GDN/PM/P/18

MANAGEMENT PROCEDURE FOR

WORKING ON PIPELINES EQUAL TO OR GREATER THAN 100MM NOMINAL DIAMETER CONTAINING DEFECTIVE GIRTH WELDS OR GIRTH WELDS OF UNKNOWN QUALITY

OCTOBER 2020

FOREWORD

This management procedure was approved by GDN approval commitees in October 2020 for use by managers, engineers and supervisors throughout the Gas Distribution Networks (GDNs).

GDN documents are revised, when necessary, by the issue of new editions. Users should ensure that they are in possession of the latest edition by referring to individual GDN's engineering policy library.

Compliance with this safety and engineering document does not confer immunity from prosecution for breach of statutory or other legal obligations.

BRIEF HISTORY

History of P18

First published.	October 1994	BGES/P18
Reissued incorporating errata.	November 1994	BGES/P18
Editorial update to reflect demerger November 2000	June 2001	P18
Editorial update to reflect Safety Case version 3 taking into account issues as detailed in the comments below. Additionally, compliance with mandatory terms along with the removal of no specific normative phrases.	July 2004	P18
Updated to comply with GRM.	October 2004	

Cadent

Editorial review and update: (a) restructuring of sections, (b) included an algorithm for determining when to apply P/18, (c) added example calculations, (d) addition of sections to cover vibration inducing activities and ground movement, (e) corrections of typos, etc. and (f) updated all references	February 2013	SEDDS\1395

NGN

Amended into NGN format	April 2007	NGN/PR/P/18

WWU

Latest Update

Updated as a gas industry document to incorporate the UKOPA PIGW P18 Sub Group Recommendations.	June 2020	PIWG/P18/08

KEY CHANGES

Section	**Amendments**
1.2	What pipelines are excluded from GDN/PM/P/18.
6.2	Introduction of phased array as a NDT inspection tool for GDN/PM/P/18 for some networks.
6.4	Clarification of weld defect limits
Section 7 & Figure 8	Updated stress assessment
Section 9	Support of pipelines according to their size
Figure 2	Updated flowchart
Appendix E	The history of P18
All sections	Rewording and clarifications

DISCLAIMER

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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.

CONTENTS

1. INTRODUCTION

This procedure has been developed by Cadent, Northern Gas Networks, SGN and Wales & West Utilities (hereafter referred to as the GDNs).

This management procedure applies to all managers and employees who are responsible for working on pipelines containing defective girth welds or welds of unknown quality.

1.1. What does this Management procedure do?

This document provides principles and actions to be followed to reduce girth weld failure whilst working on pipelines, including:

- Data collection and pre-site work
- Preliminary excavations and inspections
- Weld assessments and classifications
- Repair techniques
- Records

1.2 Scope

This management procedure is to reduce the risk of girth weld failure when working on pipelines equal to or greater than 100mm nominal diameter that have a declared maximum operating pressure greater than 7 barg.

These procedures do not apply to girth welds on pipelines:

a) of new pipeline construction;
b) constructed in or after 1972 and therefore meeting the requirements in #P2;
c) with a current declared Maximum Operating Pressure (MOP) equal to or less than 7 barg;
d) with a hoop stress level at a declared MOP above 7 barg, but not exceeding 20% SMYS.

NOTE: If a pipeline has not been formally declared as having poor quality girth weld defects but an initial visual inspection by a qualified inspector indicates abnormal welding procedures then this procedure should apply.

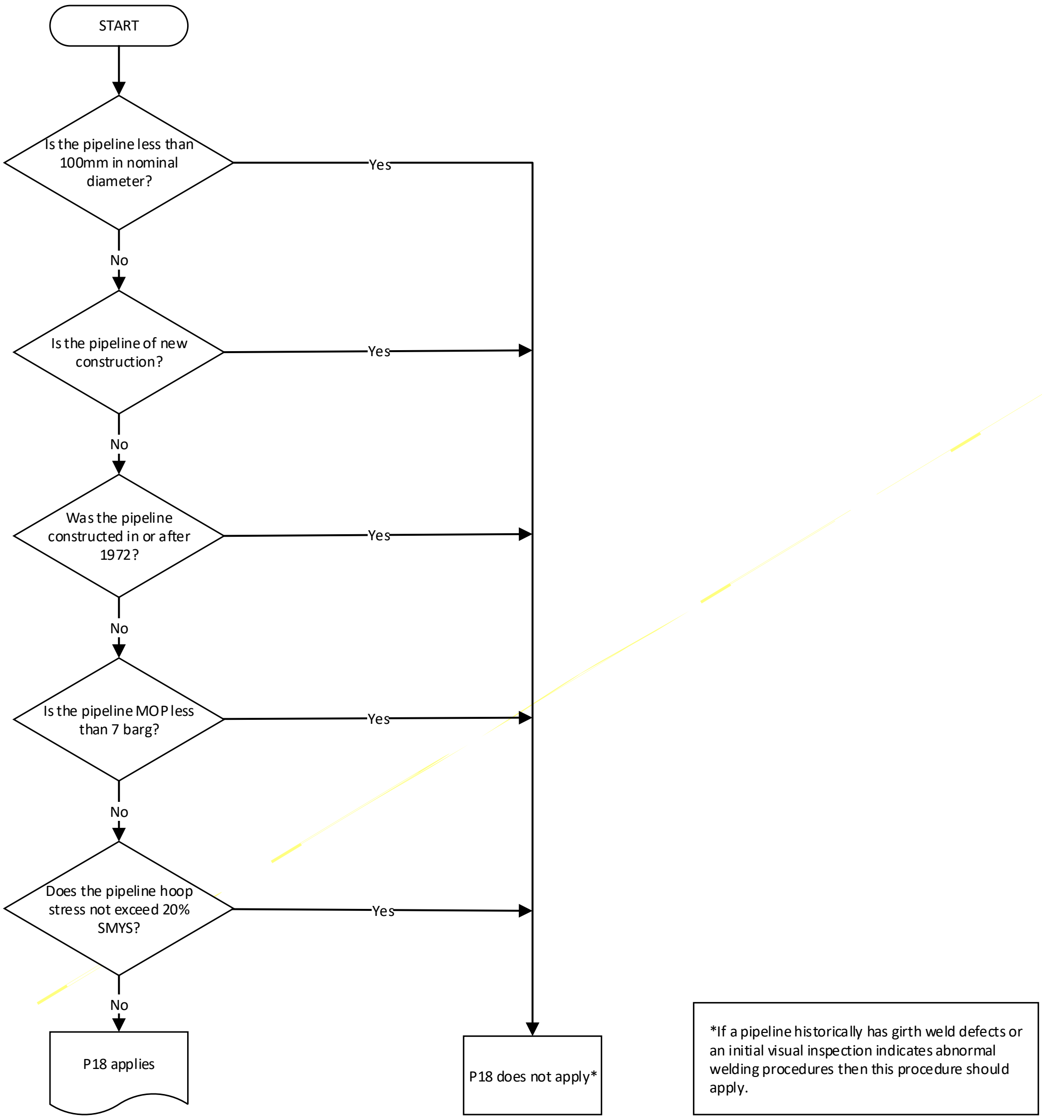


Figure 1 – Flowchart to determine if P/18 applies to a pipeline

The history of the relevant section of pipeline shall be established by reference to all available records, radiographs, drawings and reports to assess the probable condition of all girth welds near the intended works. If the examination of these records by the Competent Person establishes that the quality of girth welds is in accordance with P2#, further reference to these procedures is not necessary.

These procedures do not define safety and procedural actions relating to pipelines which have leaks. These actions shall be regulated by their circumstances and shall be at the discretion of the responsible operational or project engineer overseeing the work on site after reference to current emergency procedures.

These procedures do not apply to pipelines operating at temperatures below 0°C. Such pipelines shall include procedures additional to those specified (e.g. IGEM/TD/1), and expert assistance shall be sought.

1.3 Why do we need this Management Procedure?

To ensure that girth welds on pipelines are inspected and assessed to ensure continued asset integrity and fitness for purpose to support the requirements in the Pipeline Safety Regulations 1996 (PSR).

2. SAFETY

2.1 General

It is essential that care be exercised when examining pipelines known to be, or possibly to be, outside the limits of P2#, as the weld may contain defects.

The risk of a gas escape shall be recognized (i.e. to allow for situations where the procedures specified do not prevent weld failure).

Appropriate care shall be exercised when excavating in the vicinity of gas pipelines. The relevant policy shall be used to ensure the integrity of the pipeline.

Defective welds are at risk of potential leak failure during work on pipelines. Great care shall be exercised to prevent shock loads and overloads when making adjustments to pipeline supports. Stresses can be induced into a pipeline through activities undertaken during work (e.g. by wedging the pipe upwards from its support or inadvertently striking the pipeline with components being manoeuvred by lifting gear).

A leak clamp should be available on site, and confirmation that a suitable epoxy filled shell repair is available off-site to affect a repair if necessary is required.

2.2 Leaks

The responsible engineer shall decide how to deal with a leaking girth weld. This should include considering the accumulation of gas in excavations and other confined spaces and the repair methods available to cope with leaks.

The responsible engineer shall consider the requirements of the relevant emergency procedures when dealing with any form of gas leak.

3. PRE-SITE WORK

3.1 General

These procedures shall be implemented according to the algorithm shown in Figure 2. Clause, table and figure numbers are placed in, or adjacent to, boxes in this algorithm. These shall be consulted before implementing the instructions.

3.2 Examination of records

Before inspecting the girth welds the following data should be gathered:

a) The pipeline diameter.

b) The pipeline measured wall thickness.

c) The pipeline material grade from records or samples.

d) Defect information from: radiographs, the completed Weld Information Sheet, welding bar chart, the Inspection Acceptance Sheet, or similar documents.

e) The pipeline configuration showing, in particular, the proximity of bends.

f) Operational history of the pipeline.

3.3 Axial stresses

Changes in pipeline axial stresses at girth welds within the excavated and unexcavated zones may occur due to:

a) Changes in pipeline pressure.

b) Pipeline self-weight. The pipeline weight constitutes loading when exposing a buried pipeline results in an unsupported span.

c) Loading applied to the pipe during work (e.g. weight of repair shell or equipment).

d) Pipeline end dome effect or pressure difference across a flow restriction (e.g. a fully closed valve or stopple closure).

e) Stresses due to welding, construction or land movement.

The work procedure applied should minimise the loading applied during work by ensuring adequate support is applied to the pipeline and the work location is monitored for local ground movement during the work in accordance with good practice.

4. DETERMINING THE APPLIED AXIAL STRESS AND PRESSURE REDUCTION TO BE APPLIED WHEN WORKING ON P/18 PIPELINES

4.1. Determining the applied Axial Stress

The increase in axial stress will depend upon the nature of the work, the size of excavation required to accommodate the work, and whether the work is on a straight pipe section or a section containing a bend.

For pipelines containing girth welds of unknown quality or which are unacceptable to P2# the maximum allowable axial stress during work on the pipeline is 0.3 x SMYS.

The axial stress due to the operating pressure, excavation and applied loading during work and the pressure reduction which may be required to offset an increase in axial stress above 0.3 x SMYS is determined using the procedure in 7.2.

4.2 Pressure Reduction

Pressure reduction prior to excavation for weld location (see 5.1) or for inspection (see 5.2) is not required.

After inspection and prior to undertaking work, if the pipeline contains:

a. a girth weld having defects unacceptable to these procedures (see clause 6), or

b. a girth weld which is considered by the Competent Person likely (see 1.2 and Appendix B) to have defects defined in these procedures as being unacceptable to these procedures (see clause 6),

the pressure in the pipeline shall be reduced prior to repairing the weld in accordance Sections 7.

This reduced pressure shall not be exceeded during any work.

For excavations of effective length less than six times the pipe diameter, refer also to clause 8.

5. EXCAVATIONS TO IDENTIFY WELD LOCATIONS

5.1. Excavations for Weld Location

To establish the quality of the welds, it is firstly necessary to locate the girth welds both within the proposed excavation and on each end of it by excavating a channel (or slit trench) above the pipeline. If available, the pipeline tally may be helpful in locating the girth welds. No pressure reduction is required during this operation.

5.2. Excavations for Inspection

Excavations to facilitate radiography or phased array inspection should be as small as possible and consistent with access requirements.

An excavation of effective length not greater than six times pipe diameter will normally be sufficient for these tasks.

Care shall be taken to minimize the loads due to radiography equipment.

After preliminary excavation and examination by a competent inspector, the weld shall be assessed in accordance with clause 6.

5.3. Inspection

Any additional stress loading on a pipeline during excavation is minimised by appropriately supporting the pipeline. All welds that will be within the proposed excavation shall be inspected by a qualified inspector.

