Code of Practice

Upstream Polyethylene Gathering Networks – CSG Industry

Version 5.0

August 2019

Contents

Important note on use of the *APGA Code of Practice for Upstream Polyethylene Gathering Networks in the Coal Seam Gas Industry*.

This Code has been developed for the use of organisations involved in the CSG industry, primarily in Australia and New Zealand.

• Acknowledgements

This Code has been prepared on behalf of the Australian Pipelines and Gas Association (APGA) by members of the Association who are associated with the coal seam gas (CSG) industry. Representative members of all sections of the industry were active participants, including all major CSG producing companies, constructors, manufacturers of polyethylene (PE) resin, pipes and fittings as well as CSG engineers.

APGA gratefully acknowledges the assistance and support of the Plastics Industry Pipe Association of Australia Ltd (PIPA) and its various technical members who provided invaluable assistance during all stages of this Code's preparation. Many PIPA guidelines are referenced in the Code and all are available on the PIPA website www.PIPA.com.au.

The guidance and support from the Queensland Petroleum and Gas Inspectorate within the Department of Natural Resources, Mines and Energy have assisted in ensuring that this Code has been accepted by all stakeholders involved in the CSG industry and referenced in Queensland legislation.

In addition, many industry members contributed significant time and resources at the committee working level in developing and reviewing individual sections of this Code and its subsequent revisions.

The support of the APGA Board and the APGA Secretariat is gratefully acknowledged.

• Preface

The provision of clean energy is of vital interest to all members of the Australian community. Gas-fired power generation is widely acknowledged as a significant part of the solution to meeting carbon pollution reduction guidelines as the emissions released from modern gas-fired power stations are much less than those from coal-fired power generation and gas fired generation provides network stability with the growing influence of renewables.

During the past decade, sufficient coal seam gas (CSG) reserves have been identified and developed to support a CSG to liquefied natural gas (LNG) export industry as well as supplying the domestic market.

Polyethylene (PE) has been used widely throughout Australia for several decades in water reticulation and in metropolitan gas distribution networks. Within the CSG industry, PE has been used as the material of choice for gas Gathering Networks upstream of field compression stations and for CSG water networks. It provides a cost-effective solution with a long service life and is not subject to corrosion.

For the initial decade of CSG field development, common industry practice, based on various water and gas industry standards and codes, was followed for installing the Gathering Networks throughout the predominantly rural environment of the CSG fields. However, as the industry matured and larger diameter PE Gathering Networks were installed, requirements of the existing standards were appropriate and the need for this Code arose.

Most importantly, several safety incidents were recorded during PE pressure testing and commissioning, and the industry jointly recognised that further guidance was needed.

This Code has been developed to provide guidance to all industry participants. It is intended to encapsulate the best techniques and methods currently available to provide safe and reliable Gathering Networks and is cross-referenced against relevant Australian and international standards wherever possible.

This fifth version is intended to capture learnings as a result of the industry's development and allow recent industry innovations to be safely used. Significant changes in this Version 5.0 include the following:

a) Removal of non-mandatory guidance to the industry from the Code to Companion Papers;

b) Update of the Safety Management System process based on industry experience and research;

c) Upgrade to the Network Management System requirements to address the whole-of-life (from pre-construction to relinquishment) for both gas gathering and water gathering;

d) Clarification of risk control measures with respect to physical and procedural requirements;

e) Clarified minimum Depth of Cover requirements and introduced concept of "reduced cover";

f) Introduced ability to install temporary above ground gas and water pipes, in non-fenced locations;

g) Providing alternative materials to carbon steel for risers, in response to corrosion concerns;

h) Reduce the need for excavations in brownfield situations;

i) Facilitate the use of Gathering Networks for transportation of water for fracturing or drilling purposes;

j) Addressing in more detail requirements of network operations and controls and external interference management, of existing networks; and

k) Revision of required timing of key review intervals for network management.

It is an evolving document, and APGA proposes that reviews of the Code occur on an as required basis pending any significant industry learnings or issues. Companion Papers will be updated more frequently as best practice evolves and develops.

This Code has been developed by APGA in consultation with its membership, PIPA, the gas industry and regulatory authorities, particularly those in Australian jurisdictions with a current CSG industry. APGA members in all States are encouraged to adopt this Code and to provide feedback on its application. Other interested parties are also invited to provide feedback on this initiative. Feedback forms are available on the APGA web site.

1 Scope

1.1 Introduction

This Code has been specifically designed to be, as far as possible, a single reference source, together with the associated informative Companion Papers, for the coal seam gas (CSG) industry in working with polyethylene pipe and fittings. It should be read in conjunction with the Standards referenced in Appendix D, relevant Companion Papers and legislation.

The Code does not specifically detail environmental requirements, hence it shall be read in conjunction with the respective State's environmental protection legislation, the Operator's Environmental Licence and the APGA Code of Environmental Practice.

The maximum design pressure for Gathering Networks covered by this Code is 1600 kPa for gas and 2500 kPa for CSG water. The Operator may, in accordance with the 'fit for purpose' design requirements of this Code, design Gathering Networks with higher design pressures. Note that, unless otherwise stated, all references to pressure in this Code refer to gauge pressure.

The Code uses the concept of physical and procedural controls to mitigate risk in lieu of the risk factor. The Code addresses safety performance, design, construction, testing, operations and maintenance of Gathering Networks and places particular emphasis on jointing techniques and pressure test methods.

The Code details the obligations, and process required, to undertake and validate safety management studies (SMS) and the requirement to demonstrate as low as reasonably practicable (ALARP) where risks are not sufficiently mitigated and have to be addressed by the implementation of additional risk reduction measures.

Jointing, particularly of large diameter PE pipe, presents challenges and the Code recognises this by requiring mandatory and ongoing training and accreditation of all relevant personnel involved in PE welding including PE welders, quality assurance and quality control (QA/QC) and supervisory personnel.

Pneumatic pressure testing is used for most of the Gathering Network. It is acknowledged, however, that significant hazards need to be carefully addressed, primarily by exclusion zone design and careful planning. Again, training and competency forms a pivotal role in safety management. Several options for leak testing are listed including tracer gas for CSG nodes or networks.

In Section 5 – Construction, several PE pipe installation methods are provided, including horizontal directional drilling and thrust boring. Some emerging NDT technologies are available; however, the use of NDT is not currently addressed. For more information refer to PIPA technical note TN016 'Non-Destructive Examination of PE welds – Emerging Techniques'.

The Code recognises the importance of good engineering design in providing appropriate isolation and segregation within the Gathering Network. Good engineering design establishes the basis for safe construction of the Gathering Network, allowing an extended life and reducing the risk of future faults or emergencies. The Code also considers technical requirements such as temperature re-rating and other design factors, as well as special considerations to be made when networks are in close proximity to populated areas.

The Code sets out the requirements for commissioning and operation of the network including the requirement to review and approve important matters related to safety, engineering design, inspection and operation. This version also clarifies requirements related to Gathering Network suspension and abandonment.

The overall framework of the Code has also changed to concentrate on core mandatory requirements with industry guidance now included in the Companion Papers.

1.2 Scope

The Code applies to CSG water and gas Gathering Networks and associated piping and components of all diameters which are manufactured to the PE100 specification that transmit CSG, produced formation water (PFW), permeate, saline water, drilling water and treated water. In this Code, the term Gathering Network includes licensed pipelines manufactured to the PE100 specification.

Figures 1.2a and 1.2b show the scope of gas and CSG water networks covered by this Code. The break between the Gathering Network and the plant or lease facility shall be defined for each facility. The break should preferably be at, or adjacent to, the first Gathering Network isolation valve on the side of the valve remote from the Gathering Network.

Where the Gathering Network includes carbon or stainless steel components, or components manufactured from other materials, the requirements of Section 4.16 of this Code shall apply (e.g. risers, high point vents, low point drains, isolation valves or manifolds).

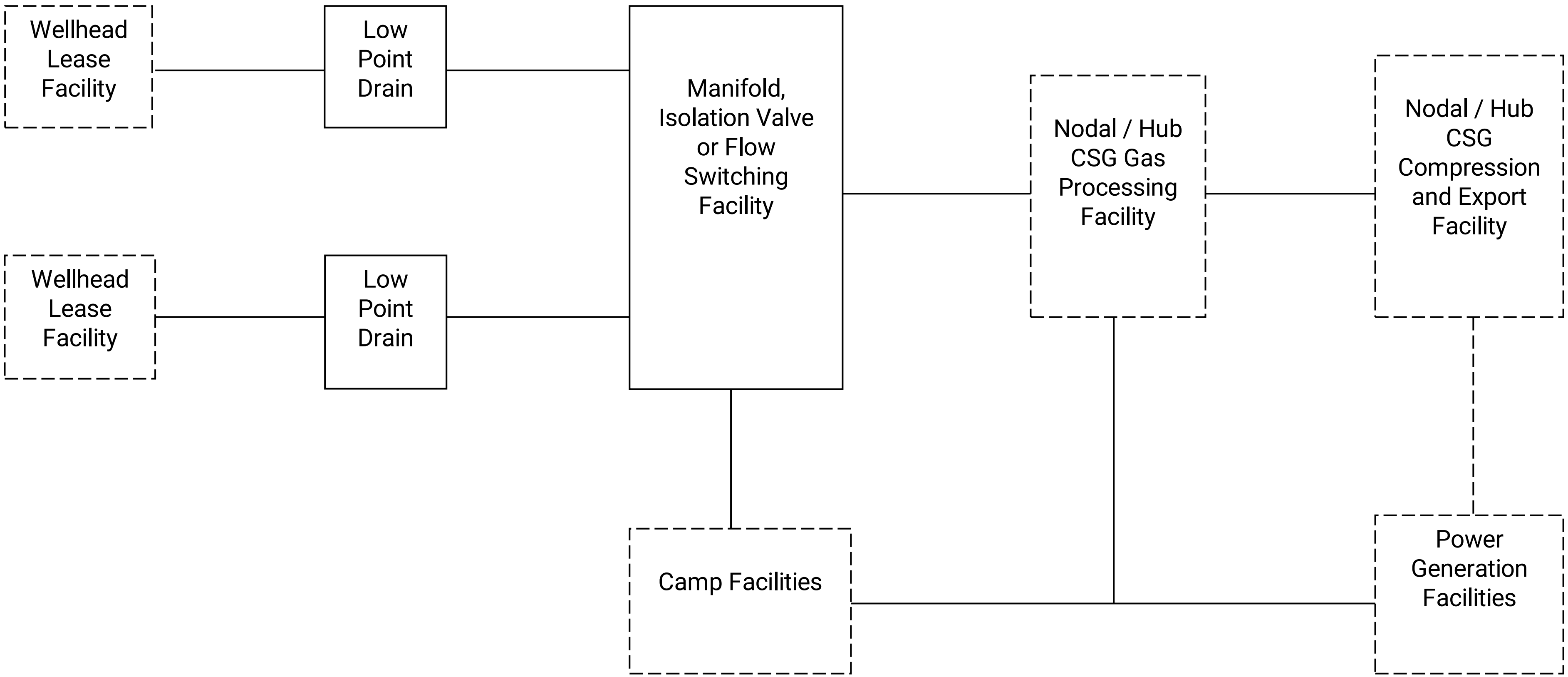
The Code also applies to modifications to a Gathering Network constructed to a previous version of this Code or alternate Standard, as well as alternative PE piping options, as allowed under Section 4.6 of this Code.

1.2.1 Exclusions

The Code does not apply to the following installations:

a) Material selection for Gathering Network constructed of materials other than PE e.g. polyamide or fibre reinforced plastic; and

b) Potable or drinking water pipes and networks.



__________ indicates network / facility included in the scope of this Code if manufactured from PE

\- - - - - - - - - indicates network / facility excluded from the scope of this Code

Figure 1.2a – Battery limits of a Gathering Network covered by this Code

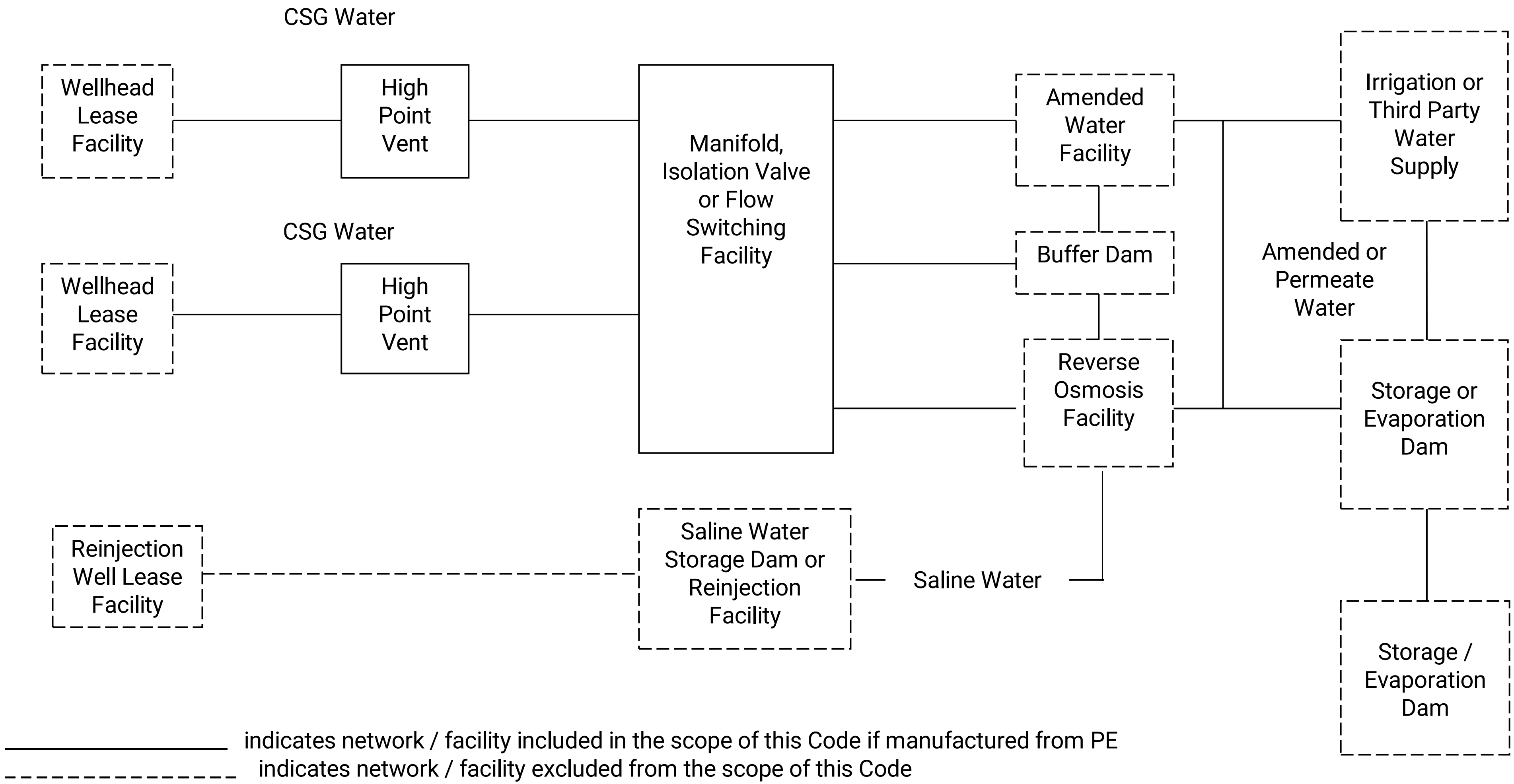


Figure 1.2b – Battery Limits of a CSG Water Network covered by this Code

1.3 Basis of this Code

The objective of this Code is to provide requirements for the safe design, construction and operation of a Gathering Network that carries CSG and water.

The fundamental principles on which this Code is based are:

a) This Code exists for the safety of the public and operating personnel and for the protection of the environment;
b) The Operator is responsible for the safety of the Gathering Network;
c) All threats to the Gathering Network shall be identified and either controlled or the associated risks evaluated and managed to ALARP;
d) The Gathering Network shall be designed to have sufficient strength to withstand all design loads to which it may be subjected during construction, testing and operation;
e) The Gathering Network shall be designed to be leak tight;
f) The stresses induced during operation of the Gathering Network shall remain within the design stress requirements determined in accordance with performance-based material properties resulting from established PE industry test results;
g) Before the Gathering Network is placed into operation, it shall be inspected and tested to prove its integrity;
h) The integrity and safe operation of the Gathering Network shall be maintained in accordance with the network management system;
i) Where changes occur to parts or the whole of the Gathering Network or its surroundings which alter the original design basis, appropriate steps shall be taken to assess the changes and where necessary implement modifications to maintain the safe operation of the Gathering Network;
j) At the end of the network's integrity life, the network shall be abandoned; and
k) The design and network management system for the Gathering Network shall be documented, reviewed, and approved.

The fundamental principles set out above, including rules and guidelines set out in this Code, shall be the basis upon which an engineering assessment, including fit for purpose design, is made.

1.4 Retrospective application

This Code is subject to continuous improvement and, when a revision of part of this Code is published, the revision should be reviewed by the Operator to identify opportunities for improvement of existing networks.

Publication of a new Code or revision of this Code does not, of itself, require modification of the existing physical assets constructed to a previous Standard or a previous edition of this Code.

Operation of the assets shall conform to the requirements of the Network Management System and Safety (Section 2) and Operations (Section 11) of the most recent edition of this Code.

Where the changes in the latest edition of this Code are considered significant, the existing network shall be assessed against these requirements and where technical or safety non-compliances are deemed to exist, mitigation measures determined by risk assessment shall be applied in accordance with this Code.

1.5 Companion Papers

Companion Papers are used for guidance on the application of this Code and do not form a mandatory requirement. They are used to document technical information and processes and good industry practice. Companion Papers form part of the suite of documents together with this Code and are intended to be:

a) 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.

Companion Papers should be read in conjunction with the requirements of this Code to ensure sound principles and practices are followed.

Companion Papers do not supersede or take precedence over any of the requirements of this Code.

Companion papers are available on the APGA website via the resources section on this page: https://www.apga.org.au/code-practice-upstream-pe-gathering-lines-csg-industry

1.6 Approvals

Throughout this Code, items that are considered fundamental to ensuring the safe operation, maintenance and integrity of a Gathering Network are identified as requiring approval.

Approval shall be given only after the conscious act of reviewing the item, recording the review has taken place and assuming responsibility for the implications of acceptance of the item.

Approval includes obtaining the approval of any relevant regulatory authority where this is legally required.

1.7 Defined terms

In this Code, the following defined term is used:

Gathering Network

A Gathering Network is defined as the network between battery limits in Figure 1.2a for gas and between battery limits in Figure 1.2 b for CSG water.

2 Network Management System and Safety

2.1 Basis of section

This Section describes the requirements of the management system to be in place before commissioning and operation and to ensure an existing network remains fit for operation.

Networks shall have a documented and approved network management system (NMS).

The NMS shall address the Operator's approach to the following areas:

a) Management including:
   - Training and competency
   - Accident/incident investigation and reporting
   - Audits;

b) Planning;

c) Measurement and evaluation;

d) Consultation, communication and reporting;

e) Safety management;

f) Environmental management;

g) Construction, testing and commissioning;

h) Operations;

i) Network integrity management plan (IMP) including:
   - External interference management
   - Change of operating conditions and remaining life review;

j) Emergency response; and

k) Records management.

The NMS should include a description of the Gathering Network covered by the NMS including suitable maps (alignment sheets and/or GIS) showing the route of the Gathering Network, the location of associated facilities such as ponds, compressor and pump stations, low point drains, high point vents and valve stations.

NOTE: In some jurisdictions there are special requirements for safety management systems/plans and these will need to be addressed in the NMS.

2.2 Network management system elements

2.2.1 General

The responsibility for creating and implementing the NMS lies with the Operator.

In this Code, the term 'Operator' refers to the entity that the regulatory authority holds accountable for the network. It should not be confused with the term 'operator' (lower case) which refers to a person carrying out a defined task.

Where two independently operated Gathering Networks are connected at a designated point (or points), each Operator's NMS should clearly define the boundary point(s) for responsibility of the Gathering Network. The operation of the isolation valve(s) (or custody transfer point) between the independent networks has to be clearly defined in the NMS of both companies.

How the Operator chooses to structure the NMS is flexible, but it should address all the criteria specified in Section 2.2.

2.2.2 Management structure

A defined management structure for the Gathering Network shall be established to identify key positions and personnel. An appropriate management structure shall be maintained.

