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MANAGEMENT PROCEDURE ASSESSMENT OF CORROSION DAMAGE ON STEEL PIPEWORK SUPPLYING MULTI-OCCUPANCY HIGH AND MEDIUM RISE BUILDINGS

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Change record

Change Date	Changes made	Author
New document		

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Brief history

Description	Date	Reference
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Key changes

Section	Amendment
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Management Approval

Name	Position
Ian Aldridge	Engineering Policy Manager

Implementation

Implementation timescales	
Approved	May 2016
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Training needs analysis

Identified users Specifically which roles must have an understanding of this Procedure	Level of understanding **A**ware **D**oes **C**ontrols **M**anages	Training document / presentation	Dissemination method **A, M** email link and brief **D, C** brief and record
FCO's nominated to undertake this procedure	D	MACAW training course (1 day)	D, C
Network Supervisors nominated as MOBs leads	A, C	Briefing pack	A, M

Contents

Document Summary

Purpose

This work procedure was approved by the Engineering Policy Manager, in May 2016 for use throughout National Grid Gas

Users should ensure that they are in possession of the latest edition and related bulletins by referring to the document library of Safety and Engineering documents available on the company Infonet.

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Disclaimer

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Where this document is used by any other party it is the responsibility of that party to ensure that this document is correctly applied.

Mandatory and Non-Mandatory requirements

In this document:
Shall: indicates a mandatory Requirement

Should: indicates best practice and is the preferred option. If an alternative method is used then a suitable and sufficient risk assessment shall be completed to show that the alternative method delivers the same, or better, level of protection

Responsibilities

This document applies to all those working directly for National Grid Gas e.g. employees, or under the direction of National Grid Gas, e.g. contractor mate working in a direct labour team.

Introduction

These National Grid procedures have been developed for the inspection, assessment and repair of (non-leaking) steel riser pipework. The procedure applies to risers and laterals on low pressure systems (up to 75 mbar), up to 100 mm nominal diameter, and located in high-rise or medium-rise buildings. The procedure covers pipe with corrosion damage only, it is not intended to be applied to:

a) Damage found during the construction of a new pipeline or pipework prior to commissioning.
b) Mechanical damage (i.e. third-party damage) that has occurred during the service life of the pipework.

NOTE: The principles of these procedures may be applied to pipe diameters greater than 100 mm. Any application of these procedures to pipe diameters greater than 100 mm should be conducted under the guidance of the Network lead (MOBs). For pipe diameters greater than 100 mm, the minimum allowable wall thickness shall be determined using the guidance in Appendix C.

1. Scope

This procedure shall be used to determine the integrity and continued fitness for service of steel risers and laterals operating at low pressure. It applies to pipework of 100 mm nominal diameter or less and up to and including grade X65 (equivalent to BS EN 10208-2 grade L450MB). It provides guidance for the more detailed assessment of material degradation classed as 'severe' - following application of the visual inspection procedure T/PM/LC/21.

The procedure outlines:

- Preparation of the riser surface for detailed inspection.
- Wall thickness determination and categorisation of corrosion damage.
- Remedial action required to ensure the integrity of the riser is satisfactory to allow for a minimum 5 year inspection frequency, as dictated by the expected design life of original or newly applied coating and repair systems.

NOTE: The implementation of a minimum 5 year inspection frequency assumes that any root cause of corrosion (other than atmospheric corrosion) has been determined and effectively mitigated for continued safe service. The exact frequency of inspection shall be determined by an appropriate risk assessment, not covered in these procedures.

2. References

This Management Procedure makes references to the documents listed in Appendix A. unless otherwise specified; the latest editions of the documents apply, including all amendments.

3. Definitions

The requirements and definitions applying to this Management Procedure are listed in Appendix B.

4. Competence

Operatives shall only undertake the tasks described in this procedure if they have been trained and assessed as competent to do so. There is a specific training course associated with this procedure and all

operatives using this document in the field shall have completed this successfully before undertaking this work.

5. General considerations

To facilitate the selection of the most appropriate repair method, consistent with safe operation, different categories of corrosion damage are defined.

Subsequent to a Detailed Inspection, the following damage categories are used when assessing corrosion damage to the steel riser pipework:

Corrosion damage classification	
Moderate	Does not significantly affect the integrity of the pipe.
Severe	Has the potential to affect the integrity of the pipe
Extreme	Constitutes significant damage and directly affects the integrity of the pipe, requiring additional impact resistance as part of a repair or replacement

6. Safety

It is essential that when removing clips and supports used to hold pipe in place and provide support, due care is taken since the remaining wall thickness may have been overestimated.

The Responsible Engineer shall ensure that the use of materials, solvents and other substances is conducted in accordance with the requirements outlined in National Grid's Hazards and Precautions Manual and/or the manufacturer's instructions/data sheets.

Any impact hand tools used in the Surface Preparation for Detailed Inspection (see Section 8.2) shall not present a sparking hazard.

The normal PPE requirements for the site, access arrangements and fire extinguishing materials shall be available throughout the inspection.

The risk assessment undertaken for the activity shall include any requirement for working at heights and emergency procedures to be followed in the event of pipe wall failure resulting in a gas escape, e.g. location of isolation valve, availability of an EM/72 competent person, etc.

7. Procedural overview

The procedure for the inspection, assessment and repair of corrosion damaged steel riser pipework is shown in Figure 1.

