No. 563 specified heavy weight steel.

15. The Fire Protection Association (FPA) booklet 'Storage and handling of Liquefied Petroleum Gases' identified the hazard of corrosion to pipes and risk associated with basements where escaping gas could accumulate.

16. The Institute of Petroleum Model Code of Safe Practice Part 9, also published as the Institution of Gas Engineers IGE/SR/6, was the only document at the time to require that the location of all pipes and valves be known, and that those responsible for the operation and handling of LPG should be aware of the guidance. It also requires that piping should be protected against physical damage and corrosion.

17. The Safety, Health and Welfare Booklet No 30 produced by the Ministry of Labour in 1965 did not set out to be a detailed guide to the design and installation but made reference to NFPA Codes 58 and 59, and LPGITC Code of Practice.

18. Buried pipelines are first addressed in the 1974 LPGITA guidance and it is at this point that the guidance covers the distribution system up to the consuming equipment. It deals with corrosion protection of underground pipework to prevent corrosion by soil conditions and includes aspects of maintenance, inspection and testing of both pipework and vessels. However the Home Office Code of Practice, later reissued as HSE Guidance Note CS5, still only covers systems up to the first stage regulator.

19. In conclusion the guidance available at the time of installation demonstrates that there was sufficient industry knowledge to identify a suitable standard for an underground pipe installation with regards to corrosion protection, location and entry point into buildings.

2.1.2 Inspection and maintenance

20. The maintenance section of LPGITA Code of Practice 1 (1974) requires comprehensive instructions covering maintenance to be provided at commissioning. It states that buried pipelines should be surveyed for leakage at a frequency dictated by the risks associated with their location, pressure of operation and aggressiveness of the environment.

21. This aspect of the guidance has relevance for the ICL installation. Whilst the original installation in 1969 would not have been subject to this edition of the guidance the change and repositioning of the tank will have necessitated the commissioning of the new tank and connection to the existing pipework. It may be argued that the information on the maintenance requirements could have been provided at that point.

22. The 1974 LPGITA Code also states that all fittings not specifically covered should be checked at intervals not exceeding one year. In section 7.16 it states that external anti-corrosion systems of vessels, pipelines and equipment should be inspected annually; it does not state whether this is applicable to systems above ground, underground or both.

23. By 1986 LPGITA Code of Practice 1 Part 3 charges the LPG supplier with ensuring that LPG users are aware of the importance of carrying out a scheme of inspection. The Code reiterates the risk-based approach to identifying the frequency at which the underground pipework should be surveyed for leakage but states that the system should have been designed and installed in accordance with LPGITA Code of Practice 1 parts 1 or 2. A leakage survey should be carried out at least every 10 years for installations operating at 5 bar or above. This survey may be a repeat of the pressure tests. LPGITA guidance is prescriptive in the broad type of inspection for different pipework designs and operating pressures/ fluids. However I do not understand prescriptive to mean that the details and frequency of the inspection are specified in all cases. The prescriptive guidance is based on the assumption that the installation standard is known and acceptable and does not discuss installations that are not designed in accordance with the relevant guidance."

24. HSE guidance HSG34 required the installation to be maintained to an acceptable standard with the objective of maintaining the safe operating limits; and emphasis to be placed on features affecting the integrity of the installation. The standard expressed is goal setting. HSG34 develops the detail of maintenance further, but in reference to underground pipework it deals only with pipes carrying liquid. No specific mention is made of pipes carrying vapour; paragraphs 182 and 183 refer to the installation rather than the vessel but 'installation' in this context is not defined in HSG34.

25. The LPGA Code of Practice 1 Part 3 2000 revision reiterates the periodic inspection of underground pipes below 5 bar as requiring survey for leakage at a frequency dictated by the risks of location, operating pressure and environment as before. It adds that surveying for leaks should be by an appropriate means such as pressure testing, gas detection, etc. It is again assumed that the system has been designed and installed in accordance with

Code of Practice 1 parts 1, 2, 4 and other relevant LPGA CoP's or equivalent standards. There are no additional requirements to examine the condition of such pipework or corrosion protection of pipework operating below 5 bar".

26. I reviewed guidance over the period 1959 to 2004 and the first mention of inspection and maintenance of pipework occurred in 1965. The inspection and maintenance guidance current between 1965 and 2004 aimed to ensure the continuing integrity of the system. The broad types of inspection and maintenance prescribed for underground pipework operating below 5 bar would only have surveyed for leakage; there was no requirement to excavate and examine the condition of the pipe or the corrosion protection. The frequency of such survey is based on the risk associated with the installation, and in addition the inspection and maintenance prescribed assumes that the system was installed to relevant codes. It may therefore have been necessary to excavate and examine the pipe in order to determine the installation standard and risk associated with it.

2.2 Institution of Gas Engineers guidance:

2.2.1 Laying of steel gas pipes: Communication No. 563 and IGE/TD/4

IGE Communication No. 563

27. The Institution of Gas Engineers published Communication No. 563 'Recommendations for the laying of steel gas service pipes' in December 1959. The recommendations supplement BS Code of Practice 331.101 'Gas service pipes'. They deal with the service pipe from the gas main to the consumer's control; they are intended to apply to steel and are also appropriate to cast iron but not other materials such as copper or plastics. The publication does not give an upper pressure limit for the applicability of these recommendations but section VIII discusses steel services operating in excess of 70 pounds per square inch (approximately 4.8 bar). For cast iron, in sections IV and VIII(B), the reader is referred in to Communication 491 'Recommendations for main laying'.

Materials

28. Section IV of the recommendations outlines the materials to be used for an installation. For services with screwed connections up to and including 3 inch diameter, *"heavy"* quality steel tube and tubulars to BS 1387 internally coated with red lead/oil paint to BS 2523 should be used. Galvanised tubes may be used. Nevertheless all tubes, tubulars and fittings should be suitably protected externally. Screw threads for tubulars and fittings should conform to BS 21. For larger services it recommends use of steel pipe, again suitably protected, or mechanically jointed cast iron pipes.

Excavation

29. Section VI outlines the requirements for the excavation. It requires that the service pipe where possible should be in a straight line and at right angles to the

main. The trench should be excavated so that the service pipe is bedded throughout its length on firm ground free from stones, rock, brick, concrete, etc. The topsoil or surface material should be kept separate from the excavated subsoil for subsequent replacement. The minimum cover on the pipe should be 12 inches.

Laying Steel Services

30. Section VIII(A) outlines the requirements for laying steel services including sleeving, coating and wrapping. Where the service pipe enters a building through a cavity wall with a sleeve of non-combustible material should be built into the wall, the internal diameter of the sleeve being at least 1 inch greater than the external diameter of the service pipe. When underground, the ends of the sleeve should project at least 1 inch beyond the finished wall surfaces. Sleeves in solid walls or through foundations may be required. It does not indicate in what circumstances they would be required. A similar sleeve may be provided when a service pipe or riser passes through any partition wall or floor.

31. The section states that the pipe should be set centrally in the sleeve and the space between the pipe and sleeve should be filled throughout the length of the sleeve by an appropriate material. Where the service pipe passes through the outer wall of premises a bitumous or similar non-setting material is appropriate. Where the service pipe passes through an inner wall or floor of the premises the space should be filled by a non-combustible material. The space between the sleeve and the structure should be filled with cement mortar throughout the thickness of the wall.

32. It further states that where a steel service pipe is laid on the outside wall of a building coated and wrapped pipe should be used to a minimum of 2 ft above ground level. The portion of the service pipe that enters the building should be fabricated with the minimum number of joints and be tested for soundness. Bare parts that are to be installed below floor level should be wrapped before being placed in position.

Testing, Wrapping & Backfill

33. Section IX requires that a pressure test is made before the protective wrapping is applied to the joints.

34. Section X covers wrapping of steel services and requires that exposed threads and unwrapped parts of the pipe and fitting should be protected with paste and wrapping, or other approved material and the wrapping should overlap the existing wrapping for at least 2 inches. Care should be taken in handling wrapped pipe to avoid damage to protective coatings, and any faults should be repaired by cleaning the damaged area and re-wrapping.

35. Section XI requires backfilling by subsoil free of stones and other hard substances which should be firmly packed around the pipe to 3 inches of cover, care being taken to not to damage the wrapping. The subsequent backfill should be firm and consolidated.

IGE/TD/4 1973

36. The Institution of Gas Engineers published Communication No. 879 'Recommendations on transmission and distribution practice IGE/TD/4 laying of steel and ductile iron gas service pipes' in November 1973. Many recommendations from IGE Communication No. 563 remained the same but some changes were made to the wording of relevant sections; these are now discussed.

Materials

37. In the 1959 document it required *"heavy"* quality steel tube and tubulars to BS 1387 to be *"internally coated with red lead/oil paint to BS 2523"*. In the 1973 version of IGE/TD/4 this changes to *"suitably protected against corrosion"*. In 1959 after allowing use of galvanised tubes and fittings it says, *"Nevertheless all tubes, tubulars and fittings should be suitably protected externally"*; but in 1973 this changes to, *"In addition all tubes, tubulars and fittings should be protected externally"*.

38. In 1959, *"Screw threads for tubulars and fittings should conform to BS 21"*; but in 1973 this is extended to include *"or another suitable standard"*. For larger services both documents recommend suitably protected steel pipe but in 1959 it gave *"mechanically jointed cast iron pipes should be used"* laid in accordance with IGE Communication 491 as an alternative; in 1973 this changes to *"mechanically jointed ductile iron pipes which should be used and laid in accordance with IGE/TD/3 Mainlaying"*.

Laying

39. In the 1973 document welded, flanged taper/ taper screwed joints are preferred for steel service pipes above 2 bar pressure; this has been reduced from approx 4.8 bar (70 lb/sq in) in the 1959 document.

40. In 1959 section VI stated that *"Where a steel service pipe is laid on the outside wall of a building, then coated and wrapped pipe should be used to a minimum of 2 ft above ground level"*; in 1973 the requirement was for protected pipe to be used to the same height above ground level.

41. In the 1959 document it states that where a service passes through a cavity wall a sleeve should be provided, in 1973 this is expanded to include *"... a solid floor, load bearing or cavity wall"*. Furthermore in 1959 the sleeve should be of *"non-combustible"* material, in 1973 this had changed to *"non-corrodible"* material.

42. Both documents state that the space between pipe and sleeve should be filled with non-combustible material where the pipe passes through an inner wall or floor. However the 1973 document states, *"Where the service passes through the outer wall of a building a non-setting material is appropriate"*; the 1959 document states, *"a bitumous or similar non-setting material is appropriate*".

43. In 1973 section VI was expanded to include a statement that no service pipe should be installed under foundations of a building or under the base of a load-bearing wall. It also included a recommendation that electrical cross-bonding

between gas and other services should be applied to the installation pipes in accordance with documents produced by the Institute of Electrical Engineers.

Testing, Wrapping & Backfill

44. The 1973 version IGE/TD/4 section VIII on testing, reiterates the requirement for the pressure test before applying the protective wrapping to the joints.

45. Section IX in the 1973 revision is entitled External Protection of Steel Services, the equivalent section in 1959 is section X entitled Wrapping of Steel Services. The wording of the section in 1973 is altered slightly from the 1959 edition in that it refers to coating rather than wrapping and requires that the *"pipes and fitting be protected by a method approved by the gas undertaking".* It further goes on to require that the protection applied on site should overlap the existing coating for at least 50mm (2 inches), that care should be taken in handling coated pipe to avoid damage to the coating, and any fault in the coating should be made good.

46. Sections on backfill in both documents (XI in 1973 and X in 1959) require backfilling by *"Subsoil free of stones and other hard substances which should be firmly packed around the pipe to 3 inches of cover, care being taken to not to damage the wrapping"* despite this terminology *"coating"* is being used elsewhere in the 1973 document.

