Code of Practice

Upstream Polyethylene Gathering Networks – CSG Industry

Version 4

Companion Paper CP-11-001

Condition Assessment

Rev 0

January 2017

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Acknowledgements

This Companion Paper has been prepared by the Australian Pipelines and Gas Association (APGA) CSG Committee working group. The working group members contributed significant time and resources at the working group level in developing and reviewing this companion paper and their support is acknowledged.

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Secretariat
Australian Pipelines and Gas Association
PO Box 5416
Kingston ACT 2604

Email: apga@apga.org.au

Preface

Companion Papers have been developed by the Working Group responsible for the *APGA Code of Practice for Upstream PE Gathering Networks – CSG Industry* (the Code) as a means to document technical information, procedures and guidelines for good industry practice in the coal seam gas (CSG) industry.

Since 2008, the development of the LNG export industry based in Gladstone, Queensland, with its related requirement for a large upstream CSG supply network of pipelines and related facilities presented the impetus for significant improvements in design and best practice approach.

The principal motivation for the initial development of the APGA Code of Practice was safety and standardisation in design and procedures and to provide guidance to ensure that as low as reasonably practicable (ALARP) risk-based requirements were available to the whole CSG industry. Accordingly, the Code is focused solely on this industry and the gathering networks using locally-manufactured PE100 pipeline. The Code is a statutory document within Queensland.

The incorporation of Companion Papers in Version 4 of the Code is intended to provide information and best practice guidelines to the Industry, allowing the Code to be limited to mandating essential safety, design, construction and operation philosophies and practices.

These documents form part of the suite of documents together with the Code and are intended to:

a) be used in the design, construction and operation of upstream PE gathering networks
b) provide an authoritative source of important principles and practical guidelines for use by responsible and competent persons or organisations.

These documents should be read in conjunction with the requirements of the Code to ensure sound principles and practices are followed. These documents do not supersede or take precedence over any of the requirements of the Code.

A key role of the Companion Papers is to provide the flexibility to incorporate endorsed industry practices and emerging technologies expeditiously, as/when necessary.

A related benefit is that the Companion Papers can be referenced by the wider resources industry which uses similar PE gathering networks for gas or water handling, including coal bed methane (CBM) in underground coal mines; mine de-watering; or the emerging biogas industries (agricultural, landfill, etc.).

1 Scope

The scope of this Companion Paper is to recommend a method to enable efficient determination of the condition of a PE network and to approximate remaining life.

Condition Assessment can be used in pipeline design as one of the integrity procedural controls in accordance with Section 4.5.2.2(b) of the Code. Condition Assessment is also referenced in the Code in Section 11.5.1 Pipeline Network Integrity Management.

2 Introduction

The procedure and tests to be considered when assessing the condition of a PE100 pipe that has been in service or storage are described. It should be understood that the service life of PE100 pipes will be dependent on the actual service conditions and these might differ from those assumed when the pipeline was designed. Similarly any service life achievable after a condition assessment will also depend up the actual conditions experienced. Accurate condition assessment is dependent on accurate records being maintained of PE pipes and their service conditions.

Stored pipes, pipes installed above ground, buried PE pipes and PE fittings are addressed. The information is equally applicable to the gathering system (i.e. PFW and gas lines), PE100 pipes associated with water treatment plants and pipes for moving water between dams.

Where the pipeline has been designed using condition assessment as integrity procedural control, as per the Section 4.5.2.2(b), the integrity management plan (IMP) shall document its implementation (method, equipment, frequency etc) to achieve required procedural control.
Condition assessment may be incorporated in IMP as part of the Operator's network integrity management strategy. It might also be implemented because:

- a pipe system is reaching the end of its design life,
- changes have been made or are to be made to the operating conditions,
- the system has been operated above the recommended service or design conditions,
- pipe has been damaged in operation by external causes,
- as part of a failure analysis, or
- a pipeline has been decommissioned and there is a prospect of using the pipe in another application.

The condition assessment of metallic fittings and risers which are part of the gathering network is not covered in detail in this paper. Condition assessment of metallic components may be required, in addition to the above reasons, due to external and internal corrosion, and coating deterioration.

3 Technical review

3.1 PE100 pipe failure mode

The procedure for the design of PE100 pressure pipes is described in the Code, but it is important to keep in mind the design stresses are based on ductile failure as shown the time – hoop stress – temperature regression curves generated in the laboratory according to the processes described in ISO 9080.

Unless the pipeline is operated at excessive temperatures or pressures, or deformed by excessive external loading and stresses, ductile failure will not occur in practice. Actual failure will ultimately be brittle in nature. The recommended condition assessment is therefore largely directed at those characteristics that relate to brittle behaviour.

4 Recommended process for condition assessment

4.1 Material identification

Confirm the pipe details by examining the printed markings.

In particular check the material is identified as PE100. If the pipe is marked 'PE100', bears the Standard Number AS/NZS 4130 and is made from a material listed in PIPA POP004 it is extremely unlikely to be made from anything other than a material complying with AS/NZS 4131. Therefore, in such cases material classification by testing is generally not necessary. However in case of PE pipe bearing different or no marking at all, examination of material certificates and testing of material would be required to establish its properties.

PE 100 pipe extruded in the modern plants locally is generally subject to significant QA/QC on many properties, including resin.

However, couplings, valves and fittings are imported from various overseas plants so pre-installation inspection and validation is recommended good practice.

4.2 Service conditions

As discussed in 'Failure mode' above, review the actual service conditions and compare them with the original design. Higher service temperatures or pressures can indicate the service life will be shorter than originally expected. Obviously this process will be facilitated if accurate service condition records are maintained.