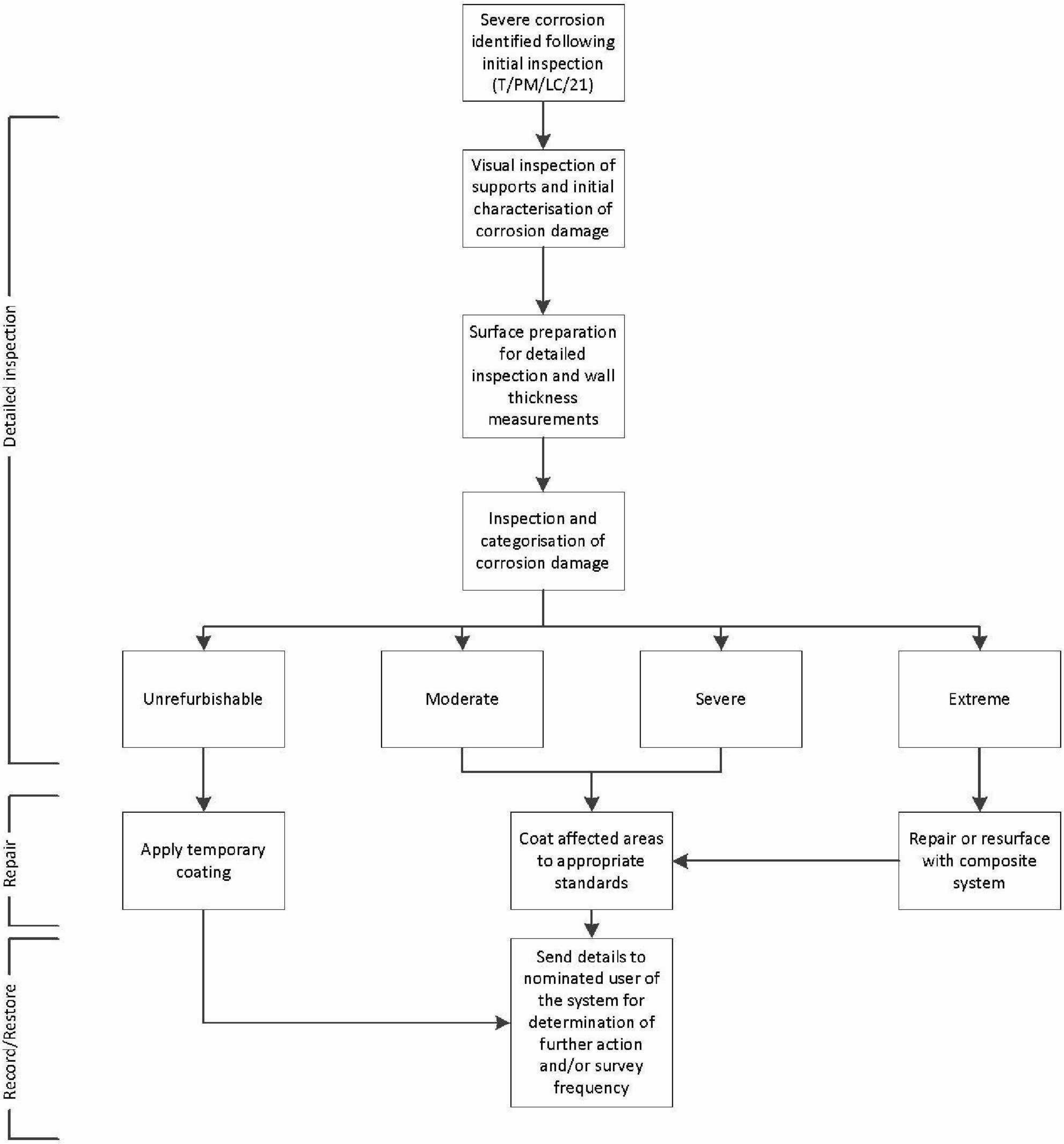

Figure 1 – Algorithm for inspection, assessment and repair of corrosion damaged pipe

8. Detailed inspection

8.1. Equipment

In addition to the normal PPE requirements for the site and access arrangements, the following equipment should be available to carry out the examination and be covered by the appropriate work permit:

a) Gas detection instrument;

b) Digital camera (5MP or above) or iPhone 5 camera minimum;

c) Torch;

d) Scale rule and calliper tool;

e) White chinagraph pencil;

f) Ultrasonic thickness (UT) gauge and depth micrometer (depth micrometers shall be calibrated, maintained and stored in accordance with the manufacturer's instructions);

g) Examination mirror on an adjustable / extendable shaft;

h) Hand-tools suitable for cleaning the pipe which may include the following:

   i. Knives, scrapers, chisels and chipping hammers for removing slag, laminated rust scale, chipping old paint, loose rust, etc.;

   ii. Hand wire brushes, abrasive coated paper and plastic fleece with embedded abrasive for final hand preparation including feathering of edges of any firmly adhering coating system;

   iii. A copy of BS EN ISO 8501-1:2007, The Rust Grade book.

8.2. Visual inspection of supports

A visual assessment of the condition of the riser supports (if applicable) shall be conducted to ensure that they function satisfactorily. The assessment shall be based on a visual estimate of the corrosion damage and the appropriate remedial action according to Table 1.

Damage category	% of corrosion damage	Remedial action
Unaffected	0%	No action required
Superficial Damage	<25%	Surface preparation and re-coat
Moderate/Severe Damage	≥25%	Replace*

Table 1: Damage categories for visual inspection

Where necessary, temporary pipe supports should be installed to prevent pipe movement.

8.3. Initial characterisation of corrosion damaged areas

The following details associated with the corrosion damaged areas shall be recorded and verified with previous LC/21 inspection evaluation:

- Damage location details, i.e. identify whether damage is in a straight section of pipe, bend or associated with a fitting.
- Visual identification of the corrosion damage type (include photographs), i.e. general corrosion, pitting corrosion.
- Axial and circumferential lengths of corrosion damaged areas.

8.4. Surface preparation for detailed inspection

8.4.1. Isolation Valve

Prior to the removal of any coating, refer to the relevant site risk assessment to confirm the location of the associated isolation valve and ensure it is available for access in the event of an emergency whilst carrying out the detailed inspection. The presence of any associated valve should have been captured in the relevant site risk assessment; if no valve is available do not proceed with works and seek guidance from the Network Lead (MOBs).

The only situation where it is possible to continue works without an isolation valve is following a review of the site-specific risk assessment and it is ascertained that the corrosion is on a section of external pipe and any escape of gas arising from the preparatory works would vent straight to atmosphere with no risk of gas entering the building through ventilation bricks, grilles, 5m clearance from flues, etc.

8.4.2. Removal of Coating and Hand-Tool Cleaning

At the initial inspection stage, a minimal amount of coating shall be removed to facilitate the inspection requirements. The corrosion damaged area and an area adjacent to the corrosion damaged area shall be prepared for pipe wall thickness measurements and re-coating procedures (see Section 8.5). Pipe covered by these procedures tends to have a small wall thickness and it is possible that the build-up of corrosion products could mask that the corrosion is close to being through-wall. Removal of any underlying corrosion product scales should only be attempted if safe and practical to do so; where it is deemed that scale removal is not a safe option, further guidance should be sought. Although caution is required in this process it is important to note that corrosion scale can be up to approximately 7 times the volume of the steel, e.g. for every 1 mm of wall loss the scale could be 7mm thick. As a precautionary approach it is advised to use a 3:1 ratio of corrosion scale thickness to pipe wall thickness. If the scale is in excess of 9 mm the system should be isolated prior to removal of coating.

Surfaces shall be cleaned with a hand-tool, such as a scraper or wire-brush, to ensure that there is sufficient thickness of un-corroded material and that the surface is primarily free from corrosion product to allow for detailed inspection. A leakage survey shall be conducted upon removal of any corrosion products and after each stage of the surface preparation process; any leaks found should be managed in accordance with T/PR/EM/72.