2.2.2.1 Responsibilities, accountabilities and authorities

The responsibilities, accountabilities and authority levels of personnel and or contractors with respect to the various aspects of the operation and maintenance of the network shall be defined.

2.2.2.2 Training and competency

Personnel shall be competent to perform the specific tasks and functions they are responsible for conducting or be supervised by a competent person.

The Operator shall establish and maintain procedures for identifying and providing the training needs of all personnel performing functions covered by the NMS.

As a minimum, personnel responsible for the operation and maintenance of the network should, as applicable to their position:

a) Be trained and experienced in all aspects of the equipment in their control;

b) Be trained in the obligations of the NMS and briefed in the requirements of the actions identified during the safety management study (see Section2.6);

c) Be aware of properties of the fluid, including its hazards (see AS 4343);

d) Ensure the safe disposal of any accidentally discharged fluid; and

e) Be capable of arranging for damaged sections of the network to be repaired, commissioned, purged and flushed as required.

NOTES:

1. Personnel competency can be assisted though training, development and assessment of personnel by use of relevant competency standards. In the case of:
    - Technicians and operators, the relevant units of competency standards are in UEG-11 The Gas Industry Training Package which can be found at www.training.gov.au/Training/Details/UEG11 and the PMA Chemical, Hydrocarbons and Refining Training Package, Units of Competency and Skill Sets which can be found at http://training.gov.au;
    - Pipeline Engineers and Approvers, the relevant competency standards are published by the Australian Pipelines and Gas Association and can be found at http://www.apga.org.au/training/competency-area/plastics-pipe.
2. Refer to the appropriate Competency Companion Paper for further information.

2.2.2.3 Change management

The Operator shall establish procedures for managing changes to ensure they are made in a controlled and authorised manner.

Any significant change to the network or its operating context shall be reviewed and approved. Significant change shall be considered to have taken place if the engineering design has been upgraded or modified, or if any event initiates an operational, technical or procedural change in the measures in place to:

a) Protect the network and associated installations;

b) Promote public awareness of the network;

c) Operate and maintain the network safely;

d) Respond to emergencies;

e) Prevent and minimise product leakage;

f) Carry out inspections; or

g) Ensure that the plans and processes continue to conform to the engineering design.

The change management processes shall address implementation of any resulting NMS changes including notification and training of staff impacted by the change, and responsibilities for any identified actions as well as timelines for completion of those actions.

2.2.2.4 Management review

The NMS shall be reviewed and, if necessary updated, at least every five (5) years or in the event of any significant change to the network.

2.3 Planning

2.3.1 General

The Operator should have appropriate planning processes and procedures for the network for any situations that may result from normal and abnormal operations including emergencies. This planning process shall include a comprehensive safety management study to ensure that risks to the Gathering Network and personnel are as low as reasonably practicable. Prior to installation, additional controls can be defined where identified.

2.3.2 Planning for normal operations

When developing or updating the policies and processes of the NMS, the mitigating actions from safety management studies and risk assessments undertaken under this Code shall be incorporated into the NMS.

Control measures required to eliminate risks or reduce them to an acceptable level, including risks to the environment as a result of network operation activities, shall be incorporated into the appropriate processes.

A process shall also be established for the identification of workplace health, safety and environment (WHS&E) hazards and mitigation of WHS&E risks prior to the commencement of any activity.

2.3.3 Planning and preparation for abnormal operations

Planning and preparation should be undertaken to ensure readiness for operation of the network in circumstances that are different from those initially considered during the design of the network. These circumstances may include the following:

a) Operating under emergency power supplies;

b) Operating without key assets such as wells or compressors;

c) Operating at low flow or pressure;

d) Operating where key areas of the Gathering Network or access roads are subject to flooding or inundation; and

e) Operating where key areas of the Gathering Network could be directly exposed to, or in the vicinity of grass and/or bushfires.

Contingency plans and procedures should be developed for actions that may be required in situations of significant disruption to normal operations.

2.3.4 Emergency planning and preparation

Planning and preparation shall be undertaken to ensure readiness for emergency events resulting from the network's operation and maintenance and also from external events that may affect the safe and reliable operation of the network.

An approved emergency response plan shall be in place and be followed in the event of an emergency. Further requirements for emergency planning and preparation are detailed in Section 11.

2.4 Measurement and evaluation

2.4.1 General

The NMS should incorporate processes that ensure the following elements are measured and evaluated appropriately.

2.4.2 Data acquisition and analysis

Processes for identifying, collecting and analysing network operational, maintenance and reliability data should be established to identify trends in the network's operation and performance.

NOTE: Analysis of this data should ensure operation of the network continues as planned. It should also identify any negative trend that may result in an event adversely impacting the safe and reliable operation of the network.

2.4.3 Accident/incident investigation and reporting

Processes for identifying, notifying, recording, investigating and reporting accidents, near misses or incidents resulting from the operation and maintenance of the network shall be established before operation. This shall cover any event that either causes or has the potential to cause:

a) Injury or death to network personnel or the public;

b) Significant damage to the environment or property;

c) Impact on the network's operation or integrity; and/or

d) Uncontrolled gas or CSG water release.

Reporting shall include notification to relevant regulatory authorities including WHS and environmental regulators as required.

NOTE: Apart from incident reporting to the regulatory authority where required by legislation, the circumstances of any incident, as defined in the APGA Pipeline Incident Database, should be confidentially reported to APGA to enable statistics of incidents to be gathered.

2.4.4 System audits

Processes for planning and implementing audits of the NMS shall be established to determine compliance with and effectiveness of the plans and processes. System audits should also assess compliance with legal and regulatory requirements and ensure the NMS adequately addresses these issues.

The threats identified and risks evaluated in the safety management study shall be considered in the audits to ensure the following is addressed:

a) The effectiveness of the NMS in managing the risks identified; and

b) The effectiveness of the monitoring processes and controls in place to identify new or changed risks.

Audits shall be performed by competent personnel who preferably are independent of the section of the NMS being audited. The audit processes should cover the timing of audits, including the conduct of external independent audits where chosen to be undertaken or where required by regulatory authorities.

Audit processes should also cover arrangements for verifying the implementation and effectiveness of corrective and preventive actions designed to address any non-conformances identified during the audit.

The outcomes of audits shall be subject to management review. See ISO/AS/NZS 9001 for more information.

NOTE: The results of audits, review and monitoring processes should be used for the purpose of management review of the NMS.

2.4.5 Corrective and preventive actions

Corrective actions are taken to deal with an existing issue while preventive actions address potential issues. Procedures should be developed and implemented for determining, approving and implementing corrective and preventive actions.

The proposed actions shall be appropriate and commensurate to the risks encountered or identified. The proposed actions shall be recorded and their effectiveness determined by audit.

The basis for any action taken shall be documented and the outcomes of actions taken along with their effectiveness and timeliness should be subject to management review.

2.5 Consultation, communication and reporting

External people and organisations with a legitimate interest in the safe operation and maintenance of the network shall be identified and appropriately consulted.

These should include landowners, local and emergency authorities, regulatory authorities and government agencies.

Procedures should be established for regular consultation with, as well as communication and reporting to, these identified stakeholders.

These procedures shall include statutory reporting requirements.

2.6 Safety management process

2.6.1 General

Safety management is integral to the planning, design, construction, testing commissioning, operation, maintenance and abandonment of a Gathering Network.

Safety management for a Gathering Network applies controls to identified threat and reduces residual risk to a level that is as low as reasonably practicable (ALARP) through a safety management study (SMS). Threats that are not controlled are investigated by risk assessment.

The Gathering Network safety management process consists of the following:

a) Location analysis and classification;

b) Threat identification;

c) Application of controls - either physical, procedural and design measures to identified threats;

d) Review and control of threats;

e) ALARP assessment of residual risk, (where applicable);

f) Review and Validation of controls and residual risk; and

g) Documentation of the safety management process.

To ensure that all relevant information on the threat identification and mitigation is available to a validation workshop required in accordance with Section 2.6.7, an appropriate safety management study shall be completed prior to the workshop.

2.6.2 Documentation

The safety management study (SMS) shall be documented with sufficient detail so that independent reviewers or future users can make an informed assessment of the integrity of the process and its outcomes, including the basis for the identification of threats.

The SMS is a 'live' document over the life of the network and new or changed threats, and methods for their mitigation should be reviewed in accordance with the SMS.

2.6.3 Threats

2.6.3.1 General

A threat is any activity or condition that can adversely affect the Gathering Network if not adequately controlled.

Threats may be:

- Generic threats
    - Over the entire length of the Gathering Network
    - At specific sections of a Gathering Network (e.g. farming, forestry)
- Location specific
    - At a specific location (e.g. excavation risk at a particular road crossing)

The safety management process applies to both generic and location-specific threats.

Threats related to workplace health and safety, construction safety and construction environmental impacts are addressed in other parts of this Code which contain specific requirements relevant to these areas.

The process safety of the Gathering Network, facilities and control systems shall also be reviewed by a hazard and operability study (HAZOP) and, as appropriate, by other recognized safety study methods.

Threats outside of the scope of a HAZOP shall be reviewed in accordance with the safety management process in this Code.

2.6.3.2 Threat Identification

Threat identification shall be undertaken for the full length of the Gathering Network. The threats to be considered shall include, as a minimum:

a) Natural events;

b) Operations and maintenance activities;

c) Construction defects;

d) Design defects;

e) Material defects;

f) Corrosion;

g) Intentional damage;

h) External interference;

i) Activities associated with other services in the vicinity; and

j) Any other identified threats to the Gathering Network.

The threat identification shall consider all threats with the potential to damage the Gathering Network and cause:

- Interruption to service;
- Release of liquid or gas from the Gathering Network; or
- Harm to operators, the public, property or the environment.

Typical data sources used to conduct the risk identification include:

- Alignment survey data to determine basic geographical information;
- Land user surveys in which Land Liaison Officers gather information from land users on the specific activities carried out on the land, and obtain any other local knowledge;
- Third-party spatial information (GIS type data) on earthquakes, drainage, water tables, soil stability, near-surface geology, environmental constraints, etc; and
- Land planning information.

The threat identification process shall generate sufficient information about each threat to allow external interference protection and engineering design to take place.

For each identified threat, at least the following information should be recorded:

a) What is the threat and associated risk to the Gathering Network?;

b) Where does it occur? (the location of the risk);

c) Who (or what) is responsible for the activity?;

d) What is done? (e.g. depth of excavation);

e) When is it done? (e.g. frequency of the activity, time of year); and

f) What equipment is used, if applicable? (e.g. power of plant, characteristics of the excavator teeth).

2.6.3.3 Threats to typical designs

The Gathering Network design process involves the development and application of typical designs to locations where there is a common range of design conditions and identified threats. Threats common to typical designs shall be documented and controlled.

Each typical design shall be subjected to the safety management process in accordance with this Code to demonstrate that the design provides effective control for the identified threats and their associated risks.

The controlled typical designs shall then be applied and validated as per section 2.6.5. Any additional threats that are identified during the design process shall be assessed in accordance with 2.6.3.4.

These threats shall be documented at the commencement of network design, maintained for the life of the network and for any subsequent network expansions including credibility of threats and effectiveness of controls.

2.6.3.4 Location specific threats

Prior to construction, each location at which a typical design is applied shall be assessed to determine whether threats other than the threats common to that design exist at that location.

Where other threats are identified, effective controls shall be applied to each of these additional location-specific risks in accordance with the safety management process defined in Section 2.6.

These threats shall be documented at the commencement of network design, maintained for the life of the network and for any subsequent network expansions including credibility of threats and effectiveness of controls.

2.6.3.5 Non-credible threats

Each threat identified as being non-credible shall be documented. The reason for it being declared non-credible shall also be documented. The validity of this decision shall be considered at each review of the safety management study.

Non-credible threats do not require controls.

Where typical threats are non-credible for a specific scope of work (i.e. HDD threats when the scope involves no HDD), these threats are not required to be documented in the safety management study for the package.

2.6.4 Controls

2.6.4.1 General

Effective controls for each credible threat shall be identified and applied using a systematic process.

Physical and procedural controls shall be applied to all credible external interference threats in accordance with Section 4.5.

Design and/or procedures shall be applied to other threats.

Control is achieved by the application of multiple independent protective measures in accordance with this Code.

Controls are considered effective when failure of the Gathering Network as a result of that threat has been removed for all practical purposes at that location.

Where failure of the Gathering Network with the controls, is considered credible for a particular threat, that threat shall be subject to a risk assessment.

2.6.4.2 Control by external interference protection

The Gathering Network shall be protected from external interference by a combination of physical and procedural controls at the location of each identified threat. All reasonably practicable controls shall be applied.

The physical and procedural controls applied shall be appropriate to protect the Gathering Network from the specified threat. Where physical or procedural controls are not sufficient, other design and/or procedures shall be applied. Re-routing is an example of a design change decision that may be taken if external interference protection is not sufficient.

To adequately manage risk, the Operator shall develop, implement and monitor the threat mitigation measures and risk management procedures that have been identified in the NMS.

The threat mitigation measures to be considered shall include the following as a minimum:

a) Physical measures— depth of cover or barriers; and

b) Procedural protection measures — one-call systems, landowner liaison, network marking, patrolling, permit to work, and approved procedures.

2.6.4.3 Control by design and/or processes

Control by design and/or processes shall be achieved in accordance with the following:

a) Design and/or processes shall be applied to threats other than external interference threats in accordance with this Code;

b) Materials shall be specified, qualified and inspected in accordance with Section 3;

c) Gathering Network design shall be carried out in accordance with Section 4.

d) Erosion protection for the full length of the Gathering Network shall be designed in accordance with Section 4;

e) Protection against stress and strain shall be designed in accordance with Section 4 and Section 5;

f) Protection against construction related defects shall be in accordance with Section 5; and

g) Operational controls shall be designed in accordance with Section 11.

2.6.5 Residual risk assessment

Where failure of the Gathering Network, with the control is considered credible the threat shall be subject to a risk assessment.

Assessment of risks shall be undertaken in accordance with AS/NZS ISO 31000.

There are circumstances where risk estimation using quantitative methods may be required to enable comparison of alternative mitigation measures as a basis for demonstration of ALARP, and in some jurisdictions, to satisfy planning criteria.

A risk associated with a threat is deemed ALARP if the threat is controlled and failure is not credible, or the residual risk is assessed to be low or negligible, or the residual risk is formally demonstrated to be ALARP.

2.6.6 ALARP

Risks found to be Negligible are deemed ALARP.

Risks found to be Low may be deemed ALARP, provided a management plan is in place to prevent any increase in risk.

NOTE: Notwithstanding that a risk has been determined to be low or negligible, if there are simple measures that could be taken to reduce risk further, and then those measures should be adopted.

Risks found to be Intermediate shall be subject to a formal ALARP assessment that considers:

a) The current level of risk (including the effectiveness of current and planned controls) and any additional justification for further risk reduction;
b) Measures available for further reducing the risk;
c) The risk change of each proposed measure;
d) The cost of each proposed measure;
e) The uncertainty in the analysis; and
f) The reasons why any measures have not been adopted.

The formal ALARP assessment shall be documented.

Where a formal ALARP assessment is required, the risk controls listed below shall be considered as part of formal ALARP assessment:

- Network relocation (to a location where the consequence is eliminated);
- Modification of land use (to separate the people from the Gathering Network); and
- Implementing controls that are effective in controlling the identified threats.

NOTE: Further guidance on ALARP can be found in Appendix A.

2.6.7 Safety management validation

The safety management study shall be completed at the Design stage of the network development.

Each safety management study shall be validated by a properly constituted workshop, which shall critically review each aspect of the safety management study.

The purpose of the validation workshop is to assess the implementation and effectiveness of all threat controls.

Appendix A provides guidance for conducting the safety management study and shall be considered in the validation workshop.

The safety management study shall be reviewed and validated, as a result of any of the following changes:

a) At any review for changed operating conditions, outside of the network design;
b) Before recommencement of operation following a Gathering Network failure where such failure has resulted from a mechanism not previously included in preceding studies;
c) At any time when new or changed location specific threats are identified;
d) At any time where the controls of generic threats have been changed;
e) Where the location class has changed;
f) At any time where there is a change of knowledge affecting the safety of the Gathering Network;
g) At any review for extension of design life;

h) Where a part of the network is suspended; and

i) At abandonment.

Where the changes relate to a specific part of the Gathering Network, a specific location or specific safety issue, the safety management study review and validation may be restricted to only that part of the Gathering Network for which the issue applies.

Where an extension to an existing network is proposed, for which a safety management study exists, the safety management study for the extension may be restricted to specific new location specific threats provided the generic threats are reviewed and deemed to adequately cover the threats associated with the network extension.

Where the changes are associated with a design change during the design phase of the network, if the change is within a previously validated corridor and there are no additional or changes to location specific threats, the changes shall be reviewed by competent parties associated with the specific threats impacted by the change and a validation workshop is not required.

The safety management study shall:

- Be completed at the maximum allowable operating pressure (MAOP) of the network;
- Have an evaluation of the threats in accordance with an appropriate radiation intensity contour;
- Be subject to a risk assessment, where required; and
- Have all risks reduced to ALARP.

A review and validation of the Gathering Network SMS shall be completed at intervals not exceeding five years.

In addition, the assessment shall consider the impact of the failure occurring due to a failure of the overpressure protection design for the network where the MAOP is exceeded.

2.7 Environmental management

Risks to the environment from each part of the life cycle of the network shall be identified and control measures implemented so that these risks are reduced to an acceptable level. Preference should be given to ensuring environmental risks are managed by avoidance (route selection) and, where necessary, specific construction techniques.

The requirements of this Code complement the requirements of regulatory authorities in assessment and management of environmental risk, and are intended to be used during planning, construction and operational phases of a Gathering Network to ensure that:

a) Environmental management effort is concentrated on significant risks;

b) Environmental management methods are assessed holistically for their contribution to minimising the impact to the environment; and

c) There is a basis for assessing alternative construction and management methods to minimise the impact to the environment.

An analysis of the impacts of construction techniques and design at sensitive locations shall be considered.

Risk of damage to the environment from operational maintenance activities shall be identified and control measures developed.

The environmental management requirements shall include approved processes for protecting the environment from construction, operation and maintenance activities. The environmental management plan should also address emergency situations.

NOTE: The *APGA Code of Environmental Practice* provides industry accepted guidance on management for the environment through the design, construction and operational phases of a project.

The following data shall be obtained prior to conducting the environmental assessment:

a) Basic environmental data (including cultural heritage and archaeological data);

b) Stakeholder survey information;

c) Constructability and safety constraints;

d) Emergency response capabilities; and

e) Legislative requirements.

The environment severity classes that apply to the project shall be defined and approved. Specification of environmental impacts should, as far as practicable, be expressed in quantified terms.

2.8 Construction and commissioning

2.8.1 Construction safety

Construction of Gathering Networks shall be carried out in a safe manner.

The safety of the public, construction personnel, adjacent property, equipment and Gathering Networks shall be maintained and not compromised.

A construction safety plan shall be prepared, reviewed by appropriate personnel, and approved. This review shall take the form of a construction safety plan workshop.

Specific construction safety requirements exist in each regulatory jurisdiction. The more stringent of the regulatory requirements and the requirements of this Section shall apply.

NOTES:

1. Review by appropriate personnel should include design engineers, construction personnel, workplace health and safety (WHS) personnel, certified environmental practitioners and the approval authority.
2. The construction safety plan details should be consistent with the nature of the work being undertaken. It may be a component of an integrated construction safety system, a construction safety case (where the regulatory jurisdiction requires this), or a project or activity specific safety plan.

As a minimum, the following shall be addressed:

a) Approved fire protection shall be provided and local bushfire and other fire regulations shall be observed;

b) Where the public could be exposed to danger or where construction operations are such that there is the possibility that the Gathering Network could be damaged by vehicles or other mobile equipment, suitable physical and/or procedural measures shall be implemented;

c) Where a power line is in close proximity to the route, safe working practices shall be established;

d) Adequate danger and warning signs shall be installed in the vicinity of construction operations, to warn of dangers including those from mobile equipment and the presence of excavation, overhead power lines and overhead telephone lines;

e) Unattended excavations in locations accessible to the public shall be suitably barricaded or fenced off and, where appropriate, traffic hazard warning lamps shall be operated during the hours of darkness;

f) Procedures to be followed for lifting pipes both from the stockpile and into the trench after welding;

g) Procedures for safe use and handling of chemicals and solvents;

h) Frequency and provision of safety talks (tool box meetings);

i) Accident reporting and investigation procedures;

j) Appointment of safety supervisor and specification of duties;

k) Travel associated with attending the worksite;

l) Statutory obligations; and

m) Traffic management plan.

