UKOPA

UK ONSHORE PIPELINE OPERATORS' ASSOCIATION - INDUSTRY GOOD PRACTICE GUIDE

MANAGEMENT OF PIPELINE ILLEGAL TAPPINGS

Guidance Issued by UKOPA:

The guidance in this document represents what is considered by UKOPA to represent current UK pipeline industry good practices within the defined scope of the guide. The document does not specify prescriptive requirements, should be considered guidance and should not be considered obligatory against the judgement of the Pipeline Owner/Operator. Where new and better techniques are developed and proved, they should be adopted without waiting for modification to the guidance in this document. The term 'shall' has been used to identify any requirement of UK law in Great Britain at the time of publication.

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This document was approved for publication by the UKOPA Board on 24th February 2016.

Document History	**Date**
Edition 1	January 2016

Planned revision date December 2016

Disclaimer

CONTENTS

1 INTRODUCTION

This document has been developed to provide UKOPA members with practical guidance on the steps that they can take to prevent, identify and repair illegal tappings on pipelines. An illegal tapping is defined as a fitting attached to a pipeline without the operator's knowledge for a criminal purpose.

2 SCOPE AND APPLICATION

2.1 Scope

This guide summarises present good practice for the detection, identification and repair of illegal tappings on oil pipelines in the UK. At the issue date all tappings found in the UK have been pipelines designated for liquid service, as such the contents are based around this, but the general principles for surveillance and repair should be applied to gas and chemical pipelines where relevant. It is not intended to cover other aspects of an operator's response to illegal tappings such as emergency leak response that will be a part of the operator's broader safety management strategy.

2.2 Application

The guidance in this document is considered by UKOPA to represent current UK pipeline industry good practice within the defined scope of the document. All requirements should be considered to be guidance only and should not be considered to be obligatory against the judgement of the pipeline owner/operator. Where new and better techniques are developed and proved, they should be adopted without waiting for modifications to the guidance in this document. UKOPA request that such improvements are advised so that they can be included in the next update of this good practice guide.

3 CONFIDENTIALITY

The industry recognises the importance of sharing good practice between operators. However, there needs to be some level of caution in sharing the methods to detect illegal activity on a pipeline as there is the potential that the information will be used by criminals. This guide will therefore be issued to pipeline operators only and not made publically available or published on the internet. UKOPA request that this guide is not disseminated outside member companies and not distributed to other third-party companies / organisations without the prior written permission of UKOPA.

4 TYPES OF ILLEGAL TAPPINGS

Various types of illegal tappings have been found on pipelines in the UK. All tappings reported to date have been on refined product oil lines.

The three generic types of tappings discovered to date are described below:

- Metal spike: The pipe wall thickness is reduced by grinding (usually in a star shape); a fitting is then attached by welding or by clamp, this is then followed by perforating the pipe using a metal spike. An example is shown in Figure 4.1.

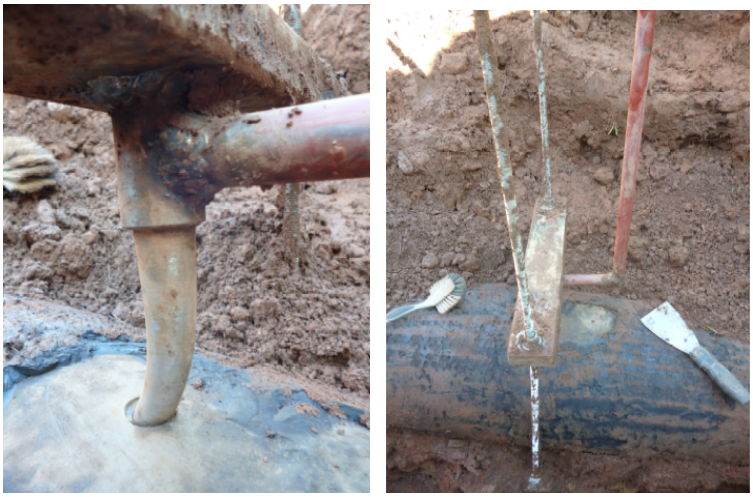
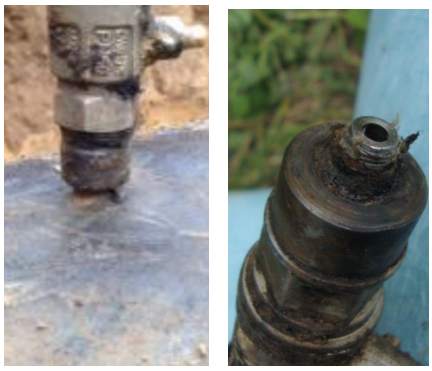