Descriptions of surface preparation methods by hand-tool cleaning - including treatment prior to, and after, the hand-tool cleaning procedure - are detailed below (taken from BS EN ISO 8504-3:2001):

1. Initial treatment – remove heavy oil or grease by means of a scraper and then, as far as possible, remove further contamination by one, or a combination of, the following methods:

    a) Cleaning with appropriate solvents or proprietary solutions (e.g. emulsion or detergent cleaners), provided that this is followed by rinsing with potable (tap) water. The solvents or solutions may be applied with a stiff fibre or wire brush.

    b) Brushing with stiff fibre or wire brushes.

    c) Wash with potable (tap) water or proprietary solution to ensure no further contamination (salts) occurs.

2. Hand-tool cleaning – hand-tool cleaning should preferably be carried out in the following sequence of operations:

    a) Use hand wire brushing, hand abrading, hand scraping or other similar non-impact methods to remove all loose or non-adherent rust and all loose paint. Try to minimise hand abrasion as much as possible as this can lead to further wall thinning of good material.

    b) Use non-sparking impact hand tools to remove laminated rust and rust scale.

3. Final preparation

    a) Remove any burrs, sharp ridges or sharp cuts that have been produced during the cleaning operation. The use of emery paper should be limited to ensure that the remaining wall thickness is not unnecessarily compromised.

    b) Ensure that any remaining intact paint has no residual gloss. Ensure that the edges of any remaining intact paint have been feathered (bevelled) using the hand-tool cleaning methods outlined.

    c) After hand-tool cleaning, the surface shall be cleared to remove loose dust and debris.

The surface finish achieved by hand-tool cleaning shall conform to the requirements of BS EN ISO 8501-1:2007, St 3 grade to allow for detailed inspection, including pipe wall thickness measurements and re-coating procedures.

NOTE: The integrity assessment of any fittings associated with the corrosion damaged pipework is not covered under these procedures. However, if the corrosion damaged section of pipework includes a fitting, the surface of the fitting should be prepared for re-coating following the same procedures as for the pipe, to ensure uniform coverage of the coating system across the corroded areas.

8.5. Inspection and categorisation of corrosion damaged areas

8.5.1. Wall Thickness Parameters for Determining Damage Category

Figure 2. Below illustrates the wall thickness parameters that shall be used in order to determine the corrosion damage category.

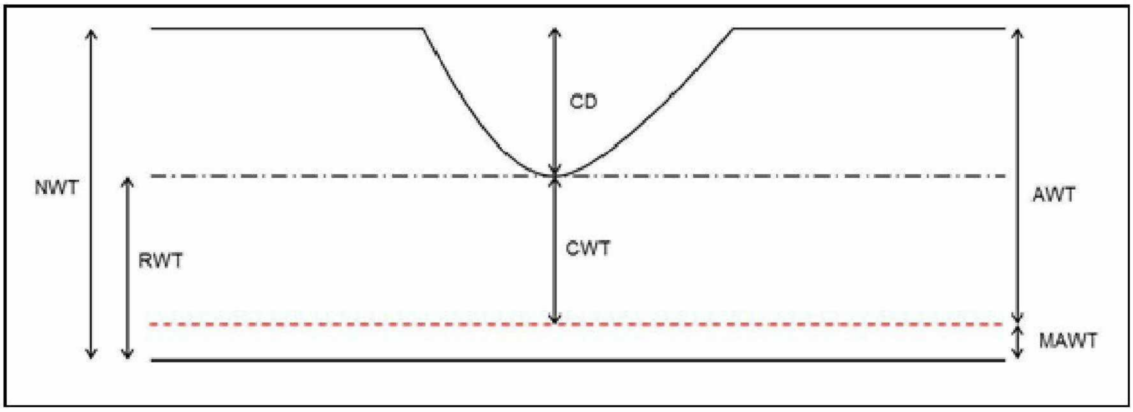

Figure 2: Diagram of wall thickness parameters used in determining corrosion damage category

Measured wall thickness parameters are:

a) Nominal wall thickness (NWT) (UT measurement, 8.5.3)

b) Remaining wall thickness (RWT) (UT measurement, 8.5.5)

c) Corrosion depth (CD) (depth micrometer measurement, 8.5.5)

The wall thickness parameters determined via calculation are:

d) Minimum allowable wall thickness (MAWT) (8.5.2)

e) Available wall thickness (AWT) (8.5.4)

f) Consumable wall thickness (CWT) (8.5.6)

8.5.2. Determining Minimum Allowable Wall Thickness

For the operational pressures covered by these procedures (up to and including 2 bar), the internal pressure is not the predominant load on the pipe. This means that the nominal wall thickness (NWT) will not be the main factor in the remaining life of the pipework. To establish the category of the corrosion damage it is necessary to determine and record a minimum allowable wall thickness (MAWT). This measure provides the thickness that gives sufficient structural integrity when the loading from the weight of the riser is considered at the point of interest.

In order to determine the MAWT, the following parameters shall be identified:

- Nominal pipe size – if the diameter is unknown or cannot be attained from previous inspection records, confirm the nominal pipe size using a calliper tool away from the corrosion damaged area.
- Storeys above point of interest to where the nearest load-bearing support accompanied by expansion bellow or 90° bend is located (see Figure C 1, Appendix C).

NOTE: A load-bearing support is not considered as a riser guide restricting lateral movement. If no load-bearing support or 90° bend can be located, the number of storeys above the point of interest shall be assumed to the top of the building.

- Number of laterals per storey.

Table 2 shall be used to determine the minimum wall thickness requirement for the steel riser pipework under inspection using the above information, nominal pipe size, number of storeys and laterals. The assumptions used in the determination of the MAWT are outlined in Appendix C

8.5.3. Nominal Wall Thickness Measurements

The nominal wall thickness (NWT) of the pipe shall be determined from the average of a minimum of six readings measured using an ultrasonic thickness (UT) gauge.

Measurements using UT gauges shall be made by creating a reference grid (sized according to pipe outside diameter - see Table below) in an area adjacent to the corrosion damaged area. The grid shall be marked using a white chinagraph pencil; once measurements have been recorded the markings should be removed by cleaning the surface with appropriate solvents or proprietary solutions.

	Nominal size (outside diameter)	
	≤ 50 mm (60.3 mm)	50 < D ≤ 100 mm (60.3 < D ≤ 114.3 mm)
Grid size, X (mm)	10	15

An example reference grid diagram for determining NWT is shown in Figure 3; readings should be taken at each corner of the grid at the 12, 3 and 9 o'clock positions respectively shown in the example diagram.