6. ASSESSMENT OF A WELD CLASSIFICATION

6.1. General

The defect limits in clause 6 and Figure 3 are only applicable to these procedures and shall not be used for other engineering critical assessments. Inspection of girth welds within the excavation required to undertake the planned work is carried out to establish their quality.

6.2. NDT Inspection Options

Two options for examination of a girth weld are given below.

6.2.1. Radiography

Radiography has the advantage of providing a two-dimensional image (length and width) that can allow positive identification of a defect type. The disadvantage of radiography is the radiation hazard presented by this method and the period of time required for prior notification of such work to the HSE. All radiography should be carried out in accordance with BS EN ISO 17636-1, 17636-2, P2# and other appropriate standards.

6.2.2. Ultrasonics

The ultrasonic phased array (PA) inspection method has the advantage that examination can start as soon as the adjacent pipe either side of the weld has been cleaned sufficiently to permit inspection. In many cases a weld defect can be measured in three dimensions; length, width and depth and the time taken to inspect a weld is much shorter than radiography. However, in some cases the interpretation of a planar defect could be prone to misinterpretation and visual defects such as arc marks will not be recorded in the PA scanning record.

Note 1: Old Seamless pipe may not be suitable for ultrasonics. Good surface contact is not possible for the ultrasonic probe due to mill marks and surface profile on seamless pipe. Dressing is not permitted unless authorised by the responsible engineer.

Note 2: Applicable Management Procedures should apply where NDT is required (Some Networks do not use or have not adopted Phased Array as an NDT technique so Radiography will be used)

Ultrasonic phased array inspection should be carried out in accordance with appropriate standard. The results of the phased array inspection should be combined with the visual and MPI results (BS EN ISO 17638).

Should any doubt exist in the interpretation of a planar defect indicated by the PA inspection in the weld or HAZ defect i.e. whether the discontinuity is a crack or a less critical defect such as lack of fusion, then a supplementary method of NDT shall be applied to the defect area to confirm the defect type.

Note: Where defect type cannot be confirmed, the worst-case assumption of a planar, cracklike defect should be applied.

6.3 Weld Classification

6.3.1 General

Welds are assessed in order to identify:

a) welds which do not require the application of these procedures (i.e. welds in accordance with the acceptance levels of P2#);

b) welds which require the application of these procedures (i.e. welds with defects outside the acceptance levels of P2#). These welds:

1) do not require repair if they are within the limits specified in 6.3.3;

2) require repair if they are outside the limits specified in 6.3.3.

6.3.2 Welds Acceptable to P2#

Welds which meet the requirements of P2# require neither repair nor the application of these procedures. When working at or near P2# girth welds, normal working practices which provide adequate support for the pipeline shall be adopted.

6.3.3 Welds Unacceptable to P2# but Acceptable to GDN/PM/P/18

Welds which do not meet the requirements of the defect acceptance levels quoted in P2#, but are equal to or less than the limits specified in 6.4 inclusive, shall be categorized as welds acceptable to these procedures and do not require repair.

6.3.4 Welds unacceptable to GDN/PM/P/18

Welds which contain defects greater than the limits specified in clause 6.4 inclusive are unacceptable to these procedures and require repair.

6.4 Weld Defect Limits

6.4.1 Root and Cap Defects

Root/internal concavity, lack of root fusion, incomplete root, lack of penetration, root misalignment, missed edge, bad pick-up, root undercut, excess penetration, irregular root, lack of cap fusion, incompletely filled groove and cap undercut shall not have a combined length greater than specified in the total surface defects curve shown in Figure 3.

6.4.2 Coincidental Cap and Root Defects

Coincidental cap and root defects (i.e. two surface defects in the same position in the weld) are not allowed. Table C.3 defines cap and root defects.

6.4.3 Burn-Through

Burn-through should not be greater than 14mm in any dimension, and the total number should be not greater than nine per weld.

6.4.4 Crater Cracks

Crater cracking shall not exceed the boundary of any burn-through. A weld shall not contain more than two crater cracks in total. Crater cracks exceeding burn-through boundaries shall be treated as cracks (see 6.4.7). The total length of crater cracking shall be not greater than 1% of the pipe circumference.

6.4.5 Arc Marks

Arc marks should be not greater than 15 mm in any dimension and the total number should be not greater than 13. If the arc marks are greater than 25mm from the HAZ of the seam or girth weld then refer to P11# as applicable.

6.4.6 Defect Separation

Arc marks, crater cracks and burn-through shall be separated by a distance greater than the average of their individual lengths. If the separation distance is less than this average, the defects shall be considered to have interacted into a single defect of length equal to the individual lengths plus the separations. The total length of an interacted defect should not be greater than 70 mm or 5% of the weld length, whichever is the lesser.

6.4.7 Cracks

Cracks (including stress corrosion cracking but not crater cracks) are not allowed.

6.4.8 Mechanical Damage

Mechanical gouges shall be not closer to the weld toe than a distance equal to the average of the axial length of the gouge and width of the weld cap. Such gouges should be assessed by reference to P11#.

6.4.9 Embedded Defects

The lengths of embedded defects in the weld (slag, porosity, voids, lack of inter-run fusion, lack of side wall fusion) shall be summed and added to the summed lengths of all the defects reported in the weld (see 6.4.1 to 6.4.6 inclusive and 6.4.10). This total defect length shall be not greater than the limits specified in the 'Total - all defects curve' shown in Figure 3.

6.4.10 Corrosion

Pitting and general corrosion indicated on the radiograph of the weld can be treated as an embedded defect (see 6.4.9) and its length included in the summation in 6.4.9. However, corrosion shall be not greater than the limits specified for pipe material in P11#.

6.4.11 Summary of Limits

Welds which contain defects within the limits in clause 6.4 do not require repair.

6.5 Weld Information Sheet

The nomenclature and definitions given in Appendix C shall be used when completing the Weld Information Sheet (see clause C.1). All information should be recorded on the weld information sheet. Copies of the weld information sheets unacceptable to P2# shall be maintained in a suitable database.

6.6 Welds Unacceptable to GDN/PM/P/18

If the pipeline contains a girth weld having defects defined in these procedures as being unacceptable then the pressure in the pipeline shall be reduced prior to work to the level required by P11# (see 4.2).

This reduced pressure shall not be exceeded during any work.

7 STRESS ASSESSMENT PROCEDURE FOR FINAL EXCAVATION SIZES UP TO 10 M IN LENGTH

7.1 Introduction

Before proceeding with final excavations* of welds not meeting the defect acceptance levels of P2#, changes in the pipeline axial stress induced by the proposed work shall be assessed.

**Final excavation size is the effective excavation length, L_e shown in Figure 4.*

A safe working procedure which ensures that the total axial stress at a defective girth weld does not exceed 0.3 x SMYS shall be specified in order to minimize the risk of failure. This requires that increases in stress due to pipeline excavation and any external loads applied during the work and the pressure reduction required to offset any increase in stress above 0.3 x SMYS shall be determined.

Procedures for estimating the axial stress due to the operating pressure and for typical, single point loads, applied to the pipe in excavations up to 10 m in length are specified in 7.2, but the procedures do not apply to pipelines liable to hogging (frost heave), or subject to significant pipe wall temperature changes (i.e. greater than 5°C) during work (see Appendix D).

Additional procedures required prior to stopple and bypass operations are specified in 13. Detailed stress assessment and pipeline decommissioning procedures required for special cases are specified in 7.3 and 7.4 respectively.

Short excavations, such as for the repair of wrapping defects, do not require a stress assessment (see clause 8).

7.2 Estimation of Axial Stress and Pressure Reduction

7.2.1 General

Procedures for determining the axial stress due to work on pipelines with defective girth welds are specified in 7.2.2 and 7.2.3. These procedures cover:

a) pipe outside nominal diameters of 100 mm to 900 mm inclusive;

b) straight pipe sections (including bends up to 30°);

c) pipe sections including bends (greater than 30° up to 90°).

All welds associated with bends (including mitre welds and welds at the end of field and forged bends) shall be considered to be in bends.

7.2.2 Straight Pipeline Sections

Determine the axial stress during work on straight pipeline sections (0° to 30°) as follows:

a) Calculate the effective excavation length, L_e using Figure 4.

b) Determine the stress change, $\Delta\sigma_e$ due to the excavation, from Figure 5.

c) Determine the stress change, $\Delta\sigma_1$, due to the externally applied load from Figure 6 for a notional 10 m long excavation.

Note: Determine the load on the pipeline in kN. Multiply the weight of the equipment in kilograms by 9.81 to convert to Newtons and then divide by a 1000 to convert to kN. Loading applied from 3 or 9 o'clock positions (e.g. side drilling) should conservatively be assumed that the load is vertical. Multiple loads should be treated as single point load.

d) Determine the stress reduction factor, F_{r1}, to be applied to the stress change, $\Delta\sigma_1$, due to the applied load for the effective excavation length, from Figure 7.

e) Determine the axial stress due to operating pressure σ_{Pa}, at the time of work from Figure 8, or calculate the axial stress due to operating pressure:

$$\sigma_{Pa} = 0.3(PD/20t)$$

Where:
P = operating pressure at the time of work
D = Outside diameter of pipe
t = minimum wall thickness of pipe

f) Calculate the total axial stress during work, σ_{ax}:

$$\sigma_{ax} = \sigma_{Pa} + \Delta\sigma_e + (F_{r1} \times \Delta\sigma_1)$$

g) Calculate:

$$\Delta\sigma = \sigma_{ax} - 0.3 \times SMYS$$

Notes:

a) the SMYS for the pipeline should be used in the above calculation.

b) If $\Delta\sigma$ is negative, a pressure reduction is not required.

h) Determine the required pressure reduction, ΔP, to offset $\Delta\sigma$ from Figure 9.

7.2.3 Pipeline Sections Including Bends (over 30° up to 90°)

Determine the axial stress increase due to excavation and applied load on pipeline sections including bends (over 30° up to 90°) as follows:

a) Calculate the effective excavation length, L_e using Figure 4. See also 8.1.

b) Determine the axial stress due to operating pressure σ_{Pa}, at the time of work from Figure 8.

c) Determine the stress change, $\Delta\sigma_e$ due to a 10 m long excavation from Figure 10.

d) Determine the stress change reduction factor, F_{re} from Figure 11, to be applied to the stress change, $\Delta\sigma_e$, for the effective excavation length, L_e See also 8.1.

e) In the case of bends excavated in stiff soil, the value of $\Delta\sigma_1$ shall be multiplied by 1.7.

f) Determine the stress change, $\Delta\sigma_1$, due to the externally applied load from Figure 6 for a notional 10 m long excavation.

g) Determine the stress change reduction factor, F_1, to be applied to the stress change, $\Delta\sigma_1$, from Figure 7.

h) Calculate the total axial stress during work, σ_{ax}:

$$\sigma_{ax} = \sigma_{Pab} + (F_{re} \times \Delta\sigma_e) + (F_{r1} \times \Delta\sigma_1)$$

i) Calculate:

$$\Delta\sigma = \sigma_{ax} - 0.3 \times SMYS$$

Notes:

c) the SMYS for the pipeline should be used in the above calculation.

d) If $\Delta\sigma$ is negative, a pressure reduction is not required.

h) Determine:

1) The required pressure reduction, ΔP^1, to offset $\Delta\sigma$ from Figure 12.

2) The multiplication factor F_p, for the effective excavation length from Figure 13. The required pressure reduction is then $\Delta P = F_p \times \Delta P^1$

7.2.4 Alternative approaches to stress assessment

In cases where the calculated pressure reductions cannot be sustained, alternative approaches are:

a) a more detailed stress assessment (see 7.3);

b) repair of welds containing defects;

c) pipeline de-commissioning (see 7.4).

Expert assistance shall be sought if any of the criteria specified above cannot be met.

7.3 Further stress assessment

Further stress assessment is required when:

a) The pressure reduction estimated in accordance with 7.2 is not possible.

b) The specific pipeline geometry, excavation and loading arrangement, is not covered by the procedures specified in 7.2, 7.3 and 13.

A further stress assessment provides a more accurate estimate of the axial stress by performing a detailed stress analysis. The results of the analysis should be used to check or modify the work procedures.

Parameters which should be considered are given in Appendix D. Relevant pipeline stress analysis software shall be used to conduct the assessment.

7.4 Pipeline de-commissioning

In cases where the predicted stress increase caused by the excavation and repair work on any pipeline section cannot be accommodated by pressure reduction and inspection has shown that the girth welds contain cracklike defects, the pipeline shall be decommissioned prior to work commencing.

8 SHORT EXCAVATIONS: LENGTH UP TO SIX TIMES PIPE DIAMETER

Excavations for straight pipe sections and pipe sections including bends of effective length up to six times pipe diameter do not require stress assessment prior to work provided that no external loads are applied to the pipeline.