IGE/TD/4 Edition 2 1981

47. The Institution of Gas Engineers published the 2nd Edition of IGE/TD/4 'Gas Services' in December 1981 as Communication No. 1180. They apply to services intending to operate at pressures not exceeding 7 bar gauge; and apply to pipe diameters up to and including 50mm nominal bore for steel pipes and 63 mm outside diameter for polyethylene pipes. The recommendations *"do not attempt to make the use of any method or specification obligatory against the judgement of the responsible engineer. Where new and better techniques are developed and proved, they should be adopted without waiting for modification of these Recommendations"*. The introduction states, *"Services laid to Edition 1 recommendations and prior to publication of Edition 2 are considered to be satisfactory for continued use. When these require relaying, however, they should be laid to Edition 2 standards"*.

48. The 1981 revision IGE/TD4 Edition 2 removes the reference to galvanised pipes but instead requires service pipes to be constructed of material inherently resistant to corrosion or suitably protected against corrosion. In Edition 2 the pressure above which welded, flanged or specially designed compression joints are preferred for steel service pipes has been reduced to 75 mbar from 2 bar for welded, flanged or taper/ taper screwed joints in Edition 1.

49. The 2nd Edition states, *"Where a (steel) service pipe is to be installed on the outside wall of a building, wrapped pipe should be used to a minimum of 150mm above ground level"*; in 1973 the requirement was for protected pipe to a minimum of 600mm (2ft) and in 1959 section VI stated that, *"Where a steel*

service pipe is laid on the outside wall of a building, then coated and wrapped pipe should be used to a minimum of 2 ft above ground level".

50. The 2nd Edition's section 8 entitled entry into buildings states that above ground service entries should be used wherever possible; in exceptional circumstances a below ground entry may be used. It goes on to stipulate at 8.1.4 that service pipes should not be installed in an unventilated void space. Section 8 states that *"Wherever a sleeve or duct is used for service entry the space between the sleeve and structure should be made good and the space between the service pipe and sleeve should be sealed to prevent gas ingress"*. It asks the reader to consider the use of all-welded installations in industrial, commercial and all but low-rise domestic premises. The 2nd Edition's section 8.6 states that, *"Where the service enters a building, a sleeve of material resistant to or protected against corrosion should be built into the wall"*.

51. Section 9 of the 1981 revision details procedures for renewing service pipes. Section 11 gives a detailed description of protection of steel services from corrosion and includes how the wrapping should be applied. Section 11.3 entitled selective backfill states *"In aggressive soils it may be appropriate to surround the service pipe with limestone dust or other inert material"*.

IGE/TD/4 Edition 3 1994

52. The Institution of Gas Engineers published the 3rd Edition of IGE/TD/4 'Gas Services' in November 1994 as Communication No. 1562. The introduction extends the scope to reflect the predominant use of polyethylene pipe and the increasing use of LPG for which, as a 3rd family gas, a new section has been prepared. This edition states, *"Services laid to the previous recommendations (Communications 879 and 1190), prior to publication of this edition are considered to be satisfactory for continued use with 1st and 2nd family gases but may not be satisfactory with 3rd family gases. However when re-laying the new pipes should be installed to the recommendations contained herein"*. For LPG the recommendations apply to services supplied from bulk storage vessel installations where the service pipe connects the first stage regulator (installed at the vessel) to the emergency control valve.

53. This edition states, *"The materials of construction should take into account the properties of the gas being transported, the environment and any potential hazard in the particular location"*.

54. With respect to entry into buildings, the 3rd edition rewords parts of the requirements to, *"Where a service is installed so as to pass through any wall or floor of solid construction: (a) The service pipe should be enclosed in a sleeve and; (b) The service pipe and sleeve should be so constructed and installed as to prevent gas passing: (i) Along the spaces between the pipe and sleeve and, (ii) Between the sleeve and the wall or floor. In addition, normal movement of the pipe should be allowed for"*.

55. Section 6.3.3.8 states, *"In addition to wrapping and in exceptional circumstances, such as in the presence of highly corrosive soils and where*

damage to the protective wrapping can occur as a result of interference, consideration should be given to cathodic protection of a steel service".

56. Section 10 is entitled *"Additional measures when dealing with 3rd family gas systems"*. It refers to un-named Health and Safety guidance and industry codes of practice, specifically the LP Gas Association COP 22. It highlights that propane and butane are both denser than air and that special attention should be paid to the proximity of voids, pits, cellars and unventilated spaces when selecting the route of LPG services. It points out that LPG may degrade natural rubber, jointing compounds, grease and many synthetic materials; and therefore all materials should be certified as suitable for LPG and its application.

2.2.2 Safety Recommendations IGE/SR/6 Liquefied Petroleum Gases (1968).

57. In July 1968 the Institution of Gas Engineers published this booklet, the text of which had been prepared by a sub-committee comprising representatives of the Institute of Petroleum, Institution of Gas Engineers and Liquefied Petroleum Gas Industrial Technical Committee. It has also been published as Part 9 of the Institute of Petroleum Model Code of Safe Practice and is discussed further under that heading.

2.2.3 Gas installation pipework, boosters & compressors on industrial and commercial premises IGE/UP/2.

58. In September 1994 the Institution of Gas Engineers published this booklet as Communication No. 1598. The introduction states that the procedures provide guidance on the installation of gas pipework and certain ancillary equipment on industrial and commercial premises. It covers similar subject matter to former British Gas plc publications IM/16 and IM/15 but includes much additional and enhanced information.

59. The scope includes installation pipework designed to convey, *"3rd family gases in the gaseous state, for example LPG"*, for a design pressure not exceeding 2 bar.

60. Section 7 deals with general principals for installing pipework with sections 8 to 12 giving more detailed guidance depending on the situation. Areas covered include: location, construction and sleeving, pipework protection and clearances.

Buried pipework

61. Section 8 covers buried pipework and recommends the route for buried pipework avoids (amongst other things) areas of known or suspected aggressive soil conditions; proximity to any structure known to have unventilated voids; areas over which heavy traffic will pass. Pipework protection is covered in 8.2. In general, pipework should be buried in such a manner that: accidental damage to pipe, fittings or wrapping is unlikely; it is guarded against physical damage e.g. rocks, sharp material, traffic loading effects; and it is protected

against chemical action e.g. by corrosive soils. In 8.2.2 it states that, *"Pipework which is otherwise liable to corrode shall be protected appropriately. Where a tape wrapping is employed, a minimum overlap of 50% shall be provided".* It notes*, "Appropriate methods include self-adhesive plastic tapes, petroleum impregnated woven cloth tapes etc. The latter may need to be over wrapped with a waterproof covering of PVC tape"*. For corrosive soil situations it goes on to discuss backfill with a passive material in addition to wrapping or sleeving.

Entry into and exit from buildings

62. Section 9 deals with entry into and exit from buildings. It states that, *"Pipework shall enter and exit from a building above ground level wherever feasible and practical and, in any event, pipework shall not be installed under the foundation of a building, under the base of a wall or under a floating raft foundation".* Section 9.5.1.2 covers steel pipe entry or exits below floor level and states that pipework shall enter or leave a building through a continuous gas tight sleeve.

2.3 National Fire Protection Association Codes NFPA 58 Liquefied Petroleum Gas Code and NFPA 59 Utility LP-Gas Plant

63. The American National Fire Protection Association (NFPA) produces a number of codes on different topics. NFPA Code 58 covers Liquefied Petroleum Gas and was first published in 1940. Nine revisions have been adopted over the years, including five in the 1960's. HSE have not been able to source the earlier issues of NFPA 58 or any edition of NFPA 59.

64. The 2001 edition of NFPA 58 applies to the operation of LP Gas containers, piping and associated equipment when delivering LPG to a building for use as a fuel gas. It does not apply retrospectively unless specified. Section 3.2 includes discussion on protecting buried pipework from traffic loading and corrosion. Section 11.2.2 requires that owners or operators of LPG bulk or industrial systems shall prepare and implement procedures to maintain the ongoing mechanical integrity of the LPG systems.

2.4 Institute of Petroleum: Model Codes of Safe Practice

2.4.1 Model Code of Safe Practice part 9: Liquefied Petroleum gas

65. In 1967 the Institute of Petroleum published this code, the text of which had been prepared by a sub-committee comprising representatives of the Institute of Petroleum, Institution of Gas Engineers and Liquefied Petroleum Gas Industrial Technical Committee. The Institution of Gas Engineers also published it as Safety Recommendations IGE/SR/6 Liquefied Petroleum Gases. It gives the purpose of these recommendations as to provide a general guide to safe storage, handling and transport of LPG. It stresses that in determining any required safe procedure the effect of any unusual circumstances, on which it is impossible to generalise, should receive due consideration; and that design and construction of plant and equipment should be carried out by experienced people.

66. The code has a general chapter covering: the properties and characteristics of LPG (e.g. LPG vapour is heavier than air); its hazards (including flammability limits and propensity of vapour to sink to lowest level); odorising gas and prevention of water deposition.

67. Chapter 3 covers industrial, commercial and domestic storage but installations are only covered up to the inlet of the 1st stage line pressure reduction. It reiterates much of the LPGITC guidance 1969 and in several sections the wording is almost identical. It differs from the LPGITC guidance in that it states at 3.4.7(d) *"piping should be protected against physical damage and corrosion".* Operations including training are not covered in LPGITC Code 1 but is covered in IP9 at 3.9.1 with two pertinent points:

    - That those responsible for the operation of equipment and handling of LPG should understand the physical characteristics of LPG and be familiar with the relevant section of this code relating to their spheres of responsibility; and

    - That the location of all gas and liquid piping/valves should be known and their use understood.

68. In February 1987 the Institute of Petroleum published IP9 Volume 1 superseding the 1967 edition; jointly prepared by the Institute of Petroleum, Institution of Gas Engineers and Liquefied Petroleum Gas Industrial Technical Association Volume 1 covers refrigerated LPG and large pressure storage at refineries, bulk distribution plants and large industrial consumer premises where such pressure storage is greater than 135 m^3 (approx 60 tonnes). The ICL installation is outside the scope of this document. However it states that Volume 2 of IP9 was intended to cover pressure storage at industrial, commercial and domestic premises but HSE have no record of this being published.

2.4.2 Model Code of Safe Practice part 13: Pressure Piping Systems Examination

69. In March 1993 the Institute of Petroleum published the 2nd edition of this publication (the first edition was published in 1973). The purpose of the 1993 version is to provide a guide to safe practices in the in-service examination and testing of piping systems in the petroleum and chemical industries, and consists primarily of scheduled examinations by Competent Persons.

70. Section 2.2 says that not all piping systems should be registered but the following should be included:

    - those required by national legislation; and

    - those known or suspected to deteriorate from corrosion, etc, and are in such a service or location that failure would give rise to an unacceptable situation e.g. a leak could harm the public, cause a reportable injury to people on site or cause serious harm to the environment.

It also notes that where the procedures are to be applied to established installations, *"existing piping system should be assessed to establish their current mechanical condition"*. Section 2.5 states, *"Unregistered piping systems may not be subject to regular examination by Competent Persons but should be examined by the user as necessary to ensure that they remain fit for service"*. At 5.5.4 it highlights that, *"the most vulnerable areas are at or near ground level where protection can break down and expose the piping to alternate wet and dry conditions, and examination should be concentrated in these areas"*.

2.5 Fire Protection Association: Storage and handling of liquefied petroleum gas (1964).

71. This publication highlights the hazard, *"As LPG is heavier than air, escaping gas tends to accumulate near the ground, to flow downhill and to collect in drains hollows and building basements where it is difficult to dissipate"*; includes in the section on pipelines, *"They may safely be laid underground if normal precautions are taken against corrosion"* and under maintenance states that tanks and other ancillary equipment should be examined periodically, with regular maintenance and repainting as necessary to prevent deterioration. It also reproduces the tank separation distances given in the LPGITC Code of Practice.

2.6 European Liquefied Gas Association (AEGPL) recommendations:

2.6.1 Installation & inspection of small bulk LPG fixed storage tanks up to 5m^3 capacity TSD/2E (1974).

72. The recommendations do not specify their audience but were prepared in 1974 by a multi-national working group of the European Liquefied Petroleum Gas Association (AEGPL) including a UK representative and are based on *"*practices currently in operation in major European countries*"*. They are applicable to domestic, commercial, agricultural and industrial usages of LPG and to all tanks or groups of tanks up to 5m^3 (approx 2.3 tonnes LPG) total capacity.