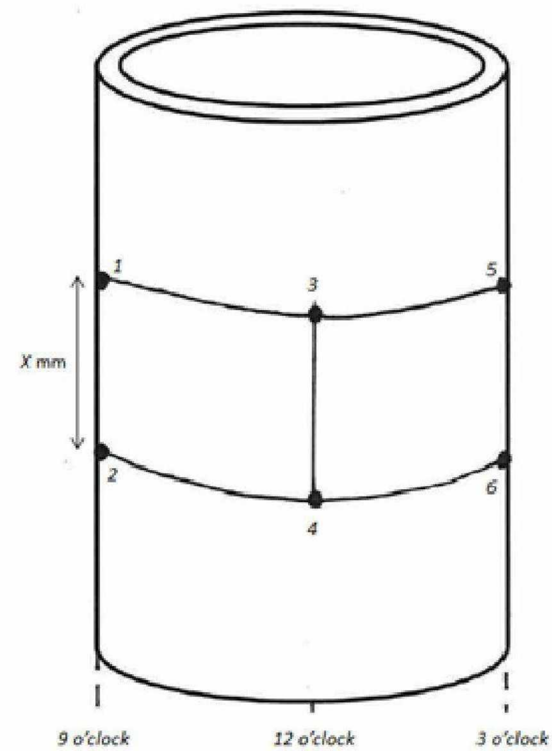

Figure 3: Reference grid example for determining nominal wall thickness.

8.5.4. Determining Available Wall Thickness

The available wall thickness (AWT) is the nominal wall thickness (NWT) minus the minimum allowable wall thickness (MAWT) (see Figure 2).

$$AWT = NWT - MAWT$$

8.5.5. Remaining Wall Thickness Measurements

The remaining wall thickness (RWT) shall be measured using a UT gauge; a minimum of six readings shall be taken using a reference grid surrounding the corrosion damage area. An example reference grid diagram for determining the RWT associated with the corrosion damage is shown in Figure 4; readings should be taken at each corner of the grid. The size of the grid should be determined by the size of the corrosion defect. The lowest reported wall thickness value of all measurements taken shall be used in determining the extent of the corrosion damage.

Due to the variability in corrosion damage location and profile, the use of a reference grid may not be sufficient. RWT measurements should be taken where possible with a UT gauge at the affected area in order to provide confidence that the lowest RWT measurement has been determined.

Alternatively, if RWT measurements cannot accurately be obtained for the corrosion damage using a UT gauge (i.e. pitting corrosion), a depth micrometer should be used to determine the depth of the corrosion damage. Depth measurements taken using a depth micrometer should ideally have a 100 mm or 50 mm base.

To accompany the depth micrometer readings, measurements using a UT gauge should be taken around the corrosion affected area in order to yield a minimum RWT (mRWT). The measurements taken using a depth micrometer will give a corrosion depth (CD) and the measurements from the UT gauge will give the mRWT. In this case the RWT is calculated as follows:

$$RWT = mRWT - CD$$

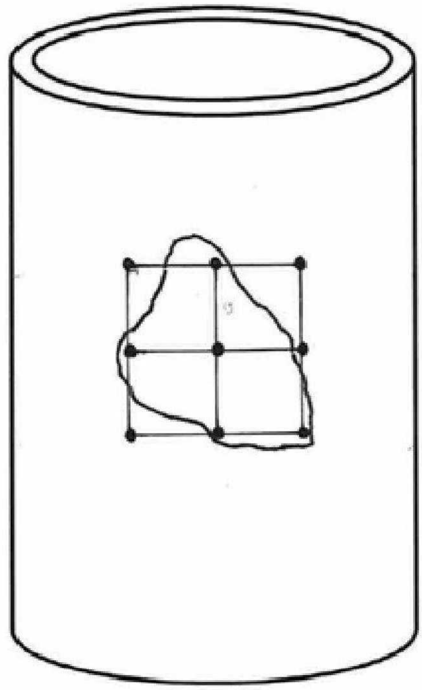

Figure 4: Reference grid example for determining remaining wall thickness.

8.5.6. Determining Consumable Wall Thickness

The consumable wall thickness (CWT) is the remaining wall thickness (RWT) minus the minimum allowable wall thickness (MAWT) (see Figure 2), given by the expression:

$$CWT = RWT - MAWT$$

8.6. Corrosion damage categories

For the purposes of these procedures the corrosion damage shall be assigned to one of the following categories which shall be used to determine the required remedial repair solution:

a) Moderate Damage.

b) Severe Damage.

c) Extreme Damage.

The pipework covered by these procedures, all occurrences of corrosion damage shall be assigned to one of the three damage categories above by applying the corrosion damage acceptance criteria given in Table 3. The categorisation of the corrosion damage compares the CWT against the AWT.

Types of damage	Corrosion Damage Categories		
	Moderate	Severe	Extreme
General Corrosion	CWT greater than or equal to 50% AWT	CWT less than 50% AWT but greater than 20% AWT	CWT equal to or less than 20% AWT
Pitting Corrosion	CWT greater than or equal to 60% AWT	CWT less than 60% AWT but greater than 10% AWT	CWT equal to or less than 10% AWT
CWT = Consumable wall thickness N/A = Not applicable AWT = Available wall thickness			

If the CD is determined to be greater than the AWT (i.e. CWT = 0) the corrosion damage shall be referred to as ‘unrefurbishable’ and alternative repair or replacement of the pipework (whole riser or affected section) progressed. This requirement shall be recorded and escalated on site to the Network Lead (MOBs) for further assessment prior to any further works.

8.6.1. Worked Example for Determining Corrosion Damage Category

General corrosion identified following initial characterisation and the measurements are summarised in the table below:

Parameter	Value
Storeys above point of interest (**Error! Reference source not found.**)	8
Number of laterals per storey (**Error! Reference source not found.**)	1
Nominal pipe size (**Error! Reference source not found.**)	40 mm
Minimum allowable wall thickness (MAWT) (**Error! Reference source not found.**)	0.8 mm
Nominal wall thickness (NWT) (**Error! Reference source not found.**)	4 mm
Remaining wall thickness (RWT) (**Error! Reference source not found.**)	2 mm

The available wall thickness (AWT) is the NWT - MAWT(8.5.4) = (4 – 0.8)
= 3.2 mm

The consumable wall thickness (CWT) is the RWT – MAWT (8.5.6) = (2 – 0.8)
= 1.2 mm

The corrosion damage category is determined using the following equation, where the consumable wall thickness (CWT) is calculated as a percentage of the available wall thickness (AWT):

(CWT / AWT) x 100 i.e. (1.2 / 3.2) x 100 = **37.5%**

From Table 3, the corrosion damage is determined to be Severe Damage

9. Repair procedures

9.1. General requirements

Corrosion damage to pipe shall be repaired using an appropriate procedure as specified in accordance with Figure 1. The corrosion damaged areas shall be repaired by one or more of the following repair procedures, subject to the restrictions on their applications given in Table 4:

a) Sectional re-coating.

b) Sectional repair with composite and re-coating.