9 PIPELINE SUPPORT

The excavated pipeline should be supported by adequate support methods installed on a firm base in the pipe trench. Supports should be placed as close as possible to the applied load. Pipe supports should be located at a maximum spacing of:

- 1 m for nominal diameters less than or equal to 200 mm
- 6D for nominal diameters 250 mm to 450 mm
- 3m for nominal diameters greater than 450 mm

10 WORK ON THE P/18 PIPELINE

All normal precautions shall be taken to minimise additional loading on the pipeline during excavation, inspection and work. Working practices should ensure that loads and supports are stable.

The procedures do not apply to pipelines liable to hogging (frost heave), or subject to significant pipe wall temperature changes (i.e. greater than 5°C) during work (see Appendix D).

Additional procedures required prior to stopple and bypass operations are specified in clause 13.

11 VIBRATION

If works close to the pipeline involve a vibration inducing activity such as, but not limited to, piling, blasting or demolition, then consideration shall be given to the additional stresses that these loads can create for the pipeline. Also follow guidance in the relevant documentation.

12 GROUND MOVEMENT AND EXTERNAL LOADING

If the pipeline is affected by ground movement, or there will be significant ground movement as a result of the work, or subjected to additional external loading, then consideration shall be given to the additional stresses that these loads can create for the pipeline. Also follow guidance in the relevant documentation.

13 ADDITIONAL REQUIREMENTS FOR STOPPLE AND BYPASS OPERATIONS

13.1 General

The responsible engineer should ensure that all stopple and bypass procedures and operations are specified and the pipeline is adequately supported at all times.

Where a stopple and bypass procedure is to be carried out on a pipeline with welds of unknown quality or which contain defects which do not meet P2# but are within the defect limits defined in this procedure, the additional requirements specified in 13.2 shall be applied.

13.2 Additional Requirements

This operation is carried out on straight pipe, typically with no reduction in operating pressure. Prior to the stopple and bypass operation, the following is required:

a) The possibility of a gas escape from a sub-standard weld within a distance of up to 20 pipe diameters along the pipeline from either end of the excavation should be recognised. A suitable risk assessment should be undertaken to determine whether a leak would be acceptable.

b) Locate all girth welds within a distance of 20 pipe diameters either side of excavation.

c) All girth welds which may contain defects outside the limits of P2#, and are either within the excavation or are within a distance of 20 pipe diameters along the pipeline from either end of the effective excavation length, should be inspected and assessed in accordance with clauses 5 and 6. Girth welds with defects outside the limits in clause 6 which are to remain as part of the pipeline should be repaired in accordance with these procedures prior to stopple and bypass operations. Consideration may be given for the use of temporary repairs for girth welds which are to be isolated as part of the stopple operation (see clause 15).

d) Immediately following the excavation and the completion of all works, a pipeline leakage survey should be conducted over a distance of 20 pipe diameters from either end of the excavation and this should be completed prior to re-instatement on the pipeline pressure.

14 EFFECT ON SURROUNDING SOIL CONDITIONS

The time that a pipeline is exposed should be minimized to reduce effects on surrounding soil conditions. During excavation and work, care should be taken to protect clay type soils or soft rock from mechanical disturbance and adverse weather conditions, the action of which could lead to loss of material strength. It may prove necessary to blind exposed surfaces if excavations are to be left open for more than a few hours. Any very soft or loose materials encountered should be removed and replaced with properly compacted, well graded granular fill.

15 REPAIR OF WELDS

15.1 General

All girth welds requiring repair should be permanently repaired to P11# or 15.3, or temporarily repaired as specified in 15.2 and P11#.

15.2 Temporary repair

Long leak clamps (5D plus) are preferred for temporary repairs to girth welds, because of their ability to contain the effects of full circumferential fracture of a girth weld. Such a fracture may be accompanied by significant longitudinal movement if locked-in stresses are present in the pipeline. However, if pipeline constraints make the use of long leak clamps impossible, short leak clamps may be used as an alternative provided that they are mechanically restrained horizontally and vertically.

15.3 Epoxy-filled flanged shells

Epoxy-filled shell repair with a length of 3D is the preferred repair method for girth welds. Details of the epoxy shell repair can be found in P11#. Other repair methods in P11# can be applied if required.

16 REINSTATEMENT

After all work on the pipeline is complete, the coating shall be repaired in accordance with CW5, the trench shall be backfilled where appropriate with adequate consolidation to provide pipe support, and reinstatement of land drains.

17 RECORDS

The inspection and any resulting repair shall be recorded in the pipeline records file.

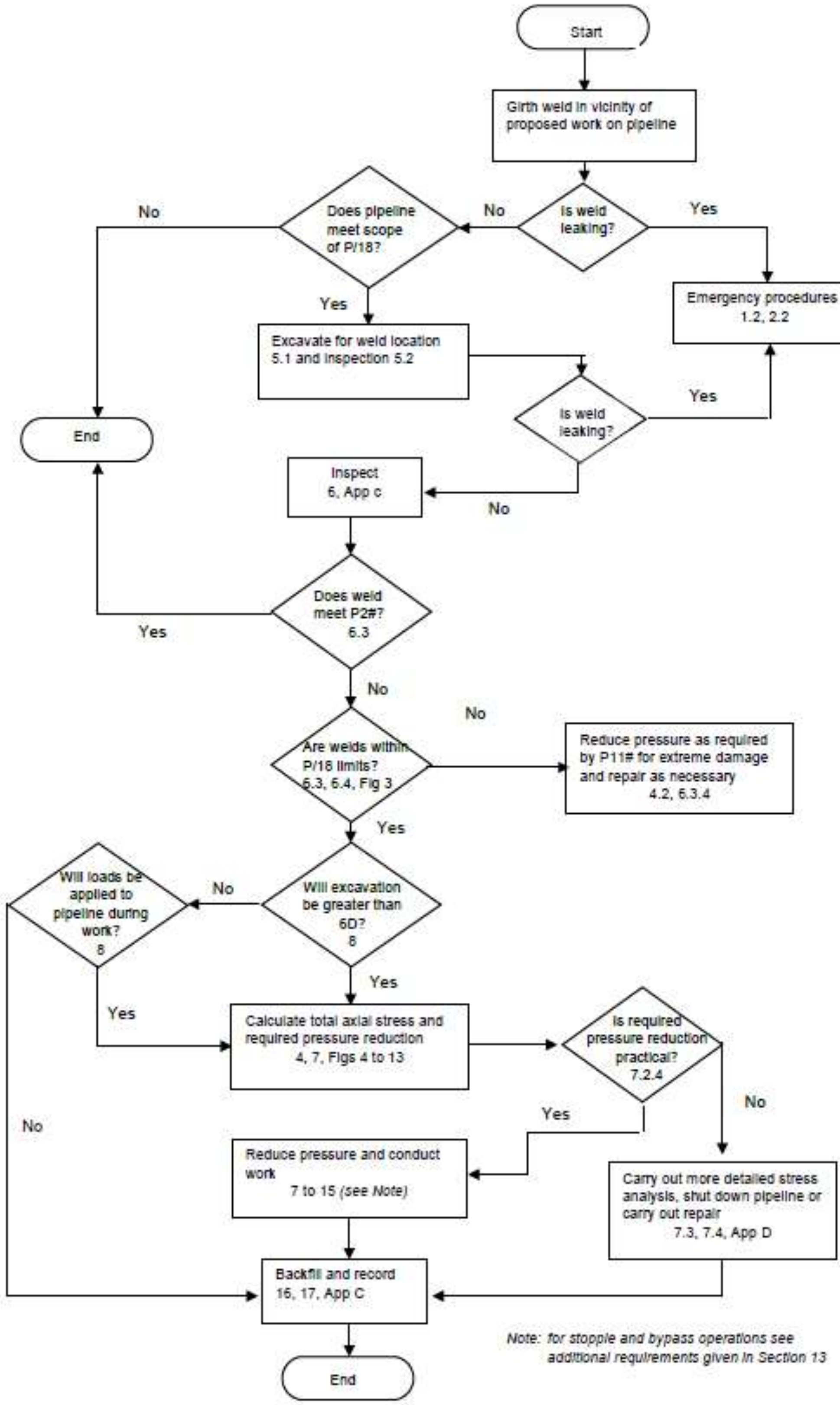


FIGURE 2 - Procedure algorithm

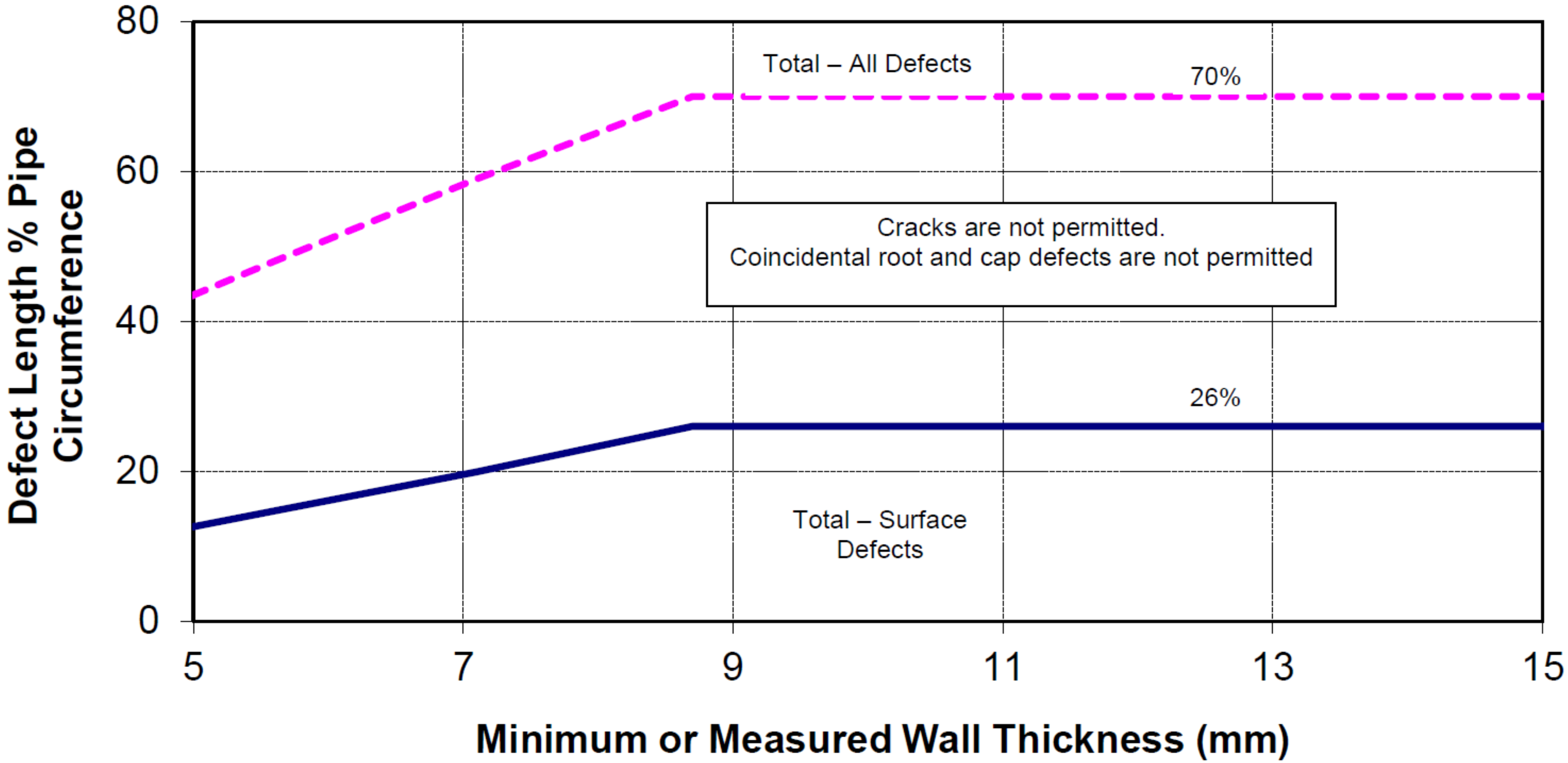


FIGURE 3 - Defect limits for in-service girth welds (for use only with these procedures)