73. Section 2.10 covers piping carrying LPG at non-reduced pressure (liquid or gaseous phase) and covers corrosion protection and expansion of unburied pipes, *"Normally these are installed outside buildings"* but goes on to give recommendation if this is not possible, including *"where the pipe passes through the wall of the building, provision is made of expansion of the pipe and protection against corrosion e.g. by sleeving"*. Section 2.10.3 on buried pipes identifies the need to protect pipes from corrosion paying particular attention to the nature of the soil. It also outlines the need to protect pipelines from physical damage when buried at 0.4 m depth, but where the pipe is buried at a greater depth i.e. 0.6m then no protection is required.

74. The recommendations also give separation distances which, at 3m from tank connections to buildings, property lines and fixed sources of ignition, etc for all

tank sizes, is less than those specified in LPGITA Code 1 (3m from shell of tank to buildings, etc. for tanks up to and including 2250 litres and 7.5m for tanks over 2250 litres to 9000 litres).

2.6.2 Installation of underground pipework for LPG vapour systems up to 4 bars working pressure TSD/6E (1982).

75. The recommendations, published in 1982, cover the minimum requirements for the selection and use of materials and components for underground LPG vapour pipework systems up to a working pressure of 4 bar. Systems of metal (copper or steel), plastic and a combination of the two are covered. Section 5 states, *"Steel pipe must be protected against corrosion and plastic coated pipe is recommended"* and advocates the use of welded or seamless steel pipe and that, *"underground pipe joints may be welded only"*.

76. Section 6 covering corrosion protection reiterates the need for steel pipe to be corrosion protected and goes on to say, *"If bitumen protection is used, it must have a minimum thickness of 4mm and must be applied according to a recognised practice. If other wrappings are used they must be applied according to the manufacturers instructions"*. It states that, *"On completion of pipe wrapping, a holiday detection test must be carried out by applying a minimum voltage of 14,000 volts"*, if alternatives to bitumen are used the test must be carried out in accordance with the manufacturers instructions. The need for soil tests are covered, *"When planning the installation, soil tests must be carried out at pipe depth to ascertain whether the soil is corrosive. If the soil is found to be aggressive, then specialist advice must be sought concerning the additional protection to be applied"*. At 6.3 it highlights that special precautions must be taken at connections after installation to protect uncoated tees, branches, etc. Where two different materials are connected the risk of corrosion due to the different potentials has to be taken into account by the use of insulated couplings. Note: A holiday test is an electrical test used to identify flaws in pipe coatings; such tests are usually used in large installations such as petrochemical plants.

77. The recommendations go on to discuss backfilling with compactable, clean filling material after pressure testing at 6 bar, for one hour, with inert gas or dry air. It also discusses leak testing of joints after installation or re-installation using vapour phase LPG at the working pressure, or at least 0.1 bar, for 20 minutes. If pipework is exposed a soap and water or similar check shall be carried out for leaks. It also states that, *"Periodic leak testing of the system should be undertaken to prove its integrity at a minimum of 10 years"*.

2.6.3 LPG installations on vessels (1982)

78. These recommendations apply to pleasure craft, cargo ships and fishing boats and are therefore not applicable to this case.

2.7 LPG Associations guidance:

2.7.1 Installation of bulk LPG storage:

LPGITC Code of Practice. Installation of bulk LPG storage at consumers' premises

79. This guidance produced by the LPG Industry Technical Committee has been reprinted and revised since 1961. In each revision it identifies at the outset the properties of LPG including that: a small proportion of LPG gases in air can give rise to an explosive mixture; and LPG gases are heavier than air, may flow along the ground through drains, and be ignited at considerable distance from the source of leakage.

80. The objective of the Code of Practice is to set minimum standards for bulk LPG installations at consumer's premises. It covers storage tanks, pipework and fittings up to the inlet of the first stage regulator. It outlines the minimum separation distances from buildings for different capacities of bulk tanks. In certain circumstance, separation distances may be slightly reduced after consultation with the approved authority e.g. with the provision of radiation walls.

81. Section 6 sets out the requirements for pipework, valves and pipe fittings stating that all materials used, including non metallic parts, shall be resistant to the action of LPG gases under service conditions. It requires that pipework for conveying liquid LPG should be of steel, and that pipework for conveying LPG vapour may be of steel or solid drawn copper and refers the reader to the relevant British Standards [BS 1387, 806, 659 and 61 Part 1]. Section 6.2.2 states that steel piping up to and including 1 ¼ inch nominal bore should be prepared for screw joints and specified as medium weight, seamless to BS 1387. This differs from the IGE guidance which requires services with screwed connections up to and including 3 inch diameter to be *"heavy"* quality to BS 1387.

82. At 6.3.1 it states that fittings and valves for liquid service shall be of steel or forged brass construction and, *"Cast iron fitting or valves must never be used. This does not prohibit the use of valves made of malleable or nodular iron".* For vapour service it states that both fittings and valves may also be of ductile iron. It goes on to require all pipelines to be tested after assembly and proved free from leaks at not less than the maximum operating pressure.

83. Section 9 describes the inspection and re-testing requirements for tanks of different capacities in terms of frequency and nature of tests. For a vessel of 500 UK gallons (1.1 tonnes LPG) capacity or less this would mean a complete thorough visual examination every 5 years; and a hydrostatic pressure test at 1.5 times the maximum working pressure every 10 years. For a vessel over 500 UK gallons capacity this would mean a hydrostatic pressure test at 1.5 times the maximum working pressure every 5 years; this would be the inspection requirement for ICL's vessel of 990 gallons water capacity operating at a working pressure of 1.5 bar. (Note: A hydrostatic pressure test is used to test

components or assemblies for leaks by filling them with pressurised liquid such as water).

84. The code does not cover corrosion protection of pipelines, periodic inspection of pipelines or routing of pipelines and point of entry to the building. These may not have been covered because the guidance only extends to the first stage regulator.

85. The code was reprinted yearly until 1968 (with the exception of 1965 and 1967) with a revision in 1963. However the 1963 revision does not contain any changes pertinent to this case.

86. In April 1969 the LPGITC Code of Practice was further revised and the title modified to *"LPGITC 1. LPGITC Code of Practice. Installation of fixed bulk LPG storage at consumers' premises"*. The objective and scope of this revision are modified in that it sets standards (rather than minimum standards) and it covers *"underground and above ground fixed bulk storage vessels, pipework and fittings up to the first stage regulator"*; where previously it had stopped at the inlet to the first stage regulator and section 4 had prohibited underground tanks. It also excludes inspection and re-test details for which the reader is referred to LPGITC 8 - *Maintenance of Fixed Bulk LPG vessels at Consumers' Premises, 1969*.

87. The 1969 revision of LPGITC 1 includes a new section 5 on storage vessel preparation and surface treatment that states *"Underground storage vessels should be given a protective coating adequate to resist soil corrosion before being placed underground"*.

88. Section 6 on vessel location includes a new requirement that pits or depressions under, or in the immediate vicinity of, above ground LPG storage vessels should be avoided. It also includes at 6.2.6 – installation of underground vessels, *"When lowering a vessel into place care should be taken to avoid damage to the coating"* that, *"the backfill material should be clean sand or other suitable non corrosive material free from rocks or other abrasive materials"* also that, *"specialist advice should be obtained on corrosion protection of vessels including coating materials and their application"* and further that *"Underground vessels should be protected from above ground loadings due to vehicular traffic or other cause"*. These criteria however are only associated with the tank installation they do not refer to pipework.

LPGITA Code of Practice 1: Installation and maintenance of bulk LPG storage at consumers' premises.

89. The 1969 revision of LPGITC 1 was revised in November 1974 and became LPGITA Code of Practice 1. This guidance again identifies at the outset the properties of LPG including its flammability limits; that a small proportion of LPG gases in air can give rise to an explosive mixture; and LPG gases are heavier than air, may flow along the ground through drains, and be ignited at considerable distance from the source of leakage.

90. The objective of the Code of Practice is to set safe standards for the design, installation and operation of fixed LPG plant at consumer's premises. In 1974 Code of Practice 8 was combined into Code 1. The new code of practice covered underground and above ground tanks, their associated pipework and fittings, and included **the distribution system up to the consuming equipment**. It sets minimum standards for the frequency of inspection and testing to be adopted.

91. Section 3.3's design requirements for pipework, valves and pipe fittings differ in some instances to the LPGITC code. It now states that cast iron shall not be used and instead of referring to maximum diameters for certain design specifications of vapour pipes, it refers to maximum pressures including *"steel vapour lines designed to operate at less that 4.83 barg should conform to BS1387 (medium or heavy gauge only) or equivalent"*. Note that this differs to IGE Comm 563 (1959) which requires services with screwed connections up to and including 3" diameter to be *"*heavy*"* quality to BS 1387. Section 3.3 of LPGITC 1969 states that on steel vapour lines operating at less than 4.83 barg (70 pounds per square inch) flanges should conform to BS10, BS5404 or equivalent and screwed fittings for use with pipe to BS1387 should be to BS143 or BS1740. For liquid line or vapour lines operating at 4.83 barg or more different standards apply including: all joints greater than 2 inch nominal bore should be welded or welded flanged; and 2" nominal bore or less should preferably be welded or flanged but screwed joints may be used. It now allows for bronze fittings and valves in addition to those of steel or forged brass construction. It also states, *"Cast iron valves and fittings other than those of nodular iron to BS2789 should not be used for liquid lines, vapour lines upstream of the first stage regulator, vapour lines designed to operate at 4.83 barg or above and where thermal shocks are likely"*.

92. The 1974 revision contained the following sections on buried pipelines:

Design

93. Section 3.3.5. *"Buried pipelines - pipelines should preferably be above ground level and suitably supported. Pipelines should only be buried where necessary, their route permanently marked and they must be adequately protected against corrosion and mechanical damage. The use of specialist advice should be considered regarding both these aspects"*

94. Section 3.11 Protection against corrosion *"UNDERGROUND VESSELS AND BURIED PIPELINES SHOULD BE GIVEN AN EXTERNAL PROTECTIVE COATING ADEQUATE TO RESIST SOIL CORROSION, HOWEVER, IT IS RECOMMENDED THAT SPECIALIST ADVICE SHOULD BE OBTAINED ON CORROSION PROTECTION, INCLUDING COATING MATERIALS AND CATHODIC PROTECTION".*

Installation and Commissioning

95. Section 6.3.8 states that, *"Buried lines shall be proved free from leaks before backfilling the trench. Due care must be taken to avoid damage to corrosion protection on backfilling, e.g. by the use of soft sand around the pipes"*.

96. Section 6.12 covers corrosion protection with the following statements: *"6.12.1 Ensure corrosion protection applied to UNDERGROUND vessels, pipelines etc is satisfactory e.g. 'Holiday' test and check presence of sacrificial nodes if this method of protection is employed"* and, *"6.12.2 Where wrapping is used, ensure correct surface preparation and overlap and that the manufacturer's instructions are followed"*. Note: See paragraph 77 for details of a holiday test.

Maintenance, Inspection and Testing

97. Section 7.1 states that comprehensive instructions covering maintenance together with details of spares requirements should be provided at commissioning. Further all personnel engaged in servicing and maintaining equipment should be thoroughly familiar with those instructions and follow the maker's instructions where appropriate.

98. Sections 7.2 to 7.7 deal with storage vessels. The table at 7.2.1 sets out the required frequency of inspection of storage vessels as follows: an above ground tank shall have a full external examination every 5 years with an ultrasonic test to supplement it if necessary and in addition; either a full internal visual examination every 10 years for vessels with manholes, or for vessels without manholes an ultrasonic or hydrostatic test every 10 years.

99. Maintenance of the storage vessel is covered in 7.3, stating that every year the external condition of above ground vessels is to be examined and immediate attention given if any corrosion has occurred. It states that particular attention should be paid to the vessel supports. Any protective system should be maintained in a satisfactory condition and repair or renewal of the corrosion protection systems must allow for the normal presence of condensation on the vessels in service.