NOTE: The APGA document Onshore Pipeline Projects: Construction Health and Safety Guidelines provide guidance on construction safety for the Australian pipeline industry.

2.8.2 Testing safety

The construction safety plan shall address safety through all phases of testing of the Gathering Network during construction.

2.8.3 Commissioning safety

The commissioning plan shall consider the safety of the activities undertaken through all phases of commissioning and, where required, develop specific procedures to manage the safety during commissioning of the Gathering Network.

Commissioning safety shall conform to Section 10.

2.9 Site safety

The safety of the public, maintenance personnel, repair personnel, the integrity of equipment and the Gathering Network shall not be compromised.

Control processes shall be established for all personnel to ensure that risks are kept to as low as reasonably practicable (ALARP) and, where necessary, risk mitigation measures are implemented.

A permit to work process shall be required for site works involving high levels of risk, when working with any Gathering Network, to ensure that high levels of WHS&E controls are maintained.

A permit to work shall be issued for:

- Work in pipe trenches;
- Pressure testing;
- Commissioning;
- Work on existing operating network including tie-ins; and
- All other high-risk tasks.

As a key requirement, a job safety analysis (JSA) shall be carried out to ensure that all on site WHS&E hazards are identified and addressed prior to work commencing. A hierarchy of mitigation applies to both safety and environmental hazards.

The hierarchy of mitigation controls is as follows:

a) Elimination.

b) Substitution.

c) Isolation.

d) Engineering controls.

e) Procedural and administrative controls.

f) Protective equipment (including personal protective equipment).

NOTE 1: Where practicable, mitigation actions designed from higher up the hierarchy to remove the hazard should be used in preference to those from lower down, which only apply controls.

NOTE 2: Safe work method statements (SWMS) may incorporate the intent of a JHA.

In additional to typical safety and environmental measures, the safety of personnel and the integrity of the Gathering Network is supported by well-considered practices that have been developed to deal with risks from specific hazards involved with Gathering Network operations often in isolated and remote locations.

The work cycle of personnel shall be established to ensure that risks associated with long distance driving and excessive hours of work are identified and mitigated.

Where operations involve travel to remote areas, suitable management processes shall be determined and implemented for communication, emergency first aid and rescue.

3 Materials and Components

3.1 General

Polyethylene is a thermoplastic and behaves differently from metals. However, these properties are well-known and are embraced in Australian and other international standards.

PE100 resins used in today's pipes have high toughness, excellent resistance to slow crack growth and rapid crack propagation. They also have an inherent resistance to water and many chemicals. Polyethylene is now the material of choice for many water, waste-water, gas and other applications.

The following information details the minimum material requirements for PE resins and PE pipe and fitting materials for use in Gathering Networks.

NOTE: Further information about PE100 and related polyethylene's is available in the relevant Companion Papers.

3.2 Qualification of materials and components

Materials and components shall be fit for purpose for the conditions under which they are to be stored, transported and used, including construction and testing. They shall have the composition, pressure rating (PN number) or standard dimension ratio (SDR), temperature rating and design life specified by the engineering design.

NOTES:

1. Information regarding the life expectancy of elastomeric seals in, for example integral hot tap fittings and ball valve stems, should be sought from the supplier.
2. The service life of adhesives, for example those used to seal threaded cap fittings associated with some hot tap drill caps, should be sought from the supplier.

3.3 Compound

PE pipes and fittings used in Gathering Networks shall be manufactured from PE100 fully pre-compounded material conforming with AS/NZS 4131 and listed in PIPA Guideline POP 004 and POP 004A as applicable.

NOTE: The test results for compounds listed in POP 004 and POP 004A have been independently scrutinised and are acknowledged to meet the requirements of AS/NZS 4131 at the time of the assessment and where appropriate also identify if the material satisfies the temperature re-rating factors listed in this Code.

Materials not listed in POP 004 and POP 004A, but for which conformance with AS/NZS 4131 is claimed, may be used provided a full assessment of independent test reports by an appropriately qualified and experienced scientist or engineer confirms conformance.

3.3.1 Pipes

PE pipes shall be manufactured in accordance with AS/NZS 4130 and shall be third-party certified by a JAS-ANZ accredited certifier under the StandardsMark, GasMark or WaterMark schemes or equivalent. Marking and product traceability shall be in accordance with the Standard. Appendix A of AS/NZS 4130 shall be used as the basis for demonstrating conformity.

Pipes for Gathering Networks shall be Series 1 conforming to AS/NZS 4130.

Pipes shall have a method of service identification, and the means of conformance for service identification shall be as per Table 3.3.1.

Alternative methods of service identification shall be documented and approved. As a minimum the pipes shall be marked with the following:

TRADEMARK S1 DN XXX PN XXX SDR XX PE100 100930 F1 AS/NZS4130

CERTMARK – 'COAL SEAM PRODUCTION GAS/LIQUID PIPELINE'

If the operator choses a method of pipe service identification different to Table 3.3.1 then the operator shall implement a process to advise property owners and other potential stakeholders (e.g. other Utility providers) advance notice of this change.

Stripes, if used, shall be applied in accordance with AS/NZS 4130 Polyethylene (PE) Pipes for Pressure Applications.

NOTE: Suitable methods of pipe service identification could include an easily visible attachment to the pipe such as a unique Bar Code or using devices such as transponders which can be queried for the relevant information.

Pipes used in above-ground applications have different colour and identification requirements than specified in this section. Refer to Section 4.13.1for colour specifications for this specific application.

Table 3.3.1 Colour Specification

Fluid	Stripe or Jacket Colour	Colour Specification		Additional Pipe Marking
Gas	Yellow		No darker than RAL 1018	none
Saline Water	None			Saline water
Produced Formation Water	Purple	AS/NZS4130	No lighter than RAL 310 70 15 nor no darker than RAL 330 40 40 or RAL 310 50 30	PFW
Permeate Water	Green	AS1345	In the range G13, G21, G23	RO Water

NOTE: Information on the RAL colour range may be obtained from RAL Deutsches Institut für Gütesicherung und Kennzeichnung, www.ral.de

Examples of markings (see AS/NZS 4130):

Gas

TRADEMARK S1 DN315 SDR 11 GAS PE100 100930 F1 AS/NZS4130 CERTMARK

Saline Water

TRADEMARK S1 DN315 SDR17 PE100 100930 F1 AS/NZS4130 CERTMARK BRINE

Produced Formation Water

TRADEMARK S1 DN315 SDR17 PE100 100930 F1 AS/NZS4130 CERTMARK PFW

Permeate Water

TRADEMARK S1 DN315 SDR17 PE100 100930 F1 AS/NZS4130 CERTMARK RO WATER

NOTE: An explanation of the nomenclature used in the marking examples is provided in AS/NZS 4130. CERTMARK refers to the certification marking required by the third-party certifier.

3.3.2 Fittings

3.3.2.1 Marking

Fittings shall be marked in accordance with the requirements of the Standard to which they are manufactured. For fittings, not manufactured to a national or international Standard, the following minimum marking requirements shall apply.

a) The manufacturer's name or registered trademark;

b) The fitting type in the form of 'PE-Steel Transition';

c) The grade of PE material in the form 'PE100';

d) Nominal size in the form 'DN315';

e) Classification in the form 'SDR11';

f) Traceability data in either of the two following formats;

- A unique batch number; or
- The date of manufacture of the fitting and the identification of place of manufacture.

The marking shall be such that it is legible without magnification and durable.

NOTE: The branding requirements for PE pipe do not apply to fittings manufactured from the PE pipe.

3.3.2.2 Rating requirements for fittings

Pressure fittings manufactured from polyethylene which are not covered by AS 1463 or AS/NZS 4129 or an equivalent International Standard, and which are intended for use with polyethylene pipes made to AS/NZS 4130 should conform to PIPA Guideline POP 006.

Where fittings are rated to a pressure in accordance with ISO 4437, based on a design coefficient of 2.0, the fittings can be installed and operated in gas Gathering Networks at a maximum pressure equaling twice the rated gas pressure divided by the design factor for the same SDR calculated in accordance with Section 4.4.

EXAMPLE: The maximum design pressure in accordance with ISO 4437 for SDR 11 pressure fittings manufactured from polyethylene for gas service is 1000 kPag, because the rating of the fittings in accordance with the ISO 4437 at 20 degrees C is based upon a minimum design coefficient of 2.0, rather than 1.25. However, in accordance with the above paragraph, SDR11 fittings used in gas Gathering Networks can be operated at 1600 kPag at 20 degrees C. At temperatures greater than 20 degrees C, the allowable operating pressure for SDR11 fittings is reduced by the appropriate value of f_1 in accordance with Table 4.4.1.2. The same principle can be applied to fittings of other SDRs.

3.3.2.3 Electrofusion fittings

Electrofusion (EF) fittings shall conform to AS/NZS 4129 and shall be third party certified by a JAS-ANZ accredited certifier under the StandardsMark, GasMark or WaterMark schemes or equivalent. Fittings for above-ground applications shall be black.

3.3.2.4 Fabricated PE fittings

Fabricated fittings shall be manufactured from PE100 pipes conforming to Section 3.3.1. Butt welding or electrofusion welding shall be the only welding processes used to connect segments or components. Fillet, extrusion or rod welding shall not be used.

3.3.2.5 Mechanical compression fittings

Mechanical compression fittings shall conform to AS/NZS 4129 and shall be third party certified by a JAS-ANZ accredited certifier under the StandardsMark, GasMark or WaterMark schemes or equivalent.

3.3.2.6 Mechanical couplings

Mechanical couplings shall meet the performance requirements of WIS 4-24-01 Type 2 and ISO 14236. Some fittings require the use of internal support bushes to be placed inside the pipe ends. Depending on the materials used, additional corrosion protection may be required in buried situations.

3.3.2.7 Backing flanges

PIPA Guideline POP 007 – 'Metal Backing Flanges for use with PE Pipe Flange Adaptors' provides dimensions of metal backing flanges suitable for the use with PE flange adaptors in the sizes DN20 through to DN1000 and flanges in accordance with AS 2129, ANSI/ASTM B16.5, AS/NZS 4331.1 (ISO 7005-1) and AS/NZS 4087.

Backing rings made from materials other than steel may be used provided they are designed and manufactured as appropriate for the service conditions.

3.3.3 Previously used pipe

Pipe that has been exhumed after being taken out or removed from service shall not be re-used in Gathering Networks, except where condition has been verified and pipe is to be used for temporary service or short-term service in accordance with Section 4.13.1)

NOTE: PE100 is a thermoplastic material and can be reprocessed. The pipe manufacturer should be consulted regarding options for collecting reclaimed pipes and off-cuts for recycling into other products.

3.4 Valves

3.4.1 Valve material

Materials used in the manufacture of valves shall be appropriate for the specific fluid being transported and shall be suitable for installation above or below ground as appropriate.

Metallic valves that are subject to corrosion as a result of being installed in a corrosive environment shall be manufactured from a corrosion resistant material such as stainless steel or be provided with a suitable surface corrosion protection such as protective coating, tape wrapping or similar protective system. The grade of stainless steel shall be selected based on the specific fluid's properties. Where protective coatings are used, requirements for coating type, surface preparation and thickness shall be determined and specified.

Valve bodies manufactured from PE shall use a PE100 material conforming to the requirements of Section 3.4.2.

3.4.2 Pressure rating of PE valves

The pressure rating of a valve shall be not less than the MAOP of the network within which it operates.

Where valves are rated to a pressure in accordance with ISO 4437-4, based on a design coefficient of 2.0, the valves may be installed and operated in upstream gas Gathering Networks at a maximum pressure equaling twice the rated gas pressure divided by the design factor for the same SDR calculated in accordance with Section 4.3.

EXAMPLE: Consider a valve rated as having a maximum operating pressure (MOP) of 1000 kPag in accordance with ISO 4437-4 that applies a design coefficient of 2.0 rather than the minimum design coefficient of 1.25 adopted in this Code. When used in an upstream Gathering Network, the valve may be operated at 20 degrees C at pressures up to 1600 kPag.

$$MAOP = \frac{2.0 \times MOP}{1.25 \times f_1 \times f_2 \times f_3}$$

The PE valves used for CSG water service shall conform to BS EN 12201-4 in its entirety.

PE valves intended for gas service shall conform with ISO 4437-4 except the allowable operating pressure shall be as detailed in this Section above. Alternative standards may be used where approved.

When the same type of PE valve is used in both gas and CSG water service there may be conflicting requirements between the relevant standards (e.g. ISO 4437-4 and BS EN 12201). The more stringent requirements shall be selected.

BS EN 1555-7 provides guidance for assessment of conformity and selection of appropriate testing.

3.4.3 Industrial thermoplastic valves

Industrial valves made of thermoplastics materials shall conform to the following Standards.

Ball valves	ISO 16135 Industrial Valves – Ball valves of thermoplastics materials.
Butterfly valves	ISO 16136 Industrial Valves – Butterfly valves of thermoplastics materials.
Check valves	ISO 16137 Industrial Valves – Check valves of thermoplastics materials.
Diaphragm valves thermoplastics	ISO 16138 Industrial Valves – Diaphragm valves of materials.

Gate valves	ISO 16138 Industrial Valves – Gate valves of thermoplastics materials.
Globe valves	ISO 21787 Industrial Valves – Globe valves of thermoplastics materials.

3.5 Transition fittings for PE pipe to carbon steel pipe

3.5.1 Fitting materials

A transition fitting is to be manufactured from PE 100 pipe or carbon steel pipe of the same or higher specification to that of the pipes to which it is being joined.

3.5.2 Pressure rating of transition fittings

All fittings shall have a pressure rating not less than that of the network within which they operate and conform to the following test requirements for mechanical compression joint fittings specified in AS/NZS 4129:

- Pressure test for assembled joints; and
- Pull-out test.

3.6 Storage and transportation

Storage and transportation shall be in accordance with AS/NZS 2033 and Section 5 of this Code.

Pipe and fittings shall be assessed for transportation damage prior to acceptance.

NOTE: Further information on storage and transportation of PE pipe can be found in PIPA Guideline POP 005 which recommends a maximum of two years exposure to heat and sunlight for other than plain black PE pipe.

4 Design

4.1 Basis of section

This section sets out requirements for the design of Gathering Networks, with their related components such as isolation valves, PE to steel transitions, manifolds, risers and other connections to above-ground facilities. Materials are limited to pipe and fittings as detailed in Section 3.

Designs for Gathering Networks shall use performance-based material properties resulting from established PE industry test results as provided in this Code. Installation designs shall use service/design factors from established PE industry experience as provided in this Code. The design shall use established engineering principles to determine stress, strain and creep resulting from the applied loads and ensure that these remain within acceptable limits for the intended life of the network. The design shall satisfy the criteria for risk mitigation by the use of the risk mitigation controls from industry experience as provided in this Code or as identified in relevant safety management studies.

Polyethylene resins shall conform with the requirements of Section 3.3. With the advent of future advances in resin technologies, it is the intent of this Code to allow Operators to take advantage of these developments as they become available. This Code encourages the use of advanced resins which have been identified to provide benefits for specific applications and complied with the testing regime outlined in the relevant ISO/AS/NZS codes and standards.

A structured design process, appropriate to the requirements of the specific Gathering Network, shall be carried out to ensure that all safety, performance and operational requirements can be met during the whole life of the Gathering Network.

4.2 Design principles

Network design uses a mechanism called the 'Design Basis' which is detailed below and is pivotal to any design procedure.

This Code also sets out the methodology for the design of PE100 networks, prescribing a minimum design through the use of design factors and risk mitigation controls as set out in this Section, subject only to the safety management study. There are two mechanisms which can be used either individually or in conjunction to complete a design.

The first mechanism is 'Prescribed Design' and uses a series of formulae and tables derived from theoretical considerations and industry practice.

The second mechanism is called the 'Fit for Purpose Design' and relies on a study of a real and present situation and the use of a rigorous risk assessment process to derive one or more of the factors used in the Prescribed Design case.

There is an overarching requirement that the use of the 'Fit for Purpose' case is not to be used in any way which would compromise the safety of people, plant or the environment.

The design of the Gathering Network shall be approved.

4.3 Network design

4.3.1 Design Basis

The basis for design of the Gathering Network and for each modification to the Gathering Network shall be documented in the Design Basis.

The purpose of the Design Basis is to document both principles and philosophies that are applied during the development of the detailed design, and specific design criteria that are applied throughout the design.

The Design Basis shall be approved.

The Design Basis is an output of the planning and preliminary design phase of a Gathering Network, including landowner requirements.

The Design Basis shall be revised during the development of the project to record changes required as a result of additional knowledge of the project requirements as the detailed design is developed and approved.

The Design Basis should be maintained and kept current throughout the network design, construction and operational phases.

Lessons learned workshops should be held where appropriate. Improvements from the lessons learned workshop should then be incorporated into the Design Basis for the next projects.

The design process shall be undertaken in parallel with, and as an integrated part of, the safety management process and shall reflect the obligation to provide protection for people, property, livestock, the network, and the environment.

As a primary requisite, every Gathering Network shall be leak tight and have the capability to safely withstand all reasonably predictable influences on which it may be exposed during the whole of its design life.

4.3.1.1 Generic design requirements

The following generic design requirements shall include, but are not limited to, the following:

a) Safety of the public, property and Gathering Network is paramount;

b) Design is specific to the nominated fluid(s);

c) Route selection considers existing land use and allows for known future land planning requirements and the environment, and the presence/location of existing pipes and facilities;

d) The fitness for purpose of the Gathering Network and its associated equipment;

e) Engineering calculations for known load cases and probable conditions;

f) Nominated limits for pressure, temperature and capacity;

g) The design shall include provision for maintaining the integrity by:

- Protection from external interference and external loading; and
- Operation and maintenance in accordance with defined plans.

h) Consideration of the types of changes which would prompt a design review; and

i) Potential supply of water to assist construction and drilling activities.

4.3.1.2 Specific design requirements

The design basis also needs to address the following project specific issues:

a) The pipe dimensions shall be in accordance with AS/NZS 4130 Series 1. The Standard provides details of pipe diameters, wall thickness and tolerances and matches pipes to a preferred number SDR series. The SDR shall be selected ensuring that it is no less than that required for pressure containment determined from the design pressure fluid, temperature, installation method and location design factors applicable for CSG or PFW and is suitable for any special construction at all locations along the network length. The Operator may nominate an SDR (with the coordination of the pipe manufacturer) other than the values provided in AS/NZS 4130. For minimum wall thickness requirements refer to Section D of AS/NZS 4130. The overall service (design) coefficient should be sourced from the Section 4 of this Code. This is not to negate the manufacturing and testing requirements defined in AS/NZS 4130;

b) The network shall be assigned a maximum allowable operating pressure (MAOP) which shall account for elevation changes, the fluid being carried, the design temperature, the installation method and all fittings and appurtenances. For guidance refer to Section 4.3.5;

c) The design factors are based on a design life of 50 years unless otherwise limited by the material properties and/or temperature design factor table;

d) The risk of the network associated with the location (population density or land use) at all locations along the network length shall be mitigated by the implementation of the selected physical and procedural controls for integrity and external interference applicable to the location under consideration;

e) Extra protection shall be provided where necessary, particularly to prevent damage from unusual conditions such as may arise at road, rail or river crossings, bridges, areas of heavy traffic, from vibration, or the possibility of ground subsidence or other abnormal forces or any other condition that may impact on the integrity of the network;

f) The network shall be pressure tested in accordance with Section 8 to verify that it has the required strength and is leak tight; and

g) The battery limits between this Code and design to other standards shall be documented.

4.3.2 Design Basis recording

The Design Basis shall record, as a minimum, the following:

a) A description of the project covered by the Design Basis;

b) Statutory legislation and industry codes and Standards applicable to the network and facilities;

c) Specific physical criteria to be used in the design including at least:

- Design life of network as applicable;

- Design pressure(s), internal and external;
- Design temperature(s);
- Fluids to be carried; and
- Where required, the maximum fluid property excursion and the duration of any excursion (e.g. temperature or composition).

d) Materials;

e) Minimum design and installation criteria for the network;

f) Specific process and maintenance criteria to be used in the design including, as a minimum, the following:

- Operating and maintenance philosophy;
- Performance requirements for network depressurisation, re-pressurisation, and isolation valve bypass;
- Pressure/flow regime established for the Gathering Network;
- Isolation principles; and
- Limiting conditions.

g) Design principles established as the basis of detailed design;

h) Design philosophies established to guide development of the detailed design;

i) The location of facilities and their functionality;

j) Communications, power and control principles;

k) Inspection and testing principles; and

l) Network reliability principles.

