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To

Process Safety Specialist Inspectors, Mechanical Engineering Inspectors

DEVELOPING AN INSPECTION STRATEGY TO ENSURE THE ONGOING EXTERNAL INTEGRITY OF BURIED, METALLIC, LPG PIPEWORK

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BACKGROUND

1. HSE knows of several cases of externally corroded buried, metallic, LPG pipework. Corroded pipework may lead to LPG releases that can accumulate, ignite and explode. Several cases of external corrosion of buried pipework, one of which led to building collapse and personal injury, have been reported to the HSE. This DIN is to promote awareness and provide a timely reminder of the safety precautions applicable to metallic underground pipes carrying LPG as a vapour or liquid. It does not detail the design and installation requirements as these are covered in OC 286/104 nor does it cover examination of polyethylene pipe used to convey LPG.

2. Liquefied petroleum gas (LPG) is propane, butane or a mixture of the two stored as a liquid. Propane and butane are both heavier-than-air gases under atmospheric conditions so if there is a leak the gas will tend to accumulate in low spots (drains, gullies, basements) or at ground level. LPG is used in industrial and commercial situations as a process raw material, process fuel, vehicle fuel and general fuel for heating and cooking. LPG is often odorised to allow early warning of a leak but not always e.g. aerosol propellant.

3. Most LPG is stored outside in cylinders or fixed bulk storage tanks and is piped to the point of use (exceptions include fork lift truck fuel and, welding and allied applications). Pipework may run above or below ground or a combination of the two, but:

- Ideally pipework should be run above ground;

- Where pipework needs to be buried it should be inherently resistant to corrosion e.g. certain grades of polyethylene or proprietary systems;

- Metallic pipework should only be run below ground where this is unavoidable (see paras 4 & 18);

- Polyethylene pipework should not be used above ground.

4. Buried metallic pipework should have been adequately protected from corrosion at the time of installation by sleeving or by the provision of a suitable coating. Sometimes cathodic protection will be used instead of, or in addition to, coating although this is more likely at large installations. Even if there is evidence that the pipework was suitably protected at the time of installation (e.g. by signs of sleeving or coating at the air/ soil/ pipe interface) it does not necessarily follow that the protection has remained effective. Sleeves and coatings may be damaged during or subsequent to installation or degrade over time. However, in some cases the pipework may have been installed without corrosion protection.

5. The supply system will often comprise:

   a. storage vessel;

   b. pressure regulator(s);

   c. emergency control valve (ECV): Defined in the Gas Safety (Installation and Use) Regulations (GSIUR) as a valve intended for use by a consumer to shut off the supply of gas in an emergency;

   d. service pipework: Defined in GSIUR as the pipe from storage vessel to outlet of the ECV;

   e. installation pipework: Defined in GSIUR as the pipe from downstream of the ECV to the appliance;

   f. appliance(s).

6. The ECV should be positioned close to the pipe entry point to the building. A pressure regulator may be present close to the tank, near the entry to the building (alongside the ECV) or close to the point of use. For premises where GSIUR does not apply items c, d and e will not be defined as above but an isolation valve should be installed at a suitable position for use in an emergency.

7. At consumer sites it is common for the storage tank to be owned by the LPG supplier but this does not have to be the case. The LPG supplier would not usually own the service pipework but under some circumstances they may own part of it e.g. to the boundary of an LPG compound. The LPG consumer will often own and be responsible for the service pipework and almost always will own and be responsible for the installation

pipework. However consumers may not always be aware of their responsibilities.

COMPARISON WITH NATURAL GAS

8. Although natural gas pipelines and service pipes are not usually excavated for inspections, currently the major asset owner of old metallic mains distribution systems have mains and service replacement policies. The mains replacement policy is a risk assessment based on a large amount of data including number of reported repairs and number of incidents. Mains with the highest risk are replaced first. Generally this means that those made of susceptible material or in susceptible locations are replaced as a priority. **Note: With the break up of the distribution network the new asset owners of these systems will be obliged to continue with the existing replacement schedule.**

9. The service replacement policy follows a similar approach to the mains replacement policy. A risk assessment approach is used to identify service pipes that should be replaced, e.g. a steel service should be replaced following an escape caused by corrosion, and all steel services should be replaced in an area where there is a high level of service leakage due to steel corrosion. If a service has not been identified because of a leak other work, such as mains replacement, may cause the service pipe to be assessed against a further set of criteria. This may lead to replacement of, for example, all unprotected steel and bitumen/ hessian wrapped below-ground steel services and PE clad steel services unless they can be determined as being in a satisfactory condition. Furthermore, if a meter control valve exchange is being undertaken in a single/ dual domestic property and the service entry is below ground and constructed of steel, consideration will be given to replacing the service pipe.