100. 7.6.4. deals with leak testing during the preparation of vessels for return to service after the examination. It states that on closure or completion the connections to the vessel, and the associated fittings and equipment should be leak tested to a pressure not less than 6 bar for propane, but not more than 90% of the vessel design pressure, using one of the methods specified in 6.2.6.

101. Section 7.8 deals with maintenance, inspection and testing of pipework, valves and fittings; and states that all above ground piping shall be inspected at least annually for corrosion and damage. Buried pipelines are dealt with at 7.8.3, saying they *"shall be surveyed for leakage at a frequency dictated by the risks associated with their location, pressure of operation and aggressiveness of their environment. For buried pipelines conveying liquid LPG or vapour operating at a pressure of 2 bar or above the interval between said surveys should not be greater than 1 year. Where practical this survey may include a repeat of the pressure test carried out upon installation (ref. 6.3.2)"*. The section also states that all valves shall be regularly checked for correct operation and re-lubricated with LPG resistant lubricant as necessary and at intervals not exceeding one year. All fittings not specifically covered above should be checked as appropriate at intervals not exceeding one year.

102. Section 7.11 says that regulators should be checked at intervals not exceeding one year; with particular attention being paid to the diaphragms, valve seats and seals.

103. At section 7.16 it states that the external anti-corrosion system of vessels, pipelines and equipment should be inspected at least annually and immediate attention should be given if rust spots are found. Particular attention should be given to both vessel and pipeline supports.

104. A new section on Operations, including training was added to this version including, *"Personnel responsible for and involved with the installation/ commissioning and operation of plant equipment and the handling of LPG should understand the physical characteristics of the product, be adequately instructed in the correct operation of the equipment and plant and be familiarised with the relevant section of this Code"*. A similar paragraph is also present in the Institute of Petroleum Code 9.

105. In 1978 the code was revised but no alterations were made to the sections reviewed in this report. This version of Code of Practice 1 remained in place until it was revised and replaced by a 4-part Code in 1991.

LPGA Code of Practice 1: Design, installation and maintenance of bulk LPG storage fixed installations; part 1 – Design and installation

106. The LPGITC Code of Practice 1 that had its origins in the 1961 Code of Practice had been further developed to extend to 4 parts. In October 1991 the LP Gas Association (LPGA) published 'Code of Practice 1: Design, Installation and Maintenance of Bulk LPG Storage at Fixed Installations: Part 1 Design and Installation'. In the scope it states that CoP 1 parts 1-3 include vessels over 150 litres, and include the associated equipment up to but not including the consuming equipment. Part 1 deals with design and installation, part 2 with small installations for domestic purposes and part 3 deals with periodic inspection and testing. For more detailed guidance on pipework the reader is referred to CoP 22. Code of Practice 1 Part 1 (CoP 1:1) notes that it is not the intention that the recommendations should be applied rigidly to existing premises, but alterations that are reasonably practicable for safety should be made.

LPGA Code of Practice 1 Bulk LPG Storage at Fixed Installations: Part 1 Design, Installation and Operation of Vessels Located above Ground

107. The revised edition published in July 1998 is the first version to have a foreword by the Health and Safety Commission Advisory Committee on Dangerous Substances (ACDS). The ACDS foreword states that the CoP is not an authoritative interpretation of the law, but if the guidance is followed the reader will normally be doing enough to comply with Health and Safety law. It also states that HSE believes that the contents of the CoP demonstrate good practice in the LPG industry and commends its use.

108. In the introduction the CoP is aimed at those involved in the safe practice of storing and handling of LPG in bulk at fixed installations. It states that it has

been produced in full consultation with HSE and supersedes HSG34 and also the 1978 edition of Code of Practice 1 Part 1 for above ground vessels.

109. Recognising the importance of health and safety management the introduction also summarises the principles of safe operation of LPG installations as: *"Safe operation of LPG Installations is achieved by preventing loss of the LPG by proper plant selection, design, installation, commissioning and operation, including training. In recognition of the fact that releases will occur from time to time, these measures are supported by control of potential ignition sources and provision of appropriate fire precautions and emergency procedures. The initial and continuing effectiveness of all of these factors is assured by the creation and maintenance of an appropriate safety management system covering all aspects of the safety of the installation."*

110. Section 1.3 covers application. Its intention is not to apply rigidly to existing premises where it may not be reasonably practicable to comply. However such alterations as are reasonably practicable for safety should be made. New installations and modifications to existing installations should comply from the date of publication. It goes on, under planning requirements, to state that the aim is to provide guidance on achieving the levels of risk appropriate to comply with Health and Safety legislation.

111. Section 3.2 deals with the distribution system and includes pipework. At 3.2.1 it requires the pipework to be in accordance with LPGA Code of Practice 22. The routes of all pipework should be carefully selected so as to avoid physical damage or failure.

112. Section 6.12 states that corrosion protection applied to buried pipelines should be checked before covering. If cathodic protection is employed the presence of a sacrificial anode should be verified. Where wrapping is used it is essential that the correct surface preparation and manufacturer's instructions are followed. It refers to CoP 22 for further guidance.

113. Section 7.8 requires that vessels, pipework and associated systems should be kept in good working order by a combination of routine inspection, periodic examination and regular maintenance. This should be carried out to written procedures describing both the scope of the work and the methods for carrying it out. It refers the reader to the LPGA Code of Practice 1 part 3.

114. In February 2004 a revised edition of CoP 1 part 1 was published containing a modified foreword by the Health and Safety Commission ACDS. It states that the CoP is not an authoritative interpretation of the law, but if the guidance is followed the reader will normally be doing enough to comply with Health and Safety law *"in respect of those specific issues it covers"*. It also states that Health and Safety Inspectors seeking to ensure compliance with the law may refer to this guidance as illustrating good practice. However it notes that installations subject to the Control of Major Accident Hazards Regulations present greater or different risks and require site specific risk assessments and consultation with the Competent Authority.

115. Section 1.3 is more detailed in its application to existing installations. It is not its intention that the recommendations should apply rigidly to existing installations but when undertaking a like-for-like vessel exchange such installations must meet the appropriate legal requirements, e.g. the Gas Safety (Installation and Use) Regulations. In addition installations should be checked against requirements and where reasonably practicable they should be complied with. It goes on to outline under what circumstances an installation would be deemed compliant and the action required if a safety risk is identified.

Design, installation and maintenance of bulk LPG storage fixed installations: Small bulk installations

116. In May 1988 *"LPGITA Code of Practice 1: Design, installation and maintenance of bulk LPG storage fixed installations; part 2 – Small bulk installations for domestic purposes"* was published. Its scope covers domestic premises and it should be used in conjunction with Code 1 Part 1, Code 1 Part 3 and Code 22. Section 4.4 covers pressure regulation and states that pressure shall be controlled in at least two stages: At the vessel a 1st stage regulator shall reduce the pressure to not greater than 2 bar; and prior to entering a premise a 2nd stage regulator shall reduce to the pressure to not more than 37 mbar (this may be at or close to the vessel). Section 5.2 notes that pipework from the storage vessel to the premises will normally be buried and may be polyethylene, steel tubing adequately protected against corrosion, or copper tubing preferably protected against corrosion by a factory applied plastic coating. The list of LPGITA publications notes that Code 22 is *"in preparation"*. As Code 1 part 2 covers domestic installations it is not applicable to ICL.

117. The 'LPGA Code of Practice 1: Design, installation and maintenance of bulk LPG storage fixed installations; part 2 – Small bulk installations for domestic and similar purposes' is noted as being first published in December 1994 with a major revision in January 2000 and an amendment in January 2003. The title has changed from the LPGITA document and it now includes installations for domestic and similar purposes. The 2000 revision contains a foreword by the chairman of the HSC's ACDS stating that the Code has been prepared *"in full consultation"* with HSE. In the same version the scope of the guidance *"deals solely with vapour take-off, above ground, buried or mounded installations of 150 – 4500 litres water capacity) where the LPG is stored under pressure at ambient temperatures in single fixed vessels"*. Under 3.2 (pipework) it now highlights that it should be in accordance with Code 22 and relevant legislation; and should be routed so as to avoid physical damage or failure. At 3.3 (pressure regulators) it now states that, *"The pressure of vapour at the appliance should be controlled by pressure regulators within the limits necessary for safe and satisfactory performance over the entire operating range"*. It goes on to say that two stage regulators should be used with the 1st stage regulator located as close as practicable to the storage vessel.

2.7.2 Inspection, Testing & Examination:

LPGITA Code of Practice 1: Installation and maintenance of bulk LPG storage consumers' premises; part 3 – Periodic inspection & testing (1986)

118. The code is intended for those interested in the use of LPG in bulk at consumers' premises. Its objective (at section 1.2.1) is to *"set safety standards and requirements for the inspection and testing of bulk LPG storage plant at consumers premises. These installations should have been designed and installed in accordance with Code of Practice No. 1 Part 1 or Part 2".* The Code gives details of the requirements for the periodic inspection, examination and testing of fixed bulk storage vessels of 130 litres capacity and above; and distribution systems up to the consuming equipment.

Scheme of Inspection and Examination

119. Section 2 requires that the inspections, examination and tests specified in this code form the basis of a scheme which may be undertaken all or in part by the operator, contractor, inspection authority or LPG supplier. Where the duties are shared between these parties the written scheme must clearly identify the respective areas of responsibility.

120. Section 2.2 requires LPG suppliers to ensure that users are aware of the importance of carrying out a scheme in accordance with this code and make available such a service, or direct them to other competent organisations, when the consumers cannot be expected to arrange this for themselves.

121. Section 2.3 requires that an appropriately trained person should carry out routine inspections in accordance with Section 3. Section 2.4 states that, *"Major examinations should be undertaken by such persons as are competent as a result of practical and theoretical knowledge and actual experience of the equipment concerned as will enable him to detect defects and weaknesses which is the purpose of the examination to discover, to assess their importance, and ultimately to certify such equipment as fit for its purpose prior to its further use".*

Routine Inspections

122. Section 3.2, dealing with routine inspections, states that storage vessels with vapour take off should be inspected as follows:

    - Vessels 5m^3 water capacity and above should be inspected annually and ancillary equipment such as valves checked for leaks.

    - Vessels with below 5m^3 capacity should be inspected either on a routine basis when being filled or at an annual inspection

123. With regards to the section covering routine inspection of pipework 3.3.1 (h) only requires the following:
    - Is the external condition of the visible pipework and equipment satisfactory?

- Are there any signs of physical damage?
- Are there any obvious leaks?

Major Examinations

124. Section 4 deals with major examinations stating that they should be carried out by a competent person. The frequency of examinations for identified vessels shall be in line with the table in 4.1.1 where for above ground tanks it requires: a 5-year full external visual examination of the vessel (NDT may be used to supplement this if necessary); a 10-year examination carrying out all the items as per the 5-year examination and also carrying out a full visual internal examination or thickness check, or hydraulic tests. Details of these examinations are given in sections 4.2 and 4.3.

125. Section 4.5 gives the requirements for a detailed examination of an **unidentified** vessel whether above or below ground. It requires the examiner to confirm that suitable materials have been used in the fabrication of the vessel, this may involve chemical analysis of parent and weld material, and hardness tests. It also requires visual examination of external/internal surfaces and all welds for signs of defects. The examination details given in section 4.5 do not extend to the associated pipework.

126. Section 4.6 sets out the examination methods: hydraulic test, ultrasonic examination and visual internal examination (see BS 470).

Pipework, valves and fittings inspection

127. Section 6.2.1 covers inspection of underground pipework. The most relevant section, 6.2.1(a), states that pipelines conveying vapour below 5 bar should be *"surveyed for leakage at a frequency dictated by the risks associated with their location, pressure of operation and aggressiveness of their environment"*.