9.2. Coating

The corrosion damaged area shall be protected by a coating selected and applied in accordance with the manufacturer's instructions and guidance given in Appendix D.

NOTE: Any area where the original coating is removed for inspection shall be re-coated regardless of the corrosion categorisation.

9.3. Repair with composite

The corrosion damaged area shall be repaired and resurfaced using a composite repair system applied in accordance with the manufacturer's instructions. The selected coating shall subsequently be applied to the repaired and resurfaced areas as per 9.2.

9.4. Records

Complete details of the investigation, assessment and any repair of corrosion damage shall be recorded and reported to the Responsible Engineer. Suggested formats for recording and assessing damage are given in Appendix E. Records should be retained as per T/PL/RE/1.

Full details of the corrosion location, damage category, defect sizes and the type of repair carried out, shall be recorded.

9.5. Restoration

Following a permanent repair carried out as required by Table 4, the pipe may be returned to service or its normal operational status should an isolation valve be used.

	Moderate Damage	Severe Damage	Extreme Damage
Re-coating	✓	✓	N/A
Composite repair and subsequent re-coating	N/A	N/A	✓

Table 4: Appropriate permanent repair methods for corrosion damaged pipe

9.6. Severely corroded pipe in concrete

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Occasionally the severely corroded pipe passes through a concrete section, e.g. floor, and it is not possible to remediate the entire section. In these circumstances the remediation process should be applied to the accessible pipe and the Nominated user (Network Strategy) notified of the situation (with photographs included for information).

Appendix A – References

British Standards	
BS EN ISO 8501-1	The Rust Grade Book
BS EN ISO 8504-3	Preparation of steel substrates before application of paints and related products: Part 3: Hand- and power-tool cleaning

Institute of Gas Engineers and Managers publications	
IGEM/G/5	Gas in multi-occupancy buildings

National Grid specifications and procedures	
GIS/L2	Specification for Steel pipe 21.3 mm to 1 219 mm outside diameter for operating pressure up to 7 bar (supplementary to BS EN 10208-1)
T/PM/LC/21	Management Procedure for the Asset Management of Gas Supplies to Multi-Occupancy High and Medium Rise Buildings
T/PR/LC/29	Work Procedure for surveys on Medium Rise Multi Occupancy Buildings
T/PR/LC/34	Work Procedure for High Rise Building Survey and Risk Assessment
T/PR/MAINT/2323	Work procedure for patch repair of coating systems on installations with inlet pressure exceeding 7 barg
T/PL/RE/1	Policy for the capture, update and retention of engineering asset records
T/PR/SL/2	Work procedure for low pressure riser installations to multi-dwelling buildings up to and including 150 mm (6") nominal diameter PE and steel pipe

American Petroleum Institute publications	
API 5L	Specification for line pipe
API 579-1	Fitness-For-Service

American Society of Mechanical Engineers publications	
ASME B31.8	Gas transmission and distribution piping systems ASME code for pressure piping, B31

Appendix B - Definitions

The definitions applying to this Management Procedure are given below (see clause 0).

Wall thickness parameters	
NWT	The minimum 'nominal wall thickness' of the pipe measured using ultrasonic equipment over a prepared and undamaged area adjacent to the corrosion damaged area.
MAWT	The 'minimum allowable wall thickness' required to provide sufficient structural integrity under the loading case caused by self-weight (of the riser) at the point of interest.
AWT	'Available wall thickness' is calculated using: The nominal wall thickness (NWT) minus the minimum allowable wall thickness (MAWT).
RWT	The minimum 'remaining wall thickness' associated with the corrosion damaged area, either measured using UT gauge or determined as the nominal wall thickness (NWT) minus the corrosion depth (CD)
mRWT – minimum RWT	When RWT cannot be accurately obtained, e.g. pitting corrosion, then readings taken with a UT gauge and depth micrometer are combined to calculate the RWT. In these situations the UT reading is the mRWT.
Corrosion depth (CD)	The greatest measured depth associated with the corrosion damaged area typically determined using a depth micrometer.
CWT	The consumable wall thickness = remaining wall thickness (RWT) minus the minimum allowable wall thickness (MAWT).
SMYS	Specified minimum yield strength. The strength of steel pipe under specific stresses as required by the relevant standard
UT Gauge	Ultra sonic thickness gauge
Point of Interest	The area of the pipe that is affected by corrosion and is being considered for remediation

Damage	
Corrosion	The result of a reaction of a metallic material with its environment causing a measurable reduction in the thickness of metal including: **General corrosion** – corrosion resulting in a reduction of metal thickness over a large area of the surface. **Pitting corrosion** – corrosion which affects small localised areas of surface pipe material, producing pits.

Repairs	
Corrosion resistant coating	A coating system designed to prevent corrosion.
Composite repair	A multi-component composite system designed to repair and resurface metal components.

Miscellaneous	
Network Lead (MOBs)	The person in the network nominated to implement the Multi Occupancy Building survey process.

Appendix C - Assessment of mechanical loading

Assumptions for determining minimum allowable wall thickness

The guidance from API 579 shall be used to assess the minimum allowable wall thickness (MAWT) requirement and the loading case caused by self-weight at the point of interest. In order to approximate the loading case the following conditions are assumed;

a) The weight of the pipework is the same as those given by API 5L for the acceptable pipe sizes outlined in GIS/L2:2006 up to 100 mm nominal size. Where exact wall thicknesses did not correlate, the next largest size was used, therefore a worst-case is always considered for self-weight

b) The bending moment acting upon the point of interest is considered to be zero, providing that all riser guides and/or supports are in place around the point of interest and is to the distance spacing specified in IGEM G5 for the pipe size concerned