LEGISLATION

10. The Health and Safety at Work etc Act 1974 sections 2(1) (and 3 where applicable) are seen by some to be the most straightforward to use, especially in view of their ability to apply to the generalities rather than the specifics of the situation.

11. The Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) could be used to enforce any improvements to arrangements for ensuring integrity of buried LPG pipework. DSEAR deals with fire, explosion and related hazards at workplaces. Certain parts of DSEAR discuss maintenance of processes and equipment. Regulations 5 & 6 in particular, are the most appropriate to apply to the use and storage of LPG in terms of application and definition. More information on DSEAR is available in the ACOP suite. [2, 3, 4, 5 & 6]

12. Provision and Use of Work Equipment Regulations 1998 (PUWER) could be used to enforce any improvements to arrangements for ensuring integrity of buried pipework. PUWER places duties on the employer to ensure that work equipment (including installations) exposed to conditions causing deterioration that is liable to result in dangerous situations is inspected at suitable intervals (regulation 6). The purpose of the inspection

is to ensure that health and safety conditions are maintained and that any deterioration can be detected and remedied in good time. This requirement will apply to LPG installations. More information on PUWER is available in Safe use of Work Equipment, Provision and Use of Work Equipment Regulations 1998 Approved Code of Practice and Guidance. [7]

13. The Pressure Systems Safety Regulations 2000 (PSSR) are unlikely to be useful in enforcement of a duty to inspect because they deal specifically with hazards from the stored energy. They apply to pressure systems that contain pressures of 0.5 bar above atmospheric pressure or greater where the pressure system is used or intended to be used at work. Pipework in which a defect may give rise to danger (from stored energy) should be included in the written scheme of examination (WSE). Generally the danger arising from defects of underground LPG pipework are those of fire and explosion rather than release of stored energy, so the WSE required by PSSR does not have to include the buried pipework. However, the duty to inspect pipework under PUWER and hence DSEAR can be satisfied by an inspection regime similar to that required by PSSR, i.e. a WSE. More information on PSSR is available in Safety of Pressure Systems, Pressure Systems Safety Regulations 2000 Approved Code of Practice and Guidance. [8]

14. The Gas Safety (Installation and Use) Regulations 1998 (GSIUR) cover LPG storage tanks, service pipework, ECV and installation pipework only where the premises themselves are covered by the regulations. They include a duty on employers to ensure that installation pipework at relevant premises is maintained in a safe condition but this does not extend to LPG service pipework. Similarly duties on landlords of domestic property to maintain gas pipework do not extend to LPG service pipework. However where work involves breaking into a gas system, for example for the purposes of installing fittings for a gas tightness test, the regulations would apply at relevant premises (such as domestic premises, schools, offices, nursing homes, petrol filling stations and caravan holiday home parks). The regulations exclude situations where the gas is being used for the purposes of an industrial process carried out on an industrial premise (these include agricultural premises, factories, mines, quarries, sewage treatment works and temporary gas installations as part of a construction activity). GSIUR does not cover design, testing or inspection of storage tanks and service pipework. More information on GSIUR is available in Safety in the installation and use of gas systems and appliances, Gas Safety (Installation and Use) Regulations 1998 Approved Code of Practice and Guidance[9] and OC 440/28.

15. In summary, we can require service and installation pipework at industrial and commercial premises to be the subject of an inspection strategy enforceable by Regulations. HSWA section 3 responsibilities for service pipework maintenance would apply:

- to the landlord for domestic rented premises;
- the site owner for holiday home parks, etc;
- the gas supplier for all premises where they own the pipework.

For domestic owner-occupied premises there is no H&S duty for the domestic customer to maintain his/ her pipework. Therefore any reminder to owner-occupiers to inspect would be purely advisory. However, any gas work carried out as a consequence of an inspection should be done so in accordance with the GSIUR (see para 21).

REVIEW OF GUIDANCE

16. OC 286/104 uses information from THSD/A3/T/2/94.[11] These do not require the use of both cathodic protection and sleeving/ wrapping to protect against corrosion but suggest them as and/or measures for buried metallic pipes.

17. The LP Gas Association Code of Practice 1 Bulk LPG Bulk LPG Storage at Fixed Installations, Part 4 Buried or Mounded LPG Storage Vessels[12] briefly discusses interconnecting pipework (between vessels) by referring to the corrosion protection – coatings section in this code. Other pipework associated with the vessels is dealt with by referring to LPGA Code of Practice 22.[13]

18. LP Gas Association Code of Practice 22 LPG Piping systems – Design and Installation[13] covers all piping systems, above or below ground. It states that metallic pipework (other than proprietary systems intended for underground use) should only be buried where unavoidable and consideration should be given to polyethylene or proprietary systems as appropriate. The following types of corrosion protection for buried pipework are mentioned: wrapping, sleeving and cathodic protection (sacrificial anodes or impressed current). It states that suitable provision should be made to facilitate periodic leak testing unless other means are provided to assess the condition of the buried pipework. The section on examination centres on the requirements of PSSR and COMAH. Examination (or inspection) of underground pipework is not covered. Note that LP Gas Association Code of Practice 1 (all parts) contains the HSE foreword; the others mentioned here do not.