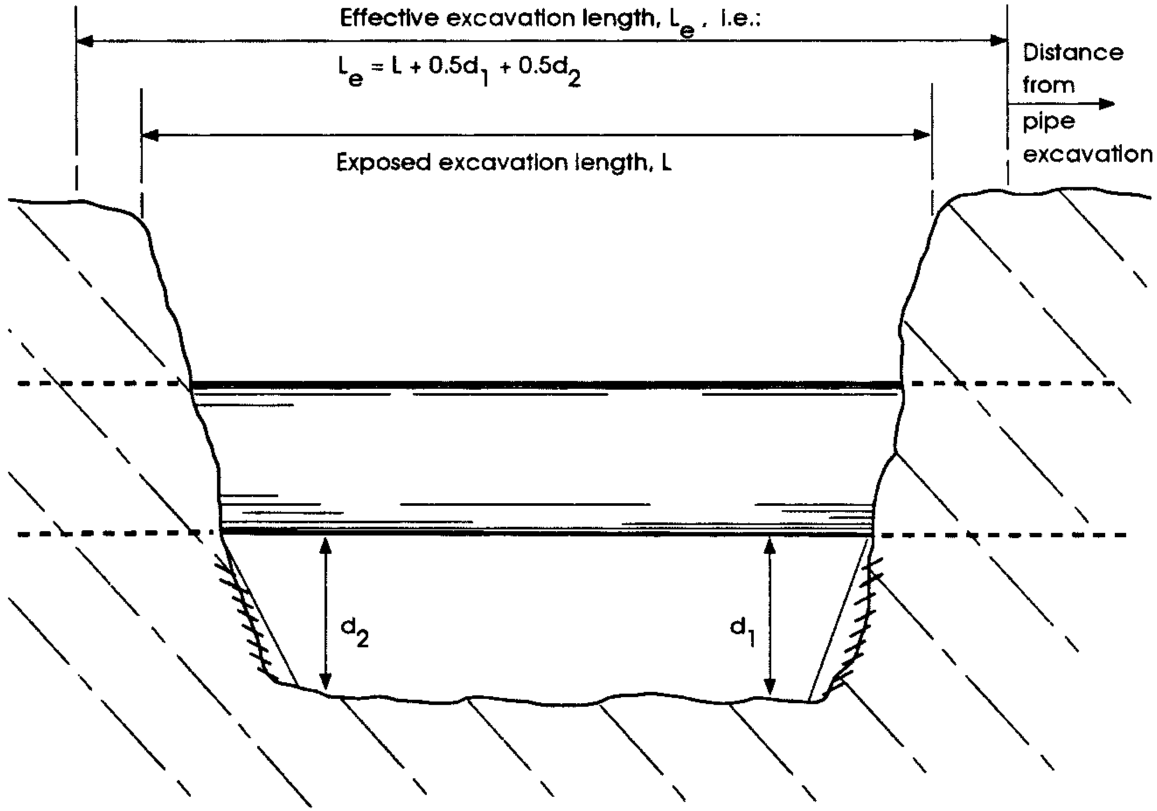


FIGURE 4 - Particular requirements for length and depth of pipe excavation

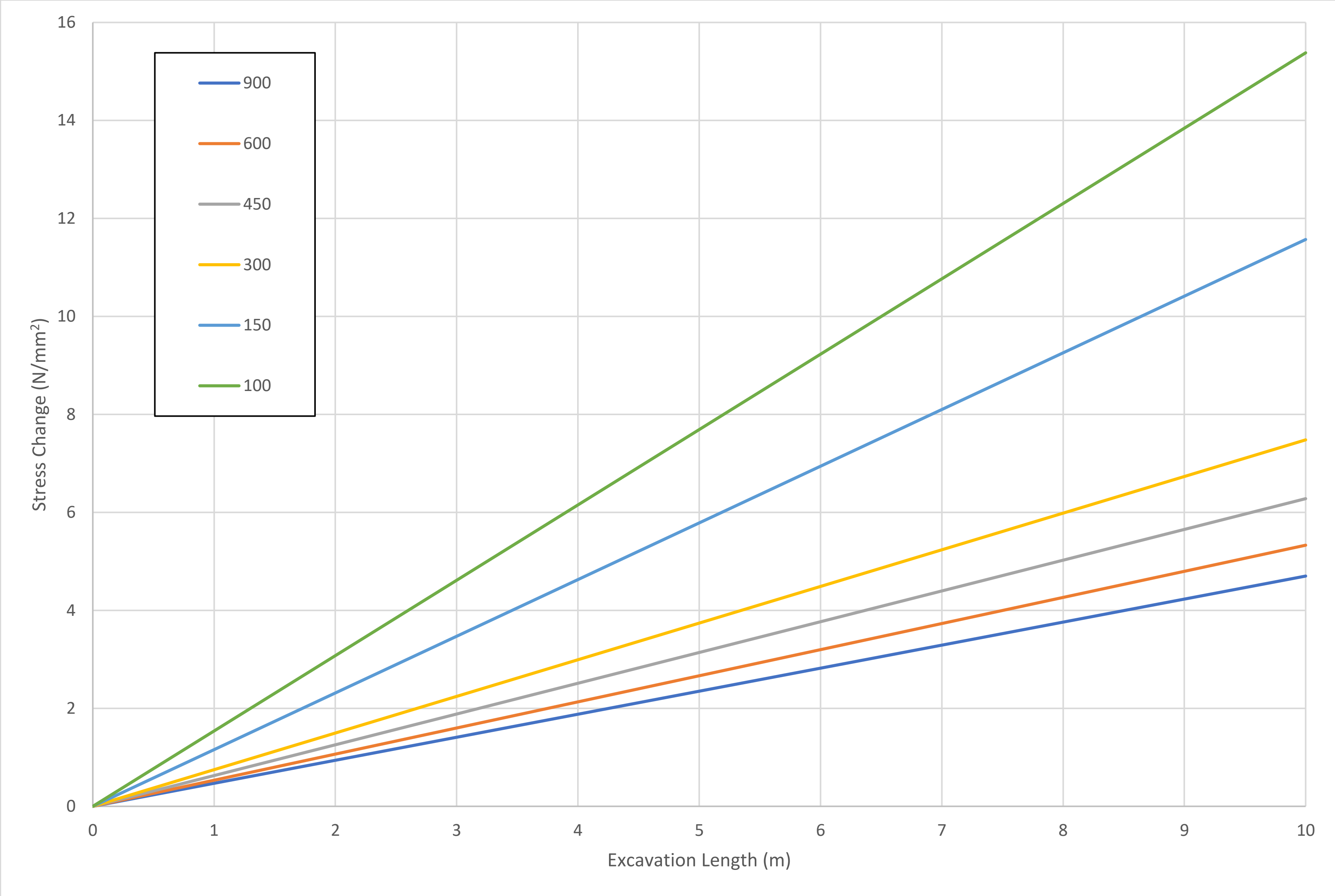


FIGURE 5 - Stress change due to excavation (for straight pipe).

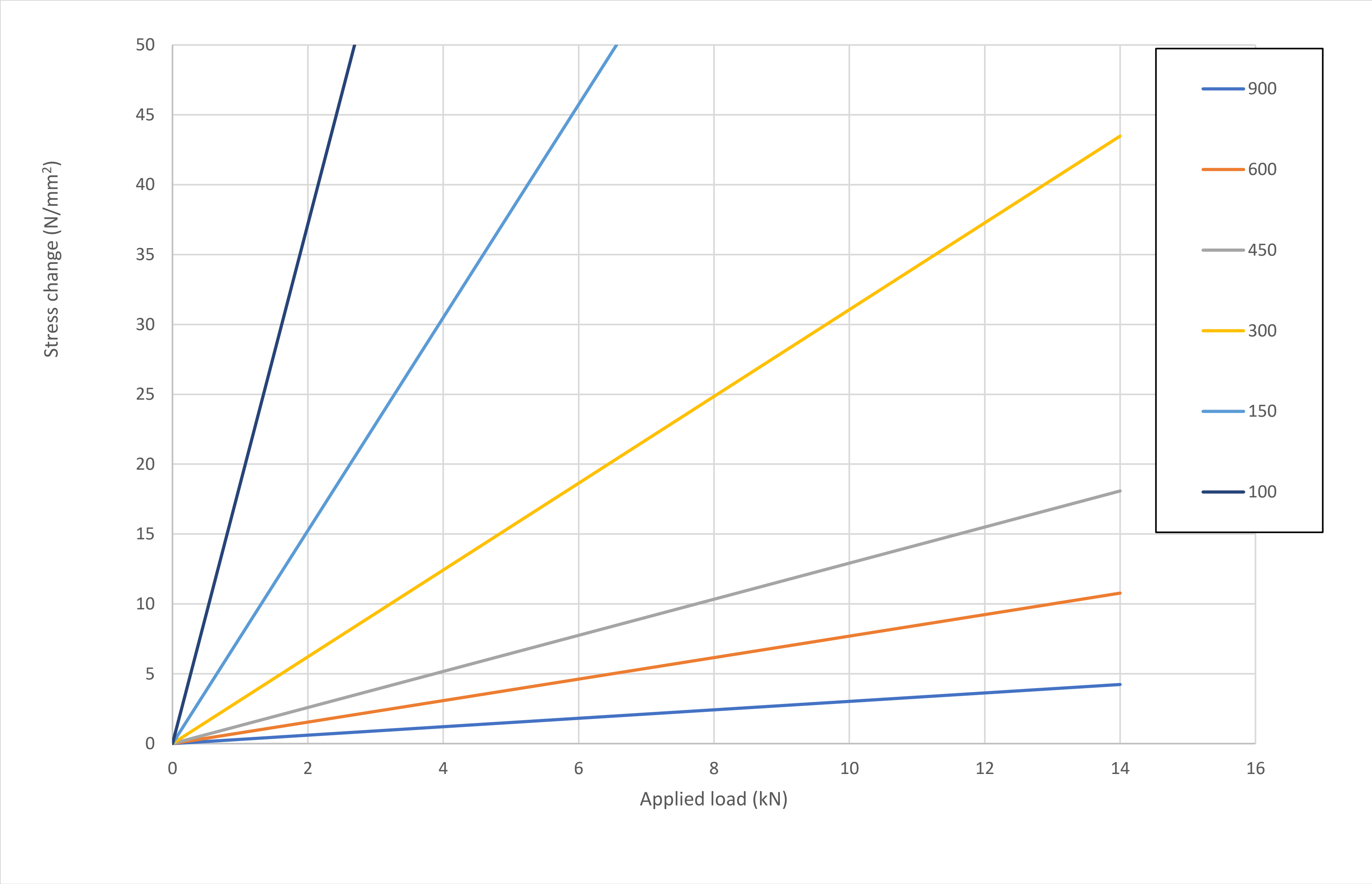


FIGURE 6 - Stress change due to applied load (straight pipe and sections with bends) in a 10 m long excavation.

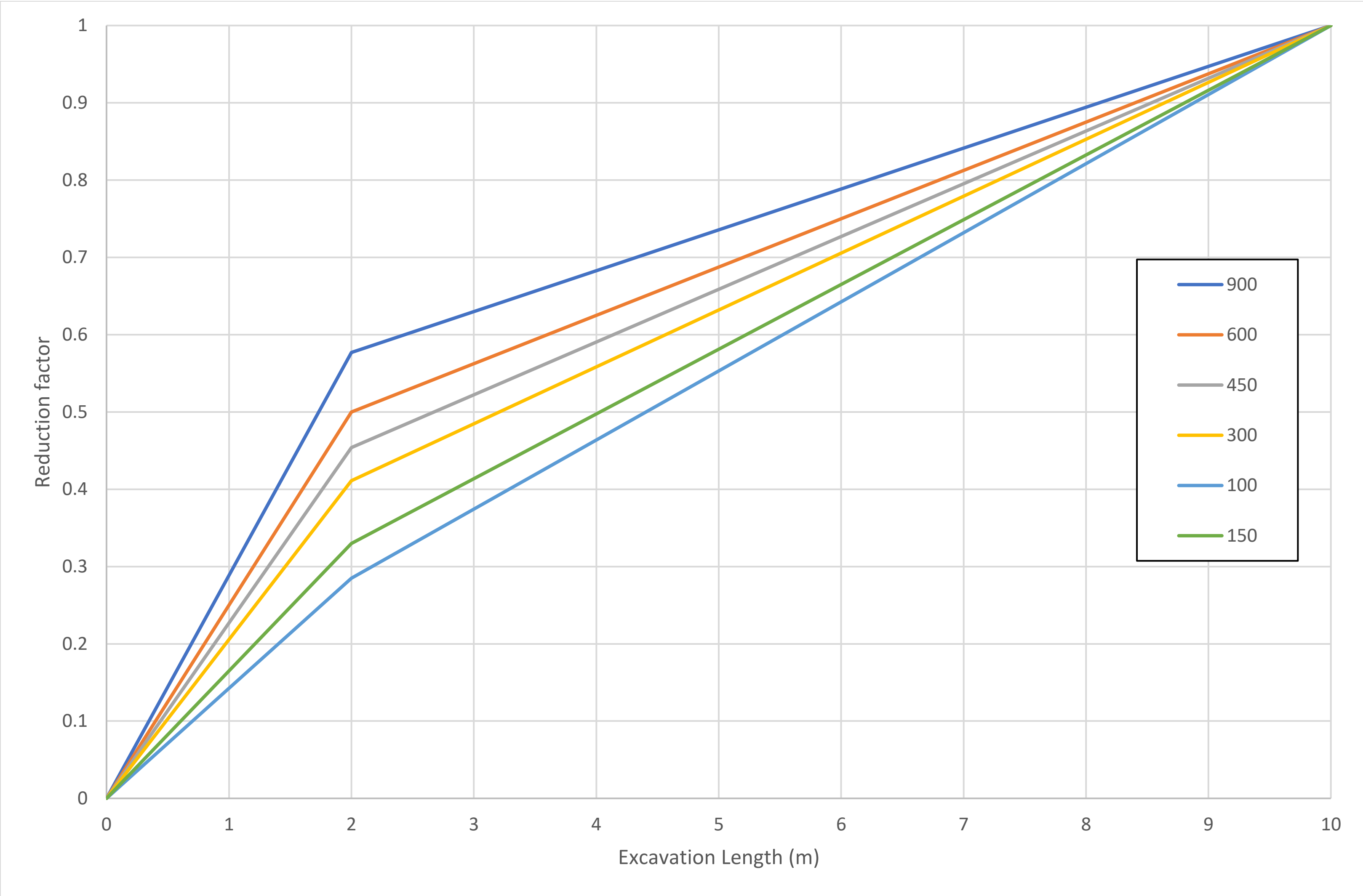


FIGURE 7 - Stress change due to reduction factor, F for bends and straight pipe in excavations less than 10 m long.