NOMINAL BORE (mm)	MAXIMUM UNSUPPORTED LENGTH (m)				
	Screwed steel horizontal	Screwed steel vertical	Welded steel horizontal	Welded steel vertical	External PE
15	2.0	2.5	2.5	3.1	See Note
20	2.5	3.1	2.5	3.1	
25	2.5	3.1	3.0	3.7	
32	2.7	3.3	3.0	3.7	
40	3.0	3.7	3.5	4.3	
50	3.0	3.7	4.0	5.0	
65			4.5	5.6	
80			5.5	6.8	
100			6.0	7.5	
150			7.0	8.7	
200			8.5	10.6	
250			9.0	11.2	

c) Lateral offtakes are assumed to be 25mmø and fully supported by the riser up to a maximum length of 1.6m *i.e.* the maximum allowable length of an unsupported lateral detailed in IGEM G/5

d) Fixtures and fittings are considered to account for 3.2 kg/m (calculated from riser design information supplied by NG)

e) The riser is considered to be free to move axially; therefore thermal expansion is not expected to contribute to the riser load. Expansion should have been accounted for at the design stages with the installation of expansion bellows at load bearing supports. This is as per IGEM G5 Paragraph 6.1.6 Note 2, and T/PR/SL/2 Paragraph 7.4.3.3 respectively

f) The entire axial force of riser above the point of interest is taken at that point. The total axial fore at that point will be affected by

   i) Either to the next 90° change in direction;

   ii) Distance to the nearest load bearing support (accompanied by expansion bellows);

   iii) To the top of the structure *i.e.* no load bearing supports or bends identified.

g) In order to allow for an onsite assessment, torsional or bending moments of fixed laterals caused by thermal expansion are not considered and are outside the scope of this assessment. It is assumed that stresses caused by thermal expansion or contraction were considered at the design stage and flexible laterals were installed where necessary as outlined in IGEM G/5 and T/PR/SL/2

h) The risk of buckling and or bending has been discounted cue to the ability of the riser to freely expand and contract with temperature variation. It is assumed that stresses caused by thermal expansion or contraction were considered at the design stage and flexible laterals were installed where necessary as outlined in IGEM G/5 and T/PR/SL/2

The riser deadweight is calculated under the assumptions in 0 and using the formula given in API 579, allowing for an over-calculation of 53% of the weight to account for any discrepancies.

$$F_{total} = (1.7(P + P_s + D)RSF_a) \cdot 9.81$$

Where

P = internal and external maximum allowable working pressure

P_s = static head from liquid or bulk materials

D = deadweight of the vessel, contents, and appurtenances at the location of interest

RSF_a = allowable remaining strength factor based on API 579 – Table 2.3

The minimum thickness requirement for structural stability is then calculated using a manipulation of the formula given in API 579, Paragraph A7.2 (Formula A.324), for thin pressure vessels:

$$T_{sl} = \frac{F_{total}}{2 \cdot S \cdot E \cdot \pi R_m}$$

Where

T_{sl} = the supplementary thickness requirement for self-weight

F_{total} = the total force of the sections of the riser above the point of interest

S = the maximum allowable stress (the maximum allowable stress calculated using the guidance of ASME B31.8 for a pipe with a location classification of Class 4 for close proximity to multi-storey buildings. *i.e.* 40% of SMYS)

E = the weld joint efficiency factor

R_m = the mean radius of the pipe

The minimum pipe grade used is assumed to be API 5L grade A with an SMYS of 210 MPa in order to account for locations where the grade of pipe is unknown *i.e.* in older high and medium-rise buildings.

Where the structural requirements of the piping are not critical and the required wall thickness could theoretically be negligible, a maximum loss of wall thickness of 80% of the original wall thickness is applied for good practice.

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Given an overloading calculation of 50% and a maximum allowable stress of 40% SMYS, the calculated allowable thickness will also provide a reasonable resistance to impact. However, the requirements will be site specific and at the discretion of the operator.

Consideration of buckling effects

Calculations have been performed in order to account for wall loss where the guidance in IGEM G5 (see 0, b) may no longer be true.

The buckling critical force has been assessed in line with the Euler Buckling equation in order to identify the required wall thickness to resist buckling. It has been assumed that the end fixing conditions are both fixed:

$$F_{cr} = \frac{n \cdot \pi^2 \cdot E \cdot I}{L^2}$$

Where

n = the end condition factor

E = Youngs modulus

I = second moment of Inertia

L = Effective length of the column

As there are lateral supports in place on the riser, it is assumed that these act as fixed points, making the end condition factor equal to 4. Where the force from the deadweight exceeds that of the critical buckling force, the WT requirement has been calculated so that the critical buckling load is equal to the actual load. This takes into accounts the 53% over calculation as discussed in the assessment of dead weight.

By rearranging the Euler equation to obtain the second moment of inertia, the wall thickness requirement can be obtained. This wall thickness requirement is then used to determine the MAWT to prohibit buckling.

Evidence for the assessment of thermal expansion

Thermal expansion is considered to be zero as per the guidance of IGEM G5 which states in Paragraph 6.1.6 Note 2:

"Pipeline supports need to permit pipeline expansion and building movement while limiting lateral movement of the pipeline"

And T/PR/SL/2 which states in Paragraph 7.4.3.2 and in Paragraph 7.4.3.3 respectively:

"Where indicated as part of the work pack, expansion bellows should be installed in a vertical riser (example shown in Figure 19 [**Error! Reference source not found.**]) and shall be fitted in accordance with the manufactures instruction to suit the thermal expansion"

"Pipe clips retaining risers should be installed in accordance with the manufacturer's instructions to avoid restricting movement caused by expansion and contraction"

As thermal expansion is considered in the design and slippage between the supports allows for this expansion or contraction the stress is assumed to be zero.