19. LP Gas Association Code of Practice 1 Bulk LPG Storage at Fixed Installations, Part 3: Examination and Testing[14] requires that buried pipework carrying vapour at less than 5 bar 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, operating pressure and aggressiveness of the environment. Underground pipework carrying liquid or vapour at 5bar or above should also be surveyed for leakage and the Code goes on to say that this may be a repeat of the pressure test carried out at the time of installation. It states that where the pipework is constantly monitored, e.g. by gas detection, no further test or survey is required. It also says that pipework should be pressure tested or excavated for visual inspection and leak tested under operating pressure or equivalent where there are buried screwed or flanged joints or where there is any doubt of the effectiveness of the corrosion protection system. This Code is currently under review.

20. API 570 Piping inspection code: Inspection, repair, alteration and re-rating in the process industries[15] is an American inspection code written for

refineries and chemical process industries but it has much wider application in practice. It suggests inspection of the air/ soil/ pipe interfaces at 5-year intervals and inspection by excavation at selected points at between 5- and 15-year intervals.

INSPECTION STRATEGY

21. Inspection of buried pipework is difficult. The only really effective inspection method currently available is to excavate and visually inspect the sleeve or coating for defects and if possible the external surface of the pipe. For this reason metallic pipework should only be buried when it is unavoidable. If the buried pipework is not inherently resistant to corrosion it should be protected from corrosion by a suitable coating, sleeve and/ or cathodic protection. A system of monitoring the cathodic protection should be implemented.

22. If an inspection strategy is not already in place for existing pipework, this will take time to develop. A gas tightness test of the pipework (and specifically the buried pipework) will highlight any leaks that require immediate attention. However a test will not indicate the exact location of the leak, nor the condition of the pipework. A test that suggests that the system is leak free does not necessarily prove that the system is gas tight because the ground conditions at the time of the test may provide a gas tight barrier so that an inspection strategy will still be required that may include a visual inspection. LPGA Technical Memorandum No. 62[16] gives advice on a gas tightness test and describes what constitutes 'no discernible pressure drop'. Any test that involves breaking into the gas pipework (service or installation) where GSIUR applies would be classed as work under the regulations and a CORGI registered installer will be required.

Items that should be considered

23. A leakage survey carried out using a gas detector is not considered an effective indication of integrity of the pipework because the heavier-than-air vapour will accumulate at low points e.g. in drains and gullies or remaining in porous ground and therefore may not be registered by gas detector sensors.

24. The inspection strategy for the underground metallic pipework should be developed by someone who is suitably competent. It may be possible to contract this work to a Competent Person attached to an insurance body (such as the Competent Person responsible for pressure systems, as defined by PSSR, on site) but recognising that it may be an activity over and above the PSSR examinations. Alternatively a replacement schedule could be developed with replacement frequencies based on the same factors that would be considered for an inspection strategy.

25. The person who is competent will need to consider a number of factors including those outlined below in developing the inspection strategy:

- the age of the pipework:

- how long it has been buried:
- the type of corrosion protection e.g. type of coating, sleeving or cathodic protection;
- its operating pressure;
- size of pipe;
- materials of construction;
- corrosivity of the environment/ ground conditions;
- soil resistivity;
- type of backfill (if known);
- proximity to occupied buildings;
- building type (likelihood of accumulation in building of leak occurs); amount and weight of traffic passing over the pipe;
- phase of LPG in the pipe (liquid or vapour);
- failure modes;
- if there have been excavations near the pipe.

26. It is not considered good practice to excavate a live pipe, i.e. containing LPG. Often, when the ground or pipe itself has been disturbed a corroded pipe will fail (sometimes catastrophically) causing a significant release of gas. Where excavating along a pipe cannot be avoided, safe digging practices should be used such as using hand tools, excavating alongside the pipe rather than above it then exposing the pipe by horizontal digging, supporting the pipe if necessary. If there is a likelihood of a gas release, further precautions may be required, e.g. monitoring the LPG concentration in the excavation. HSG 47[17] gives further advice on avoiding danger from underground services.