Figure 4.1: Metal spike (left) with its clamp and stand-pipe (right)

- Directly connected valve: A valve is connected directly to the pipeline and the pipe wall is drilled through the valve. Attachment of the valve is achieved by either partial drilling of the pipe wall, threading it, then screwing the valve in place or, alternatively, by direct welding of the valve to the pipe. The connection may be reinforced with solder or weld deposit. A coupon may also be welded to the pipe prior to attachment of the valve. Examples are shown in Figure 4.2.



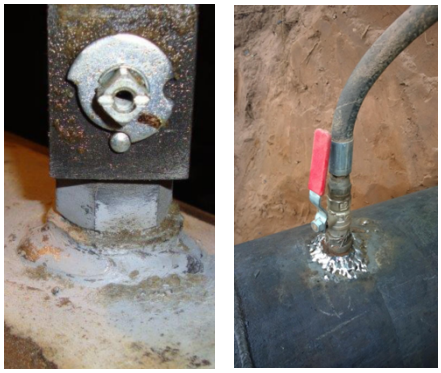


Figure 4.2: Directly connected valves

(clockwise from top left: threaded valve in-situ; threaded valve removed from pipe; solder deposit; weld deposit)

- Clamped connection: A pre-formed circumferential clamp with pre-welded fitting and valve is attached to the pipe. The pipe wall is then drilled through the valve. An example is shown in Figure 4.3.

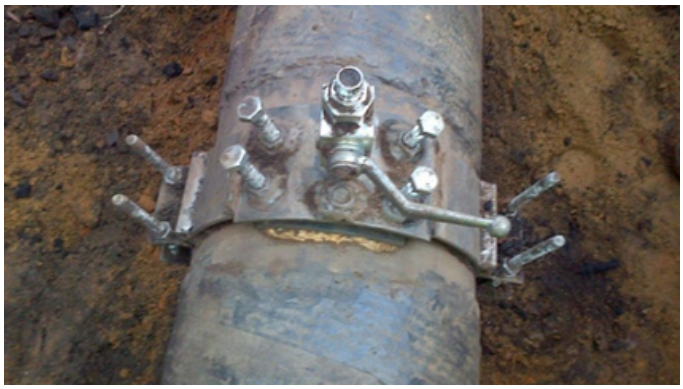


Figure 4.3: Circumferential clamp with pre-welded valve

Numerous combinations of the above have been found. Some have been drilled and tapped but have had no valve or hose attached, others include final perforation of the pipe wall at the same time as the fitting is attached and tightened.

The majority of tappings found to date have been connected to hydraulic hoses, which are then run to a location used for collecting the fuel. The majority of the hoses used are standard metallic-braided hydraulic hose, but in some cases short sections of non-metallic, non-conductive hoses have been used, possibly to reduce the chance of them being detected.

Although most clamps and fittings to date have been ferrous in nature, some have used non-ferrous fittings brazed to the pipe making them more difficult for intelligent pigs to detect.

Due to the possibility that tapping techniques will change over time, operators should be aware that other types may be used.

With the exception of illegal tappings made by driving a spike into the pipeline, the perforation is typically a drilled hole between 2mm and 6mm in diameter. Most illegal tappings have been installed at or near the 12 o'clock position on the pipe.

5 INDICATION OF ILLEGAL TAPPINGS

5.1 Scope

Pipeline tappings are normally linked to theft of product from a pipeline, loss of primary containment of the pipeline, or unauthorised activity in the vicinity of the pipeline. Existing surveillance and monitoring is generally designed to detect these indications and they therefore already provide a degree of protection. However, due to the nature of tappings (low theft flowrate, disguised activities undertaken at night), it is considered that increased surveillance coupled with improved detection techniques should be implemented as necessary to increase the probability of illegal tappings being detected. Recommended enhancements to standard surveillance techniques are summarised in this section.