4.3.3 Network design considerations

The design of an overall Gathering Network shall take into account factors such as:

- Location;
- Land usage;
- Existing network and facilities;
- Future network and facilities;
- Repurposing (e.g. change of service including potential supply of drilling water to well sites via the Gathering Network);
- Future compression;
- Vent and drain automation;
- Scale build-up;
- Microbial influenced corrosion (MIC);
- Solids build-up;
- Internal examinations; and
- Licensed pipelines and access requirements.

NOTE: Consideration should be given to locating the right of way alongside existing or new access roads and tracks to minimise overall impact.

4.3.4 Process design

Process design of the network shall be undertaken in accordance with the network requirements detailed in the Design Basis. Examples of network requirements include:

- High point vents (and possible reinjection of gas into the gas network);
- Low point drains (and possible reinjection of water into the water network);
- Network isolation;
- In-field gas and water re-injection facilities;
- In-field pipeline pressure relief stations;
- Future field compression; and
- Abandonment.

The design process shall include as a minimum:

- Process flow diagrams (PFDs) and piping and instrumentation diagrams (P&IDs);
- Alignment (including revision date), with control measures implemented;
- Hydraulic calculations; and
- HAZOPs and risk assessments.

The designer may include further activities as deemed necessary for completeness of the Gathering Network design.

4.3.5 Maximum allowable operating pressure (MAOP) and design pressure for Gathering Networks

The actual maximum allowable operating pressure (MAOP) of a Gathering Network shall be no greater than the lesser of:

a) The design pressure of the Gathering Network;

b) The pneumatic strength test pressure divided by the pressure test factor (f_p)), (refer to Table 8.4.1a);

c) For CSG water networks hydraulically tested, the lesser of:

   - The hydraulic strength test pressure at the low point divided by the pressure test factor (refer to Table 8.4.1c); or
   - The hydraulic strength test pressure at the high point.

d) For gas networks hydraulically tested:

   - The starting hydraulic strength test pressure at the high point divided by the pressure test factor (refer to Table 8.4.1b).

The MAOP shall be determined, or calculated, and recorded for each section of network

The pressure test factor is normally 1.25, although may vary depending upon the location classification and the physical and procedural protection measures chosen in accordance with Section 4.5, as detailed in Section 8.4.1, Table 8.4.1(a) Pressure Test Factor.

In the case of PFW and Saline water pipes, the MAOP shall take into account the effect of the static head of the water due to changes in elevation of the pipeline.

4.3.5.1 Design pressure calculation

The pipe Design Pressure (MPa) shall be calculated from the following equation:

$$P \le \frac{2 \times MRS}{C \times (SDR - 1)}$$

where

MRS = Minimum required strength for the material in MPa.

C = Design Factor (See Section 4.3.6)

SDR = Standard dimension ratio as per AS/NZS 4130 Series 1

NOTE: The MRS for PE compounds is determined in accordance with AS/NZS 4131 and is expressed as a hoop stress in megapascals. The MRS for PE100 is 10.0 MPa. Pipe Hoop Stress, σh, is calculated using the following formula:

$$\sigma h = \frac{P \times (D - t)}{(2 \times t)} = \frac{P \times (SDR - 1)}{2} \text{ MPa}$$

where: P = Design pressure in MPa

D = Outside diameter in mm

t = Pipe wall thickness (minimum) in mm

SDR = Standard dimension ratio

4.3.6 Design factor - general

The minimum design factor for the Gathering Network pipes is calculated using the factors nominated below.

The Design Factor, C, shall be calculated as follows:

$C = f_0 \times f_1 \times f_2 \times f_3$

where:

f_0 is the material factor
f_1 is the operating temperature factor
f_2 is the installation method factor
f_3 is the fluid factor

4.4 Prescribed Design

4.4.1 Other design factors

4.4.1.1 Design factor for material (f_0)

The design factor for material is included in the calculation of the overall design factor, C. This factor is independent of the fluid and is 1.25 for all fluids.

4.4.1.2 Design factor for temperature (f_1)

The design factor for the associated pipe temperatures shall be in accordance with Table 4.4.1.2.

Table 4.4.1.2 Design factor for temperature

Temperature °C	Design factor for temperature f_1	Minimum potential service life (years)
≤20	1.0	100
25	1.1	100
30	1.1	100
35	1.2	50
40	1.2	50
45	1.3	35
50	1.4	22
60	1.5	7

At continuous service temperatures above 20°C, the service life shall not exceed the minimum potential service lives listed in this Code. Refer to Section 11, for means to extend service life.

NOTE: Definition of minimum potential service life is the expected life when continuously operated at a single temperature. The above values are supported by current test data and should be used in establishing design life.

4.4.1.3 Design factor for installation (f_2)

The design factor corresponding with the installation method shall be in accordance with Table 4.4.1.3.

The installation factor shall not be less than 1.0. For installations other than open trench, the factor may be reduced taking into account the potential for surface damage and installation loads. Trials may be used to provide guidance to the factor.

Table 4.4.1.3 Installation factor

Installation Method	Installation Factor f_2
Open Trench	1.0
Plough-in (Refer Note 1 below)	1.1
Directional Drilling (Refer Note 2 below)	1.2

NOTES:

1. Pipes may be ploughed in by pulling the pipe into the soil cavity behind the plough. Alternatively, the pipe can be placed into the soil cavity as the plough moves along thereby minimising damage to the pipe.
2. The appropriate value is to be determined by assessing the magnitude of surface damage and longitudinal strain caused by proprietary methods. There are other possible factors to be considered when selecting the installation factor f_2 including tensile loads, critical buckling pressures, long term soil loads and the as-built hydraulic grade. Lower values might be appropriate in some circumstances depending upon, for example, the soil conditions, the equipment being used and the length of the drilling operation.

4.4.1.4 Design factor for fluid (f_3)

The design factor for the fluid transported shall be 1.0 for gas and CSG water types. For all other fluid types, refer to Section 4.6

4.5 Risk control and mitigation

The design for gas and saline water Gathering Networks shall implement the external interference and integrity controls to mitigate risk in accordance with the applicable class locations for the network. The physical and procedural measures selected in accordance with Section 2 shall be documented and approved. The selected design shall be reviewed by the safety management study validation workshop.

NOTES:

1. Saline water is defined as water having greater than 40,000 mg/TDS (total dissolved salts as determined by laboratory analysis in accordance with CAS number GIS-210-010).
2. Section 4.5 replaces the prescribed risk factor contained in Version 3 (and earlier versions) of the Code for gas and saline water pipes. As the prescribed risk factor for PFW in the previous versions of the Code was 1.0, the application of Section 4.5 to PFW pipes is not mandated, however the design of PFW pipes shall mitigate the risk associated with the construction and the operation of the PFW network. The principles of this Section may be applied to PFW pipes where the SMS has determined that risk mitigation is required due to the nature of the PFW pipe (e.g. large diameters, higher gas volumes than expected or the closeness of the facility to the public or infrastructure). It is considered that PFW pipes in excess of 2000 standard cubic metres (SCM) of gas / 100 kilo litres (kl) of water should be designed as gas pipes.

4.5.1 Risk control requirements

Risk shall be controlled by selecting a combination of physical and procedural controls to mitigate integrity and external interference threats as detailed in Section 4.5.2. The network designs within Rural Residential and High Use / Sensitive areas shall apply the number of additional control measures as detailed in Table 2.

Table 2 Risk control measures

Location classification	Integrity	External interference
Rural Residential, High Use (for gas)/ Sensitive (for saline water)	2 x Procedural *or* 1 x Physical and 1 x Procedural	1 x Physical and 1 x Procedural

The risk control measures required for the Residential (T1) location class shall be determined separately in accordance with Section 4.6.

The physical and procedural control measures shall be applied to, or installed over, the network for the full length of the location class. Where a higher location or sub-location class (Rural-Residential, High Use or Sensitive), (refer to Section 4.8.2.2), falls within the lesser location class the requirements of the higher location or sub-location class shall be applied to, or installed over, the network for the full length of the higher location or sub-location class plus a distance either side of the higher location or sub-location class equal to:

a) In the case of gas pipes, the distance equal to the 4.7 kW/m^2 full diameter rupture radiation contour for the network MAOP and diameter. Where there are multiple gas pipes in the location class, the highest 4.7 kW/m^2 radiation distance shall be used.

b) In the case of saline water pipes, the drainage distance determined by the elevation profile in the vicinity of the Sensitive location class.

4.5.2 Integrity and external interference controls

Integrity and external interference control shall be achieved by selecting a combination of physical and procedural controls from those given in Table 4.5.2 to conform to the requirements of Table 2.

Table 4.5.2 Additional Integrity and external interference controls

Control Type	Physical controls	Procedural controls
Integrity	• Enhanced crack resistant pipe. • Section isolation by instrumented isolation valves (specifically for saline water networks) • Additional wall thickness (minimum of one standard SDR as per AS/NZS 4130)	• Increased strength pressure test. • Increased QA/QC in accordance with Section 4.5.2.2 c • Condition assessment of pipe and joints in accordance with Section 11.6.2
External Interference	• Additional depth of cover as defined as "Protective Measures" in Table 4.10 • Barrier exclusions • Penetration barriers	• No additional control required, however still required to meet mandatory requirement of Procedural control for external interference risk mitigation in accordance with Section 4.5.2.4

4.5.2.1 Physical controls for integrity risk mitigation

Physical controls for Integrity risk mitigation shall be selected from the following:

a) Enhanced crack resistant pipe

The purpose of enhanced crack resistant pipe or fittings is to improve the resistance to stress crack initiation caused by stress concentration (slow crack growth) due to physical damage. There are several types of stress concentration experienced by operating networks caused by point loads and/or mechanical stress.

Use of enhanced crack resistant pipe or fittings, as an effective integrity control, shall be assessed under Section 4.6 'Fit for Purpose Design'.

b) Section isolation by instrumented isolation valves

Section isolation reduces the consequence of the loss of integrity rather than achieving improved integrity. Nonetheless it is considered a physical risk reduction technique. Section isolation can be used for either gas or saline water pipes.

For section isolation to be an effective control, the isolation valves should be remotely controlled fail close valves and subject to regular critical function testing as per the IMP schedule.

c) Additional wall thickness

Allowing for an increased wall thickness should provide an additional buffer to help reduce crack initiation by reducing stresses within the pipe wall.

4.5.2.2 Procedural controls for integrity risk mitigation

Procedural controls for Integrity risk mitigation shall be selected from the following:

a) Increased strength pressure tests

Increasing either or both the level of pressure and the duration time of the pressure test provides assurance that components making up the network, particularly joints, have a higher level of integrity.

For increased pressure and duration tests to be effective, the minimum test pressure shall be in accordance with the location class and shall conform to Section 8.4.1 Table 8.4.1(a) for a minimum period of six hours.

b) Testing and Inspection

Conformance with testing and inspection requirements as specified in Section 7 of this code.

c) Increased quality assurance and quality control (QA/QC)

QA/QC can provide improved integrity assurance through material selection and traceability of all materials and joints in the section of the Gathering Network under consideration.

Options should include:

- Visual inspection of pipe ends to ensure the absence of voids by examination of swarf;
- NDT of fittings against an approved methodology and acceptance criteria; and
- Completion of oxidation induction time (OIT) and Fourier transform infrared spectroscopy (FTIR) tests on targeted pipes and fittings to verify conformance with the prescribed pipe and fittings standards.

The approach to increased QA/QC shall be documented and approved.

4.5.2.3 Physical controls for external interference risk mitigation

Physical controls for external interference risk mitigation shall be selected from the following:

a) Separation by burial

Burial is a protective method that separates the pipe from most activities of external parties. Burial may be counted as a physical control when the depth of burial (below grade level) is considered to preclude damage to the Gathering Network by the defined external interference threats relevant to the location.

For separation by burial to be effective, the depth of cover shall conform to Table 4.10.

b) Separation by barriers

Barriers are a physical protection mechanism against certain types of external interference events, particularly those involving vehicles and mobile plant.

Examples of separation by barriers include:

- Crash barriers on bridges carrying pipes; and
- Fencing around surface equipment (such as wellhead facilities and infield risers).

c) Penetration barriers

Physical barriers may be used to resist penetration. Where a barrier prevents the defined external interference threat from access to the Gathering Network the barrier may be counted as a physical control.

Barriers may be one of the following:

- Concrete slabs: Where slabs are used to provide protection, they shall have a minimum width of the nominal diameter plus 600 mm. They shall be placed a minimum of 300 mm above the pipe; and
- Other barriers: other physical barriers may also be used such as PE plates with appropriate markings using the relevant sections of 3.3.1 as a guide (or using warning tape, which should be positioned directly above the barrier).

Barriers shall have the mechanical properties necessary to provide the required protection to the network from the external interference threats and shall have the chemical and physical properties necessary to maintain the integrity of the barrier.

4.5.2.4 Procedural controls for external interference risk mitigation

All procedural controls associated with external interference shall be in accordance with the control measure determined during the SMS as per Section 2.6.4.3 with consideration to the location classification risks.

NOTE: Except for major highways (high capacity roads managed by state and territory government agencies) and railways, where due to the installation method the depth of cover is likely to exceed 1200 mm, the High Use locations are most likely to be in the vicinity of the Operator’s compressor stations or camps, so first party interference is the most likely threat. Effective mitigation should be provided through construction exclusion zones, excavation plans and work permitting.

4.6 Fit for purpose design

Subject to the exclusions detailed below, this Code allows the design and construction to occur under a ‘Fit for Purpose’ design as detailed in this Section of the Code.

4.6.1 Basis for fit for purpose design

This Section sets out the basis for a ‘Fit for Purpose’ design of the network or network, which subject to the conditions below, shall be deemed to conform to this Code. However, nothing in this process is to place any personnel, community, plant or the environment at increased risk.

Fit for purpose design does not apply to and cannot be used for:

- The use of the option where it has been excluded by legislation; or
- The design of plant piping.

Examples of where fit for purpose design could be used, subject to the above exclusions, include:

a) PE materials other than PE100;

b) Advanced resin compound variants, such as higher strength resins, PE100-HSCR (high stress crack resistant PE100 as defined by PIPA Guideline POP 016) and PE-RT (polyethylene of raised temperature resistance);

c) Operating conditions - pressures and or temperatures outside the scope of this Code;

d) Fluids other than those covered by this Code (hydrocarbon fluids with C3+, or hypersaline water);

e) Residential (T1) locations as defined in Section 4.8.2;

f) Construction methodology (trenched, ploughed, bored, etc) in relation to design factor 2, Section 4.4.1.3; and

g) Above ground water and gas services.

4.6.2 Minimum requirements

The minimum conditions under which a 'fit for purpose' design may be undertaken, and deemed to conform to this Code are:

a) Where it is inappropriate to use a prescribed design as there are unusual threats, complications or land-use requirements. The areas of unsuitability shall be documented and included in the design;

- The fit for purpose design shall be based upon a demonstrated methodology, which conforms to international standards, Australian or International experience or research;

b) The design shall be fully documented in a 'design book approach' incorporating but not limited to:

    - An overview (reason for use);
    - Basis of design as per (b);
    - Design calculations;
    - Threat assessments;
    - Risk assessments and mitigations;
    - Construction and test methodology including test factors; and
    - Operational and integrity management plans.

c) The design shall be approved;

d) The design shall conform to the requirements of the Network Management System and Safety (Section 2), Commissioning (Section 10), and Operations (Section 11) of the most recent edition of this Code;

e) The design shall be constructed and tested in accordance with the most recent edition of this Code; and

f) Where appropriate, the design should be based upon activity agreements with other entities. For example, an activity agreement may be considered to contribute to the safety or environmental performance of the design (and the network) where the owners of adjacent assets are party to the agreement and they have systems in place to conform to the provisions of the agreement.

4.6.3 Network design – Fit for purpose method

The design factor(s) shall be evaluated subject to the conditions detailed in Section 4.3.5, 4.3.6 and 4.4.1. These factor(s) shall not be less than 1.0.

The risk control measure(s) shall be evaluated subject to the conditions detailed in Section 4.5.

The process for evaluating the design factors (for example with the use of ISO Miners rule or exploitation of advanced resin properties) shall involve a detailed risk and engineering assessment on the proposed operating and design conditions of the Gathering Network and be subject to a third-party review by a competent designer or assessor. This process shall be approved.

The different design factors or risk control measures require specialist evaluation skills. Relevant personnel shall be competent in the specialist subject matter pertinent to the design factor under consideration as detailed in Table 4.6.3.

Table 4.6.3 Design and risk control factors under fitness for purpose

Design factor / risk control measures	**Competency / skill to include appropriate tertiary qualifications and relevant expertise**	**Minimum personnel involved**
Material Factor (f_0)	Resin and pipe manufacturing characteristics	Designers, resin manufacturers, construction personnel
Temperature factor (f_1)	Resin characteristics	Designers, resin experts
Installation factor (f_2)	Construction methodology	Designers, pipe/resin experts, construction personnel
Fluid factor (f_3)	Resin characteristics, chemistry	Process engineers, resin experts
Risk control measures	Risk management	Designers, EHS personnel, stakeholders
Overpressure Excursion using ISO Miners Rule	Resin and pipe manufacturing characteristics	Designers, resin manufacturers

Examples of this review cover different installation techniques with an f_2 factor higher than 1.0. Test results after installation can be undertaken to prove the integrity of the method of construction. These results can be used to gather evidence for a change in the installation factor.

Another example is for higher temperature conditions than stated in this Code. This impacts the factor f_1. Extra testing can be conducted to determine if a higher mean wall temperature can be used and its effect on the strength of the material. This may be needed when pumping brine solutions as tests to date indicate that temperature of the fluid exceeds 85°C in some cases.

The ISO Miners rule is a method for predicting cumulative damage caused by cyclic variant loading. This allows the designer to predetermine a safe exposure period (i.e. hours/year/50-year design life) whereby the HDPE pipe can exceed 110 per cent of MAOP by a calculated margin. Note, this rule is to be determined post design pressure calculation outlined in Section 4.3.5.1 and does not require the designer to alter the design factors listed in Table 4.6.3.

Design and evaluation of a defined overpressure excursion other than the nominal 110 per cent of MAOP already stated in this Code, may be evaluated, and provided the evaluation is in accordance with the requirements above and Section 4.18.

To provide mechanical protection of the pipe extra wall thickness in many cases may not be the best solution and extra depth, marker board and/or concrete slabbing may be a suitable method of providing this physical protection. In addition, other procedural methods such as extra signage and/or extra warning tape may also be considered to reduce the risk of damage.

4.7 Route

The route of a network shall be selected having regard to public safety, network integrity, environmental impact, and the consequences of a loss of containment of the fluid due to leakage or rupture.

Route selection should take into account the location of start and end points, well locations and access requirements, hydraulic requirements based on topography, existing services and infrastructure, and current and future land use. Route selection shall form part of the network design process.

The route of a Gathering Network shall be selected such that the pipe can be installed, tested, and operated safely and practically. This includes considerations such as limiting of significant elevation changes, proximity to existing roads and infrastructure and avoiding areas of high land use.

Route selection shall also include the grouping of pipes into common trenches as appropriate, along with consideration of separation distances where new pipes are required to cross existing assets.

The presence of existing pipes shall be identified and documented, along with any requirements to amend existing access arrangements in areas where the new network is likely to closely parallel or cross a licensed pipeline.

Other considerations should include:

- Locations of water sources for dust suppression and/or hydro testing;
- Soil rehabilitation requirements e.g. the need for gypsum immediately after first disturbance or during rehabilitation, and/or if reseeding is required;
- Locations for storage of cleared vegetation;
- Requirement for mulching;
- Spindle lengths on valves depend on depth of cover (DOC);
- Crossings of third-party infrastructure as close as possible to perpendicular;
- Co-location of infrastructure wherever possible to reduce the impact to the property and reduce long term rehabilitation obligations;
- Avoid steep slopes and side slopes if possible and align straight up and down hills;
- Avoid rocky areas where possible;
- The exact location of isolation valves, LPDs and HPVs surface infrastructure for constructability and flooding potential;
- Traffic management – designated property entry and exit points; and
- Lead time for approvals of third-party crossings.

4.8 Location classification

4.8.1 General

The network route shall be allocated location classes that reflect threats to network integrity and risks to people, property and the environment. The primary location class shall reflect the population density. For a new network, the location class analysis shall be based on the land use permitted in gazetted land planning instruments. Although CSG and PFW Gathering Networks are generally located in remote areas, and within mining and/or petroleum leases under the occupation and control of the various lease owners, consideration needs to be given to the surface use of the land (farming, grazing etc.).