27. After each inspection, someone who is suitably competent (see para 24) should review the strategy and inspection frequency and amend them as necessary. The inspection frequency should be based on the condition of the pipe at the initial inspection and other factors, including, but not limited to, those outlined in para 25 taking into account relevant industry inspection codes and standards, e.g. API 570.[15]

Items that may be considered in an inspection strategy

28. Checking the continued effectiveness of any cathodic protection by measuring pipe-to-soil potentials and anode or transformer current outputs or as defined in the manufacturer's instructions.

29. Inspection of the pipework at all air/ soil/ pipe interfaces. This is where corrosion tends to occur due to the change between atmospheric and ground conditions if a suitable and effective coating system is not in place.

30. Excavation and inspection of a number of joints (including welds) of the pipework to determine:

    a. if the joints appear to be in good condition;

    b. if the joints and immediately adjacent pipework are suitably protected against corrosion, e.g. coating and/or sleeving;

    c. the condition of the coating or sleeving;

    d. the type and condition of the back fill.

31. An assessment of the condition of the rest of the pipework, inferred from the condition of the interfaces, joints and sample points.

32. If the condition of the rest of the pipework cannot be inferred, then it will be necessary to assess the relative risks of excavating the remaining pipework e.g. damage to pipe and/ or corrosion protection (either coating, sleeving or cathodic protection) during excavation versus existing localised corrosion causing release of LPG and its consequences.

33. If the condition of the rest of the pipework cannot be inferred, suitable non-destructive testing (NDT) techniques and strategies may need to be considered. More information is available from HID Safety Report Assessment Guidance (Technical Aspects) – Inspection/ Non-Destructive Testing.

34. If the pipework is suspect, further investigation will be required such as those outlined in para 32 and 33 and remedial action may be required.

GUIDANCE & FURTHER READING

1. OC 286/104, **Pipelines for Conveying LPG Liquid and Vapour – Design and Installation 1995.**

2. **Dangerous Substances and Explosive Atmospheres, Dangerous Substances and Explosive Atmospheres Regulations 2002**, Approved Code of Practice and Guidance L138 HSE Books 2003 ISBN 0 7167 2203 7.

3. **Design of Pant, Equipment and Workplaces, Dangerous Substances and Explosive Atmospheres Regulations 2002**, Approved Code of Practice and Guidance L134 HSE Books 2003 ISBN 0 7167 2199 5.

4. **Storage of Dangerous Substances, Dangerous Substances and Explosive Atmospheres Regulations 2002**, Approved Code of Practice and Guidance L135 HSE Books 2003 ISBN 0 7167 2200 2.

5. **Control and Mitigation Measures, Dangerous Substances and Explosive Atmospheres Regulations 2002**, Approved Code of Practice and Guidance L136 HSE Books 2003 ISBN 0 7167 2201 0.

6. **Safe Maintenance, Repair and Cleaning Procedures, Dangerous Substances and Explosive Atmospheres, Dangerous Substances and Explosive Atmospheres Regulations 2002**, Approved Code of Practice and Guidance L137 HSE Books 2003 ISBN 0 7167 2202 9.

7. **Safe Use of Work Equipment, Provision and Use of Work Equipment Regulations 1998**, Approved Code of Practice and Guidance L22 HSE Books ISBN 0 7176 1626 6.

8. **Safety of Pressure Systems, Pressure Systems Safety Regulations 2000 Approved Code of Practice L122**, HSE Books ISBN 0 7176 1767 X.

9. **Safety in the Installation and Use of Gas Systems and Appliances, Gas Safety (Installation and Use) Regulations 1998**, Approved Code of Practice and Guidance L56 HSE Books ISBN 0 7176 1635 5.

10. OC 440/28 **The Gas Safety (Installation and Use) Regulations 1998, The Gas Safety (Management) Regulation 1996 and the Pipelines Safety Regulations 1996** – Liaison between FOD and HID on gas safety matters Rev 2 2002.

11. THSD/A3/T/2/94, **Pipelines for Conveying LPG Liquid and Vapour 1994.**

12. LP Gas Association, **Code of Practice 1 Bulk LPG Storage at Fixed Installations, Part 4: Buried or Mounded LPG Storage Vessels 1999.**

13. LP Gas Association, **Code of Practice 22 LPG Piping Systems – Design and Installation 2002.**

14. LP Gas Association, **Code of Practice 1 Bulk LPG Storage at Fixed Installations, Part 3: Examination and Testing 2000.**

15. API570 **Piping Inspection Code: Inspection, Repair, Alteration and Rerating of In-Service Piping Systems.**

16. LP Gas Association Technical Memorandum No. 62 **Gas Soundness Testing of LPG Service Pipework, Installation Pipework and Appliances.**

17. **Avoiding Danger from Underground Services** HSG47 HSE Books 2000 ISBN 0 7176 17744 0.

18. HID Safety Report Assessment Guidance (Technical Aspects) – **Inspection/ Non-Destructive Testing**.