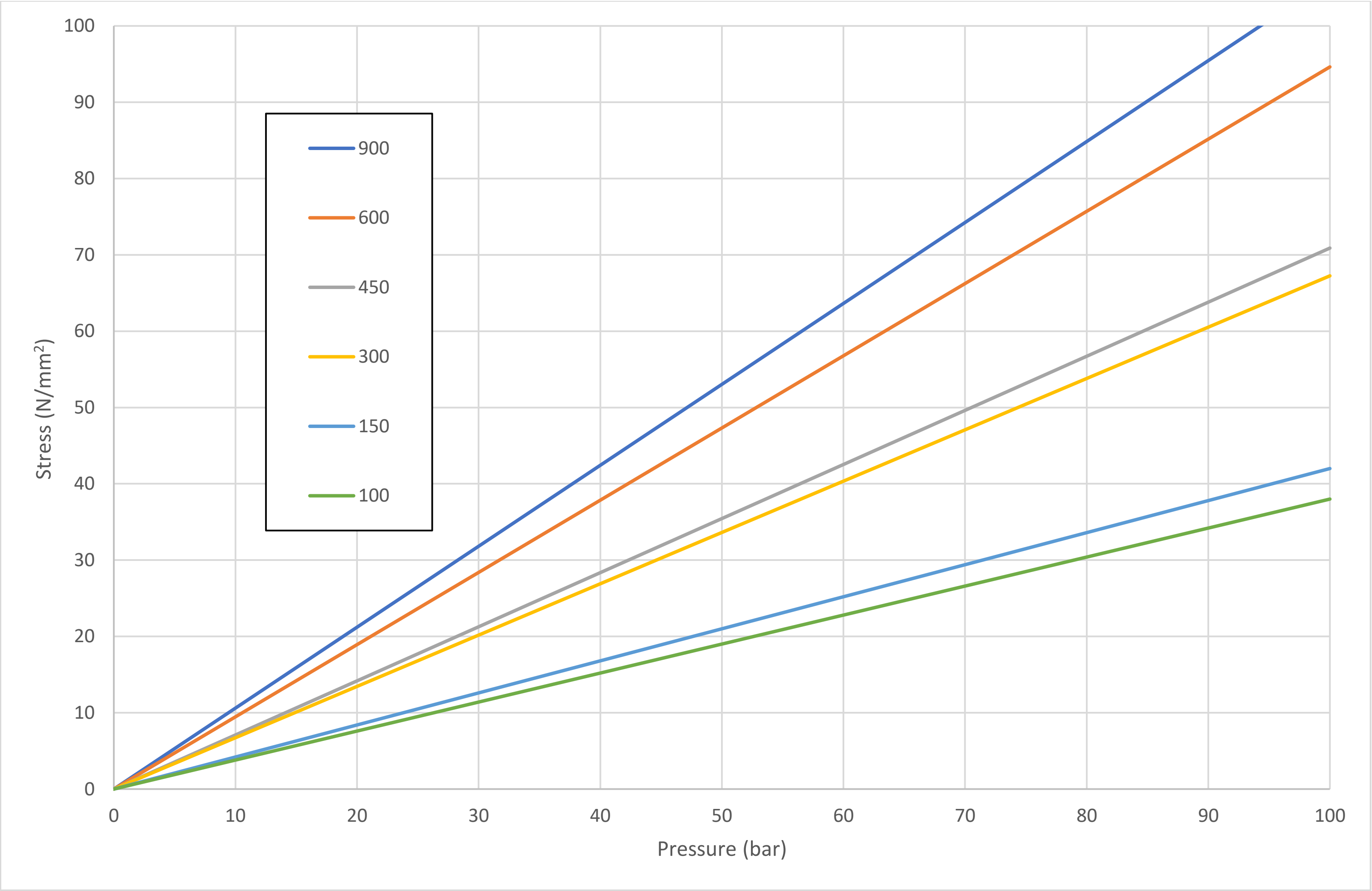


Figure 8 - Stress due to Operating pressure

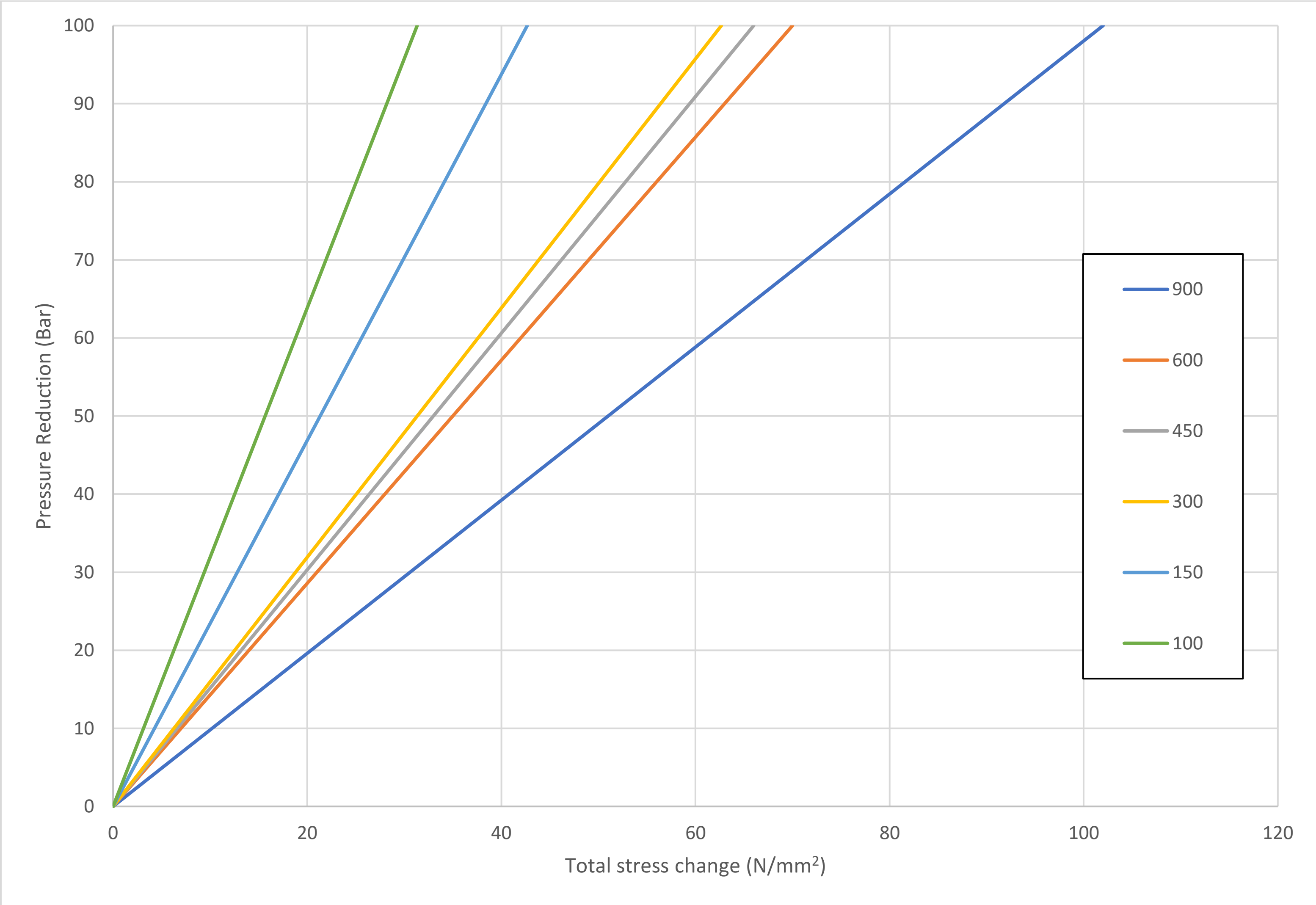


FIGURE 9 - Required pressure reduction for straight pipe sections.

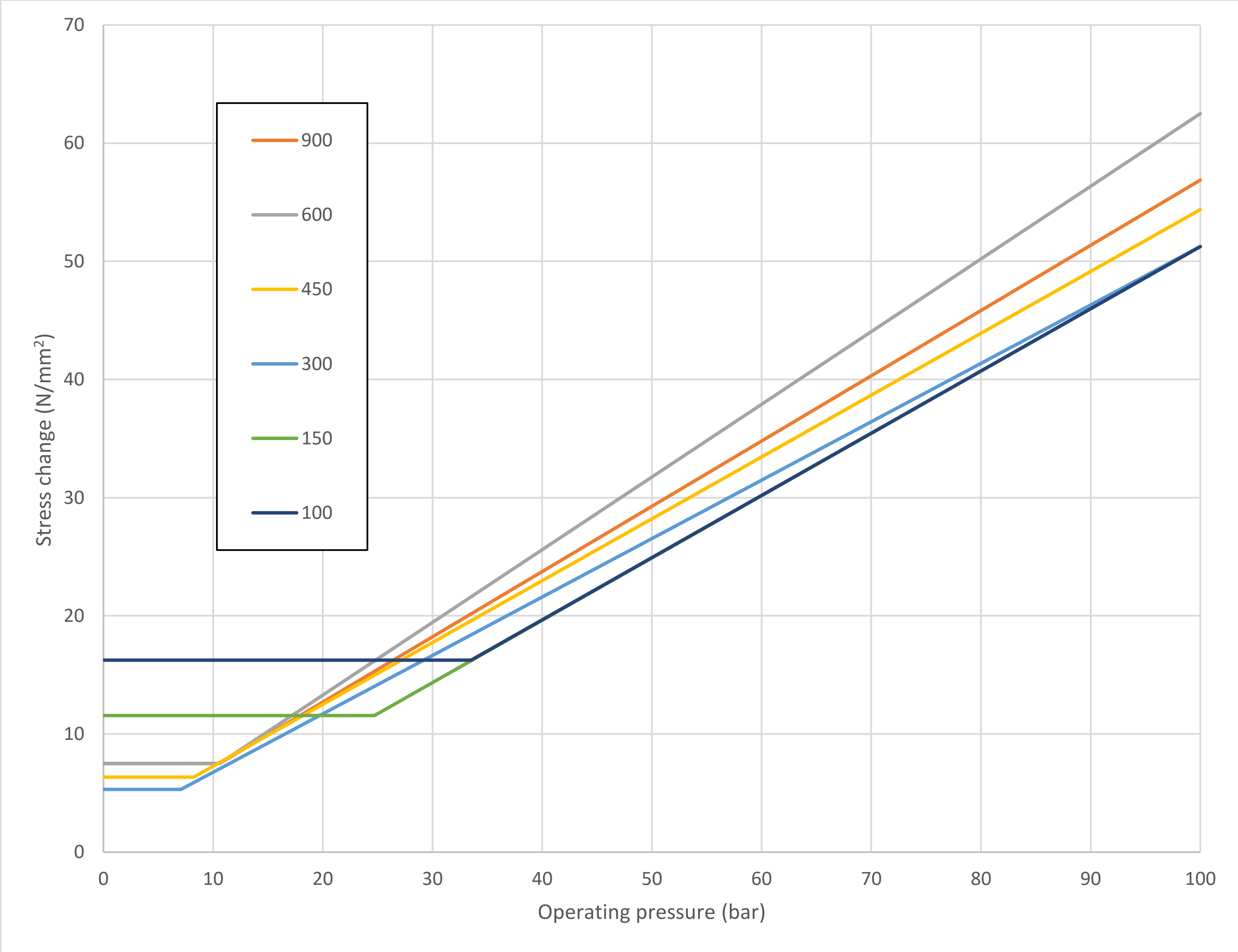


FIGURE 10 - Stress change with operating pressure (bend angle 3° up to 90°) in a 10 m long excavation.