128. Subsection 6.2.1.d states that *"pipelines conveying liquid LPG or vapour (at pressures of 5 bar or above), which incorporate buried screwed or flanged joints,* ***or where there is any doubt of the efficacy of the corrosion protection system,*** *shall be pressure tested annually to the requirements of CoP 1 Part 1 Section 6,* ***or excavated annually for visual inspection and leak tested under operating pressure, using soapy water or equivalent for leak detection****"*, (Note: CoP1 part 1 (1978) section 6.3.2 requires a test pressure of 1.5 times the maximum working pressure or 0.3 bar whichever is the greater). These two tests are given as alternatives but in reality they deliver very different information on the condition of the underground pipe. Subsection 6.2.1.d does not apply to the ICL installation as the vapour pressure was less that 5 bar however this is the only mention in the LPGITA CoPs of a requirement to excavate for inspection purposes.

129. Appendix 1 contains a summary of the inspections and examinations to be carried out. The requirements for underground pipework are as follows: a routine annual inspection and a 10-year examination, both as per section 6.2.

LPGA Code of Practice 1: Bulk LPG storage fixed installations; part 3 – Examination & Inspection (2000)

130. In 2000 LPGA revised the 1986 edition and it continues to date (with a modified version agreed for publication late 2006/ early 2007). The 2000 edition of CoP1:3 contains the ACDS foreword and was produced in full consultation with HSE. It states that the code gives guidance for items that have to be included in the written scheme of examination (WSE) of bulk LPG vessels having a capacity of 150 litres or more, and those items to be included in the WSE of distribution systems up to the consuming equipment operating at pressures in excess of 0.5 barg. It also deals with routine inspection of bulk LPG vessels having a capacity of 150 litres or more and the periodic inspection of equipment associated with bulk LPG vessels. It is again assumed that the system has been designed and installed in accordance with Code of Practice 1 parts 1, 2, 4 and other relevant LPGA CoP's or equivalent standards.

131. Section 1.3 covers the legal requirements, in addition to those under the Health and Safety at Work Act 1974, LPG storage vessels and associated systems operating at pressures greater than 0.5 barg are also subject to the Pressure Systems Safety Regulations 2000 (PSSR). An important requirement of PSSR is that the user of the system has a WSE for periodic examination.

132. Section 1.4 covers definitions:

- An examination is the statutory examination, as defined in PSSR;
- A periodic inspection is an inspection of an installation, other than those parts covered by the WSE, the results of which are to be recorded;
- A routine inspection is an external inspection of the visible parts of the vessel, its fittings and associated equipment; carried out at intervals more frequent than, and in addition to, the examination or periodic inspection;
- A WSE is a document containing information relative to a pressure system prepared, or certified as being suitable, by a competent person.

133. Section 2.3 states that the inspections described in the code may be undertaken all or in part by the operator, a contractor, inspection authority or by the LPG supplier. Where the duties are shared between such organisations the respective areas of responsibility should be clearly identified and defined to ensure that the entire installation is adequately covered.

134. Subsection 2.3.1 states that periodic inspections should be carried out at defined intervals in accordance with section 5 and a written procedure, by an appropriately trained person and the results recorded. At 2.3.2 it states that routine inspections of installations should be carried out in accordance with section 6, by an appropriately trained person. Appendix 1 sets out the suggested frequency for periodic inspection and section 5.1 states that this is assuming that routine inspection is being carried out in accordance with section 6.

135. Sections 2, 3 and 4 deal with the examination under the WSE and do not discuss examination of underground pipework.

Periodic Inspection of Underground Pipework

136. Section 5.3 deals with underground pipework and in particular section 5.3.1 deals with vapour pipework operating at pressures below 5 bar. It states that such pipework should be surveyed for leakage by appropriate means, such as pressure testing, gas detection etc, at a frequency dictated by the risks associated with its location, pressure of operation and aggressiveness of environment. There is no mention of excavation as an appropriate means for inspection of vapour pipework at pressures below 5 bar.

137. Section 5.3.2, deals with liquid pipework and vapour pipework at pressures of 5 bar and above. It states that pipework should be pressure tested, or excavated for visual examination and leak tested under operating pressure using leak detection fluid or equivalent when it:

- Incorporates buried screwed or flanged joints; or
- Where there is any doubt of the effectiveness of the corrosion protection system.

Routine Inspection

138. In section 6 there is no mention of any routine inspection of underground pipes. There should simply be a check that the external condition of visible pipework and associated equipment is satisfactory with no signs of corrosion or physical damage, and a check that there are no obvious leaks.

Summary of Requirements

139. Appendix 1 deals with the summary of examinations and inspections. There is no mention of underground pipes under examinations, but under 'Periodic Inspection' it says as per section 5.3, and that the frequency of underground pipework inspection will be subject to risk assessment.

2.7.3 Piping Systems

LPGITA Code of Practice 22; LPG piping system – Design and installation (1990).

140. The code was published in February 1990 (copyright 1989) by the LPGITA for the guidance of those involved in the design and installation of LPG pipework systems; to give guidance on the selection of materials, the design, installation and testing of pipework for LPG liquid and vapour. Under legal requirements it does not discuss the Pressure Systems and Transportable Gas Containers Regulations 1989 but this may be due to the fact that the regulations had only just come into force.

Section 2 Design & Layout

141. Section 2 commences by saying that, where practicable, pipework should be routed in the open air and should be above ground. It may be buried underground provided it is inherently resistant to, or otherwise adequately protected against, corrosion.

142. At 2.1.3 *Service pipe entries, emergency shut off valves and meters* it states that the recommendations made in this section apply to domestic and low rise premises. For medium and high rise multi storey buildings it refers the reader to IGE/TD/4. The recommendations applying to domestic and low rise premises include: Pipework entry should preferably be above ground; where below ground entry is unavoidable then it describes the use of steel or steel encased polyethylene pipe passing through a straight sleeve built into the wall. It states at 2.1.3.7 that pipework should not be installed in an unventilated space. At 2.1.3.9 it states that pipework passing through solid or cavity walls shall be sleeved with a continuous, non-porous material that is protected against corrosion; where practicable the sleeve should be sealed at each end to the pipe with flexible fire resistant compound and the sleeve should be sealed to the structure with suitable building material. It concludes that the installation shall ensure that gas cannot pass between the pipe and the sleeve and between the sleeve and the wall.

143. Section 2.2 Materials stipulates that all pipes, fittings and joints etc shall be properly assessed for suitability for the service conditions. Cast iron pipe should not be used. The classes of pipe acceptable for LPG services are given in appendix 2; for below ground services up to 2 bar pressure these are: carbon steel seamless, carbon steel welded seam, 15-35mm solid drawn copper or SDR 11 polyethylene pipe.

144. At 2.3.6 the guidance states that installations not inherently resistant to corrosion should be suitably protected, for below ground this includes wrapping and/or sleeving and cathodic protection.

Section 4 Pipework materials and construction below ground level (buried)

145. Section 4 states that, *"All buried pipework and fittings must be inherently resistant to corrosion or otherwise protected against it"*. It refers the reader to section 3.3.1 for details of carbon steel pipework for use in vapour service below 4.83 bar thereby giving the same specification for both above ground and below ground pipework, i.e. *"Welded seam gas pipe, heavy or medium weight or seamless pipe to an acceptable thickness"* and for threaded fittings it allows, *"Wrought steel or malleable iron fittings or forged carbon steel"*. Copper pipework is also suitable up to 35mm diameter.

Section 6 Installation – Below Ground Level (Buried)

146. Section 6 commences by saying, *"Pipework should only be buried when unavoidable. Materials and construction shall conform to Section 4. The pipeline route shall be permanently marked or recorded. It must be adequately protected against corrosion and mechanical damage"*. It goes on to say that,

"Unless otherwise provided with the means to assess the condition of buried metallic pipework, suitable provision shall be made to facilitate periodic leak testing" and adds, *"Steel pipe conveying liquid laid in a backfilled trench should be examined for corrosion, or tested in such a way as to establish its continuing integrity, at least once every 10 years. See Code of Practice No 1, Part 3"*.

147. Section 6.1 gives details of the required protection for both liquid phase pipework and vapour phase. For vapour phase pipework it states that:

- Pipework may be buried in an open excavation and backfilled with a suitable material;
- Corrosion protection should be provided and gives as examples proprietary wax or tar/bitumen impregnated tape wrapping and/or cathodic protection;
- Protection shall be provided, e.g. in the form of load bearing slabs, for pipework over which traffic passes or where superimposed loads will occur.
- *"To facilitate future repair and maintenance a minimum clearance of 250mm should be maintained, whenever reasonably practicable between the LPG pipework and other service"*.

148. Sections 6.4, 6.5 and 6.6 discuss the trench requirements including the required depth of cover; that the pipe should rest on firm even ground free from stones, rocks, bricks or concrete; and that prior to backfilling all coating and wrapping should be inspected and where necessary repaired. It also requires that the pipe should be identified with yellow plastic indicator tape except where: The route is adequately recorded, marked or is obvious; other means are available for pipe location; or the pipe is a service or installation pipe which can be isolated from the main or gas supply.

LPGA Code of Practice 22; LPG piping system – Design and installation (1996 onwards).

149. Another edition of CoP 22 was produced by LPGA in 1996 but HSE currently has no copy of this edition. Revised again in 2002 it does not contain a foreword from HSE's ACDS because its contents are outside the scope of previous HSE guidance. However it states that HSE Inspectors seeking to secure compliance with the law may refer to this guidance as illustrating good practice. It also points out that the CoP is not an authoritative interpretation of the law, but if the guidance is followed, the reader will normally be doing enough to comply with the law. The CoP covers pipework for conveying LPG both in the liquid and vapour phases.

150. Section 2 now states that buried pipework should be inherently resistant to, or otherwise adequately protected against, corrosion e.g. polyethylene piping, cathodic protection; and that joints should be readily accessible for inspection unless specifically designed for the purpose.

151. At 2.1.3 it reiterates the comments in 2.1.3 of the LPGITA Code but further restricts the scope of this section to premises subject to the Gas Safety

(Installation and Use) Regulations referring as before to IGE/TD/4 but also IGE/UP/2 for industrial and commercial buildings. The recommendations applying to the premises covered include, *"Service pipe entries to buildings should, wherever possible, be above ground"*.

152. At 2.2.2 it requires that the pipework route should be permanently marked or recorded and reiterates the minimum clearance stated at 6.1 in the LPGITA Code. It states that metallic pipework, *"should only be buried when unavoidable, consideration should be given to the use of polyethylene or proprietary systems as appropriate. However where necessary metallic pipe may be laid either: in a trench backfilled with inert, non corrosive material free of abrasive material likely to damage its corrosion protection; or inside a buried outer pipe or duct which terminates either above ground or in a suitable inspection pit"*. It reiterates LPGITA section 6 by saying, *"Unless otherwise provided with the means to assess the condition of buried metallic pipework, suitable provision shall be made to facilitate periodic leak testing"*.

153. Section 2.2.6 reiterates LPGITA Code 22 sections 2.1.3.7 and 2.1.3.9 stating, *"Pipework should not be installed in an unventilated space"* and dealing with sleeving of pipework passing through external walls and gas-tight sealing of the annuli.

154. Section 2.2.9 deals with corrosion protection as it applies to design, reiterating LPGITA Code 22 section 2.3.6 in that installations not inherently resistant to corrosion should be suitably protected; for below ground this includes wrapping and/or sleeving and cathodic protection. But 2.2.9 goes on to give more detailed wrapping instructions.

155. Table 4 at section 3.2 lists the types of pipe acceptable for LPG service; for below ground services up to 4 bar pressure these are: carbon steel, carbon steel BS1387, solid drawn copper, SDR 11 polyethylene pipe and subject to manufacturer's specifications stainless steel or proprietary systems. The table differs slightly to appendix 2 of the older guidance, in particular in relation to the maximum pressure (previously 2 bar). Further data on specific types of pipe are given in Table 5. For threaded fittings on liquid or vapour above 4 bar 3.3.2 requires forged carbon steel fittings but allows wrought steel or malleable iron fittings for vapour service up to 4 bar. However it requires subsequent seal welding if used on below ground pipework.