5.2 Surveillance

Surveillance enhancements should be considered as part of routine pipeline surveillance to increase the probability of preventing and detecting illegal activity. As part of this, additional high visibility patrolling of areas deemed to be at a higher risk should be considered.

Risk assessments should be carried out to identify locations at higher risk (vulnerability to a tapping being installed) and enable surveillance to be prioritised (based on risk and consequence) to these locations. This should be reviewed regularly and when new intelligence is available.

Examples of high risk areas are:

- Areas of previous illegal activity.
- Above ground pipeline sections or facilities (e.g. pipe bridges, block valves) that are not considered to be secure.
- Sections of pipeline that are shut down and depressurised for repair or modification, possibly during repair of a tapping.
- Locations where leak detection systems or other intelligence has indicated the possibility of illegal activity.
- Secluded areas.

- Areas with security criteria similar to locations of previous tappings. It is recommended that previous tapping locations are profiled to assist with this. Profiling should include all relevant information such as:
    - Geographical location;
    - Location type (rural, residential, industrial, overgrown/woods etc.);
    - Access (e.g. distance from vehicle access);
    - Product type targeted where relevant (e.g. gasoline, diesel);
    - Ground cover;
    - Proximity to previous tappings;
    - Type of pipeline facility (valve, above ground section etc.);
    - Any buildings/structures near to the pipeline used for the tapping.

Higher risk locations should also be ranked on consequence to allow surveillance to be targeted in particular at those locations with higher overall risk. Consequence should consider (but not be limited to):

- Environmental sensitivity (e.g. receptors, watercourses, groundwater, SSSI);
- Proximity to people such as schools, large populations, transient population such as sporting venues;
- Proximity to major roads and railways.

Particular features of tappings for which surveillance should monitor are described in this paper.

Surveillance is greatly assisted by ensuring the routes are maintained and vegetation kept to a minimum, especially near road accesses. This assists with surveillance, raises the general profile of pipeline surveillance activities and reduces the number of locations where criminals can work unseen. Minimising the number of structures in the easement also helps by reducing the number of possible concealed tapping sites.

5.3 Third Party Contact

Owner/occupiers may be aware of any suspicious activity being undertaken on or adjacent to their land. It is therefore useful to maintain an increased level of contact, especially in high risk areas.

There is always the potential that owner/occupiers are themselves involved in illegal tapping. This should be borne in mind during liaison or investigations. Tenanted farms and farmed estates, where the landowner is absent, are likely to be at higher risk.

5.4 In-Line Inspection

In-line inspection (ILI - intelligent pigging) has had a degree of success at detecting illegal tappings. Increasing the frequency of in-line inspection should be considered, especially in high risk areas.

There are some limitations in the capability of intelligent pigs to detect tappings. These should be addressed with the ILI supplier prior to inspection being undertaken.

The ILI supplier should be made aware that illegal tappings may be an issue, as they might otherwise classify potential tappings differently. A comprehensive list of all known fittings and repairs on the line should be provided to the supplier for comparison.

It should also be confirmed that the ILI tool to be used is capable of detecting the small through-wall holes associated with tappings.

Additional information regarding ILI tools is provided in Appendix 1.

5.5 Line Loss Monitoring / Leak Detection

Product theft is usually carried out at relatively low flowrates (typically <1m3/hr) and in small quantities, compared to the volumes being shipped through a typical pipeline. Therefore, thefts are not readily detectable using general leak detection systems. Available techniques to monitor for theft are summarised below.

5.5.1 Line Balance

Line balance should be trended over short and long term periods and any unexplained loss or gains investigated. Although this method typically provides only a coarse check, it is useful for monitoring longer term changes on pipeline sections.

5.5.2 Statistical and Modelling Systems

Statistical and hydraulic modelling leak detection systems monitor the pipeline conditions and provide details of any suspected anomalies; these techniques can also provide an approximate location of any product loss (suspected tapping). Proprietary systems have shown success in detecting tappings.