4.3 Failure records

Examine the service/failure record for the pipeline. An increasing failure rate not attributable to third party damage or other external causes can indicate the pipeline had reached the end of its service life.

4.4 Installed conditions

Check the installed conditions in which pipeline or assembly was found, to determine if it had been stressed, overloaded or mechanically damaged. This could by incorrect backfilling, inadequate support in the trench or on aboveground supports, or transfer of load from other adjacent pipe/assembly. Look for inadequate compaction, subsidence, trench erosion, lack of separation between the services and similar.

4.5 Visual examination

Visually examine whatever pipe samples are available or installed pipe is accessible to assess the extent of any mechanical damage, erosion or surface cracks.

Pipes installed above ground, especially those with coloured jackets or stripes might exhibit cracks on the exposed surface. These indicate the pipe may be approaching the end of its service life. The possible remaining life will depend upon the depth of the cracks and the operating conditions. For example, intermittent use at low stresses might allow for continued operation, especially if the pipe is in a location where the condition can be regularly monitored.

Cracks on the internal wall are harder to monitor and should be taken as evidence the pipeline has reached the end of its service life, especially if failures have already occurred.

4.6 Wall thickness

Measure the wall thickness to confirm the SDR is correct and whether any significant erosion has taken place, especially in pipelines carrying a significant amount of solids.

4.7 Laboratory tests

It is recommended that both a) oxidation induction time (OIT) and b) Fourier Transform Infrared (FTIR) tests are performed.

a) The OIT test provides a measure of the residual antioxidant. Oxidation of the polymer itself occurs when the antioxidant is largely depleted.

There is a substantial incubation period between the commencement of antioxidant depletion and degradation of the polymer properties. It is when the antioxidant content is largely depleted that oxidation (i.e. polymer degradation) commences. The commencement of polymer degradation does not result in immediate pipe failure but a predilection for slow crack growth. For this reason OIT cannot be used as a quantitative predictor of residual life, but it shows whether or not there is any residual protection of the polymer against oxidation.

b) Polymer oxidation is measured by the FTIR test and reported as the ‘carbonyl index’. The carbonyl index is a measure of the increase in the carbonyl moieties such as ketone, acid and ester resulting from oxidation of the polymer chain. It is determined by comparing the ratio of the combined carbonyl peak with an internal C-H peak. The higher the value of the carbonyl index the greater the level of the polymer oxidation that will ultimately lead to failure.

4.8 Investigation of field failures

If a pipe has failed in the field, assess whether the mode is ductile or brittle. Ductile field failures are rare and are usually a consequence of over pressurisation at the service temperature, or higher pipe operating temperatures, commonly due to exposure to solar radiation. Confirm the correct SDR pipe was installed; bend radius and other installation factors were in accordance with the Standards and codes.

4.9 Welded joints

In the CSG gathering lines and associated CSG pipelines, service conditions are not expected to affect welded joints any more than the parent pipes. The performance of welded joints is largely determined by the quality achieved during construction.

4.10 Fittings

It generally expected that the condition of PE fittings in a pipeline will be consistent with the condition of the associated pipe. If fittings are to be assessed in their own right, the same processes as described for pipes can be applied. If premature failure of fittings does occur it is likely to be associated with construction problems, for example misalignment imposing higher stresses.

4.11 Residual life using Miner's rule

Where the pipeline has been subjected to variable operating conditions and where these conditions are known, a Miner's rule analysis can be performed as described in ISO 13760. It should be noted that Miner's rule is an empirical approximation and does not represent an exact solution to the question of residual life. If ISO 9080 data is available for the PE100 material this can be used in the analysis. Otherwise, generic data can be obtained from, for example, ISO 15494.

5 Summary

It is not possible to precisely determine the residual service life of a PE100 piping system. However, if the pipeline is designed, constructed and operated in accordance with the *CSG Code of Practice for PE gathering lines,* the actual service life should exceed the design life. The design life will depend on the service temperature as shown in the CoP. Up to 30°C the extrapolation rules in ISO 9080 allow us to extrapolate to 100 years for the POP004 listed materials; 50 years for 35° and 40°; 35 years for 45°C and so on.

Pipeline material condition assessment is a complicated process entailing consideration of a range of factors and requires significant experience and expertise in pipe material analysis. Therefore condition assessment is best undertaken by experienced personnel with an understanding of all aspects of PE pipelines design, construction and material properties including material characteristics, manufacturing processes, installation and operating conditions. This will ensure all relevant information is considered and also that unnecessary but potentially costly testing is avoided.

Consideration can be given to carrying out opportunistic assessments of the pipe quality during normal service. For example, if a damaged pipe has to be repaired or a tie-in or other modification performed there may be an opportunity to examine the pipe or even cut out a sample piece of pipe or fitting for further material and weld quality testing.

6 References

AS/NZS 4130, Polyethylene (PE) pipes for pressure applications

AS/NZS 4131, Polyethylene (PE) compounds for pressure pipes and fittings

ISO 9080, Plastics piping and ducting systems —Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation.

ISO 13760, Plastics pipes for the conveyance of fluids under pressure – Miner's rule – Calculation method for cumulative damage.

ISO 15494, Plastics piping systems for industrial applications – Polybutene (PB), polyethylene (PE), polyethylene of raised temperature resistance (PERT), crosslinked polyethylene (PE-X), polypropylene (PP) – Metric series for specifications for components and the system.

PIPA POP004, Polyethylene pipe and fittings compounds.