156. Under the fabrication and assembly section 4.2.9, not specific to buried pipework, it states that carbon steel pipework not protected by galvanising or equivalent should be protected from corrosion by some other method, e.g. painting. Section 5 covers special requirements for buried pipework but refers to section 4 for fabrication and welding techniques. It requires that joints be kept to a minimum in buried sections of pipe and that consideration should be paid to preserving the integrity of any corrosion protection of the pipe and fittings. Sections 5.3 to 5.5 discuss the trench requirements, which are identical to those in the LPGITA Code (6.4 - 6.6).

Technical Memorandum 11 Part 1: Recommendation for the use of polyethylene pipework for buried LPG vapour systems up to 4 bar working pressure

157. Technical Memorandum 11 Part 1 was published in March 1983 by LPGITA. It covered installation, backfilling and pressure testing of polyethylene pipework but did not include advice on inspection.

Technical memorandum 62: Gas soundness testing of LPG service pipework, installation pipework and appliances (1999)

158. TM62 was first published in December 1999 and it was withdrawn after the publication of BS 5482 Part 1: Domestic butane- and propane-gas-burning installations in 2005. The scope of TM62 includes small commercial installations, and pipework and appliances with a total internal volume of 0.02 m^3 or less (equivalent to 40 m of 20mm pipe). It details the use of soundness test C (for bulk tank service pipework from the tank outlet upstream of the 1st stage regulator to the emergency control at the premises) where the standard is no discernible pressure drop when the test pressure is held: for 2 minutes for low pressure (37 mbar); or for 15 minutes for intermediate pressure (approx 750 mbar).

2.7.4 General information

LPGITA booklet: Introduction to LPG (1974)

159. This booklet, first published in 1974, describes the essential properties of LPG, their major uses and precautions necessary for safe application. It is intended as an introduction for technical and sales staff involved in its handling or sale, for students and for users of the fuel. It notes that a wide range of texts, codes of practice and standards are available for those interested in a deeper or specialised study with such references included at the back of the booklet. In the storage and handling section it states, *"A particular reason for care in their storage and handling is the fact that butane and propane gases, unlike towns gas and natural gas, are heavier than air and may therefore accumulate in spaces below the level at which any leakage occurs from a container or its connecting pipework system"*. The document was still listed in the 1991 edition of the LP Gas Association Code of Practice 1 part 1 but by the 1998 edition the LPG technical fundamentals document was referenced instead.

LPGA: LPG Technical fundamentals (1997)

160. This document was first printed in December 1997. It notes that LPG does not affect metals but many non-metallic substances are chemically attacked by LPG, e.g. natural rubber and traditional jointing compounds. On page 30 it discusses LPG piping systems, highlighting the need for pipework conveying liquids or vapour to be fit for purpose concluding that, *"It is essential that any organisation installing LPG systems is familiar with the Code of Practice 22"*.

2.8 HSE Guidance

2.8.1 The storage of LPG at factories.

Safety, Health and Welfare Booklet, New Series No 30.

161. 'The Bulk Storage of Liquefied Petroleum Gas at Factories' is a Ministry of Labour publication. SHW 30 identifies in the introduction that the major potential hazard from storage was that of fire and explosion which could be reduced to *"acceptable proportions"*, provided that the plant was suitably designed and adequate safety measures adopted. It notes the American National Fire Protection Association Codes of Practice No 58 (1963) and No 59 (1963) describe minimum standards of safety thought to be necessary for bulk storage of LPG and goes on to identify the Liquefied Petroleum Gas Industry Technical Committee as producing a similar code (Installation of Bulk LPG Storage at Consumers' Premises). The objective of the booklet is to give general guidance to *"*would-be users of LP gas*"* on the problems with storage; it does not attempt to deal with detailed design, such information being available in the relevant codes and from specialist firms. It does however recommend that factory occupiers should seek the advice of HM District Inspectors of Factories when planning a bulk storage installation or material extension of an existing plant.

162. Under General Properties it states, *"danger may be prevented by a high standard of ventilation and maintenance including frequent checking for leaks by brushing soap solution around joints and valves and by the use of a flammable gas detection instrument"*. It goes on to explain that because the density of LPG vapour is greater than that of air, LPG vapour will tend to accumulate at low levels and in enclosed areas, will flow down gradients, and into sumps, underground rooms and passages; ventilation systems should be designed to take that into account.

163. Under Hazards (page 9) it states that *"a flammable mixture may spread out over a considerable distance at ground level before becoming dispersed and diluted below the lower limit of flammability".* It suggests that where the possibility of LPG gas entering underground passage ducts cannot be eliminated permanent gas detection equipment has in some installations been fitted to give warning of accumulations in event of leakage.

164. The Precautions section suggests that the references mentioned (NFPA 58/ 59 & LPGITC COP) give a minimum standard but every opportunity should be taken to provide a better standard where possible and appropriate.

165. The Location section states the most important single factor contributing to the safety of any bulk installation is its correct location. It also identifies that storage tanks should *"invariably be located above ground in the open air and separated from important buildings, plant, public highways or from the line of adjoining property, whether built or not".* The separation distances, given as examples, are reprinted from the LPGITC Code. It advises that the separation distances should provide adequate protection against: Serious mutual exposure of a tank

or building to radiant heat in case of fire; escaping gas from small leaks entering buildings or plant and flammable concentrations and causing an explosion; and flammable concentrations of escaping gas from small leaks reaching a source of ignition with subsequent flashback to the tank. At page 12 it considers tank locations undesirable where, amongst other things, nearby buildings have basement entrances.

166. The Installation section advises that regular maintenance and inspection at the recommended intervals should ensure that the rapid deterioration of the shell does not occur owing to corrosion. It further advises that a more likely source of major spillage would be the failure of a valve or flange point on associated pipelines. For smaller sites, with tanks of five to ten tonnes, it recommends the use of retaining walls not higher than 15 inches around the immediate storage area to prevent uncontrolled spread of liquid in the event of a major spillage. It distinguishes these from bund walls which should not be constructed around LPG gas pressure storage tanks.

Health and Safety at Work, No 30.

167. In 1973 the booklet was renamed HSW 30 'The Storage of Liquefied Petroleum Gas at Factories' and published by the Department of Employment. The foreword states the publication is based on the experience of HM Factory Inspectorate with help given by representatives of industries and others with special knowledge. It also notes that there was no intention to provide an interpretation of legal requirements.

168. The Introduction refers to the 1971 'Code of Practice for the Storage of Liquefied Petroleum Gas at Fixed Installations' prepared by the Standing Advisory Committee on Dangerous Substances courtesy of the Home Office. It also refers to Codes of Practice by the Institute of Petroleum, Institution of Gas Engineers and the Liquefied Petroleum Gas Industry Technical Association. The object of the booklet has not changed from that published by the Ministry of Labour. It still does not deal with the detailed design of individual items of plant and refers would be users to LPG suppliers in addition to the previous referral to the relevant Codes of Practice and specialist firms. It reiterates that factory occupiers should seek the advice of HM District Inspector of Factories when planning a storage installation or the extension of an existing plant and adds that the storage of LPG at factories (and other places that the Factories Act 1961 applies) is subject to the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972.

169. The storage and handling section discusses pipelines at page 15, *"Buried lines should in addition be specially protected against corrosion and should not be run in ducts with other services unless special attention has been given to the potential hazards. Trenches and ducts should be backfilled with sand to eliminate the potential hazard of flammable vapour, derived from a leak, collecting there"*.

170. In the Precautions section it now allows for tanks, *"buried beneath open ground"*. The separation distance tables are reprinted from the 1971 Home Office 'Code of Practice for the Storage of Liquefied Petroleum Gas at Fixed

Installations'. Page 20 echoes the previous Ministry of Labour booklet's reasons for separation distances and what they protect against. At page 23 it states that, *"Openings into underground drains, service ducts etc within the specified separation distances are best sealed against penetration of gas"* and later it identifies gas loading and unloading operations as the most likely source of a mishap leading to spillage and fire.

171. The Installation section (starting on page 26) identifies that regular maintenance and inspection of the storage tank should ensure against external corrosion. It also states that underground tanks, *"should be prepared by shot blasting or chemical treatment and then given a protective coating adequate to resist soil corrosion conditions and the coating should be strongly bonded to the shell"* and mentions that such underground tanks should be protected from above ground loadings due to traffic or other cause. It does not make any specific mention about underground pipework in this context.

172. The fire precautions section at page 42 notes that, *"the advice of HM District Inspector of Factories and of the Fire Authority should be sought at an early stage when consideration is being given to fire protection arrangements"*.

173. In 1975 a third impression, with amendments, of the booklet was prepared by the Health and Safety Executive but it does not contain any reference to the Health and Safety at Work etc Act 1974. The differences include, at page 15, a separate paragraph heading for pipelines but reiterates earlier advice on buried lines.

Health and Safety series booklet HS(G)15.

174. In April 1981 HSW30 was published with minor amendments as HSG15 'The Storage of Liquefied Petroleum Gas at Factories'. The object and scope of the guidance remains the same. The foreword does not appear to be present. The reference to the Home Office code in paragraph 5 notes that it has been republished by HSE as Guidance Note CS5 'The Storage of LPG at fixed installations'. The separation distance tables have been reprinted from CS5. There are no other relevant differences.

2.8.2 The storage of LPG at fixed installations

Code of Practice for the Storage of LPG at fixed installations

175. In 1971 the 'Code of Practice for the Storage of Liquefied Petroleum Gas at Fixed Installations' was published courtesy of the Home Office. The 3rd impression of 1973 (with no specified changes) is reviewed below.

176. In the foreword this document is described as a general guide to safe practice in storing and handling LPG at fixed storage installations where tanks are filled on site. Installations are covered only up to the inlet of the first stage regulator. It was prepared *"primarily as guide for any bodies given the task of enforcing safety requirements at these installations"*. It recognises however that each case must be considered on its merits and special circumstances may necessitate variations of the recommended requirements and also states that,

"It is not the intention that the recommendations of the code should be applied rigidly to existing premises, where for a variety of reasons it may not be practicable to comply with them. Only such alterations as are considered to be reasonable, or essential for the public safety should be made." The references include the Institute of Petroleum Code of Practice and the LPGITA Codes of Practice on installation, control of fire and maintenance.

177. Part 1 provides general information on LPG, its characteristics and hazards including: LPG vapour is heavier than air it may flow along the ground and into drains sinking to the lowest level of the surroundings; its flammable range (approximately 2% to 10% of LPG vapour in air); and the fact that any vapour / air mixture arising from leakage may become ignited some distance from the point of escape and the flame may travel back to the original source of leakage.

178. Part 3 is the relevant section for the type and size of installation at ICL (990 gallon water capacity) as it covers the smaller storage facilities (up to the inlet of the first stage line pressure reduction) at industrial, commercial and domestic premises where the total LPG storage capacity is 30,000 gallons water capacity or less.

Section 3.2 Storage tank location and safety distances

179. Table 3.2.1 contains the same minimum separation distances as LPGITC Code 1 (1969). For above ground tanks of over 500 – 2000 gallons water capacity a minimum distance of 25 feet from building, boundary, property line or fixed source of ignition is required. The guidance allows that, *"With the provision of radiation walls or adequate fixed water spray systems, separation distances for above ground tanks may be reduced but specialist advice should be obtained"*.

180. Separation kerbs, with a maximum height of 15", to prevent spillage reaching important areas are discussed in 3.2.2.c but they are not required for tanks with no bottom liquid LPG outlet. In 3.2.3.d the protection of underground tanks from above-ground loading, e.g. due to vehicular traffic, is discussed.

Section 3.4 Piping, Valves and Fittings

181. Materials are covered in 3.4.1 where it states, *"All materials including non-metallic parts for valves, seals, gaskets and diaphragms should be resistant to the action of LPG under the service conditions to which they are subjected"*. It further requires that all piping over ½ inch diameter should be made of steel, that cast iron or other unsuitable piping materials should not be used and that copper or brass pipe and tubing should be seamless and should only be used for diameters of ½ inch and under.

182. Section 3.4 notes that pipe joints over 2 inches nominal diameter should be welded or flanged. Joints of 2 inches nominal diameter or smaller may be welded, flanged or screwed.