5.5.3 Pressure Wave Detection

Pressure waves caused by the opening/closing of small valves attached to a pipeline for theft and the withdrawal of product at a tapping can be detected by pressure instruments with a suitably high sensitivity and high response frequency. These can be installed relatively easily at existing sites across a pipeline system. This technique also provides an approximate location of the leak. Proprietary systems have shown greater success in detecting tappings.

5.5.4 Static Monitoring

During shutdown periods, pipeline pressures should be monitored to detect pressure drops that cannot be explained by temperature changes or other effects. Pressure trends provided by most control systems can also be monitored for these unexplained pressure changes during static periods. The leak detection systems described above include facilities to monitor static pipelines.

Depending on the line configuration, it may be useful to section the line when static to enable any pressure drops to be localised to shorter sections of the pipeline.

5.5.5 Fibre Optic Cable

Various techniques using fibre optic cable are available for detection of leaks or encroachments near the pipeline. It is not normally practical to retrofit such systems along the entire length of a pipeline, but they may be targeted at high-risk areas. Technology that uses fibre optic cable includes Distributed Acoustic Sensing (DAS) which can detect vibration from activity adjacent to the pipeline; also other indications of an anomaly can be detected, such as ground temperature changes caused by a leak.

5.6 Coating surveys

Coating surveys may be a useful process to help identify an illegal tapping as the installation requires the removal of / damage to the pipeline coating. Increased frequency of coating surveys may be considered, particularly in high risk areas, and any change of results investigated. Local DCVG surveys are also useful if a tapping is suspected but cannot be found; however, the signature seen may not be definitive as the survey may identify general coating deterioration rather than criminal damage.

5.7 Leak Detection Dogs

Trained dogs provided by proprietary companies can detect very small quantities of hydrocarbons on the surface and at depths approaching 1m. They have been shown to be capable of detecting traces of hydrocarbons that would equate to, for instance, small leaks and spillages from hose joints or from the tapping itself.

They may be used to carry out either periodic leak surveys of a pipeline, or localised searches in the area of a suspected tapping. Localised searches would be carried out once other indications had provided an approximate location of the suspected tapping.

5.8 Other Detection Methods

Several other methods that have been used are outlined below. Operators should maintain awareness of any new technology available and apply it where relevant.

Chemical tracers can be added to the fuel and then proprietary equipment can be used to scan for traces of the chemical; such techniques are time consuming so are normally only used once other techniques have provided an approximate location.

Specialist cameras such as infra-red cameras are an additional tool that may detect ground temperature changes in the area of spilt fuel. CCTV cameras may also be considered in suitable areas.

Magnetic tomography may also be used to locate illegal tappings as it detects anomalies in the pipe material.

6 IDENTIFICATION OF ILLEGAL TAPPINGS

6.1 Scope

The surveillance and monitoring detailed in the previous section may provide an indication of a suspected tapping (e.g. indication by leak detection system) or provide immediate confirmation that a tapping has occurred (e.g. discovery of tapping equipment). Methods used to confirm whether there is a tapping and its location will therefore vary greatly. This section provides guidance for locating illegal tappings, including safety and security precautions to be considered.

6.2 Safety and Security

Prior to investigation of suspected tapping locations, a risk assessment should be carried out to determine whether it is safe for personnel to visit these areas. Police feedback has indicated that some individuals involved with fuel theft have links to violent crime and the possibility that criminals may still be in the area and the danger this may pose to staff should be considered.

Low risk survey methods should be considered initially until it is confirmed that the area is safe. These include:

- Survey from a distance or from vantage points;
- Drive-past survey using unmarked vehicles;
- Working in groups of at least two during searches;
- Maintain contact with a supervisor as with lone working arrangements.

The possibility that landowner/occupiers are involved in illegal tappings should also be considered.

If there is considered to be an unacceptable risk to personnel, the police should be contacted to provide support.

6.3 Surveillance

Surveillance should be carried out in the area(s) of the suspected tap to attempt to identify the tapping location. To enable fuel to be collected in a more convenient or harder to detect location, hoses may have been run to a location some distance from the pipeline (distances of up to several hundred metres have been reported). As hoses may be removed between instances of theft, possible hose routes should be searched as well as suspected storage locations or vehicle parking areas.