Location class analysis of an existing network shall take full account of current land use and authorised developments along the network route, and consideration needs to be given to land use which is planned, but not yet implemented.

4.8.2 Location classification

The network route shall be classified into Location and Sub-location classes as defined below.

4.8.2.1 Location classes

a) Rural (R1): Land that is unused, undeveloped or is used for rural activities such as grazing, agriculture and horticulture. Rural applies where the population is distributed in isolated dwellings. Rural includes areas of land with public infrastructure serving the rural use; roads, railways, canals, utility easements.

b) Rural Residential (R2): Land that is occupied by single residence blocks typically in the range 1 ha to 5 ha or is defined in a local land planning instrument as rural residential or its equivalent. Land used for other purposes but with similar population density shall be assigned Rural Residential location class. Rural Residential includes areas of land with public infrastructure serving the Rural Residential use; such as roads, railways, canals and utility easements.

c) Residential (T1): Land that is developed for community living. Residential applies where multiple dwellings exist in proximity to each other and dwellings are served by common public utilities. Residential includes areas of land with public infrastructure serving the residential use such as roads, railways, recreational areas, camping grounds/caravan parks, suburban parks, and small strip shopping centres. Residential land use may include isolated higher density areas provided they are not more than 10 per cent of the land use. Land used for other purposes but with similar population density shall be assigned Residential location class.

4.8.2.2 Sub-location classes

a) High Use

The High Use sub-location class is defined as areas of activity, within the 4.7 kW/m^2 full diameter rupture radiation contour, such as processing plants, site camps, workshops, major highways and railways where personnel or the public is expected to be present on a frequent basis. This sub-location class is applicable to the rural and rural residential location classes for gas and water networks having high gas to water ratios (See Note 2 – Section 4.5) only.

b) Sensitive

The Sensitive sub-location class is defined as environmentally sensitive areas such as major waterways and river crossings. This sub-location class is applicable to all location classes for saline water networks only, (See Note 1 - Section 4.5 for definition of saline water).

4.9 Isolation requirements

The isolation principles based on risk assessment protocols shall apply to each network. Each network shall have sufficient valves and isolation facilities as required to enable the effective commissioning, regular operation and maintenance activities, and limit exposure in the event of a controlled or uncontrolled release. The water network should be capable of transporting water, as required, to support wellhead activities, such as drilling, stimulation and future workovers. The position, type and spacing of valves and isolation facilities shall be approved.

The location of valves shall be determined for each network. An assessment shall be carried out and the following factors shall be considered:

a) The fluid;

b) Security of supply required;

c) Response time to events;

d) Access to isolation points;

e) Ability to detect events which might require isolation;

f) Consequences of fluid release;

g) Volume between isolation points;

h) Pressure; and

i) Operating and maintenance procedures.

Valve selection shall provide the appropriate level of isolation and leak tightness based on the fluid in the network and the location. Location may include end-of-line or infield infrastructure, and shall also take into account above or below ground installation.

When using alternate riser materials (other than carbon steel), as part of the wellhead facilities, in case of fire downstream isolation valves shall be installed at an appropriate distance.

If a gathering pipe is designed to be ‘piggable’, valve selection shall be limited to full bore through-type (ball, through-conduit gate, etc).

Valves shall be installed so that, in the event of a leak, the valves can be expeditiously located and operated. Consideration shall be given to providing for remote operation of individual valves to limit the effect of any leak that may affect public safety and the environment.

4.10 Depth of cover

PE pipes shall be buried at a minimum depth of cover (below grade), as shown in Table 4.10 below, except where specific circumstances exist which would justify a lesser depth. Examples of “reduced cover” could include wooded areas (where reduced working width is required and future land activities unlikely) and/or rocky ridges. In these locations the conditions may make the installation risk with minimum depth of cover greater than the expected risk reduction. Depth of cover may also be reduced where one pipe crosses an existing pipe operated by the same Operator, and the Operator has full control over networks in that area.

For above ground pipe refer to Section 4.13

The basis for the specific circumstances where depth of cover is reduced shall be assessed and documented in the safety management study and shall be approved.

Pipes buried at "reduced cover" should be subject to:

- The sub-location class not being High Use or Sensitive;
- A risk assessment confirming no decrease to safety and network integrity, safety during testing and detailing any required mitigation controls;
- Consideration given to external loading;
- Consideration given to buoyancy mitigation; and
- Consideration given to soil erosion.

Table 4.10 Minimum Depth of Cover

Location classification	**Minimum depth of cover (mm)**		
	Standard for all fluid types	**Protective measure** (Refer Table 4.5.2 and Section 4.8.2)	
		Gas	Saline water
Rural	750	750	750
Rural-Residential	900	900	900
High Use	N/A	1200	N/A
Sensitive	N/A	N/A	1200

The depth of cover shall be increased as required to provide additional protection based on the network safety management study completed in accordance with Section 2. (Further guidance is provided in Appendix A).

4.11 Resistance to mechanical damage

The risk of mechanical damage to the pipes shall be determined based on location, land use and depth of cover. Where required, the depth of cover shall be increased or suitable protection placed above the pipes. Land use shall include the frequency and type of deep blade ploughing regularly undertaken on rural properties.

External interference protection shall consider physical measures to prevent personnel access to the network in the vicinity of the CSG well-heads.

As PE pipes have very little resistance to penetration, additional early warning physical measures such as tracer wire, marker tape or detectable marker products should be used to assist in non-intrusive pipe detection and early warning confirmation during exploratory dig-ups.

4.12 Separation

Separation of buried pipes shall be adequate to address design aspects related to:

- Constructability;
- Future tie-in requirements;
- Maintenance; and
- Emergency response, especially related to the use of squeeze-off equipment.

4.12.1 Adjacent parallel buried pipes

Where pipes are grouped in a common trench and are servicing various utility providers/owners the minimum separation distances shall be used as shown in Table 4.10. Where pipes within a common trench are operated by an individual operator, deviation from the following separation requirements may be selected based on risk assessment.

Table 4.10 Minimum separation distances

External diameter (mm)	Minimum spacing (mm)	Preferred spacing (mm)
≤315	200	300
>315, ≤450	300	400
>450	300	500

Where pipes of different diameters are used, spacing shall be determined based on the average diameter of the two.

The separation distances may need to be increased should they prove to be insufficient for installation and maintenance purposes.

4.12.2 Vertical separation of crossing PE pipes

Pipes crossing within a Gathering Network should be avoided where possible but, where necessary, adequate spacing should be allowed for construction, maintenance and emergency response purposes.

The minimum vertical separation between pipes shall be 300 mm. This separation shall be filled with compacted embedment material.

Where 300 mm separation is not possible, or is impractical, the separation may be reduced to a minimum of 200 mm based on a risk assessment and with the agreement of the Operator(s) concerned. Compressible packing (e.g. expanded polystyrene) should be used between the pipes to reduce the risk of point loading.

4.12.3 Foreign crossings

PE pipes may cross a variety of other services including fibre-optic, telephone and electrical cables, high pressure gas steel pipelines and other gas and CSG water PE gathering pipes. Adequate separation shall be maintained, with a minimum of 300 mm, and other precautions, similar to Section 4.12.2 above, may be used.

Where necessary, specific attention should be directed to the provision of additional buried marker tapes and/or marker posts at these locations.

4.13 Special construction

Special construction methods apply to sections of the Gathering Network that are not generally formed from full pipes joined together and laid in a trench at normal cover.

Because these sections are location and network specific, each application requires special consideration to identify and analyse factors that exist at the location and to develop special designs that are adequate to protect the network from the threats that do, or may, exist at that location.

4.13.1 Above-ground or reduced cover networks

PE CSG water pipes may be installed permanently above ground or at reduced cover within a facility or other location where public access is excluded by fencing or equivalent measures. Examples of permanent above ground water pipes include dam connections to truck filling lines.

Temporary water pipes without fencing can be used above ground, where acceptable by the SMS process, and defined end uses of the temporary line identified. An example where this can be considered is a water transfer line during drilling activities.

PE CSG gas pipes may be installed for short term periods, in limited circumstances, above ground or at reduced cover at locations where public access is excluded by security fencing or equivalent measures.

PE CSG gas and water PE risers may be installed permanently above ground, limited to locations within a facility or other location where public access is excluded by fencing or equivalent measures. This is to reduce corrosion issues in risers as discussed in Section 11. When installing above ground risers due consideration shall be given to vandalism, bush fires, integrity and any other external threats identified in risk assessments.

The design shall be risk assessed and consider issues such as increased temperature and ultraviolet (UV) degradation and include appropriate protective measures. For example, shading may be required for mitigation of elevated pipe temperature, especially in the case of black pipes. Pipe operating temperatures shall be in accordance with Section 4.19 and 4.20.

As UV degradation of coloured PE compounds occurring beyond the normal storage period (i.e. >2 years) may lead to crack initiation within the coloured compounds, all above-ground pipe subject to internal pressures greater than 80 kPag, shall conform with the following criteria:

- Striped or coloured pipe, other than those defined below, shall not be used, except for temporary pipes approved by the Operator.
- Pipe shall be extruded from black compound or black compound with a full coextruded white jacket.

- White jacketing compounds shall conform to PIPA Guideline POP 017. Compounds evaluated against these requirements are listed in PIPA Guideline POP 004.
- Pipe fittings shall share an equivalent level of protection as the parent pipe. This may be achieved by using the same PE material as for the pipe, wrapping, shading, or use of suitable paint.
- MAOP and design pressure shall conform to Section 4 of this document.
- Pressure testing of above-ground or reduced cover sections of PE Gathering Networks shall be performed in accordance with Section 8 of this document.

Above-ground networks shall be installed to provide protection and support for the PE material. Installations shall also include measures for temperature control to ensure the material does not exceed its maximum rated temperature due to environmental effects. This includes special start-up sequences to cool the PE material when surface temperatures result in the pipe strength being too low to provide suitable pressure containment.

Where PE is installed with reduced cover, the basis for the reduced cover shall be assessed and documented in the safety management study.

NOTE: The intent of permitting above ground use of gas pipes is to cater for circumstances such as mine de-gassing interconnects, where operating pressures are less than 100kPag and interconnects are re-located several times per year, in line with mine operations.

4.13.2 Installation of pipes on a curve

PE piping can be safely installed by roping the pipe to accommodate direction changes using methods described in the PIPA Guideline POP 202. Jointing by butt fusion or electrofusion should always be done on straight pipes.

4.14 Design for external loads and seismic survey activity

External loads may be imparted onto the network by various forms of dead and live loads. However, for axle loads <=120 kN no action is needed provided the depth of cover is >0.75 m and the SDR is <=21.

For axle loads >120kN and/or SDR>21, an engineering assessment shall be required. The assessment shall be approved.

External pressure loads may also be imparted onto PE pipes as a result of seismic surveys or other underground blasting being conducted in the local area. Blast loads are seen as a potential threat to a network, and shall be appraised during the risk assessment.

NOTE: PE pipes have performed better than other materials installed in earthquake zones.

Reference documents such as 'PRC – Pipeline Response to Blasting – PR-15-712' and 'US RI 9523 – Surface Blasting near Pressurised Pipelines', although not strictly applicable to PE pipes, may be used as a guide for consideration of seismic loads.

4.15 Network route marking

Network route design and planning shall include the installation of markers to identify the location of PE Gathering Networks.

Both gas and CSG water pipe marker signs shall conform with Section 5.11.

4.16 Riser and valve assemblies

Above-ground steel valve assemblies shall conform to the requirements of ASME B31.3 or AS 4041.

PE may be used for above ground risers. Consideration shall be given to risks associated with the material, service and environment (such as solar radiation and fire) as part of the SMS process, refer to Sections 2 and 4.13.1.

Other materials, i.e. composite pipe and GRE, shall meet the required standards.

Underground valve assemblies shall be buried in accordance with the manufacturer's instructions. Provision shall be made for operational and maintenance access to buried valve assemblies.

Location of risers, low point drains and high point vents shall be included on the alignment sheets. The design process shall include provision for capturing and draining liquid from low point drains.

Consideration shall be given to the locking or other valve operating mechanisms to prevent unauthorised operation.

Vents on CSG water pipes shall be used in rural locations only, and should be located a minimum of 100m away from the property line of rural-residential and residential areas. Vents on CSG water networks shall be designed to vent intermittently.

4.17 Structural design

Structural design of PE pipes shall take into account all expected stresses and loads which may impact on the Gathering Network during its lifetime. Transitions from surface to sub-surface should particularly be addressed. Further information can be found in PIPA Guideline TP005 'Flexible Pipe Design'.

4.18 Over pressure protection

PE Gathering Networks shall be equipped with facilities to prevent pressures rising above 110 per cent MAOP. The number, type, and location of over-pressure devices shall be documented and approved. Over-pressure design shall ensure the network does not exceed MAOP under normal operating pressure scenarios. Over pressure protection shall include events during normal and abnormal operating conditions.

The MAOP of a network can be exceeded by up to 10 per cent for transient situations subject to the network having been tested to 125 per cent of MAOP.

Operators may nominate an overpressure excursion limit beyond the 110 per cent, for a defined period, given they conform with the requirements of the 'Fit for Purpose' assessment detailed in Section 4.6 Fit for purpose design.

Where any pressure control or overpressure protection discharges fluids from the network, the discharge shall be safe, have minimal environmental impact and not impair the performance of the pressure control or over pressure protection system. Risks associated with liquid discharge shall be managed to ALARP.

4.19 Over-temperature protection

Over-temperature protection is not generally required for CSG PE Gathering Networks.

For Gathering Networks, over-temperature monitoring and/or protection shall be incorporated in locations and services where excess temperature is likely to reduce the

PE strength to a point where pressure integrity may not be guaranteed (e.g. above-ground pipes in hot conditions).

The design and selection of over-temperature protection systems shall be documented and approved. Consideration may be given to a system which initially cools the PE material prior to introduction of pressurised fluids.

4.20 Temperature consideration

4.20.1 Temperature re-rating

The pressure rating of PE pressure pipe shall be based on the temperature of the pipe wall, which may be determined from:

a) An assumption of a constant pipe wall temperature typical for continuous service at a set temperature;

b) The determination of a mean service temperature where temperature variations are likely to occur in a predictable pattern; or

c) The maximum service temperature less 10°C for installations where large unpredictable temperature variations occur up to a maximum of 60°C.

For installations where predictable temperature variations occur, the average material temperature shall be determined from (a) or (b) above as follows:

- Across the wall of the pipe, the material temperature taken as being the mean of the outer and inner pipe wall temperatures.
- For pressure and temperature conditions where flow is stopped for prolonged periods so that fluid temperature and outside temperature may equalise, a time weighted mean temperature may be determined.

4.20.2 Provision for expansion and contraction

For fully welded buried PE pipe there is generally no need to allow for thermal expansion and contraction. For above ground PE refer to Section 4.16, and do consider thermal expansion and contraction.

For PE100, the value of the thermal expansion coefficient used in calculations shall be 20×10^{-5}/°C.

4.21 Static electricity

For CSG PE gathering lines where the gas generally has a high moisture content, static electricity may be generated.

These areas of the Gathering Network identified as having potential for static build-up shall be treated as hazardous areas in accordance with AS/NZS 60079.

AS 4645.3 may be used as a guideline for design against the effects of static electricity.

4.22 Mine subsidence

Where CSG network infrastructure is in the same physical area as underground longwall mining, there is the potential for the PE network to be affected by mine subsidence.

NOTE: Refer to the appropriate Companion Paper for further information.

4.23 Effects of pressure surge – CSG water only

Networks for CSG water shall be capable of withstanding surge or transient loads experienced in the events of pump start-up, shut-down, and unexpected trips or valve closures.

Refer to PIPA Guideline POP 010A for information about the fatigue resistance of PE pipes, which can result from multiple surge events.

Where required, the network design should be supported by transient analyses to identify areas of high surge potential, and determine appropriate restraining mechanisms. Such analyses may be undertaken in conjunction with those for determining over-pressure protection requirements.

Pumps, valves (including opening and closing rates), pipe diameter and flow velocity shall be selected to minimise the possibility of surge events.

Consideration shall also be given to the fitting of such devices as pressure accumulators (pneumatic or hydro-pneumatic) to mitigate water hammer from transient loads and/or air/vacuum valves to mitigate vacuum re-closure water hammer.

4.24 Effects of vacuum – water only

Where potential vacuum effects cannot be avoided, CGS Gathering Networks shall be designed to resist buckling under full vacuum.

CSG water networks may contain a mixture of water and gas. Design of external protection devices should ensure that air is not introduced into the network in quantities which may give rise to an explosive atmosphere.

4.25 Elevation control – other materials – CSG water only

In CSG water Gathering Networks, where the pressure at the lowest point exceeds 2,500 kPag, due to elevation head difference, and exceeds the design rating of PE 100 materials under either the ‘Prescribed’ design (Section 4.4) or the ‘Fit For Purpose’ design (Section 4.6), suitably pressure rated alternate materials for pipe and fittings, such as fibre reinforced plastic (FRP – composites) or glass reinforced epoxy (GRE), may be used for the short distances over which the pressure due to elevation exceeds 2,500 kPag.

These materials have specific design, installation and test methods which differ substantially from that used for PE in this Code. Materials shall be supplied in accordance with API 15S, API 15LR or AS 3571.2. Design, installation and testing shall be in accordance with either ISO 14692 or DNVGL-RP-F119.

Where these materials are used, the requirements of the Network Management System (Section 2), Records Management (Section 9), Commissioning (Section 10) and Operations (Section 11) shall apply where relevant.

NOTES:

1. ASTM F2805 and F2896 provide additional guidance for the material requirements.
2. AS 2885 Appendix AA provides additional guidance for design, installation and test procedures.
3. Steel is not recommended due to issues associated with corrosion.

5 Construction

5.1 Basis of section

The Gathering Network installation and construction shall conform to the engineering design and the following:

a) Construction shall be carried out to ensure the safety of the public, construction and operating personnel, equipment, adjacent property and the network;

b) During construction care shall be taken to minimise damage to the environment;

c) On completion of construction any necessary restoration along the route shall be carried out to minimise long-term degradation of the environment and shall be conducted in conformance with the relevant Government Environment conditions and landowner agreements; and

d) Construction personnel shall be competent and, where required, qualified for their task.

NOTE: This section covers both PE Gathering Network construction in new greenfield activities and existing brownfield situations involving live Gathering Networks.

5.2 Types of construction

Several types of construction methodology are used in the installation of PE Gathering Networks and are covered by this Code. These types are:

- Trenching;
- Plough-in;
- Trenchless; and
- Bell-holes.

NOTES:

1. Refer to the appropriate Companion Papers for further information.
2. Specifically. for brownfield locations, the validation of information available for buried legacy assets, especially electrical cables, should be considered within the work procedures and related excavation and permitting procedures.

5.3 Development of specifications and procedures

5.3.1 General

Consideration should be given to the general criteria below which are applicable to all installation methods:

- Installation techniques shall ensure that the minimum design depth of cover is achieved.
- The location of above- and below-ground existing services shall be identified and located prior to commencing pipe installation with necessary controls implemented.

5.3.2 Trenching

Consideration shall be given to the following criteria when developing specifications and procedures for installing a trenched PE network:

- Trench excavation is to be achieved by the use a trenching machine, excavator with an attachment or similar. In both instances, the objective is to achieve a trench bottom free of rocks, stones or other material with an angular profile that may cause damage to the pipe, and a trench profile in continuous contact with the pipe. When such conditions are achieved, the PE pipe may be laid directly on the bed of the trench; and
- Where necessary, blasting shall be carried out in a safe manner and in accordance with AS 2187.2, statutory requirements, and the blasting procedures shall be approved. In such instances, strung PE pipe should not remain in the blast vicinity.

5.3.3 Plough-in

Plough-in installation should be achieved by the use of plough-in equipment in combination with excavators or other equipment.

Consideration shall be given to the following when developing the specifications and procedures for installing a PE pipe using plough-in technology:

- The plough-in installation methodology shall not place induced stress on the pipe which may cause kinking, deformation or damage to the pipe;

  Note: Plough technologies shall be assessed and tested to ensure such conformance. These can be achieved through investigation pits within new ground conditions.

- The material surrounding the pipe shall be such that damage from rocks or stones is minimised;
- Care shall be taken to protect the integrity of the pipe during any compaction or subsequent works in proximity to the installed pipe; and
- Likelihood of rupture due to excessive pipe movement in the trench allowing rubbing of the pipe against sharp objects.