183. Valves are covered in 3.4.3, *"The primary shut off valve for tanks with a water capacity in excess of 2000 gallons should be of steel or of nodular iron made to BS 2789 or an equivalent standard. Other valves should be of steel or forged*

brass, except that valves of nodular iron made to BS 2789 or an equivalent standard may be used. Cast iron valves should not be used, other than those of nodular iron made to BS 2789, or an equivalent standard".

184. The requirements for installation and testing are in 3.4.5 including, *"All pipeline systems should be tested after installation and proved free of leaks at not less than the maximum operating pressure. Piping should be protected against physical damage".*

185. The Health and Safety Executive produced the 1977 reprint (4th impression) as 'Guidance notes for the Storage of Liquefied Petroleum Gas at Fixed Installations' and there were no changes to the relevant sections.

The Storage of LPG at Fixed Installations Guidance Note CS 5 from the Health and Safety Executive, May 1981.

186. This guidance note is introduced as a reprint with minor amendments of the Home Office Code of Practice outlined above. It provides a general guide to safe practice in storing and handling LPG at fixed storage installations where tanks are filled on site. It identifies in the introduction section that it is aimed primarily at authorities acting as enforcing authorities. It recognises however that each case must be considered on its merits and special circumstances may necessitate variations of the recommended requirements. It states that, *"Nor is it the intention that the recommendations should be applied rigidly to existing premises, where for a variety of reasons it may not be practicable to comply with them. Only such alterations as are considered to be reasonable, or essential for the public safety should be made."* Page 1, Introduction, paragraph 2 concludes, *"Installations are covered only up to the inlet of first stage line pressure reduction"*. The Introduction closes by saying, *"The Guidance Note does not include detailed guidance on the design, construction and maintenance of LPG equipment"*. For such guidance readers are referred to sources listed on page 19 where the only HSE reference is Guidance Note CS 4, Keeping of LPG in Cylinders.

187. The general section provides information on the characteristics and hazards of LPG as for the previous document.

188. Paragraphs 137 – 230 deal with industrial, commercial and domestic bulk storage, as would apply to the ICL installation. At paragraph 137 it again states that installations are covered only up to the inlet of first stage line pressure reduction. It reiterates the standard separation requirements at paragraphs 138 – 146 and table 6 on page 13.

189. Paragraph 176 deals with corrosion protection requiring that tanks and their supports should be adequately protected against corrosion by painting or other means. Paragraphs 177-180 deal with the installation of underground tanks and comments that before being placed underground tanks should be given a protective coating adequate to resist soil corrosion conditions. Once the tank is in place, the coating should be checked by suitable fault detection apparatus. It recommends that specialist advice be obtained on corrosion protection of tanks, including coating materials, application and whether cathodic protection is

necessary. It also notes that the backfill should be free from rocks or other abrasive materials.

190. Paragraphs 183-186 deal with piping, valves and fittings. It reiterates the same standard specified in the previous Home Office guidance with regards to material and pipe specification, i.e.: all piping over 13mm (½ inch) should be made of steel; cast iron or other unsuitable piping materials should not be used; copper or brass pipe and tubing should be seamless and used only for sizes 13mm (½ inch) and under. Paragraph 193 reiterates the same standard paragraph which requires, *"All pipeline systems should be tested after installation and proved free from leaks at not less than the maximum operating pressure. Piping should be protected against physical damage".*

191. Paragraph 231, under the heading of Operations subtitle Training, suggests that personnel responsible for the operation of equipment and handling of LPG should understand the physical characteristics of the product and be familiar with the relevant section of this guidance appertaining to their spheres of responsibilities. This paragraph was present in previous version of the Home Office guide and is also reminiscent of the training section in the Institute of Petroleum Model Code of Practice 1967 and LPGITA Code of Practice 1 both of which are referenced at the back of this Guidance Note.

2.8.3 HSG34 The storage of LPG at fixed installations (1987)

192. HSG34 was first published in 1987; it states that it updates and supersedes Health and Safety series booklet HSG15 and HSE Guidance Note CS5, discussed in sections 2.8.1 and 2.8.2 of this report respectively. HSG34 was withdrawn in 2000 after being superseded by LP Gas Association guidance written in full consultation with HSE; starting with LPGA Code of Practice 1 Part 1 published in 1998.

Introduction, Scope & Legal Requirements

193. The publication provides a general guide to safe practice in storing and handling liquefied petroleum gas (LPG) at fixed storage installations. It provides a guide to safe practice both for people storing LPG and those enforcing safety requirements. The guide may be used where people have duties under the Health and Safety at Work etc Act and may also be used as good practice in other circumstances. The recommendations are intended to minimise the risks of fire and explosion from escaping LPG and from a fire at or near a store.

194. The information in this guidance gives one way of achieving an acceptable standard of safety. Each case must be considered on its merits and special circumstances may necessitate variations from the recommendations. It is not intended to preclude the use of alternative designs, materials and methods where these provide equivalent safety standards. Neither is it the intention that the recommendations should be applied rigidly to existing premises where for a variety of reasons it may not be practicable to comply with them, although such alterations that are considered to be reasonable or essential for safety should be made. New installations should comply with the advice in this guidance from the date of publication.

195. The guidance deals solely with installations where LPG is stored under pressure in fixed vessels over 150 litres. It applies to all such installations and includes guidance on the design, construction and examination of LPG storage vessels.

196. The guidance states that the storage of LPG will usually be subject to the general duties of the Health and Safety at Work etc Act 1974. It may also be subject to additional legal requirements including the Highly Flammable and Liquefied Petroleum Gas Regulations 1972, the Control of Industrial Major Hazards Regulations 1984, the Fire Certificates (Special Premises) Regulations 1976 and the Fire Precautions Act 1971.

Properties & Hazards of LPG and Locations, Separation & Grouping

197. The guidance notes that LPG vapour is heavier than air and does not disperse easily. It will tend to sink to the lowest possible level and may accumulate in cellars, pits, drains and other depressions. LPG forms flammable mixtures with air in concentrations of between approximately 2% and 10% and can therefore be a fire and explosion hazard. LPG vapour/ air mixtures may be ignited some distance from the point of escape and the flame travel back to the source.

198. Page 5 deals with the location and spacing for vessels, and the condition of the ground below and close to the vessels. Page 7 deals with catchment pits or bunds but only refer to vessels over 56,250 litres capacity. Firewalls are dealt with on page 9.

Mechanical Integrity

199. The guidance states that the mechanical integrity of vessels will not initially be assured unless the correct design criteria are adopted. The design of underground or mounded vessels will require an appreciation of the more arduous conditions introduced. LPG vessels should be designed, constructed, tested and certified to an appropriate standard and the publication outlines the design requirements. It states that existing butane installations should be checked by a competent person to determine whether they meet the design criteria in paragraph 38 and if not the vessel or installation should be modified to meet the criteria.

200. Page 13 deals with underground or mounded vessels which should be located in ground which is well drained and preferably located within a concrete or brick lined pit which will allow sound installation and backfill, and provide easy access for inspection. The surface of such vessels should be suitably prepared or treated to protect them from corrosion. Methods may include surface coatings and cathodic protection. When lowering the vessel into place, care should be taken to avoid damage to the coating. When the vessel is in place the coating should be checked by suitable fault detection apparatus and any damage repaired. Backfill material should be inert, non-corrosive, and free from abrasive materials or particles likely to damage the vessel coating.

201. The publication states that after installation and before being filled with liquid the vessel should be examined by a competent person. Particular attention should be paid to site fittings, protective devices, site loading and vessel

supports/foundations. The vessel should be certified as fit-for-purpose. Any additional site inspection or testing necessary should be determined by a competent person and the safe operating limits of pressure, temperature and loading should be certified. For underground or mounded vessels the inspection should take place before backfilling or mounding. Existing vessels should carry similar fit-for-purpose certification issued by a competent person. Before the first periodic examination this will relate to the as-new condition. After the first and subsequent examinations the safe working limits should be endorsed or reassessed by the competent person dependant on the inspection findings.

Fittings

202. Page 16 deals with the suitability of fittings. Each vessel should be fitted with a pressure relief valve connected to the vapour space, a drain (or other means of emptying the vessel of liquid), a maximum level indicator and preferably a contents gauge, a filling connection, a means to prevent excess vacuum if dictated by vessel design, a pressure gauge for vessels over 5000 litres or for smaller vessels a provision to determine pressure e.g. valved tapping in vapour space or adjacent pipework. The guidance states that all connections in a vessel greater than 3mm diameter for liquids and 8mm diameter for vapour should have an emergency shut-off valve e.g. an excess flow valve, a non return valve or a remotely operated emergency valve.

Piping

203. Page 19 deals with the suitability of pipework. Piping should be properly designed and constructed with due regard to low temperature service. The materials used should be suitable for use with LPG. In general steel piping should be used but for vapour lines solid joint copper tubing may be used. Cast iron pipes should not be used. Pipes conveying vapour should be constructed from materials suitable for use at a temperature down to –20^{o}C, where these pipes may be subject to two-phase flow lower design temperatures may be appropriate.

204. HSG34 states that detailed advice on piping for use with LPG can be found in LPGITA CoP 22. All metal piping with nominal bore greater than 50mm, all piping at full vessel pressure and all pipes carrying liquid should be designed and constructed to an acceptable standard, e.g. BS3351 or ANSI B31.3

205. Joints should be kept to a minimum. Piping more than 50mm outside diameter should have welded or welded flange joints except where connected to a vessel by screwed connections. Piping 50mm diameter or less may have screwed joints. Where piping has screwed joints which may be subject to vibration, consideration should be given to tack welding them to prevent them from coming loose. Jointing compounds and rings should be suitable for use with LPG.

206. To prevent the accumulation of static electricity metal piping should be electrically continuous so that the resistance to earth of the installation does not

exceed 10^6 ohms (in practice a value of 100 ohms is readily attainable). Reference is made to BS5958: Part 1: 1980 for further information.

207. Piping should be sized and routed to keep restrict contents to a minimum thus reducing potential hazard. The route should minimise the possibility of physical damage particularly from vehicles but where such damage may be foreseen protective barriers etc. should be provided. Piping should preferably be run above ground and routed away, or protected against, excessive heat or cold.

208. Routing of piping containing liquid LPG or vapour at a pressure above 37 millibar gauge in buildings should be avoided. Where this is not reasonably practicable any such pipe within a building should be in a well-ventilated position, protected from physical damage. The length of pipe within the building should be kept to a minimum.

Piping: Underground pipes

209. Paragraph 79 refers to underground piping carrying liquid and requires:

- Correct piping design: All welded pipe joints; isolation valves at both ends of underground section; allowance for additional loading imposed by backfill or underground locations;

- Correct design of trench and backfill: Pipe adequately supported and laid in a shallow open concrete or masonry-lined trench with open grid covers or run the pipe inside an outer pipe sealed at both ends and space monitored to detect leaks, normally by registering a pressure change; backfilled with an inert, non-corrosive material free from abrasive particles likely to damage the corrosion protection; protection from superimposed/ traffic loads by load-bearing slabs or covers;

- Corrosion protection where necessary e.g. wax tape, bitumen overwraps, cathodic protection and the need to seek specialist advice.

210. Route of pipe-run should be recorded and where practical permanently marked.

211. Paragraph 80, page 20 deals with suitable polyethylene (PE) pipe which it states may be used to convey LPG vapour and LPG/air mixtures. PE pipe should be buried but where terminals come above ground it should be as short as possible and protected against ultraviolet and mechanical damage e.g. by sleeving. Alternatively the transition to metal pipe can be made with a suitable fitting below ground.

212. Paragraph 81 (numbered 80 in error) deals with LPG pipes carrying vapour which it states may be buried in an open excavation, backfilled with material which is non-corrosive. Metal piping should be protected from corrosion e.g. using proprietary wax impregnated tape, tar/bitumen overwraps or cathodic protection. The backfill material for metal piping should be free from abrasive particles likely to damage the protective coating.