Product storage has normally involved the use of IBCs (intermediate bulk containers) or bladders located in a van, warehouse, or buried in the ground (see Figure 6.2). Any area where vehicles could approach within several hundred metres of the pipeline should be considered including:

- Laybys, lanes, picnic areas, driveways, fields with easy access;
- Sheltered parking where vehicles would be hidden from aerial surveys such as in woods;
- Warehouses, barns or other buildings, including disused buildings.

Indications of illegal tapping activity that may be apparent during surveillance are summarised below:

- Disturbed ground over the pipeline where it has been excavated;
- Disturbed ground or slit trench leading away from the pipeline where trenching of a flexible hose has been carried out (see Figure 6.1);

Figure 6.1: Disturbed ground due to trenching

- Evidence of tanks including disturbed ground where tanks have been buried (see Figure 6.2);

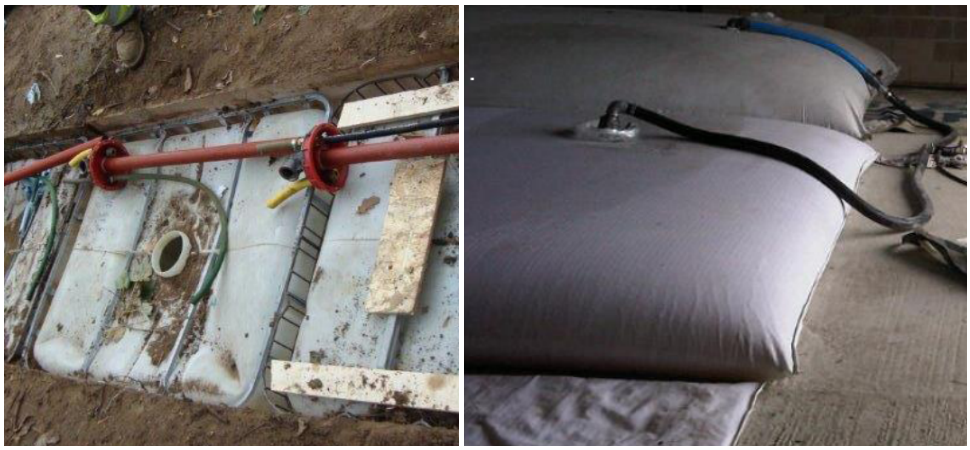


Figure 6.2: Example of tanks: buried IBCs (left); pillow sacks in shed (right)

- Vehicle tracks, either fresh or old;
- Unexplained maintenance or roadworks (see Figure 6.3);

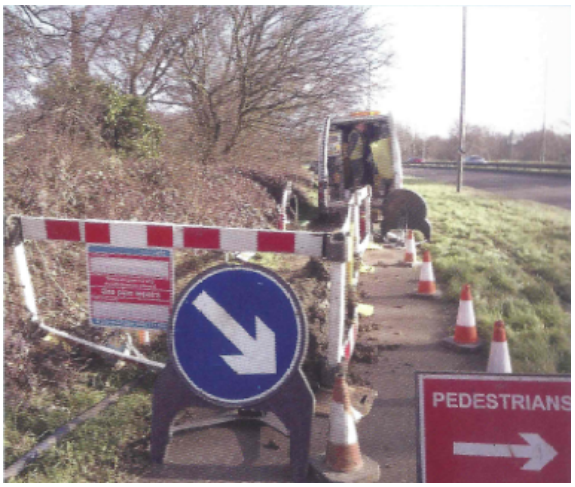


Figure 6.3: Example of fake road works

- Dead vegetation (due to disturbed ground or product leak);
- Markers such as tape on CP post, bag tied to hedge, stakes in ground, dead wildlife attached to fence (see Figure 6.4);

Figure 6.4: Examples of markers
(clockwise from top left: tape on CP post; stake in ground; dead bird tied to tree; bag tied to gate)

- Laying of sticks horizontally (or other markers) to indicate to the criminals that an area has been disturbed (see Figure 6.5);

Figure 6.5: Example of sticks used to detect any disturbance

- Twigs or sticks/branches placed deliberately as direction markers;
- Stones placed deliberately as identification markers;
- Signs of product such as hydrocarbon smell or staining;
- Tipped soil nearby;
- Unmarked vans or unexplained vehicles, frequently seen in laybys, fields near to pipeline or other vulnerable locations;
- Other signs of activity such as tools, shovels, wire brushes, hose, rubbish pile, food cartons, and worn path (see Figure 6.6).