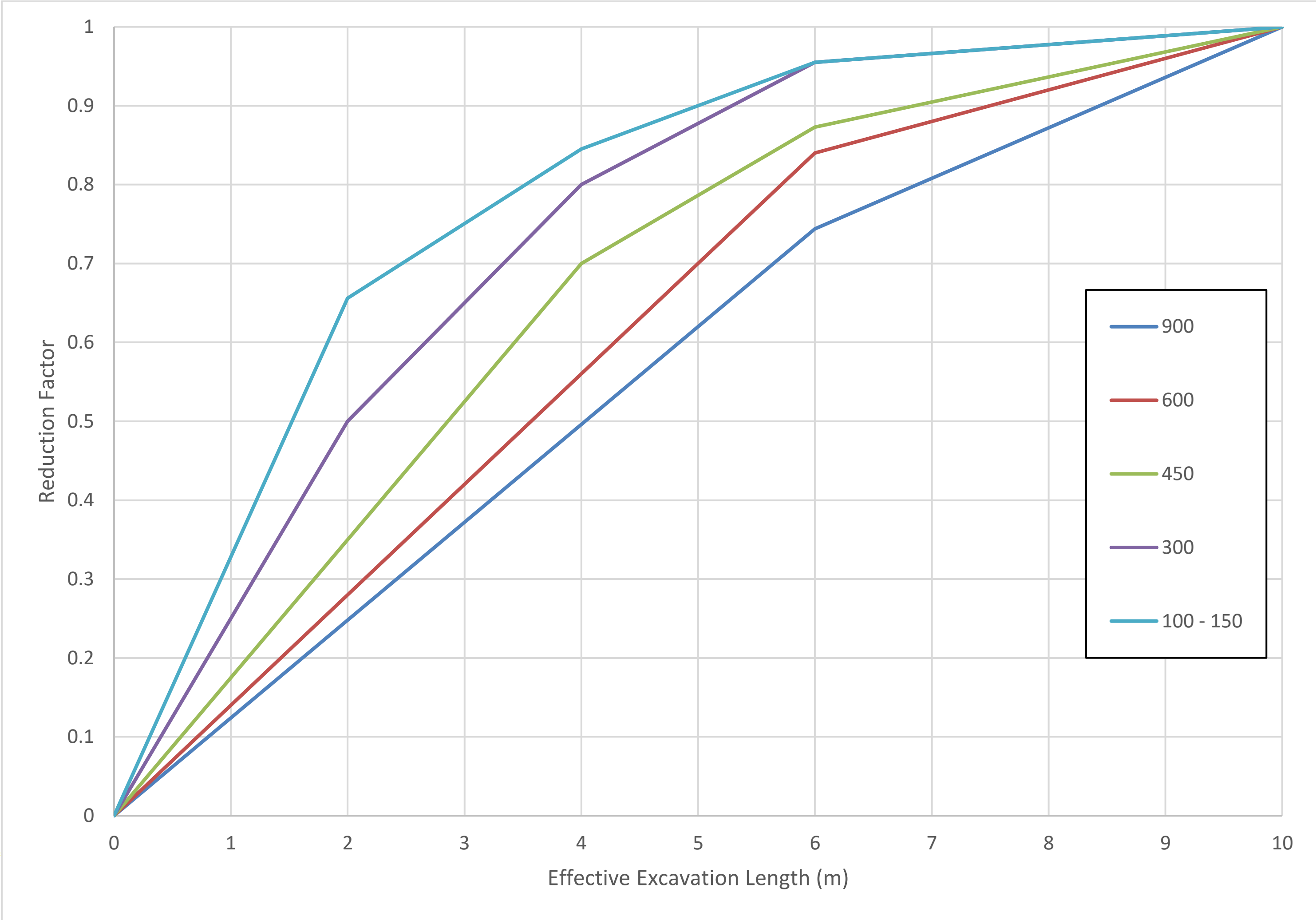


FIGURE 11 - Stress change reduction factor, F_{re}, for bends in excavations less than 10 m long.

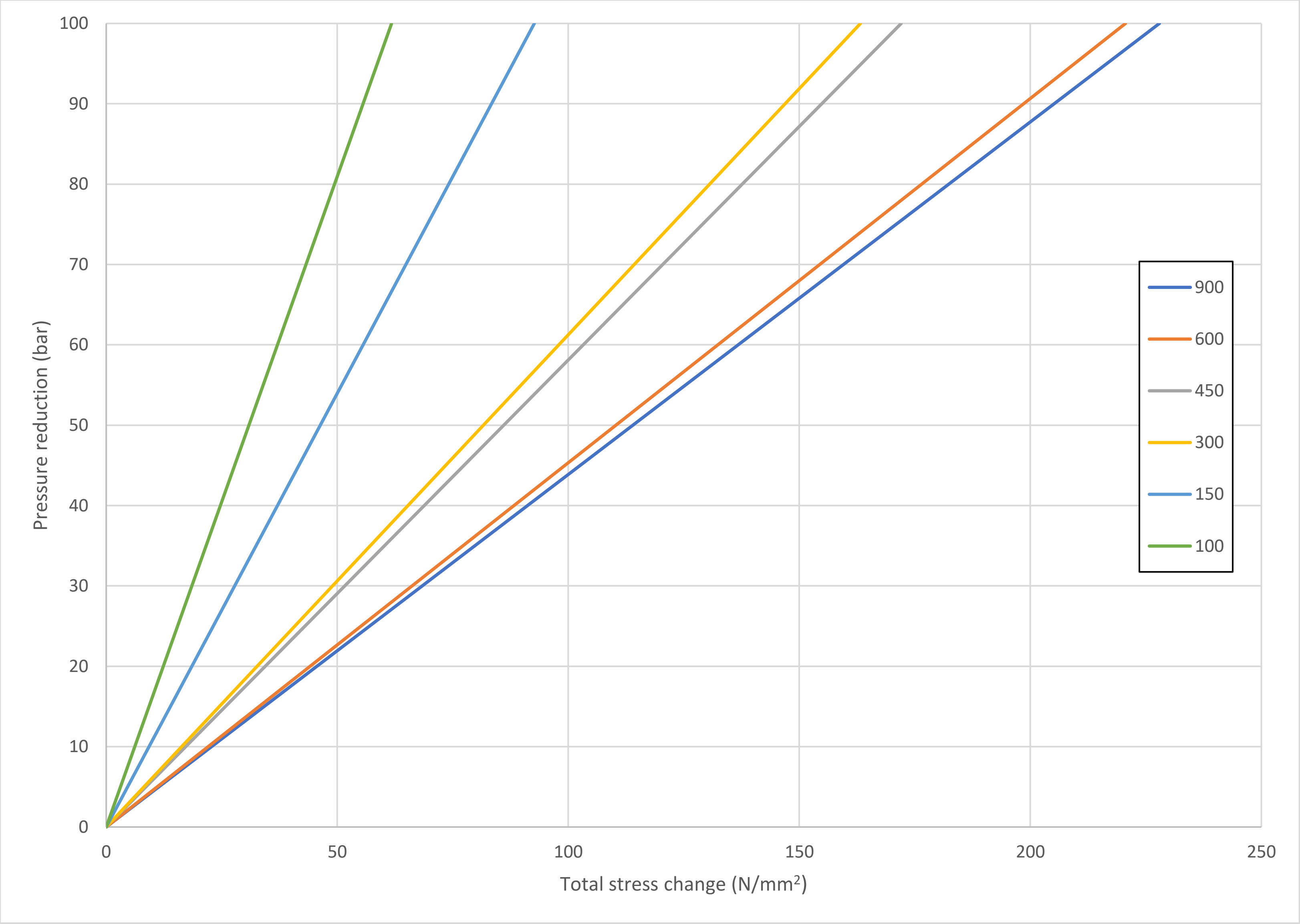


FIGURE 12 - Required pressure reduction for bends (30° up to 90°) in pipe sections.

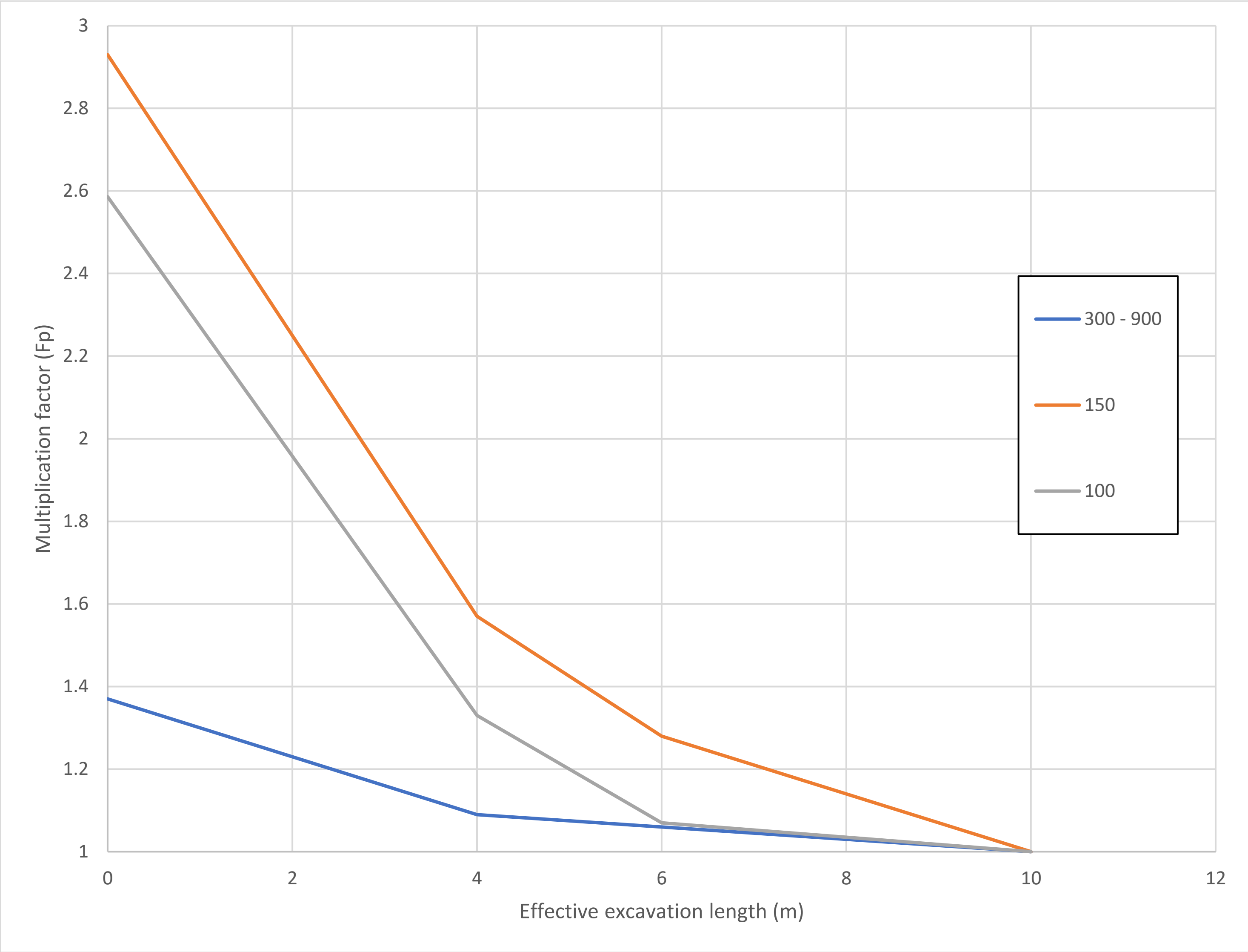


FIGURE 13 - Multiplication factor, F_p, for pressure reduction for bends in excavations less than 10 m long.