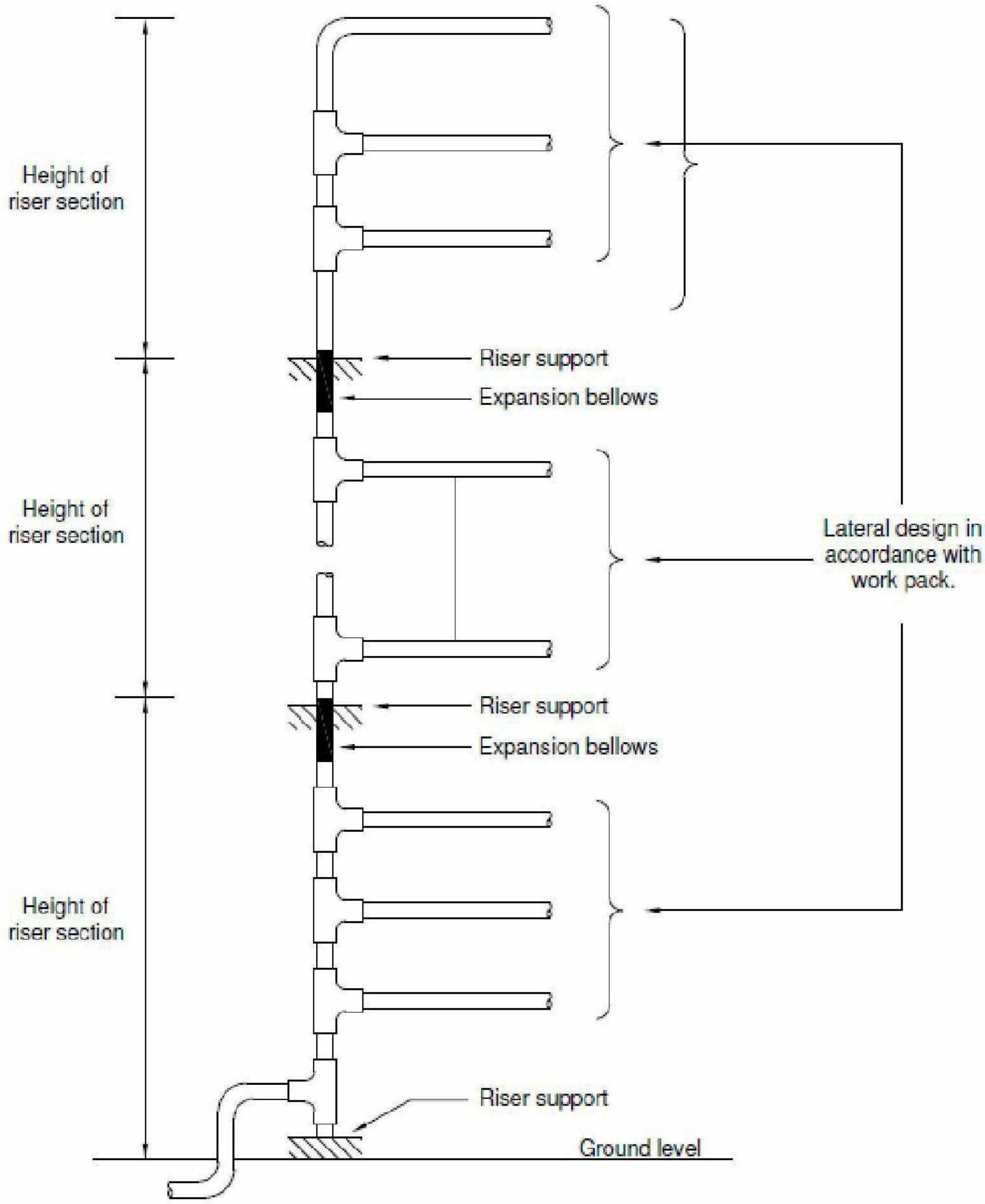

Figure C 1 – Permissible method of Network Riser and Lateral Design (from T/PR/SL/2)

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Appendix D – Guidelines for coating and resurfacing repairs

Before Starting Works

This activity SHALL NOT be carried out by a lone worker unless a lone worker risk assessment has been carried out.

Where applicable, ensure that the necessary arrangements have been made with the customer prior to the work being carried out.

Establish good communications with your manager or supervisor ensuring that your whereabouts are known.

Comply with all applicable safety and environmental codes, rules and regulations including the Control of Substances Hazardous to Health (COSHH) Regulations.

Review site conditions and ensure all hazards have been identified and are controlled. Consider personal safety and the safety of others. If at any time you are unsure of the precautions to be taken, STOP WORK AND CONTACT YOUR MANAGER.

Fire extinguishers shall be deployed as appropriate to the risk but are mandatory when undertaking intrusive maintenance.

Establish a safe working environment to prevent access by passers-by and to eliminate any ignition sources. Erect signs and barriers as appropriate.

Consideration should be given to the presence of confined spaces and these shall be managed with reference to NGUK/PM/SHE/018.

National Grid SCO procedures shall be adhered to at all times.

Equipment that is not certified shall only be used in hazardous areas with the approval of the Authorising Engineer.

For sites within boundaries of unodorised gas sites, checks shall be made for unodorised gas (T/PR/SSW8).

Preparation of Surfaces

The procedure requirements for surface preparation are detailed in Section 8.4 Surface Preparation for Detailed Inspection.

The area adjacent to the damaged area shall be lightly abraded for at least 5cm onto sound coating.

The coating/resurfacing repair systems shall only be applied to clean, dry and structurally sound surfaces. Surfaces should be free of any loose material and all contaminants such as dirt, oil, grease, salt, loose or flaking paint, *etc*.

The surface finish achieved by hand-tool cleaning shall conform to the requirements of BS EN ISO 8501-1:2007, St 3 grade to allow for detailed inspection, including pipe wall thickness measurements and re-coating procedures.

Application of Coating

The coating system should only be applied when the ambient air temperature is above 7°C and when the relative humidity is below 85%. Surfaces being treated should be at least 3°C above the dew-point. The ambient air temperature, metal surface temperature and relative humidity parameters at time of re-coating shall be recorded.

The coating system should be applied by brush in a single brush-stroke direction. The material should be applied at a wet film thickness of approximately 500 - 600 microns to

achieve the desired dry film thickness of 400 microns per coat. Remove excess paint so no runs or sags appear.

All repaired areas should be allowed to cure for the period recommended by the manufacturer of the coating material before any assessment of the patch repair is attempted.

Wipe excess material from tools and equipment immediately. Use soap and water as needed.

Application of Plastic Metal Repair Systems – Plastic Metal Repair Stick

The surface must be clean and free of grease; roughen up, if necessary. The procedure requirements for surface preparation are detailed in Section 8.4 Surface Preparation for Detailed Inspection.

Prepare at room temperature (approx. 20°C) where possible. At higher temperatures the pot life and curing time are reduced, and at temperatures below 16°C the curing time will be longer. No reaction takes place from approx. 5°C.

Cut or break off the required quantity.

Knead the resin and hardener (inner hardener component with outer resin) until the mixture has a uniform colour.

Put the finished mixture within the pot life on the surface to be treated; work in with pressure to achieve a flat surface to minimise further surface preparation prior to re-coating. If further surface preparation is required following curing, lightly abrade surface using emery paper to a re-coatable surface.

Application of Plastic Metal Repair Systems – Plastic Metal for Larger Area Repairs

Application of the Plastic Metal should be carried out immediately after surface pre-treatment to avoid oxidation and instantaneous rust formation.

Before adding the hardener, it is necessary to stir up the fillers in the resin component thoroughly and bubble-free.

Mix resin and hardener for at least 4 minutes with the processing spatula to get a uniform mass with a uniform colour. Do not mix more material than you are able to use within the pot life of 5 minutes.

Apply to surface using the processing spatula. Apply release agent to flexible plastic mat and smooth applied material to pipe contour and surface finish. Ensure material is worked into surface to fill all corrosion damaged areas.

Allow to cure for minimum of 3 hours before re-coating surface.