Figure 6.6: Example of hose and rubbish pile

If a suspected tapping site is located, a probe can be used to test the firmness of the ground; soft ground may indicate recently excavated soil. The probe may also release a hydrocarbon smell on withdrawal if there is product in the ground. Care should be taken when using electrical equipment or potential sources of ignition near the suspected tapping, in case there are hydrocarbons present that could ignite.

Pipeline locators can be used to detect any hoses; however, this may have limited success if they are non-conductive. Also, routing of hoses below wire fences can interfere with the signal.

The use of rakes has also proved effective during detailed searches of the ground for hoses and slit-trenches.

Care should be taken during searches to ensure hoses and other fittings are not accidentally damaged or disturbed as this is likely to increase the risk of leakage.

6.4 Emergency Equipment

Due to the increased risk of leaks caused by tappings, operators should confirm that their emergency leak equipment and response remains fit for purpose. This should include confirmation that all equipment is complete and functioning correctly, that staff are trained in its use and that emergency procedures are current.

Consideration should also be given to providing equipment specific to the plugging of tappings, such as threaded plugs.

Stocks of repair clamps and other leak repair equipment should also be reviewed. Existing clamps may not be suitable for all tapping types, for example when a tapping cannot be removed and there remains a substantial protrusion from the line. A review of the available repair options should be conducted to ensure that mitigation measures are in place for all potential scenarios.

6.5 Police Liaison

The police maintain a national register as part of their ongoing investigations of illegal tappings. Once an illegal tapping or attempted tapping has been confirmed, they should be informed immediately. The location of the tapping is a crime scene and consideration should be given to the preservation of evidence. Prior to entering the location the police should be consulted as they may wish to either gather detailed evidence or carry out surveillance of the area prior to any further investigation by the operator.

If there is a leak or it is suspected the tapping is likely to fail, environmental protection may take priority over preservation of the crime scene. In this case, where possible the following should be carried out:

- Photographs should be taken;
- Any evidence should be recovered, wearing gloves, as early as possible;
- A record of place, date and time of the recovery of any evidence should be recorded, and by whom.

To ensure timely contact with the police, operators should maintain police contact details for all pipeline routes.

7 INSPECTION OF TAPPINGS

Prior to excavation and inspection of an illegal tapping, the risk of disturbing the area should be assessed. The majority of illegal tappings have been secure at the time of discovery but some have shown signs of leakage and there is a risk that any disturbance could cause the condition of the tapping to deteriorate. The following should be considered:

- Reduction of pipeline operating pressure and possibly shutdown and depressurisation. Depending on pipeline design and operation parameters, the pressure at a location may be lower whilst pumping than when shut-in; where this is the case, consideration should be given to a suitably controlled shutdown;
- Putting emergency personnel on standby in accordance with the operator's emergency procedures;
- Assessment of pipeline details (profile, isolation valves etc.), carrying out drain-down calculations and consideration of all logistics in case of a leak and to prepare for any repair works;
- Assessment of environmentally sensitive, populated or other high risk locations in the area.

The tapping and the pipeline should be assessed by qualified personnel to determine the condition of both.

8 REPAIR METHODS

8.1 Scope

Repair methodologies applicable to illegal tappings are similar to those that would be used for other pipeline defects, however it may be that the tapping will protrude from the pipeline if it is not practical to remove it. The selected repair method will depend on the nature of the tapping, pipeline geometry, operating characteristics, and operational constraints. This section describes the regulations covering repairs, repair methods available, and the main considerations for selecting the repair process.

8.2 Regulatory Framework

Document UKOPA/13/028, UKOPA Pipeline Inspection and Maintenance Recommendations outlines the regulatory framework governing all pipeline repairs and maintenance. Other guidance notes specific to repairs of pipeline defects and applicable to illegal tappings include:

- UK HSE: Temporary/permanent pipe repairs - Guidelines (2001/038);
- UK HSE: Leak sealing repair clamps (2012).

The HSE's approach is linked to the principles of prevention outlined in their Management of Health and Safety at Work guidance which states that the repair philosophy should be as follows:

- Replacement like-for-like;

- Temporary repair until replacement can be carried out;
- Permanent repair only where replacement is not practical.