5.3.4 Trenchless construction

Trenchless construction comprises various types of subsurface construction techniques that employ materials, methods and equipment to install a pipe or casing between two defined points where it has been determined that the usual open trenching or plough-in is not practicable. e.g. crossing railways, roads and major water courses, etc. Some common methods are horizontal directional drilling (HDD), micro-tunnelling (closed face) and auger or thrust boring (open-faced).

Consideration shall be given to the following criteria when developing specifications and procedures when using trenchless construction:

- Profile and layout design shall be performed by qualified engineers with relevant design experience;
- Consideration of crossing configurations, soil characteristics and any possible loads that may be applied to the pipe network as a result of sub-terrain or surface conditions;

- Reaming techniques to ensure that the inserted pipe and ground surfaces are not damaged;
- Control measures to protect the pipe from damage or excessive tensile stress during insertion. The tensile force applied during installation shall not allow pipe deformation or yielding;

  Note: A suitably rated breakaway coupling can be used to achieve this objective
- Cleaning of the casing pipe before insertion and removing obstructions so that the inserted is not damaged during installation;
- Collars and sheaths at entry/exit points to protect the new pipe from being gouged;
- Management of environmental factors such as disposing of slurry or chemicals used in fluid mix and protection of waterways;
- Inspection of the first 2m of the inserted pipe on exit to check for damage;
- Installation of pipe locating/detection products e.g. tracer wire; and
- Requirements from utility owners, including identification and separation from existing services, and structures.

NOTE: Each trenchless construction technique has its own suite of considerations. Refer to appropriate Companion Paper for further information. In addition, the Australian Society for Trenchless Technology has reference guidelines.

5.3.5 Bell-hole excavation

5.3.5.1 General

Bell holes occur in all aspects of both greenfield and brownfield network construction activities including the following:

- Network tie-ins and connections;
- Installation of related network facilities low point drains, high point vents, air release vents, test points etc.;
- Crossings of existing services, corridors etc.; and
- For trenchless construction, commencement and completion working locations.

Bell-hole excavation shall be performed in a safe manner, using established procedures, work permitting systems and competent staff.

NOTE: Bell-hole excavations involve various hazards (such as hazards associated with the excavation process, working in a confined space, and lifting) which require appropriate controls such as work permitting and endorsed work method statements.

5.3.5.2 Brownfield

For bell-holes in Brownfield installations additional hazards may be present and hence consideration should be given to:

- Gas presence, in both the gas Gathering Network and (partially) in the produced water Gathering Network; and
- Electrical and communication cables in the excavation.

When excavation is required, consideration shall be given to:

- Locating of existing services e.g. by pot holing or similar; and
- Partial excavation by machine only-normally no closer than 300 mm (the minimum prescribed distance of marker tape above existing PE pipes and related infrastructure).

5.4 Survey

5.4.1 General

A survey shall be made to locate the Gathering Network (and all related infrastructure) relative to permanent marks and benchmarks conforming to Mapping Grid of Australia (MGA 94) or other approved datum. The construction survey shall adopt the same marks and benchmarks as used in the engineering design unless otherwise approved.

The survey shall develop sufficient information on the constructed Gathering Network to satisfy the materials traceability requirements of this Code.

Specific survey locations which should be captured are those which occur at crossings (such as road, rail, creeks, rivers, third-party infrastructure), at changes of direction, fence lines and boundaries.

The existence of services, structures, and other obstructions in or on the route shall be checked, identified and recorded before construction begins, and the location of these shall be recorded in the as-constructed survey record.

5.4.2 Survey accuracy

The survey shall establish the coordinates that suitably locate the Gathering Network in accordance with the engineering design. The uncertainty of the x-y coordinates shall not exceed 500 mm in R1 location classes and 100 mm in all other classes.

5.4.2.1 Standard Construction

The uncertainty of the as-built top of pipe level shall not exceed 50 mm. Where the survey is required to establish the elevation of the pipe, the accuracy of the elevation measurement shall be documented.

5.4.2.2 Trenchless construction (boring/drilling)

Where a section of the network is installed by trenchless construction methods, an as-built survey shall be undertaken to establish the position of the installation in x-y-z coordinates.

As a minimum:

a) The deviation from the design x-y coordinates shall not exceed 0.4 degrees measured from the coordinates of the pipe string at the start and the end of the drill;

b) The survey shall be compatible with the survey coordinate system used for the network; and

c) The accuracy limits of the as-built survey shall be defined on the as-built alignment sheets (and/or GIS).

5.4.3 Survey Records

As required by Section 9, a record of surveys shall be made so that, after the Gathering Network has been constructed, an accurate record of the constructed network can be made to show the precise location of the pipes and related facilities and should include, as a minimum, weld numbers and pipe numbers for identification.

A consistent weld numbering format, to enable unique numbering and identification of each weld, shall be used and documented.

All spatial data shall be referenced against an approved datum and provided to the operator in an approved electronic format, suitable for incorporating in a geographic information system (GIS). Where necessary, permanent reference marks and benchmarks shall be provided.

Electronic and paper records of the as-constructed design may also be required by the owner.

AS 5488 Classification of Subsurface Utility Information (SUI), provides a framework for the classification of subsurface utility location and attributes information in terms of specified quality levels.

5.5 Transport, Handling and Storage

5.5.1 Polyethylene pipes and fittings

Pipes and fittings are transported long distances from their manufacturing origins using many transport and road types. Lifting, handling and driving safety protocols need to be considered throughout the transport period to minimise damage (due to PE being relatively soft and susceptible to damage).

Additional information on storage, transport and handling of PE pipes may be found in PIPA Guideline POP 005. In particular, attention is drawn to the dangers associated with stored energy in coiled pipes or those rolled on drums.

Pipe loading and unloading procedures shall incorporate protection for the work crew from stored energy in the pipe as well as to preserve the integrity of the pipe.

5.5.2 Handling

PE pipes and coils, and other components, shall be handled, transported and stored in a manner that will provide protection from physical damage and other types of deterioration. For pipe lengths and coils, handling in temporary stockpiles should be minimised by delivering direct to the end-use construction right-of-way location, wherever possible.

For pipe lengths in particular:

- Pipes shall be stacked to prevent excessive localised stresses and to minimise damage;
- Supporting blocks and bearers shall not damage pipes;
- Pipes that may be subjected to damage from traffic, shall be located either at a safe distance from the traffic or be guarded by protective barriers;

- Stringing, joining and lowering-in operations shall be carried out in a manner to protect the pipe from damage;
- During lifting, the pipes shall be adequately protected to prevent damage such as scouring and crushing; and
- Sharp sections bearing against the pipes shall be avoided as these can cause indentations in, or scoring of, the pipe wall.

5.5.3 Storage

Pipes shall be stored in a manner to prevent damage from elevated temperatures, contact with chemicals, and prolonged exposure to direct sunlight and distortion. If pipes are to be stored over long periods, the pipes shall be covered to prevent exposure to direct sunlight which can often result in degradation of the PE pipe material. Pipes other than plain black should not be stored for more than 24 months unless protected from direct sunlight. If this is not done, assurance tests and checks should be carried out to verify the condition of the pipe for its intended use.

Pipes stacked for transport or storage shall be adequately supported to avoid distortion. This shall include adequate support and protection using bolsters, timbers or other means to alleviate the potential for damage during transport and storage.

Safety and handling shall be considered with respect to stacking height, taking into account surface and climatic conditions. Bundled packs of pipe should be stacked in a suitable manner to allow the use of mechanical loading and unloading equipment without the risk of accidental damage to the pipes.

5.5.4 Coils and Drums

PE pipe may be stored and transported in coils or wound on drums. In both instances, stored energy is involved. Care shall be taken when uncoiling or unrolling the pipe to address this potential hazard and the movement of the ends of the pipe should be controlled to prevent whiplash.

Additional information on storage, transport and handling of PE pipes may be found in PIPA Guideline POP 005.

When PE pipe is transported in coils, care shall be taken during uncoiling to ensure safety of personnel, from risk associated with stored energy contained within the coils, as well as ensuring sharp objects do not score the pipe. When stored for use on a work vehicle, pipes should be uncoiled on a dispensing reel.

Coiled pipe shall be stored on a flat surface and only to such a height that ensures the bottom layer does not become distorted.

PE pipes stored on drums are still susceptible to risks associated with stored energy although the pipe is better restrained on a drum. Drums are very heavy and should always be handled with the appropriate equipment.

Drums should be stored on flat, stable ground to ensure that they will not topple over, and should be controlled by the use of chocks to ensure that they do not roll out of position.

5.6 Clearing and Grading

Clearing and grading shall be carried out in accordance with the Environmental Management Plan and other project related approvals.

Consideration shall be given to the following:

- The route shall be cleared to the width necessary for the safe and orderly construction of the network;
- The cleared width shall not exceed the permissible width of the right of way;
- Where a route is graded, permanent damage to the land shall be minimised and soil erosion prevented; and
- In developed farmland, liaison with property owners is to be maintained to minimise disruption to farming activities.

5.7 Stringing of PE Pipes

PE pipe should only be strung on areas of the right of way where clearing and grading is complete.

When pipe is strung from end to end, adequate provision shall be given to allow for overland flow/drainage, access by property owners, fauna and construction traffic.

5.8 Laying of the Network

Consideration shall be given to the following:

- Laying stresses, induced in the PE pipe during construction, shall be minimised;
- The trench bottom shall be prepared to reduce likelihood of damage to the pipe;
- Care shall be taken not to jerk the pipe or impose any stresses that could kink or cause a permanent bend in the pipe;
- The coefficient of thermal linear expansion for PE pipe is approximately ten times higher than that of steel. As such, final connections of the pipe to existing networks on extremely hot and cold days should be performed only after the pipe temperature has stabilised; and
- Ends of network or network sections shall not be left open to avoid unwanted ingress of contaminants.

5.9 Backfill and compaction

Compaction shall be performed in a manner to ensure the required compaction level is achieved while ensuring that any stress placed upon the pipe is acceptable.

- Unless other provisions are made, the installed pipe shall be supported (restrained) in its intended position by the trench and the compacted backfill;
- The standard of backfill and compaction shall minimise subsequent soil movement, and prevent subsidence of the trenched area.
- Compaction shall be performed in a manner to ensure that no induced stress is placed upon the pipe;
- Where backfill material contains rocks or stones that could damage the pipe, care shall be taken to prevent such damage;
- Precautions shall be taken to avoid the trench becoming a drainage path (e.g. compaction, backfill material selection, trench-breakers);

- The backfilling materials surrounding the pipe shall protect the pipe both during installation and through subsequent operation;
- The permeability of the backfilled and compacted trench shall be similar to that of the unexcavated material to minimise damage along the trench invert, and potential ‘tunnel’ erosion;
- When the trench is required to be bottom padded prior to lowering the pipe into the trench, the material used shall be screened excavated material or imported fines;
- Where the trench is flooded with water to consolidate the backfill, steps shall be taken to ensure that the pipe does not float from its firm bearing on the bottom of the trench; and
- Where scouring could occur in a trench, barriers shall be installed to prevent scouring. Barriers shall be built of non-degradable foam, sandbags or other approved material.

5.10 Positioning

5.10.1 Alignment

Pipes should be laid true to line. Any significant deviation shall be recorded.

5.10.2 Structures

Pipes shall not be installed under structures and foundations where:

a) Integrity of the network will be affected;

b) Integrity of the structure or foundation will be affected; or

c) Gas leaks may accumulate in a confined space.

5.11 Network locating methods

Detection by accurate as build survey, is considered the most reliable form of pipe location. The following additional measures shall be implemented to alert people of the presence of the buried pipes and assist in on site location.

5.11.1 General

When installing a pipe in an open trench, one of the following shall be installed above the pipe:

- Marker tape (non detectable);
- Detectable tracer wire and marker tape; or
- Detectable marker tape / detectable marker product.

As a minimum, non-detectable marker tape shall be used in all locations, except where additional risks are identified, where detectable materials shall be used. These locations include:

- Roads / rail crossing;
- Third-party gathering system and pipelines; and
- Other third-party infrastructure (such as Telstra / NBN).

When installing a pipe using a boring technique, consideration should be given to the use of tracer wire, or an appropriate detectable marker product, which can be drawn in with the bore, where such installation is considered beneficial. This is to enable the location of the pipe to be traced with a pipe locator, and so reduce the likelihood of damage during future excavations in the vicinity of the boring crossing.

The products shall be impervious to corrosion by being totally encased in corrosion proof materials.

5.11.2 Multiple pipes in a trench

Where multiple gas and CSG water pipes are laid in a common trench, at a minimum a single marker tape shall be installed. Use of less than one marker tape per pipe shall be documented and approved.

Note: Electrical and communication cables shall have their own markings.

5.11.3 Tracer wire

Where installed, tracer wire should be durable and connected using an approved technique.

Tracer wire shall be metallic, electrically insulated and have a minimum diameter of 14 gauge. Tracer wire shall be resistant to corrosion damage either by use of coated copper wire or by other means.

5.11.4 Detectable marker products

Detectable marker products shall use active or passive marker technology, which is embedded into an industry colour coded caution tape or carrier.

5.11.5 Network marker signs

This Code mandates the placement of markers for each buried pipe at a wide range of specific locations. Pipe marker signs shall conform to the requirements for safety signs in accordance with AS 1319 'Safety Signs for the Occupational Environment.'

The purpose of pipe markers is to alert people of the presence of the Gathering Network and if they plan to carry out work nearby of the possible consequences of inflicting unintended damage. Markers also instruct those people intending to work near the Gathering Network to contact the nominated network operator and provide suitable contact details.

The requirement for effective pipe marking applies regardless of land use, including remote areas.

5.11.6 Sign location

Signs shall be placed at the following locations and be inter-visible:

a) Both sides of public roads;

b) Both sides of railways;

c) At each property boundary (and at internal fence lines as appropriate);

d) Both sides of creeks and rivers;

e) Both sides of vehicle tracks;

f) Each change of direction;

g) Utility crossings (buried or above ground);

h) At all network facilities; and

i) At all other places where signs marking the location of the network are considered to contribute to network safety by properly identifying its location.

Signs shall not exceed the maximum separation listed below for classification areas:

- R1 - 500 metres;
- R2 - 250 metres;
- T1 - 100 metres; and
- High Use or Sensitive sub-locations - 100 metres.

Note: In land subject to cultivation where the required sign placement, as specified above, is unacceptable to the landowner or cannot be maintained, an acceptable alternative is to place an appropriate sign at fence lines and at every gate giving access to the cultivated area. Elsewhere on the property, signs need to be placed on the RoW as close as practical to the edges of cultivated areas.

5.11.7 Marker sign contents

Marker signs shall:

a) Indicate the approximate position of the pipe;

b) Indicate that excavating near the pipe is hazardous; and

c) include a direction to contact the Gathering Network operator before commencing excavation near the network.

5.11.8 Buried pipes installed in parallel

Buried PE pipes running in parallel are at particular risk of being impacted when an excavation or drilling machine operator is unaware of the presence of more than one pipe in the immediate vicinity. Therefore, where pipes share a common trench, or where two or more pipes run in parallel, one of the following options shall be applied:

5.11.8.1 Individual network pipe marking

Where network pipes are marked individually, the requirements stated above shall apply as a minimum requirement for each network pipe. At each location, where the presence of one network pipe is indicated by a marker sign, an additional sign shall also be placed to represent the presence of each additional network pipe in the vicinity. Posts shall be separated from each other to clearly indicate the presence of all pipes.

5.11.8.2 Grouped network pipe marking

Pipes may be marked by a single sign at each location. In such cases, the sign shall clearly indicate the presence of multiple buried pipes in the vicinity. The marker sign format, visibility and display of company information shall be in accordance with the above requirements.

5.12 Reinstatement

After backfilling has been completed, construction tools, equipment, and debris shall be removed. Areas that have been disturbed by the installation shall be reinstated. Reinstatement should be completed as soon as practicable.

Appropriate measures shall be taken to prevent erosion and minimise long-term degradation of the environment (e.g. the construction of contour banks or diversion banks).

Fences that have been removed to provide temporary access to the route shall be re-erected.

Reserves shall be reinstated in accordance with the prescribed requirements of the appropriate authority.

In developed farmland, it shall be ensured that topsoil is being replaced without contamination, and drains and general contours are reformed.

6 Jointing

6.1 Basis of section

This section includes general information on the recommended procedures for the most common methods of joining PE pipe and fittings.

The user of this jointing information shall consult and follow appropriate safety instructions for jointing equipment, which are available from manufacturers. Further information is contained in PIPA Guidelines POP 001, POP 003 and POP 014.

6.2 General provisions

PE pipe or fittings can be joined to each other only by heat fusion (welding) or with mechanical fittings.

NOTE: PE pipe and fittings for CSG and PFW applications cannot be joined by adhesives, cements or elastomeric joints.

PE pipe and fittings may be joined to other materials by means of mechanical fittings, flanges, or other qualified types of manufactured transition fittings. There are many types and styles of fittings available from which the user may choose, but whatever fitting is used it shall conform to the requirements of Section 3 of this Code.

Each jointing method offers its particular advantages and limitations for each situation the user may encounter. The relevant manufacturers should be contacted for guidance in proper applications and methods available for joining.

6.3 Heat fusion

6.3.1 General

There are three types of heat fusion joints currently used - butt fusion welding, electrofusion welding and saddle fusion welding. Saddle fusion welding is typically not used in the CSG industry.

A unique weld numbering system shall be established so as to identify each production weld and tie-in for traceability records.

The welding process of PE pipe shall be nominated and approved prior to welding procedures being developed and prior to commencement of any PE welding. Section 7.5 provides guidance relevant to weld procedure and welder qualification.

The following sections provide general procedural guidelines for each of these heat fusion methods.

NOTE: Fusion heating of new pipe to previously in-service pipe may require additional steps to ensure satisfactory weld quality where liquid hydrocarbons or moisture may have been absorbed from process fluids. A Companion Paper is proposed to be prepared to provide further information.

6.3.2 Conducting Heat Fusion Welding

6.3.2.1 Environmental conditions for carrying out fusion welding

The fusion or welding process is sensitive to weather and climatic conditions and, as such, the welding process needs to be carried out in clean, dry and draft free conditions. To manage these aspects the following is advised:

a) Where necessary, a weather shelter or cover shall be used to keep moisture and dust away from the prepared weld surface;

b) When temperatures fall near or below zero, special precautions may need to be taken – consult pipe manufacturer's recommendations; and

c) Cover the remote open ends of the pipes being welded to avoid draughts. Air can be drawn through open ends and pass over the surfaces being welded, cooling them prematurely, which can result in a poor-quality weld.

6.3.2.2 Planning for successful fusion welding

To ensure the integrity of the fusion welds the following procedures should be adopted:

a) The welding contractor shall have:

- Demonstrated experience in fusion welding of PE pipe;
- Suitably sized equipment which has been maintained in good condition with calibration status documentation available; and
- Qualified operators who have an up to date log detailing project and welding experience.

b) Assessment of the proposed welding procedures:

- Pre-qualified welding procedures for pipe class and diameters being proposed for the project and the welding machines or control box which will be used and destructive weld testing data may be considered;
- Carry out trial welds on the actual pipe to be used for the contract and have these destructively tested to meet the specified performance requirements (testing and minimum performance requirements are detailed in Section 7 – Inspection and Testing);
- Determine and document the agreed welding parameters, procedures, and welding equipment (this may also include the use of welding tents, pipe end covers etc.); and
- The agreed welding parameters, procedures and welding equipment then become the contract requirements and should not be varied without additional evaluation and testing.

c) Determine quality control and assurance requirements including but not limited to:

- Inspection for wall thickness and welding zone preparation;
- Internal inspection of pipe for obstruction and cleanliness. Including the removal of swarf after machining welding face for butt welding;

- Maintaining a detailed welding log for each weld;
- Destructive testing of a percentage of welds; and
- Visual and non-destructive assessment of each weld (refer Section 7.8).

d) Continuously review process and results.

Further details for weld inspection and testing can be found in Section 7.

6.3.3 Butt fusion welding

The most widely used method for joining individual lengths of PE pipe is by heat fusion of the pipe butt ends as illustrated in Figure 6.3.2a.

Figure 6.3.2a – Standard Butt Fusion Joint

This technique, which precludes the need for specially modified pipe ends or couplings, produces a permanent, economical and flow-efficient connection.

Welding parameters are detailed in PIPA Guideline POP 003 which provides guidelines for butt fusion welding parameters as detailed above.