APPENDIX A - REFERENCES

This Management Procedure refers to the documents listed below

A.1 Statutes and Regulations

1996 No 825	-	The Pipelines Safety Regulations 1996
2000 No 128	-	Pressure Systems Safety Regulations 2000

A.2 British Standards

BS499-1:2009	-	Welding terms and symbols. Glossary for welding, brazing and thermal cutting.
BS EN 17636-1:2013	-	Non-destructive testing of welds. Radiographic testing. X- and gamma-ray techniques with film.
BS EN 17636-2:2013	-	Non-destructive testing of welds. Radiographic testing. X- and gamma-ray techniques with digital detectors.
BS 4515-1:2009	-	Specification for welding of steel pipelines on land and offshore — Part 1: Carbon and carbon manganese steel pipelines

A.3 Institution of Gas Engineers and Managers

IGEM/TD/1	-	Steel Pipeline and Associated Installation for High Pressure Gas Transmission

A.4 Internal Documents

#/P/2	-	Specifications for field welding of steel pipelines and installations for high pressure gas transmission (the version, or similar recognized welding standard (e.g. API 1104), applicable at the time of the pipeline fabrication)
#/P/11	-	Management Procedure for Inspection, assessment and Repair of Damaged (non-leaking) Steel Pipelines Greater than 150mm Nominal Diameter, Designed to Operate at Pressures greater than 2 bar

APPENDIX B - DEFINITIONS

The definitions applying to this Management Procedure are given below

P2#	-	The recognized welding standard (i.e. P2 or similar), applicable at the time of fabrication of the pipeline. If unknown or unavailable, the latest edition of P2 (e.g. GDN/SP/P/2) shall apply.
Competent Person	-	As defined by Pressure Systems Safety Regulations (PSSR) 2000, and who recommends whether or not to apply these procedures.
Effective excavation length (L):	-	The exposed excavation length increased by half the depth of soil removed below the pipe at each end, to account for the reduction in soil support at the ends of the excavation (see Figure 4).
Emergency procedures:	-	Documents which give guidance to all interested parties as to the actions to be taken in the event of an incident which affects pipelines.
Expert assistance	-	An organization or engineer familiar with these procedures and their background, with established access to the full range of relevant specialist services in the fields of material engineering, non-destructive testing (NDT), design and plant operation.
responsible engineer	-	The engineer who applies these procedures. This will typically be an operational or project engineers who is overseeing the work on site. The responsible engineer will use supporting information (e.g. pipeline details, pressure data etc.) from Asset/Integrity/Network Control to ensure the inspection is completed. **This definition of responsible engineer shall not be confused with the title 'Responsible Engineer' within SCO which is typically the Network Director or Head of Asset Integrity.**
Stiff clay soil	-	Soil which cannot be moulded by fingers and can be indented by thumb. (Undrained shear strength exceeding 75 K/m^2).
Working on pipelines	-	Activities taking place on pipelines that impose loading conditions which are additional to the existing operational loads.
Applied load	-	Weight of repair sleeve or other equipment added to pipe

APPENDIX C - WELD INFORMATION SHEET AND INSTRUCTIONS FOR COMPLETION

C.1 The Weld Information Sheet

<u>Weld Information Sheet</u>

Network:			
Route:		Sheet No:	
Location:			
PSR No:			
Weld classification (tick relevant box)	P2	P18	Reject
Pipeline diameter (mm):			
Pipeline measured thickness (mm):			
Pipeline SYMS:			

Coordinates:	
Date of inspection:	
Date of construction:	
Weld Type:	
Material specification & grade:	
Pipe type (Straight, Field bend, Forged end):	
Pipeline Maximum Operating Pressure:	
Pipeline Design Pressure:	

Defect start (mm)	Extent (mm)	Interaction	Defect Type (see Table C.3.)

Defect start (mm)	Extent (mm)	Interaction	Defect Type (see Table C.3.)

Repair (tick relevant box(es))	None	Grind	Welded shell	Epoxy shell	Cut-out	Other

Responsible engineer's comments:

____

____

Signed: ____________________ Date:____________________

C.2 Instructions for Completing the Weld Information Sheet

C.2.1 General

All defects indicated on radiographs shall be recorded on the Weld Information Sheet and issued to teh Competent Person within the required operational timescales. A list of defined terms for defects (and their abbreviated code letters to be used when completing the Weld Information Sheet) is given in Table C.3.

C.2.2 Information required

The following information shall be inserted in the relevant boxes:

a) **Network:** the network that the weld inspection has been carried out.

b) **Route:** this shall be the pipeline number/name (shown on the 'as laid' drawing).

c) **Sheet number:** if available, this shall be the strip plan number (i.e. 2500 scale ordnance survey (OS) map) encompassing the site in question.

d) **Location:** this shall indicate the site name, field or geographical name.

e) **PSR No:** the PSR number for the system that the pipeline is assigned to.

f) **Weld classification:** the classification of the weld deduced from these procedures as follows:

   1) #P2 - this indicates that defects are within #P2 defect acceptance levels.

   2) GDN/PM/P/18 - this indicates that defects are within the limits specified in section 6, but outside the limits stated in #P2.

3) Reject- this indicates that defects are outside the limits specified in section 6.

g) **Pipeline diameter:** from records**.** The diameter should be confirmed on first excavation.

h) **Pipeline measured thickness:** using ultrasonic methods on first excavation at four quadrants around pipeline circumference near to weld, ascertain the nominal measured wall thickness of the pipeline.

i) **Coordinates:** this should be recorded in easting and northings.

j) **Date of inspection:** the date the X-ray or PA inspection was carried out.

k) **Date of construction:** the date when the weld was constructed. If the exact date is not known, insert the year the weld was constructed.

l) **Weld type:** this is the actual welding process used.

m) **Material specification & grade:** determine from records. Confirm from sample if required.

n) **Pipe type:** this shall comprise the identifier S - Straight, F - Field Bend or B- Forged Bend.

o) **Pipeline operating pressure:** maximum permitted operating pressure defined in IGE/TD/1.

p) **Pipeline design pressure:** from asset records, or as defined in IGE/TD/1.

q) **Detect start:** the defect start position, in mm, from the zero position on the radiograph. The marker tape for defect location shall start at zero on the top of the pipe and progress clockwise around the pipe looking downstream. For horizontal welds, zero shall be on the North side of the pipe.

r) **Extent:** this is the actual length, in mm, of a defect.

s) **Interaction:** interactive length between defects as specified in clause 6.

t) **Defect type:** the defect letter assigned to a particular defect (see Table C.3).

u) **Repair:** indicate type of repair.

v) **Responsible engineer's comments:** includes, where necessary, remedial works to be carried out, special precautions, etc.

A copy of the completed Weld Inspection Sheet shall be recorded in the pipeline records file.

C.3 Types of defect, their definitions and code letters

Type of Defect	Definition of Defect Term	Code Letter(s)
Corrosion:		C
General Corrosion	Corrosion resulting in a reduction of metal thickness over a large area of the surface.	CG
Pitting Corrosion	Corrosion which only affects small areas on the surface producing pits. Corrosion in this instance is considered to be a pit when the maximum surface dimension is not greater than three times the wall thickness.	CP
Stress Corrosion Cracking (SCC)	Colonies of intergranular and transgranular cracks caused by the simultaneous action of specific corrosive media and tensile stresses.	CS
Fusion (internal) defects:		F
Lack of inter-run fusion	Discontinuity between adjacent weld beads, but not breaking the surface.	FI
Lack of side wall fusion	A Discontinuity between weld bead(s) and the parent metal, but not breaking the surface.	FS
Crack:	A planar, two-dimensional defect with displacement of the fracture surfaces which can be detected or measured by appropriate equipment.	K
Crater Crack	A ‘crack’ where the length of the crack is enclosed entirely within the bounds of the weld finish crater.	KC
Definite crack (but excluding ‘crater crack’)	A defect which can be confirmed as a crack.	KD
Suspect crack	A crack-like defect which cannot be confirmed as being either a crack or an alternative defect.	KS
Cap (outer surface) defects:		O
Arc marks or arc strike	A surface depression caused by an electric arc between a welding electrode, or other component in the welding circuit, and the pipeline material.	OA
Lack of cap fusion	Lack of fusion between the weld metal and the parent metal at the cap.	OF
		OG

Gouge (mechanical)	Mechanically induced damage to the surface which causes a localized reduction in pipe wall thickness.	
Incompletely filled groove	A continuous or intermittent channel at the surface of a weld, running along its length due to insufficient weld metal.	OI
Cap undercut	The burning-away of the edge of the walls of the welding groove at the outer surface.	OU
Weld run on pipe	Where a weld deposit has been made to the surface of the pipe which is not directly associated.	OW
Porosity:		P
Hollow bead – elongated root porosity	Elongated linear porosity occurring in the root pass.	PH
Large porosity – single voids gas hole	Voids greater than 1.5mm diameter occurring in the weld metal.	PL
Scattered porosity - piping	Voids equal to or less than 1.5mm diameter occurring in the weld metal. Often in clusters.	PS
Root (inner surface) defects:		R
Burn-through	That portion of the root bead where excessive penetration has caused the weld puddle to be blown into the pipe.	RB
Root concavity; internal concavity	A condition whereby a root bead is properly fused and completely penetrates the pipe wall along both sides of the bevel, but where the bead surface is below the inside of the pipe wall.	RC
Lack of root fusion	Lack of fusion between the weld metal and the base metal at the root.	RF
Incomplete root; lack of penetration	Incomplete filling of the weld metal.	RI
Root misalignment, missed edge	Where the internal surfaces of the pipes on either side of the weld are not in the same plane. This can lead to an incomplete root fusion on one side and is known as ‘missed edge’.	RM
Bad pick-up	Local lack of fusion between the end of one root pass and the following pass. Often as an ‘H’ configuration.	RP
Root undercut	The burning-away of the edge of the walls of the welding groove at the inside surface.	RU
Excess penetration	Excess weld metal protruding through the root of the weld.	RX

Irregular root	Length of root bead having uneven depth or width or lacking straightness.	RZ
Slag: Slag inclusions Linear slag	 Non-metallic solid entrapped in the weld metal. An inclusion of linear form situated parallel to the axis of the weld.	S SI SL

APPENDIX D - FURTHER STRESS ASSESSMENT

D.1 Introduction

D.1.1

In cases where the requirements specified in 7.2, 7.3 and 13 are not met, a more detailed assessment should be carried out as specified in this Appendix D before proceeding with final excavations. The results of the assessment should then be used to check the suitability, or determine the dimensions, of the excavation or any additional or temporary support required. This Appendix D outlines a suitable stress assessment procedure, but it will require specialist software and expert assistance to implement.

The stress in the axial direction at any point across a girth weld in an operating pipeline is the sum of:

a) operating stress due to internal pressure and work on the pipeline, and

b) ground movement stress and support, and

c) construction stress, and

d) stresses due to welding, and

e) environmental stress (e.g. temperature changes or frost heave).

Due to the nature of construction and welding stresses, it is possible that local secondary stress across any girth weld could be plus or minus yield strength. Therefore, changes in the primary stress level due to imposed loads before and during work or repair should be assessed and compared to an appropriate limit, before any action is taken. The limit required in this procedure is 0.3 SMYS.

D.1.2

The local operating stress, ground movement stress (if applicable) and imposed stress (due to work) should be estimated using the stress assessment procedure in clause D.2.

Changes in the stress level caused by:

a) excavation;

b) operating changes (i.e. pressure reduction);

c) repair/hot work

should be estimated so that a safe working procedure, which prevents increase in stress during excavation and subsequent work, can be specified.

D.1.3

Care should be taken if the operations include:

a) a pipeline cut out;

b) large pressure differential across a valve;

c) a closed end in the vicinity of a weld requiring repair, or

d) a weld that may require repair.

Additionally, any stress caused by pipe hogging (frost heave) should be calculated, where appropriate.

Parameters which should be considered and a recommended procedure for stress assessment is specified in clause D.2.

Relevant pipeline stress analysis software shall be used to conduct the assessment.

D.2 Stress Assessment Procedure

D.2.1

The total stress change across a defective girth weld due to:

a) pipe excavation;

b) loads imposed during work;

c) pressure reduction,

should be predicted by the procedures specified in D.2.2 to D.2.6 inclusive.

D.2.2

Estimate the axial operating stress, σ_{Pa} in the unexcavated pipe. Pressure, temperature and soil restraint should be considered.

Changes in this stress level due to fluctuations in normal operating conditions should be assessed, and the worst case assumed.

NOTE - Sensitivity of the predicted stress level to soil property assumptions should be considered.

D.2.3

Estimate the change in stress due to pipe excavation, $\Delta\sigma_e$ This involves the removal of soil restraint and the assessment of gravity loading on the unsupported pipe span. In the analysis, the excavation length should be increased by half the depth of undercut removed below the pipe at each end, to account for reduction in soil support at the excavation ends (see Figure 4).

Local changes in pipe temperature (due to direct sunlight, wind chill) may be relevant. A change in through wall pipe temperature greater than 5^o or a minimum local temperature change of $\pm$ 15°C should be considered.

D.2.4

Estimate stress change, $\Delta\sigma_1$, due to application of all proposed working loads.

All these estimated working loads should be applied simultaneously to the excavated pipeline as point loads, assuming no support of the pipeline.

D.2.5

Estimate the stress change $\Delta\sigma_P$ due to a reduction in operating pressure, require in clause 6., and:

a. if the pressure reduction causes a decrease in stress ($\Delta\sigma_P$) at all points, go to D.2.6,

or

b. if pressure reduction causes an increase in stress at any point, expert assistance should be sought.