Appendix E – Record sheet

1.0 Assessment details			
Site			
Pipe location		Pipe ID	
Technician		NG Engineer	
Date		Time	
Additional information			

2.0 Assessment process			Comments
Gas detection	Y	N	
Initial photographs	Y	N	
Visual inspection/Nominal diameter	Y	N	
Identification of corroded area	Y	N	
Removal of corrosion product	Y	N	
Gas detection	Y	N	
Preparation of NWT area	Y	N	
Photographs	Y	N	
Cleaning of pipe (potable water)	Y	N	
UT for NWT	Y	N	
UT of corroded area	Y	N	
Pit depth assessments	Y	N	
Calculations	Y	N	
Weather checks	Y	N	See section 5
Preparation for coating	Y	N	

3.0 Measurements				
MAWT (Refer to table)	Nominal diameter	Storeys above pipework	Number of laterals	MAWT

NWT (Average across 6 readings)	1	2	3	4	5	6	NWT
mRWT (lowest recorded UT measurement (corroded area))	1	2	3	4	5	6	Lowest
CD micrometer measurements (deepest pit depth)	1	2	3	4	5	6	Deepest
RWT = mRWT – CD (lowest recorder UT – deepest pit depth							RWT

CWT	RWT - MAWT	CWT		AWT	NWT - MAWT	AWT

4.0 Damage classification - Refer to table				
CWT / AWT x 100	Moderate	Severe	Extreme	Unrepairable

5.0 Weather checks				
Relative humidity	Ambient air Temperature	Surface Temp	Dew point	Delta point

6.0 Coating application	Type		Photographs		Comments
	Re-coat	2 – part	Y	N	

Appendix F - Assessment record sheet

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LC/33 PROCEDURE ASSESSMENT REPORT AND RECORD SHEET

Technician:	Contact details:
Engineer in charge:	Contact details:
Scheduled work start date	

SITE DETAILS	
Property Name/Number	
Street/Road	
Town/City	
Postcode	
Building ID	

PREVIOUS ASSESSMENT DETAILS	
Pipe ID	
ID of previous survey	
Year of previous survey	

VISUAL INSPECTION OF SUPPORTS			
☐ UNAFFECTED	☐ SUPERFICIAL	☐ MODERATE/SEVERE	☐ N/A
Remedial Action			
☐ No action	☐ Surface prep. and re-coat	☐ Refer for replacement	☐ N/A

DAMAGE LOCATION DETAILS (Sketch as appropriate – attach photographs to report)

Comments:

VISUAL IDENTIFICATION/CHARACTERISATION OF CORROSION DAMAGE	
☐ General corrosion	☐ Localised corrosion (*e.g.* pitting)
(Sketch as appropriate – attach photographs to report)	
Comments:	

CORROSION DEFECT/DAMAGE AREA DIMENSIONS (Excluding depth measurements)	
Axial length	mm
Circumferential length	mm

MINIMUM ALLOWABLE WALL THICKNESS (MAWT) DETERMINATION	
Nominal pipe size	mm
Storeys above point of interest	
Number of laterals per storey	
MAWT (*determine from table in procedure*)	mm

NON-DESTRUCTIVE TESTING OF DAMAGED AREAS					
Ultrasonic thickness (UT) measurements					
Nominal wall thickness (NWT)					
Sketch of reference grid (Label numbered UT measurements, attach photographs to report)					
UT measurement (mm)					
1	2	3	4	5	6

Average NWT	mm
Available wall thickness (AWT)	
AWT = NWT – MAWT	mm
Remaining wall thickness (RWT)	

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Sketch of reference grid (in relation to corrosion damage, label numbered UT measurements, attach photographs to report)					
UT measurement (mm)					
1	2	3	4	5	6
Minimum RWT measurement		mm			
Depth micrometer measurements *(if UT measurements cannot be accurately obtained as above)*					
Corrosion depth (CD)					
Depth micrometer measurement (mm)					
1	2	3	4	5	6
Greatest CD measurement		mm			

RWT = NWT – CD	mm		
Consumable wall thickness (CWT)			
CWT = RWT – MAWT	mm		
DAMAGE CATEGORY CALCULATION			
(CWT / AWT) x 100			
Damage category (*from table*)			
☐ MODERATE	☐ SEVERE	☐ EXTREME	
REPAIR ACTIONS			
☐ Re-coating	☐ Composite repair and re-coating		
Ambient air temperature:	Relative humidity:		
Metal surface temperature:	Dew-point temperature:		
Comments:			
Other records sent with this assessment record sheet (labelled photographs, faxed or e-mailed):			
Technician signature:	Date:		
Engineer in charge signature:	Date:		

Appendix G - Table 2: Minimum allowable wall thickness (MAWT) reference table

MAWT Requirement (mm)	Storeys Above Point of Interest																			
	1		2		3		4		5		6		7		8		9		10	
	Number of Laterals																			
Nominal Pipe Size (mm)	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
15	0.6	0.6	0.6	0.6	0.6	0.6	0.6	1.5	1.5	1.8	1.8	2.2	2.1	2.5	2.3	2.7	2.5	3.0	NOT POSSIBLE WITHOUT EXCEEDING CRITICAL BUCKLING LOAD	
20	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.6	0.8	0.7	0.8	0.8	0.9
25	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
32	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
40	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
50	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
80	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
100	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

MAWT Requirement (mm)	Storeys Above Point of Interest																			
	11		12		13		14		15		16		17		18		19		20	
	Number of Laterals																			
Nominal Pipe Size (mm)	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
15																				
20	0.9	1.0	0.9	1.1	1.0	1.2	1.1	1.3	1.2	1.4	1.2	1.5	1.3	1.6	1.4	1.7	1.5	1.8	1.5	1.9
25	0.8	0.9	0.9	1.0	0.9	1.1	1.0	1.2	1.1	1.3	1.1	1.3	1.2	1.4	1.3	1.5	1.3	1.6	1.4	1.7
32	0.8	0.8	0.8	0.9	0.8	1.0	0.9	1.1	1.0	1.1	1.0	1.2	1.1	1.3	1.2	1.4	1.2	1.4	1.3	1.5
40	0.8	0.8	0.8	0.9	0.8	0.9	0.9	1.0	0.9	1.1	1.0	1.1	1.1	1.2	1.1	1.3	1.2	1.4	1.2	1.4
50	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	0.9	1.1	1.0	1.1	1.1	1.2	1.1	1.3
80	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.2
100	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

NOTE: The fields highlighted in red show where buckling has been found to be a potential issue caused by the deadweight of the riser exceeding the critical buckling load. This has been accounted for by increasing the MAWT requirement in these particular cases as given in the table (see Appendix C).

End note

Comments

Comments and queries regarding the technical content of this document should be directed to:

Safety and Engineering Registrar

SHE Directorate

National Grid

National Grid House

Warwick Technology Park

Gallows Hill

Warwick

CV34 6DA

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