Security (vehicular damage) & Fire precautions

213. Page 24 covers the effect of vehicle damage and states the location of vessels and their attachments (e.g. piping) in areas used by motor traffic should be avoided. Where protection is required substantial crash barriers or bollards should be provided. Underground vessels should be protected from the effects of ground loading by traffic either by fencing off or provision of load-bearing covers. Underground pipework should be similarly protected where necessary.

214. Page 25 deals with general aspects of fire precautions and states that the possibility of major fire outbreak can be minimised by good plant design and layout, sound engineering, good operating practice, proper instruction, training of personnel in routine operations, and action to be taken in an emergency.

Loading and unloading facilities

215. Pages 29 to 31 deal with facilities for loading and unloading LPG. They refer to the need for written instructions, which define the responsibilities for all personnel involved in such operations. For many installations this would normally be the road tanker driver and an employee from the site however in some cases, particularly at domestic premises or small installations, this may be impractical.

216. Paragraph 150 states *"over-filling can have extremely serious consequences and any over-filled tank or vessel should have the excess LPG removed immediately in a safe manner".*

Commissioning

217. Before filling with LPG the vessel and its fittings it should be tested and proved free of leaks and fit for use. A method of leak testing is to pressurise vessel with air or inert gas and check for any pressure drop. For further information on safe methods of pressure testing it refers to HSE Guidance Note GS4 'Safety in Pressure Testing'. There is no reference to pipework.

Maintenance and examination

218. Page 32 covers maintenance and examination. Paragraph 182 states that the installation should be properly maintained to acceptable standards determined and overseen by a competent engineer of appropriate discipline, with the objective of maintaining the established safe operating limits. Emphasis should be placed on features affecting the integrity of the installation or the ability to take emergency action. For installations rented from the gas suppliers this work may be carried out by the company owning the vessel.

219. Paragraph 183 states that a maintenance scheme should be prepared which includes protective devices and instruments, the form and detail of which should reflect the needs of the particular installation. Servicing and maintenance handbooks may be adequate for simple installations. Suitable records should be kept so that all maintenance schemes are properly monitored. All significant repairs or replacements should be recorded.

220. A scheme for examination of the installation should be drawn up or endorsed by a competent person and reviewed after each examination. The scope of any particular examination and inspection techniques used should be decided by the competent person. Examinations of underground or mounded vessels should include tests for corrosion e.g. detailed ultrasonic thickness tests. If internal access is not possible the external surface of the vessel will need to be exposed to enable examination to take place.

221. Underground pipework carrying liquid which is laid in a backfilled trench should be examined for corrosion or tested in such a way as to establish continuing integrity at least once every 10 years. No specific mention is made of pipes carrying vapour however paragraphs 182 and 183 refer to the installation rather than the vessel but 'installation' in this context is not defined in HSG34.

222. Any significant deterioration/ defects found and any remedial work undertaken should be recorded on the examination report with particulars of the inspection techniques used. The effect of such deterioration should be assessed by the competent person and the safe working limits endorsed or modified accordingly. The examination report should specify the minimum and maximum safe operating pressures, minimum safe operating temperature, maximum permissible load and date of next examination. Any repair or modification undertaken should be to a standard which is at least equal to the original design and construction code. Where such work may affect the integrity of the installation it should be overseen and certified by a competent person who should endorse or modify safe operation limits accordingly.

Operational procedures, training and bibliography

223. Page 33 covers operational procedures and training. Written operating procedures should be prepared which clearly define the actions of functions required of people involved. These should cover both normal and emergency operations and be regularly reviewed to ensure they are appropriate. They should be amended to take into account any alterations or modifications to the installation. Procedures should include: transfers of LPG to/ from the installation, permit-to-work systems, plant maintenance and modification, and emergency procedures.

224. Employers should ensure that employees concerned with LPG are familiar with the properties and hazards. Employees should be instructed in normal operations including loading and off-loading procedures and emergency operations.

225. The bibliography refers to legislation, Health and Safety Executive guidance, British Standards and American Petroleum Institute Standards and American National Standards. Reference is made to LPGITA Code of Practice 1, March 1978, Installation and Maintenance of Bulk LPG Storage at Consumers' Premises and LPGITA Code of Practice No 22, LPG Piping - System Design and Installation.

2.8.4 Guidance note CS4 cylinders & similar containers (1981)

226. As guidance note CS4 covers the keeping of cylinders and similar containers rather than bulk tanks it is not applicable to the ICL installation.

2.8.5 HSE Information Sheet Chemical Sheet 4 'Use of LPG in small bulk tanks' CHIS4 (1999)

227. After the withdrawal of HSG34 there was a need for free HSE guidance produced for small-scale users of LPG either from bulk tanks or cylinders. Two HSE Information Sheet were issued in October 1999: CHIS4 'Use of LPG in small bulk tanks' and CHIS5 'Small scale use of LPG in cylinders'; the latter is not applicable to the ICL installation.

228. Chemical Information Sheet CHIS 4, aimed at small-scale users of LPG in bulk tanks covers the hazards of LPG, precautions, and actions in the event of a fire or leak. It highlights the fact that LPG vapour is heavier than air and will collect in drains, gullies and cellars. It deals with the need to ensure there are adequate arrangements for inspection and maintenance of the tank and its equipment but states this is normally arranged by the LPG supplier. It states, *"For underground piping, make sure you know the route it takes, and avoid putting anything in the ground which may damage the pipework".* It does not discuss inspection or maintenance of the pipework, nor its ownership.

3. Relationship/ involvement with LPGA guidance.

229. Historically there were two sets of guidance on the storage and use of LPG; one set produced by HSE and the other set by the main LPG trade association now known as the LP Gas Association. The two sets of guidance involved a duplication of effort. Inspectors used the HSE guidance as a benchmark for good practice and as one way of achieving an acceptable standard of safety. The LPGA Codes were written by the LP Gas industry and contained further practical details.

230. When HSG34, and HSE Guidance Notes GN CS4, GN CS8 and GN CS11 were due for review in 1997 it was decided to produce one set of guidance with input from the LP Gas Industry and HSE. LPGA drafted, published and sold the Codes. Those Codes covering information previously contained in HSE guidance included a foreword signed by the chairman of the HSC Advisory Committee for Dangerous Substances (ACDS). HSE was fully consulted on the endorsed Codes and they were not published until HSE and LPGA had agreed the content and comments from an external consultation exercise had been considered.

231. At the time of the ICL incident joint Codes were still being revised in full consultation with HSE and subject to external consultation. Not all LPGA Codes of Practice contained HSE's foreword, for example LPGA CoP 1 contained the foreword but CoP 22 did not and Codes without the foreword did not need to be agreed with HSE.

Penny Taylor
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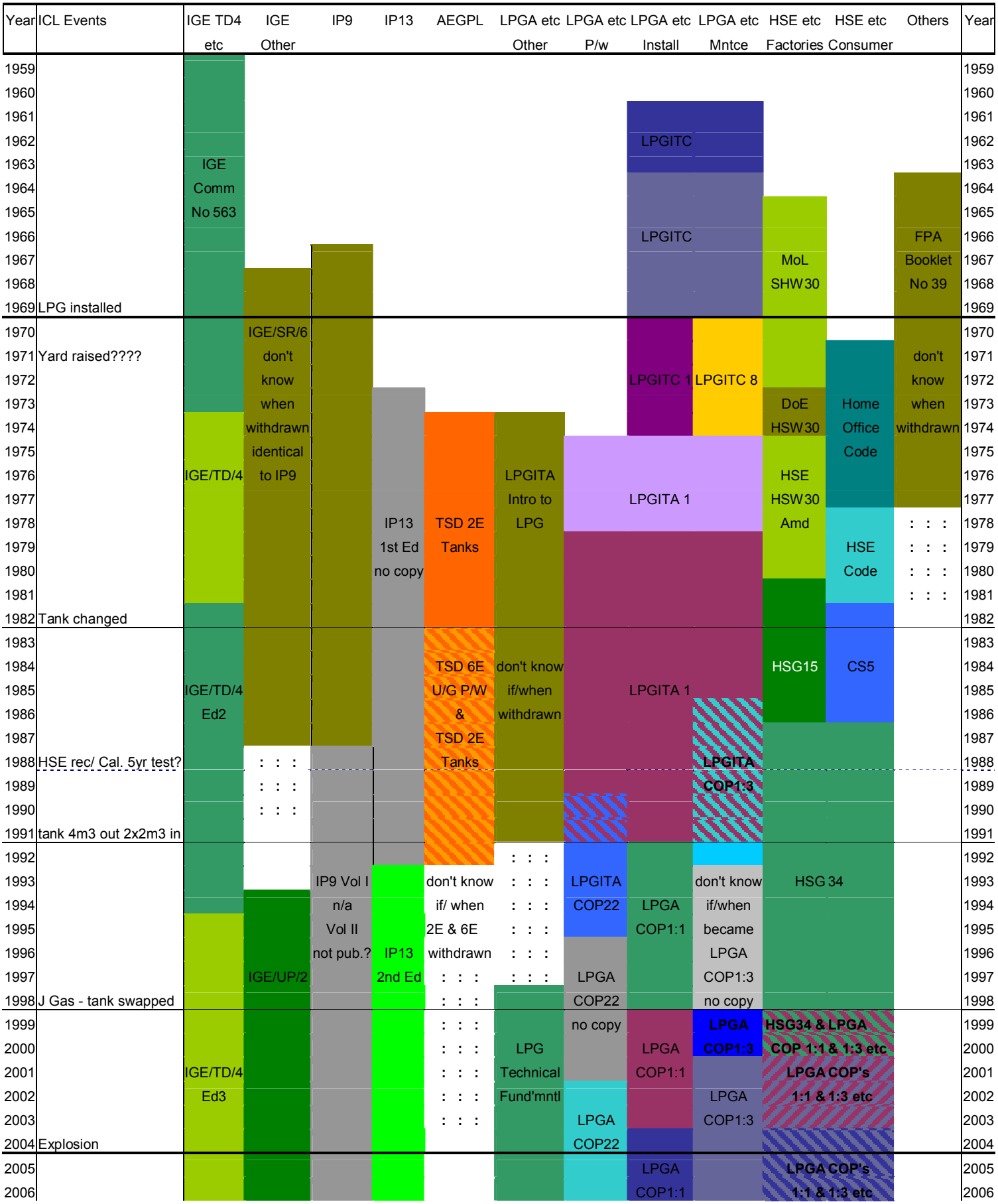
HID SI5 - Process Safety CTG

Annex A


Year
ICL Events
IGE TD4 etc
IGE Other
IP9
IP13
AEGPL
LPGA etc Other
LPGA etc P/w
LPGA etc Install
LPGA etc Mntce
HSE etc Factories
HSE etc Consumer
Others
Year
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
LPG installed
1970
1971
Yard raised????
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
Tank changed
1983
1984
1985
1986
1987
1988
HSE rec/ Cal. 5yr test?
1989
1990
1991
tank 4m3 out 2x2m3 in
1992
1993
1994
1995
1996
1997
1998
J Gas - tank swapped
1999
2000
2001
2002
2003
2004
Explosion
2005
2006
IGE Comm No 563
IGE/TD/4
IGE/TD/4 Ed2
IGE/TD/4 Ed3
IGE/SR/6 don't know when withdrawn identical to IP9
IGE/UP/2
: : :
IP9 Vol I n/a Vol II not pub.?
IP13 1st Ed no copy
IP13 2nd Ed
TSD 2E Tanks
TSD 6E U/G P/W & TSD 2E Tanks
don't know if/ when 2E & 6E withdrawn
LPGITA Intro to LPG
don't know if/when withdrawn
LPG Technical Fund'mntl
LPGITA 1
LPGITC
LPGITC 1
LPGITC 8
LPGA COP1:1
LPGITA COP1:3
LPGITA COP22
LPGA COP22
no copy
LPGA COP1:3
don't know if/when became LPGA COP1:3 no copy
MoL SHW30
DoE HSW30
HSE HSW30 Amd
HSG15
HSG 34
HSG34 & LPGA COP 1:1 & 1:3 etc
LPGA COP's 1:1 & 1:3 etc
Home Office Code
HSE Code
CS5
FPA Booklet No 39
don't know when withdrawn