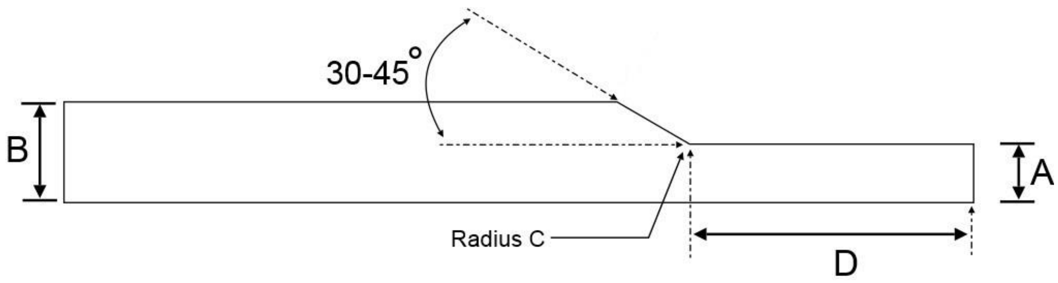
Data loggers are now extensively employed to verify conformance to the nominated welding parameters.

Butt fusion welding is a skilled operation and, to achieve a successful joint, a number of very specific procedures need to be carried out. All operators shall be trained by appropriate registered training organisations (RTOs) meeting the prerequisite training requirements specified in section 6.3.5.

6.3.3.1 SDR Transitions

Butt fusion welding can be carried out only with pipe or fittings of the same SDR unless a suitable transition piece, approved by the manufacturer, is used or the pipe end is transitioned as shown in Fig 6.3.2b.

A transition piece can be used for joining a pipe of one SDR to another pipe with a different SDR (See Figure 6.2.3b). The transition piece shall be manufactured in a controlled environment with approved machining processes and equipment. Other transition pieces or transition pipe/fitting ends shall be to an approved design and manufactured and certified in a controlled environment. All components shall have adequate nominal pressure rating for the operating conditions.



A = Nominal wall thickness of the thinner pipe

B = Nominal wall thickness of the thicker pipe

C = 0.15A

D = not less 50 mm or 2A

Figure 6.3.2b - Transition piece design for SDR step

Field-site butt fusions may be made by trained operators using specially developed butt fusion machines that secure and precisely align the transition piece and pipe ends for the fusion process.

6.3.4 Electrofusion welding

Electrofusion is a skilled operation and, to achieve a successful joint, a number of very specific procedures need to be carried out. Welding procedures shall be approved. All operators shall be trained by appropriate RTOs.

To consistently make satisfactory electrofusion joints it is important to follow the jointing procedure with particular emphasis on pipe surface preparation, cleanliness, restraint of the joint during the fusion and cooling cycles, and temperature control.

Pipes and fittings of different SDR can be joined together by the electrofusion process, e.g. a DN250 SDR11 pipe can be successfully electrofused to a DN250 SDR17 pipe using a DN250 SDR17 or SDR11 coupling.

Further information can be found in the PIPA Guideline POP 001 - *Electrofusion Jointing of PE Pipe and Fittings for Pressure Applications*. This comprehensive document provides detailed information and requirements to make successful electrofusion joints.

6.3.5 Welder training

All fusion jointing operators shall be trained by appropriate RTOs. Prerequisite training courses shall consist of PMBWELD 301 for butt fusion welding and PMBWELD 302 for electrofusion welding.

These courses provide the minimum competency to perform basic small diameter joints. For more advanced welding including large diameter fusion joints (315mm and larger), it is the duty of the employing company (typically the installation contractor) to ensure that fusion operators are provided with task specific training and a Verification of Competency (VOC) is completed and recorded. Operating companies shall approve the training and VOCs to ensure fusion operators are appropriately trained and competent to safely perform advanced welding.
Refer appropriate Companion Papers for further details.

6.4 Mechanical joints

Where fusion joints are not appropriate, mechanical fittings can be used, particularly for the small sizes of PE pipe. There are three basic fittings which can be used:

- Mechanical compression joints (CSG water pipes only);
- Mechanical couplings; and
- Flanges.

When jointing is required to other materials a flanged joint is generally the most practical for field jointing. Otherwise a material transition fitting can be considered and welded in.

Mechanical joint materials shall conform with the required standards as detailed in Section 3.

6.4.1 Mechanical compression joints

Mechanical compression joints shall be used only for CSG water pipes. Mechanical compression joints shall be installed in accordance with the manufacturer's requirements.

6.4.2 Mechanical couplings

Mechanical couplings shall be installed in accordance with the manufacturer's requirements.

6.4.3 Flanges

When jointing is required to other materials a flanged joint is generally the most practical.

Jointing to other pipe materials may also be achieved by the use of mechanical flange adaptors which are similar to mechanical couplers except one end is replaced by a flange.

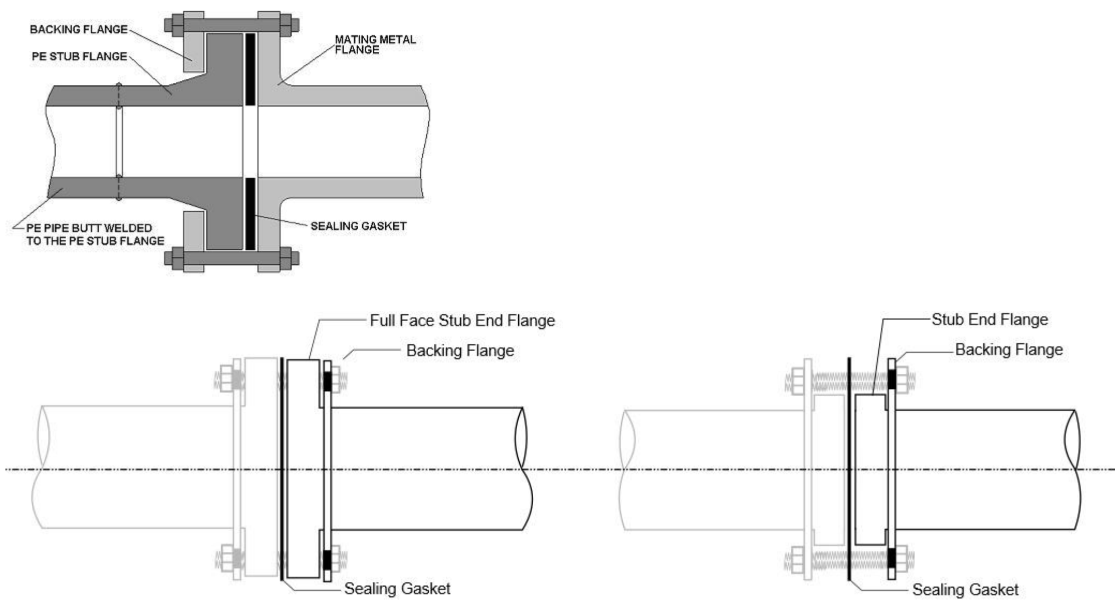


Figure 6.4.3 - Typical flanged connections

6.4.3.1 Flange management

Consideration shall be given to the following when fitting a bolted mechanical joint:

a) Cleanliness;

b) Alignment;

c) Gasket type;

d) Temperature;

e) Torque settings;

f) Tightening sequence; and

g) Torque checks after relaxation.

Prior to completing a mechanical joint, the flange faces shall be free from dirt and debris. The flange faces shall be free from scratches, gouges and defects. Check to ensure the flange face is ‘flat faced’ and not bowed.

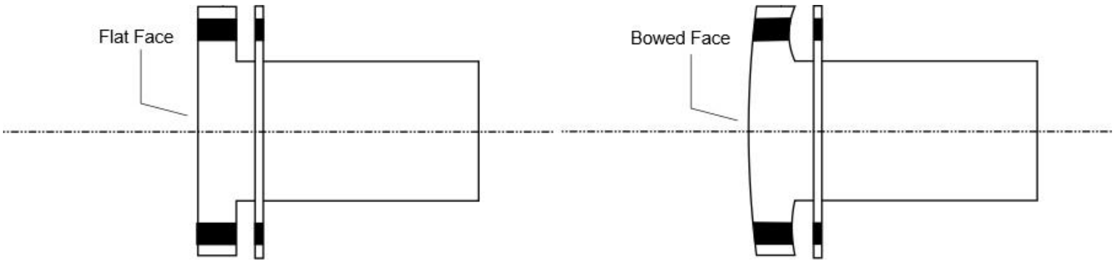


Figure 6.4.3.1a - Flange Face Check

The materials used for the sealing gaskets must be suitable for the intended purpose.

Gasket materials shall be chemically and thermally compatible with the internal medium of the Gathering Network and external environment. They should be recommended by the gasket manufacturer for use with PE pipe flanges. Types of gasket used in conjunction with PE are listed as follows:

Figure 6.4.3.1b - Types of gaskets

Flanges shall be properly supported or free from stress when bolting a mechanical joint. Flange temperature shall be kept below 40°C (minimal latent heat) prior to tightening. Flange bolts should be tightened to the appropriate torque value by turning the nut with a calibrated torque spanner. Each nut should be tightened to the sequential number patterns as in the example 6.4.3.1c.

In the first instance, establish an initial sealing surface pressure by tightening the flange as per the example sequence below and applying a torque setting of 7-15 Nm.

Bolts should be tightened to a value recommended by the gasket manufacturer.

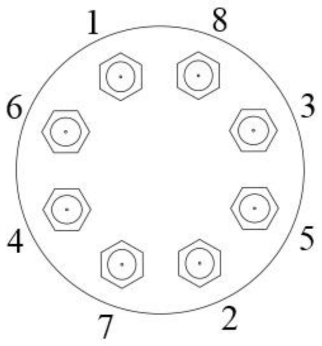


Figure 6.4.3.1c - Typical tightening sequence

Flanges should be re-checked for torque tightness after the joint has had adequate time to relax. Typically, this is recommended at intervals of four hours and 12 hours respectively after the initial torque.

NOTE: Depending on the face pressure requirements of the particular gasket in use, consideration should be given to allow up to 50 per cent of additional torque to allow for creep. All tightening is to be performed at temperatures as low as practical.

7 Inspection and Testing

7.1 Basis of section

Inspection and testing form an integral part of the Gathering Network. It ensures all parts of the Gathering Network including the material manufacture, design, and installation have been carried out in accordance with this Code. The Operator shall ensure that the appropriate inspections and testing are carried out during the total life cycle of the works.

The Operator shall ensure that inspection and testing is undertaken as necessary during manufacture, transport, handling, welding, network construction and commissioning to ensure that the completed network conforms with the engineering design, this Code, relevant Standards, and has the intended quality and integrity.

7.2 Inspections and test plans

Inspection and test plans shall be designed, approved and implemented for the required parts of the works including materials handling, installation and commissioning. Inspection and test plans (ITP) shall as a minimum include:

a) Description and item number of the activity;

b) Description of each test, examination or inspection to be performed;

c) Responsible persons;

d) Reference documents, controlling specifications and procedures;

e) Acceptance criteria;

f) Verifying documents or check sheets; and

NOTE: The ITP itself may also be used as a check sheet.

g) Provision for hold, witness, verify and review points.

ITPs shall be applied to specified sections of the works so as to allow sign-off in discrete stages, not just at final completion. ITPs shall be approved and cover all stages of the works.

7.3 Materials inspection

Pipe and fittings shall be packaged, handled and transported in accordance with the PIPA Guideline POP 005, relevant industry standards and Company procedures. On receipt of pipe and fittings, and before installation, inspection of materials shall be carried out to ensure:

a) Correct type, size, PN rating and SDR of pipe and fittings;

b) No damage is evident that reduces the wall thickness more than 10 per cent;

c) Correct identity and traceability markings are present; and

d) No debris is in the pipe.

7.4 Installation

Inspection and testing upon installation shall verify that:

a) Correct lifting and laying equipment have been used;

b) Trench bottom is free of debris, rocks or clumps that could cause damage to pipe;

c) Trench depth and cover is correct to specification;

d) Adequate bedding has been used where required;

e) Pipe and fittings are within specified tolerances for diameter and out of roundness;

f) Correct amount of embedment is around pipe;

g) Pipe is not laid up against sharp objects on wall of the trench;

h) Correct backfill has been used;

i) Marker tape and/or trace wire has been installed;

j) Compaction of backfill is in accordance with the specification; and

k) As-built records have been completed before final backfill.

7.5 Welding/joining

Joining pipes and fittings by electrofusion or butt welding shall be to an approved joining procedure that has been qualified by destructive testing in accordance with ISO 13954 '*Plastics pipes and fittings - Peel decohesion test for polyethylene (PE) electrofusion assemblies of nominal outside diameter greater than or equal to 90 mm*' and ISO 13953 '*Polyethylene (PE) pipes and fittings - Determination of the tensile strength and failure mode of test pieces from a butt-fused joint*' respectively.

For electrofusion welding, an acceptable alternative method of destructive testing may be undertaken in accordance with ISO 21751 *'Plastics pipe and Fittings - Decohesion test of electrofusion assemblies – Strip-bend test'*. Due to the simplicity of the ISO 21751 testing methodology, it is also practical for indicative checks on site (e.g. when trying new fittings, procedures, equipment or for training of the welders).

For the welding procedure qualification or production tests, the ISO 21751 testing needs to be done in a testing laboratory by competent personnel.

The acceptance criteria for ISO 13954 and ISO 21751 peel decohesion tests require the test samples to rupture in a ductile mode with the percentage of brittle failure de-cohesion being less than or equal to 33.3 per cent of the total length of fusion zone for each test specimen (not the overall test specimens combined). The percentage of brittle failure is determined as a ratio of *the largest length of brittle failure* to *total length of fusion zone* at the same location - refer to ISO 13954 for more information.

The acceptance criteria for ISO 13953 tensile strength test require the test samples to present a ductile failure mode, be free from defects and contamination in the weld plane, and shall have a minimum tensile strength of 90 per cent of the parent pipe.

NOTE: Qualified procedures may be grouped by diameter to reduce the amount of qualification testing. The recommended groupings are shown in Table 7.5.

Table 7.5 Welder and welding procedure qualification groupings

Procedure qualification test diameter	**Type of joining process**	**Qualifies for sizes within range**
Any ≤ DN110	Butt weld	Any ≤ DN110 [Note 1]
Any ≥ DN 125 and ≤ DN280	Butt weld	Any ≤ DN280 [Note 1]
Any ≥ DN 315 and ≤DN 800	Butt weld	Any ≥ DN 315 and ≤ DN800 [Note 1]
Any ≤ DN 110	Electrofusion weld other than a EF saddle weld	Any ≤ DN 110 [Note 1]
Any ≥ DN 125 ≤ DN280	Electrofusion weld other than a EF saddle weld	Any ≤ DN280 [Note 1]
Any ≥ DN 315 and ≤ DN 800	Electrofusion weld other than an EF saddle weld	Any ≥ DN 315 and ≤ DN 800 [Note 1]
Any ≤ DN 160 (carrier pipe)	Electrofusion saddle weld	Any ≤ DN 160 (carrier pipe) [Note 2,3]
Any > DN 160 and ≤ DN 315 (carrier pipe)	Electrofusion saddle weld	Any > DN 160 and ≤ DN 315 (carrier pipe) [Note 2,3]
Any > DN 315 (carrier pipe)	Electrofusion saddle weld	Any > DN315 (carrier pipe) [Note 2,3]

Note 1: Where a qualification range is specified within the limits of diameter ranges defined above, the largest diameter and lowest SDR (thickest wall pipe) shall be used to qualify the range. For example, if the qualifying diameter range is from DN315 to DN630, then DN630 can be used to qualify the range, not DN800.

Note 2: Where the qualification range is specified within the limits of diameter range defined above, the thinnest wall pipe with the range shall be used to qualify the range.

Note 3: Hot tap saddle qualifications should account for live network temperatures and pressures and be in accordance with Section 11.11.4.

The essential variables for the weld qualification shall include:

- Procedure (process type: high pressure, low pressure, dual pressure);
- Individual welder (training and competency);
- Diameter (single size e.g. above DN800 or range/group size as per Table 7.5); and
- Pipe thickness;

Qualification for individual welding machines shall be undertaken where design differences between machines may lead to unacceptable operator error.

Equipment used for welding such as butt fusion and electrofusion machines shall be qualified for the diameter group size as per Table 7.5. The welder shall be qualified for operating the welding machine which has been qualified for the weld procedure.

All welders undertaking work on the network shall be assessed by performing test welds on the same size groupings in Table 7.5. Destructive testing shall then be carried out in accordance with ISO 13954 or ISO 21751 for electrofusion welding, and ISO 13953 for butt fusion welding. This assessment is in addition to the competency certificate issued by an appropriate RTO.

Supplementary specialised training by the proprietor or other qualified person is a requirement for all personnel involved in welding using proprietary equipment/ methods as described in Section 6.3.

Site welding assessments may be considered approved provided the welder has been welding the same type/group of pipe and fittings in the past 12 months.

Site welding assessments may be transferred between projects provided that:

- The welder has been welding the same type/group of pipe and fittings in the past 12 months;
- There is a record of a destructive test undertaken in the past 12 months; and
- They are approved by the Operator.

Minimum inspection that shall be carried out during electrofusion and butt welding include:

a) Materials checked for damage and type;

b) Clamping and alignment conforms with qualified procedure;

c) Cleaning and oxidised material removal of components conform with qualified procedure;

d) Heating and pressures are within the qualified procedure;

e) Bead shape and height to be assessed as per PIPA POP 014; and

f) As-built and material traceability records are completed.

7.5.1 Final construction and repair tie-ins (golden welds)

Final butt or electrofusion tie-ins (golden welds) connecting pipe sections that have already been pressure tested shall be installed in accordance with the weld jointing requirements of Section 7.5 and shall be evaluated for integrity. The methodology of evaluation shall be approved. Appendix C provides guidance on testing of golden welds.

For high use and sensitive locations, the following shall apply:

- Golden welds within greenfield developments shall be avoided and designed out; and
- Golden welds within existing brownfield developments may be used, subject to an approved risk assessment.

In the case of emergency response golden welds are deemed acceptable regardless of location class.

7.6 Personnel

Quality assurance and inspection shall be carried out by competent personnel who have had appropriate knowledge and skills, built up by training, qualification or on the job experience to be able to carry out and assure the work.

7.7 Pressure testing

Except for components that are exempt from field pressure testing, all pipes and components shall pass an approved pressure test in accordance with Section 8 of this Code.

7.7.1 Exemptions from a field pressure test

The following items may be exempted from field pressure testing:

a) Pipes and other pressure containing components that have been pre-tested to a pressure that is not less than that specified for the pressure test;

b) Tie-in welds made between pressure test sections after they have been pressure tested; and

c) Small bore controls, instruments and sampling pipes.

7.8 Visual and non destructive tests

All components of the Gathering Network shall be visually inspected by nominated QA inspectors before installation to ensure conformance with Section 3 of this Code.

Each butt weld or electrofusion weld shall be visually inspected in accordance with PIPA Guideline POP 014 before testing or commissioning.

7.9 Production testing

After the initial qualification of both EF and butt welding procedures there shall be a requirement for ongoing testing by the removal of a butt and an EF joint out of the Gathering Network during construction or installation works and destructively testing them to ISO13954 or ISO 21751 for EF welding, and to ISO13953 for butt welding. The frequency of testing shall be approved by the Operator with a recommended minimum requirement of one butt and one electrofusion weld taken within the first 10 welds of the individual welder for each type (i.e. EF or butt welding). Test samples shall be taken from a range of different diameters where practically possible. If the weld conforms then a sample rate of 1 in 200 for the same welder shall apply. If the production weld fails then two more welds from the same welder shall be removed for testing, if either fails to conform then an investigation is to be carried out to determine the cause and recommend action.

NOTES:

1. To effectively carry out this testing it is necessary to have a high level of weld traceability back to the welder and weld location.
2. Data loggers can provide valuable information in assessing welds.

8 Pressure Testing

8.1 Basis of section

Pressure testing is considered one of the major hazards in the development of a CSG PE Gathering Network.

Pressure testing shall be the joint responsibility of the Constructor and Operator with the Operator having paramount responsibilities to ensure that an appropriate strategy is developed. The strategy shall be based upon testing for every part of the Gathering Network and to be executed by experienced competent staff.

Qualification requirements for test procedures and personnel are provided in Sections 8.7 and 8.8 respectively.

All new components of the Gathering Network and any part of an existing network that is diverted or altered in any way shall be subject to a pressure test to validate mechanical strength and detect leakage of the network prior to commissioning. See section 11.11.2.2, which permits in service tests for emergency repair pipe.