The guidance also states that for all pipeline repairs, the operator needs to perform a structured risk assessment that includes the consideration of all of the potential future damage or deterioration mechanisms.

8.3 Repairs

Various methods for repair at illegal tapping locations are available. These include:

- Mechanically bolted stand-off repair clamps (see Figure 8.1);
- Grouted sleeves and tees (see Figure 8.2);
- Welded tees (see Figure 8.3);
- Composite wraps (see Figure 8.4);
- Purpose designed epoxy filled split tees (see Figure 8.5);
- Pinhole repair clamps (see Figure 8.6).

An example of each of these repair methods is shown below.

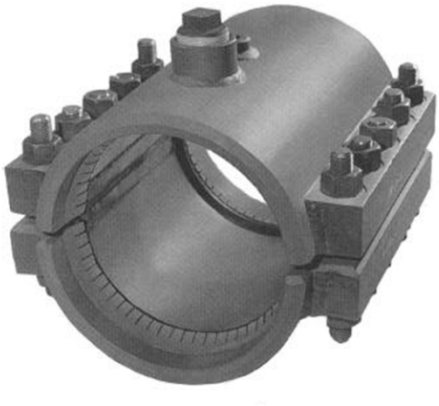


Figure 8.1: Stand-off repair clamp

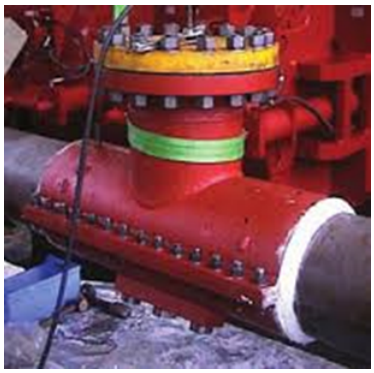


Figure 8.2: Grouted tee

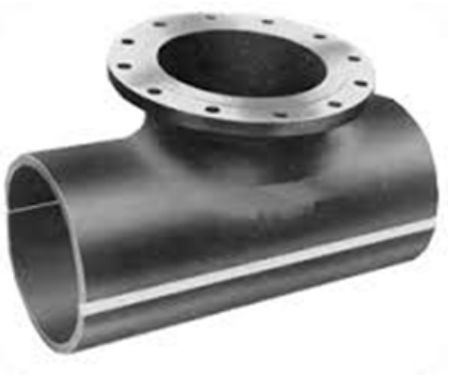


Figure 8.3: Welded tee

Figure 8.4: Composite wrap

Figure 8.5: Epoxy filled split tee

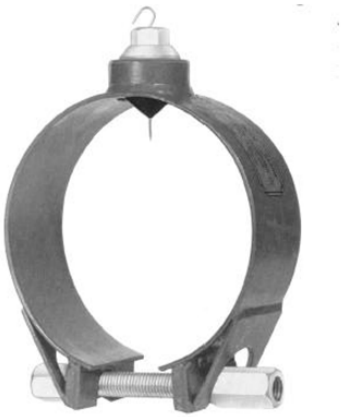


Figure 8.6: Pinhole clamp

The HSE guidelines differentiate between stable and unstable defects.

A stable site is one where the cause of the leak and material degradation has been arrested and the repair method will not introduce other degradation mechanisms to the area such as fatigue. Only if the site is stable can it be considered to be a permanent repair, subject to the considerations below.

An unstable site is one where the degradation mechanism or feature growth cannot be arrested, such as where the tapping has caused stress raisers which could lead to cracking, or the repair itself is not stable. In this case the repair should be considered to be temporary. The guidance available does not specify the lifespan of a temporary repair but states that it should be removed at the next available opportunity.