D.2.6

Estimate the total stress change using the following equation:

$$(\Delta\sigma = \Delta\sigma_e + \Delta\sigma_1 + \Delta\sigma_P)$$

a. if the stress assessment procedure indicates that the total stress change predicted is negative and is more than 5% pipe specified minimum yield (SMYS) strength, the proposed repair/work sequence can be applied. No pipeline monitoring is required. Or

b. if the total predicted stress change, $\Delta\sigma$, is positive, $\Delta\sigma_1$ should be recalculated taking into account:

   1) different repair/work sequences;

   2) pipeline support, and

c) if this re-calculated total stress change is negative and is greater than 5% pipe SMYS, the proposed repair/work sequence can be applied. Or

d) if this recalculated total stress change is negative and is less than 5% pipe SMYS, or is still tensile, the following should be considered:

   1) further residual stress pressure reduction, and repeat D.2.5 and a), b) and c) above;

   2) pipeline de commissioning before repair/work can be carried out.

APPENDIX E – THE HISTORY OF THE P/18 DOCUMENT

Introduction

Previous versions of this management procedure required that prior to work on a pipeline constructed prior to 1972 containing defective girth welds or welds of unknown quality, the pressure was reduced to compensate for the additional axial stresses arising from the work. Such pipelines have now been in operation for more than 45 years, and will have been subject to a range of operational conditions which could have induced a maximum axial stress of 0.5 x the circumferential stress due to pressure, i.e. 0.36 x SMYS for a pipeline operating at 0.72 x SMYS. The full-scale tests of defective girth welds carried out for the development of the original P/18 procedure demonstrated that girth welds containing defects meeting the defect limits defined in this procedure failed at axial stresses greater than the specified minimum yield stress of the pipe material. DNVGL have undertaken work to evaluate the maximum allowable axial stress for pipelines with defective girth welds. An assessment of the results of this work indicates that a conservative value of the allowable axial stress is 0.3 x SMYS for all pipelines. It is concluded that providing the total axial stress induced during work does not exceed 0.3 x SMYS, girth welds containing defects which meet the limits defined in this procedure will not fail. This procedure therefore includes a stress assessment to be carried out to determine whether a pressure reduction is required.

History of High Pressure Gas Pipeline Construction in the UK Gas Industry

The construction of high pressure pipelines in the UK gas industry, and the development of the required standards, commenced in 1967 with the development of the National Transmission System. Prior to this most high pressure operations in the gas industry was at 2 bar (30 lbsf/in sq), with the exception of Wales Gas, where steel HP piping systems at 23 bar (350 lbsf/in sq) were constructed from the mid-1950s.

Pipelines Department of British Gas Corporation Production and Supply Division [Ref 1] was formed in 1967, with the commencement of the design and construction of the NTS. Prior to this, all works on the design and construction of the NTS were carried out by the Regions through which the system was routed; the exception was No 2 Feeder, which was designed and constructed by Consultants.

The first major NTS pipeline was the 450 mm from Canvey Island to Leeds, known as the methane pipeline. This 320 km long pipeline transported liquid natural gas (LNG) from the Canvey terminal at 69 bar, and supplied 8 of the 12 area boards with natural gas. The pipeline has 240 km of spur lines ranging from 168 – 355 mm diameter, to East Greenwich, Bromley, Slough, Reading, Hitchin, Dunstable, Coleshill, Sheffield and Manchester.

The Gas Council was responsible for this project, which was constructed as a co-operative scheme in which the design and construction of the pipeline, which commenced in 1963, was carried out by a committee of distribution engineers from the Area Boards. This committee was responsible for agreeing a set of standards applied to the project.

Natural gas was discovered on the UK continental shelf in 1965, and production commenced in 1967, and the Gas Council and the Area Boards began a 10 year programme to introduce natural gas nationally.

Feeder 1 From Easington was then constructed in 1967, to transport gas from the Easington terminal across the Humber to the East Midlands gas works at Killinghome. Feeder 1 was extended to Totley near Sheffield, where it was connected to the methane pipeline in 1968. Feeder 2 from Bacton terminal was constructed in 1968.

NTS Feeder pipelines were constructed to transport from the North Sea gas terminals to the NTS. Most of the NTS was constructed between the late 1960s and the early 1980s.

History of UK High Pressure Pipeline Welding

As previously stated, prior to commencing No 2 Feeder, most high pressure work in the gas industry was at 2 barg (30 lbsf/in sq) apart from the Wales Gas pipelines. At this time, the only available standards were American. Working groups from the Regions involved in the Canvey Island to Leeds pipeline visited the US to study the application of the ASME B31 standards.

In Wales, where early small bore steel piping HP systems at 23 bar (350 lbsf/in sq) were constructed from the mid 1950s. Wales Gas high pressure piping systems were built by American contractors (CJB), however pipeline construction was brought in-house due to the high cost of constructing pipelines to supply small, remote communities over difficult terrain. Trained welders were transferred from fabrication shops to pipeline spreads and American welding standards were not applied.

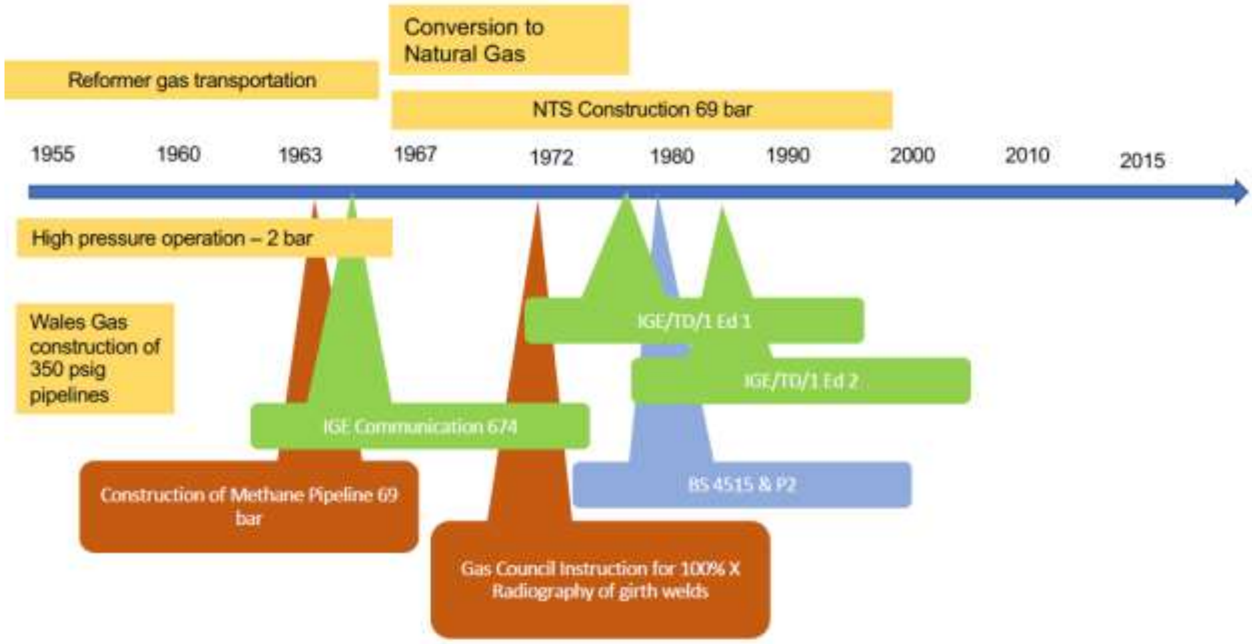
ASME B31.8 applied to gas transmission and distribution systems. This standard lists all the other American National Standards and Manufacturer's specifications relating to design, materials and construction. The American Standards were recognised and applied worldwide, so the material required were widely available. Many British Standards in the early days were copies of the American standards.

In the early days of high pressure engineering in the UK, the main knowledge lay in the major consultancies and in the petroleum industry, most of which were American. The welding standard was API 1104 1953, which covered:

- API 1104 1953: Standard for Field Welding of Pipe Lines
- Part 1 – Welding Specification
- Part II – Radiographic Inspection (10% gamma)
- Part III – Standards of Acceptability
- Part IV – Inspection & Testing

Experts in this field had to be familiar with American standards, the level of standardisation and availability of equipment to these standards made change difficult. The growth of the UK gas industry led to changes in the UK and development of IGE standards.

The publication of Gas Industry standards commenced with Communication 674 in 1965. The Gas Council issued an Instruction for 100% X radiography in 1969. This coincided with the publication of BS 4515. TD.1 Edition 1 was published in full in 1977, Edition 2 1984.



History of High Pressure Gas Pipeline Construction

As previously stated, the formal requirement for 100% x radiography of girth welds was introduced in 1969 (Gas Council Instruction), however the full implementation taken as 1972 and girth welds fabricated from 1972 are considered to be good quality.

P/18 Background

In April 1981 during a hot tap and stopple operation a girth weld failure occurred on the Nantgarw – Aberavon pipeline. The weld contained many defects, failure was brittle, the weld did not sever but a long circumferential fracture occurred, a gas escape occurred, but did not ignite. Fortunately, no personnel were in the excavation at the time of the failure. Further inspections of other girth welds in the pipeline identified further defects.

British Gas Engineering Research Station (ERS) was actioned to investigate the reasons and develop a safe working procedure. The high number of poor quality girth welds and the severity of the defects found in the Nantgarw – Aberavon pipeline invoked interest in controlling the axial load on this and similar pipelines.

Wales Gas were advised by the engineer leading the work at the time that the best way to relieve stress was to excavate (as for pipelines subject to subsidence). Progress was not made, and the timescale extended so Wales Gas made a complaint to ERS, stating that management of significant lengths of excavated pipelines was not acceptable. The work was reassigned to Dr Phil Hopkins, who developed procedures such as P11 and PV11.

The drive to reduce axial stress focussed on pressure reduction, as used in P11 to reduce hoop stress. The development of pressure reduction philosophy based on pipeline stress analysis was actioned. A short timescale for completing the procedure, in response to the issues raised by Wales Gas.

This was met by applying the very conservative assumptions that defective girth welds in older (pre-1972, when 100% X radiography was included in the pipeline construction standards) contained defects which were on the point of failure, and any increase in axial stress would cause failure, this was recognised as over onerous, but avoided the detailed investigation of a lot of unknowns.

It was recognised that pressure reduction would have a minimal effect on axial stress, but this was a proactive action. The defective welds obtained from Wales Gas were subject to full scale test, and the results showed that all but 2 of the 68 welds failed at an axial stress of 100% SMYS.

The results were used to derive defect limits which would withstand 100% SMYS axial stress. The view of welding experts at ERS was that the defects from the Nantgarw – Aberavon pipeline represented a worst case population which reflected poor quality control, and were not generally representative girth welds in older pipelines.

The P18 procedure was developed and issued within the short timescale set, with the qualification that all regions and NTS would implement the procedure, and the operational records (inspection results, repairs, failures etc) would be reviewed within 5 years, and the results of the review would be used to identify the subset of gas industry pipelines in which welds did not meet the P18 defect levels, and the procedure would be revised for application to these pipelines only. However, ERS closed in this period, and the review was not undertaken so the procedure was not withdrawn/changed. In the meantime, P18 became even more onerous and conservative.

Provisional P/18 Procedure

The procedure was based on expert conservative judgement and a programme of fast research work. The procedure was only to apply to girth welds that required excavation for emergency or operational reasons.

No systematic inspection to establish girth weld quality and likelihood of failure during the work was carried out, it was intended this would be done during a review of the implementation of the procedure. Girth weld failures occur as leaks, and have limited consequences, but the safety of personnel in the trench shall be ensured. Ultimately, the review of procedure was not carried out.

The conservative assumptions are that the girth weld contains critical defects, any increase in stress will cause failure. The safe working procedure applies a safety margin introduced by a pressure reduction which reduces the axial stress across the girth weld. The safety margin prevents failure.

Assessment and Classification & Figure 3

The defect limits in P/18 are based on the full-scale tests on the girth welds from Wales Gas. The defect limits are semi-empirical and they were subsequently incorporated in a revised form in the Tier 3 of the EPRG guidelines on the assessment of defects in transmission pipeline girth welds.

ERS conducted 68 full-scale tests on defective girth welds obtained from Wales Gas. The girth welds were from pipes of 450mm (18”) diameter, 7.9-10.3 mm (0.312-0.406 inch) nominal wall thickness, Grade B. The girth welds were loaded in axial tension to 1% strain and/or 100% yield strength (approx. 46 ksi) or until through-wall failure.

UKOPA Weld Quality Project The UKOPA weld quality project investigated the quality of girth welds in pre 1972 pipelines operated by UKOPA members. The results confirmed that while the historical welds may contain defects that would not meet modern construction standards, the mechanical and metallurgical tests showed that the welds were fit for continued service. In addition, analysis of the UKOPA Fault Database confirms that with the exception of the girth weld failure which occurred on the Nantgarw – Aberavon pipeline in 1981, girth weld loss of product incidents have occurred as pin or small holes only, there have been no large or catastrophic failures. 97% of the loss of product incidents in girth welds occurred on pipelines constructed before 1972.

ENDNOTE

Comments

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