The lifespan of all repairs should be assessed and plans for inspection, permanent repair or pipe replacement made as appropriate. The assessment should include the location and nature of the tapping and repair method, and whether they could cause failure of the linepipe in the future. Assessment should include:

- Structured risk assessment (see regulatory framework above);
- Level of quality assurance and inspection applied during repair;
- Degradation of the repair due to internal or external corrosion;
- Compatibility of the sealing components with the operational fluids;
- Ability to monitor elastomer seal performance;
- Pressure fluctuations between the inside and outside of the pipe within the repair fitting;
- Fatigue life of the repair and original pipe;
- Access to the repair for periodic inspection and maintenance;
- Structural integrity of the tapping within the repair if it was not removed;
- Structural integrity of the pipeline and the repair itself;
- Whether the tapping has weakened the original pipe (e.g. on or adjacent to a weld, defects introduced by pipe deformation or grinding, high temperatures due to welding, and multiple adjacent tapping attempts with interacting defects);
- Timescale for replacement with a permanent repair.

It should also be noted that some repairs that use an epoxy-filled shell or composite wrap are reliant on the effectiveness of the seal between the epoxy filler and the pipeline steel. The working life of this seal where there is a potential for it to be exposed to hydrocarbons should be considered. Some fillers are not rated for use in contact with hydrocarbons and therefore should only be viewed as a permanent repair if it can be demonstrated that the defect will not leak.

Supervision and quality assurance checks of the installation process should be undertaken to ensure that the repair is carried out correctly. Some repairs could be subject to a reduced warranty period if they are installed without independent inspection.

Temporary repairs may need to be monitored in order to ensure their integrity is maintained. This may involve periodic inspection, for example via boreholes, to confirm that the repair is not leaking.

8.4 Additional Repair Considerations

Illegal tappings often present one or more of the following characteristics:

- Unknown quality of materials, welding and construction;
- Interaction with other stress raisers such as other tappings, welds, dents or areas of corrosion;
- Difficult pipe features (e.g. on a bend or near a weld or other fitting);

- Active leaking of product;
- Unusual geometry of the tapping;
- Multiple incidents and locations in a short time period which would stretch resources and materials for repair implementation. An example of this is following in-line inspection if several tappings are discovered;
- Operational constraints that limit available time to implement the preferred repair option.

To address these issues, the operator should consider all available repair options on a case-by-case basis.

The following factors should also be considered as part of the repair design and selection process:

- Future access for maintenance and inspection;
- Future access for permanent repairs;
- Encapsulation repairs may significantly reduce soil cover and it may be necessary to provide additional protection to prevent inadvertent 3rd party damage; examples of suitable protection are fencing the area, small concrete slabs and buried marker tape.

9 NOTIFICATION PROCESS

The following should be informed as soon as possible after any illegal tapping is found:

- Environment Agency as necessary (Emergency contact and national offices);
- HSE (Hazardous Installations Directorate - Gas and Pipelines Unit);
- HSE (RIDDOR report);
- Police (local, regional and NCA);
- DECC.

10 REFERENCES

1. UKOPA/13/028, UKOPA Pipeline Inspection and Maintenance Recommendations
2. HSE - Temporary/permanent pipe repairs - Guidelines (2001/038)
3. HSE - Leak sealing repair clamps (2012)
4. HSE - Guidance to the Management of Health and Safety at Work Regulations (1999)

APPENDIX 1: ILI – ADDITIONAL INFORMATION

As stated in Section 5.4, limitations in the capability of intelligent pigs to detect illegal tappings should be addressed with the ILI supplier. This appendix provides further details of ILI techniques to assist operators in their selection of the most appropriate ILI tool.

MFL (magnetic flux leakage) is currently the most appropriate ILI technique for detecting the small holes associated with illegal tappings. MFL tools can currently detect through-pipe drilled holes of 3mm diameter and above; it is unlikely that holes smaller than this would be detected. Ultrasonic tools are less able than MFL tools to detect illegal tappings at present.

Different magnetic flux levels used by MFL tools have different capabilities of detecting drilled holes and clamps:

- More conventional high-flux tools will detect any ferrous material in contact with the pipe wall such as steel clamps or bosses. However, fittings made from non-magnetic materials and clamped or attached by brazing would be invisible to the tool.

- Low-flux tools will provide the hot spot (i.e. hard spot) signature of the pipe wall. They may, therefore, detect changes associated with any welding carried out during illegal tappings, but will lose visibility of ferrous material attached to the outside of the pipe wall. Brazing reduces the hot spot signature on the pipe wall due to the reduced heat input meaning brazed fittings will be less visible compared to arc welding.