A formal test procedure shall be developed and qualified prior to being used. This procedure shall clearly contain the:

- Acceptance criteria;
- Design and operation of test equipment; and
- Risk mitigation measures to ALARP.

NOTE: It is recognised that all networks include untested joints (such as closure joints or golden welds) which cannot be subject to pressure testing, but these should be kept to an absolute minimum.

Experience has demonstrated that the risks associated with pressure testing are among the highest in the field development and construction activities associated with Gathering Network development.

Pressure testing organisations certified under NATA or an equivalent organisation should be considered preferentially.

The test procedure and the instruments used shall demonstrate clearly that there is no leakage that l constitutes a hazard following commissioning of the tested network. The test procedure shall be established to ensure that, when the testing is carried out, the highest standards of safety are maintained throughout the test period. Adequate facilities shall be provided by the Operator to enable these standards to be met.

For a CSG PE Gathering Network, the use of pneumatic strength testing of Gathering Networks within High Use areas (Section 4.8.2.2) should only be considered if it can be demonstrated that the pneumatic test blast radius does not impact the receptor or if hydraulic test methods are not feasible.

Due to the visco-elastic nature of PE, it is not practical to conduct such tests in a manner that ensures no pressure change. Variations of atmospheric pressure, temperature of the test fluid in the pipe and material creep have a significant effect on the test pressure. Therefore, it is necessary to permit some drop in measured pressure over the test period.

Consideration for volume increases due to creep occurring during the testing period have to be made for PE pipes. When a PE pipe is subjected to a test pressure there will be pressure decay, even in a leak free network, due to creep of the PE material.

As a result of this material behaviour, pipe testing procedures used for other materials such as steel may not be suitable for PE pipe.

The networks may be tested whole or in sections depending on the test pressure requirements, the length and diameter of the pipe, exclusion zone limitations and the spacing between sectioning valves or blanking ends.

The designer/Operator should, in the process of designing the network, give due consideration to how the network will be tested, including:

a) The number of test sections in relation to the exclusion zones;

b) The potential for reduction in size of the exclusion zones as discussed in Section 8.2 of this Code; and

c) Minimising the number of closure joints (tie-in joints).

The network (or section) shall be properly supported and, if it includes non-load bearing joints, be anchored to prevent the movement of pipes or fittings during the test.

8.2 Safety

8.2.1 General precautions

The hazards involved in pressure testing shall be considered, and the following requirements shall be observed:

a) Owing to the presence of one or more undetected defects in equipment or the network, or for other unforeseen reasons, a rupture may occur at some stage during the application of pressure. The test procedure shall ensure that, as far as is practicable, if the test equipment or network fails during the testing, there shall be no possibility of injury to any person;

b) Test equipment, including flexible hoses shall be marked with their MAOP which shall not be less than twice the set pressure of the pressure safety valve (PSV), if installed on the pressurising equipment, or twice the maximum pressure the network can generate. Flexible hoses shall be fit for purpose and include whip socks if required for risk mitigation;

c) A service test of temporary test equipment shall be performed prior to commencement of pressurisation;

d) Flexible hoses and their connections shall be visually examined prior to use to ensure that they are fit for their intended purpose and have a current certificate of compliance. They shall be secured and anchored by a secondary restraining device (e.g. whip check chain, hose sock or similar) to prevent movement in the event of failure;

e) Test instrumentation shall have a valid certificate of calibration from a recognised and certified testing agency;

f) Verification of testing instrumentation (i.e. gauges, recorders etc.) shall be performed in accordance with a documented procedure against a prime reference instrument that is traceable to a primary standard;

g) All flanges which are blanked for the purpose of the test shall have their full component of bolting and be of the same pressure rating;

h) Work to be undertaken at any pressure shall be conducted under an approved procedure or be subject to a risk assessment;

i) Testing shall not be carried out against closed valves. Installed valves shall be open and plugged, or capped;

j) The test section should be physically isolated from any commissioned network;

k) Normally the test section is to be buried. However, if pipework is exposed it should be adequately secured and protected against temperature variation.

l) Adequate barriers and signage shall be positioned at the limit of the primary exclusion zone, as determined in Section 8.2.3., Section 8.2.5 and Section 8.2.6 It is recommended that barrier tape, coloured blue and white with the wording 'Pressure Testing', is placed at regular intervals;

m) The testing supervisor shall ensure that all necessary precautions are taken:

- Before pressurisation;
- During pressurisation;
- During de-pressurisation and before dismantling of equipment; and
- After de-pressurisation and during dismantling of equipment.

n) The impact of noise generated during pressurisation and de-pressurisation shall be considered and minimised by the controlled introduction and release of the test medium. Noise exposure limits for personnel in the area shall be assessed and not exceeded;

o) Prior to commencing a pressure test a detailed Emergency Response Plan shall be available;

p) After the completion of a low-pressure test (<200 kPa as per Section 8.4.1.12), personnel shall not enter the primary exclusion zone throughout the duration of the strength test unless the test section has passed the strength test and the pressure has been reduced to MAOP or lower;

q) If the test section is being strength tested and there are indications that it is failing, authorised personnel shall only enter the primary exclusion zone to check for causes as to why it has failed after the test section has been depressurised to below 200 kPa.

r) Throughout the duration of the strength test only personnel involved in the testing operation shall enter the secondary exclusion zone;

s) When using nitrogen for testing components, tracer gas and pre-commissioning purposes, consideration shall be given to the dangers associated with asphyxiation, high pressure and nitrogen handling, particularly for work in confined spaces. Vent stacks and pipes should be positioned at least two metres above-ground in order to achieve a safe atmosphere. A separate risk assessment shall be performed; and

t) Temporary valves used for testing purposes, such as isolation or control valves, should be positioned upright as shown below.

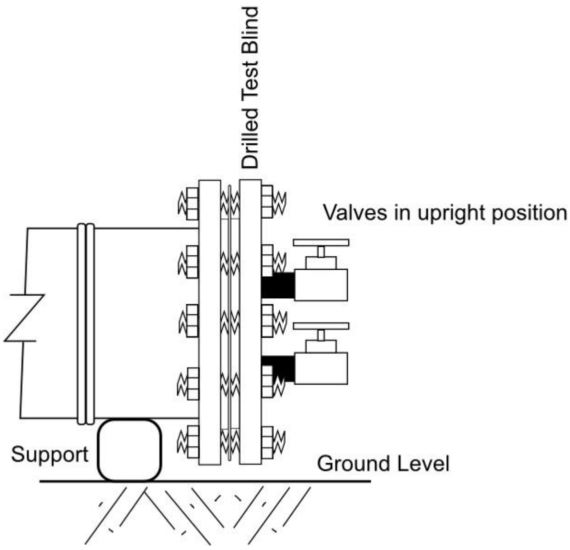


Figure 8.2.1 - Temporary valve positioning for pressure test

8.2.2 Site test exclusion zones

The primary safety control for pressure testing is QA/QC conformance, primarily in material selection and welding. The secondary safety control measure is the introduction and use of calculated exclusion zones.

The test section shall have a defined exclusion zone. This shall be defined as the primary exclusion zone. On the completion of the low-pressure test (<200 kPa), no persons shall enter the primary exclusion zone while the test section is being pressurised and while the test section is being strength tested. After successful completion of the strength test and after the pressure has been reduced to MAOP or lower, authorised personnel may be allowed inside the primary exclusion zone.

The test equipment shall be located outside the primary exclusion zone and be surrounded by a secondary exclusion zone. Only authorised personnel shall enter the secondary exclusion zone.

Land owners, contractors and other relevant persons shall be notified where they may be directly affected.

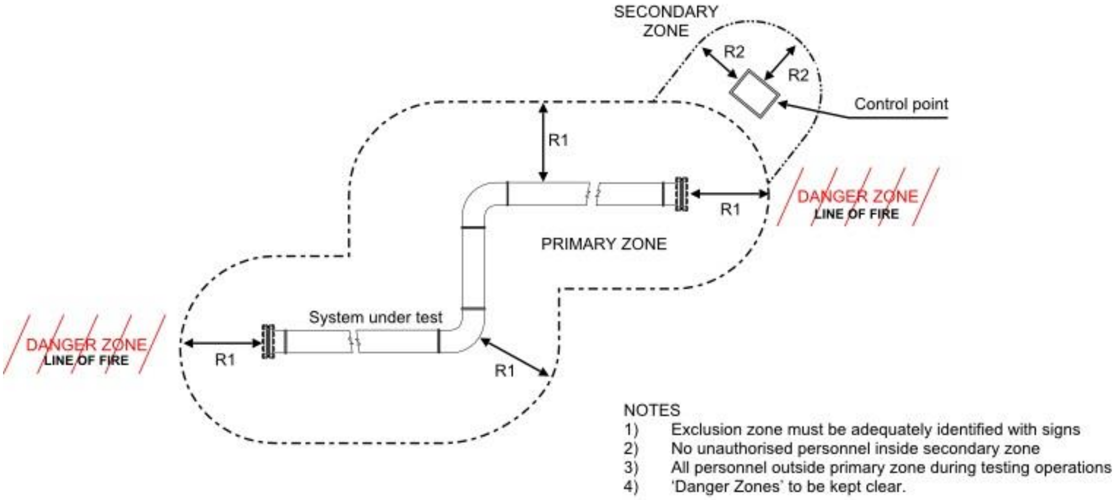


Figure 8.2.2 - Defined Exclusion Zone

While the test pressure is being introduced, and for the period of the actual strength test, strict precautions shall be implemented to ensure that unauthorised persons are prevented from entering the exclusion zone (primary and secondary) test areas. Barriers, signs or other markers shall be clearly displayed to indicate the restricted area. Consideration should be given to patrolling road crossings and other higher risk locations while the test section is under test to ensure that no persons enter the test area.

The number of personnel involved in conducting the test shall be kept to a minimum.

The test equipment needs to be located with respect to escape routes in the event of an emergency and ease of installing the test equipment. In addition, the location of the test equipment shall consider the effect of projectiles that may come from a failed test section. A general rule is not having the control point in line with the test end as per illustration Figure 8.2.2 'Defined Exclusion Zone', and to be away from network features such as tees, elbows and tapping saddles.

The primary exclusion zone shall be designed to surround the entire test section. Consideration shall be made for other work in the vicinity of the primary exclusion zone. A formal risk assessment should be made for routine work such as driving along access tracks near the pipe being tested as long as the track is not near network features such as elbows, tees or tapping saddles.

The primary exclusion zone is designed to achieve a specified distance from the test section to the area that any unauthorised person can be present during the test.

The primary exclusion zone area needs to be determined to take into account the amount of stored energy released upon test section failure.

The distance to the primary exclusion zone boundary shall take into account the following:

- The diameter of the pipe being tested;
- The length of the network being tested;
- The test pressure; and
- Potential projection of solid objects from a failed test section.

The distance that objects travel in the event of a pipe rupture is related to test section pressure.

8.2.3 Pneumatic testing primary exclusion zone (R1)

The primary exclusion zone boundary shall be calculated by using the approach defined in ASME PCC-2 or in accordance with the requirements of Section 8.2.9. This approach calculates the amount of stored energy and then calculates a distance based on the blast wave impact to personnel and structures. The minimum primary exclusion zone is:

- 30 m if the calculated energy is less than 135.5 MJ;
- 60 m if the calculated energy is between 135.5 and 271 MJ; and
- For energy levels greater than 271MJ, the distance $R_{scaled}(2TNT)^{1/3}$ in metres, calculated in accordance with Appendix B2, based on an R_{scaled} number of 20, where TNT is the energy measured in kilograms of TNT (Trinitrotoluene).

These distances are subject to increase in specific direction of failure to allow for potential projected missiles.

Appendix B2 details the method of calculating the stored energy and the safe distance from the pipe to be used in pneumatic strength tests.

NOTE: Refer to the appropriate Companion Paper for further information.

8.2.4 Pneumatic testing secondary exclusion zone (R2)

The secondary exclusion zone boundary shall be established around the control point. The minimum recommended approach is to use the distance based on an R_{scaled} number of 20. In this calculation, the stored energy is the energy in the test equipment – hoses and headers. An alternative is to use an exclusion distance of 10 m.

NOTE: A 100 m long, 50 mm diameter hose has an exclusion zone of less than 5 m.

During testing operations, no unauthorised person should be permitted to enter this zone.

Appendix B2 details the distance calculation to be used in pneumatic strength tests.

8.2.5 Hydraulic testing primary exclusion zone for above-ground sections and open bell-holes (R1)

This distance shall be calculated with a minimum distance of five (5) metres from any part of the test section. The calculation shall determine the amount of stored energy in the test section. The Operator and testing personnel shall be required to ascertain the air content of the test section and determine if this is acceptable.

Appendix B3 describes the process of calculating the amount of stored energy in the hydraulic test section taking into account the additional energy resulting from the residual air content.

The minimum safe distance to be applied to the hydraulic test primary exclusion zone (R1) shall be the greater of:

a) 5 m

b) R = Rscaled (2TNT)^1/3

where R = actual exclusion zone distance from test section/equipment.

R_{scaled} = 20 (Scaled consequence factor)

TNT = Energy measured in equivalent kilograms of TNT (Trinitrotoluene).

NOTES:

1. TNT in the above equation is the sum of stored hydraulic energy (calculated in accordance with Appendix B3) and stored pneumatic energy from residual air remaining in the test section (calculated in accordance with Appendix B3). The volume (V) used in the calculation given in Appendix B3 is to be adjusted to match the estimated volume of residual air in the test section (e.g. 0.2 per cent of the total test section volume).
2. This reduction in the exclusion zone for hydraulic testing is based on the extremely small calculated energy content. The risk of a pneumatic blast wave, present during hydraulic tests, is only applicable to the minimal residual air component during hydraulic tests which enables reduction in the safe distance used.

8.2.6 Hydraulic testing primary exclusion zone for buried sections of pipes (R1)

The test section shall have an exclusion zone around all above-ground or open sections. The buried section does not need an exclusion zone however, consideration shall be given to sensitive areas such as road crossings, right of ways, access tracks and populated areas. These areas should have signage stating ‘Entering Pressure Testing Area. Remain in vehicle at all times’ erected within the area of the network under pressure. In special circumstances consideration should be given to patrolling the area. At exits, the area should have signage stating, ‘Exiting Pressure Testing Area’.

NOTE: This reduction in the exclusion zone for hydraulic testing is based on the calculated energy content.

8.2.7 Hydraulic testing secondary exclusion zone (R2)

The secondary exclusion zone boundary shall be erected around the control point. The minimum secondary exclusion zone shall be five (5) metres.

8.2.8 Preliminary testing

Sections of the network in key areas may need to be preliminary tested or pre-tested separate to the main network section. Examples are road, creek crossings, and sections near plants and houses where the impact of a failure of a pressure test is critical. The fabricated pipe sections to be installed by trenchless construction methods, as defined in Sections 5.3.4 and 5.3.4, should be preliminary tested where possible. These sections can later be tied into a longer test section. In these cases, the exclusion zone around the preliminary section can be reduced as it has previously passed a strength test.

See appropriate Companion paper for further details.

8.2.9 Alternative safe distance calculation methodologies

ASME PCC-2 remains the minimum requirement under this Code unless the Operator independently qualifies an alternate calculation methodology which is as safe as the mandated requirement prior to use and has been verified by a qualified third party. Note: ASME PCC_2 offers alternative methods of calculating stored energy and the most appropriate method is to be selected by the Operator.

See appropriate Companion Paper for more on safe distance calculations.

Use of alternatives to ASME PCC-2 shall require assessment of the following minimum considerations:

a) Full review of all design and constructability issues related to the network due to be pressure tested;

b) Pressure test method to be nominated;

c) Full hazard assessment to be conducted for each location;

d) Formal risk assessment to be conducted based on the above; and

e) Calculation of stored energy based on the qualified length of pipe test section.

8.3 Test plan

A test plan shall be developed for all pressure tests. This plan can be a general document to cover most cases. However, in all cases the risks and hazards of the particular test shall be understood and managed.

The testing plan shall be able to:

- Ensure the implementation of all risk controls;
- Ensure that a JSA is completed and all items identified are adhered to;
- Ensure that all relevant equipment has a current calibration certificate from a recognised and certified testing agency;
- Ensure that all measuring equipment is located at a suitable distance from the test section to conform with exclusion zone requirements; and
- Ensure that the EMP is followed for the disposal of the test fluids and other wastes.

The person or persons responsible for preparation of the test plan shall have appropriate qualifications and experience.

8.3.1 Approvals

The test procedures and plans shall reference the equipment used and shall be approved by the Operator. This approval shall include a suitable risk assessment method.

The water used in testing needs to be approved as being suitable to be used for the test and for subsequent disposal.

Potential environmental impact of loss of containment in the event of pipe rupture during testing should also be assessed.

8.3.2 Test sections

When developing the test plan, the person or persons responsible for defining the test sections should take into consideration the following:

- Exclusion zone distances to boundaries;
- Water sources and discharge points;
- Configuration of the test network; and

- Elevation of the high and low points of the network.

Where it is not feasible to pneumatically test due to constraints associated with larger exclusion zones, the pipe may be strength tested in smaller sections hydraulically and then installed within the larger test section. The larger test section may then be pneumatically tested as the sub-sections in vulnerable areas would have already undergone strength testing. This process eliminates untested joints within the test network.

8.3.3 Testing different SDRs

Normally a lower SDR rated pipe (and hence thicker wall pipe) should be used for special crossings such as road crossings, rail and river crossings. The pipe strings are preliminary tested prior to insertion and are normally incorporated into a final test.

It is common when designing the network to allow a lower SDR and thicker wall pipe at low points and special crossings as illustrated in Figure 8.3.3.

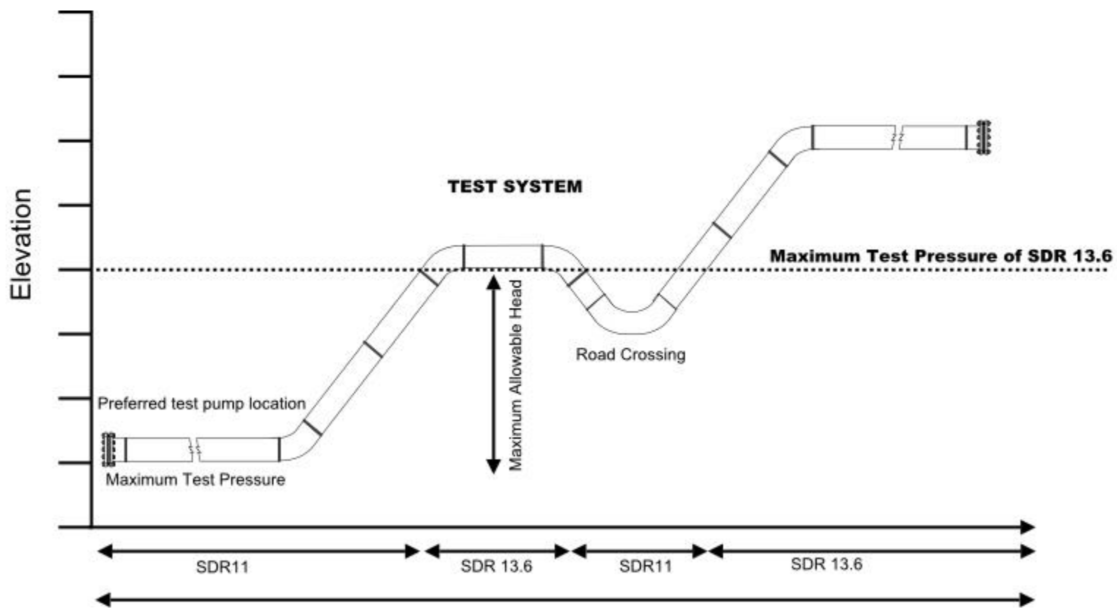


Figure 8.3.3 - Testing different SDR rated pipes

The test pressure shall always correspond to the higher SDR (thinner wall) pipe in the test section. Where lower SDR (thicker wall) pipe is used in the same test section, the maximum pressure applied during hydraulic testing shall be determined by the elevation difference as recorded by the 'As Built' survey data.

8.4 Test methods

The pressure testing of the PE Gathering Networks should be broken into separate test types - a strength test[1] and a leak test. These can be conducted either by hydraulic or pneumatic methods.

Pressure testing PE pipes may require special processes since they may continue to expand significantly throughout the test period. When a PE pipe is sealed under a test

[1] Sometimes also called a "Proof Test".

pressure there may be decay, even in a leak free network, due to the creep response and stress relaxation of the PE material. Due to this material behaviour, standard pipe testing procedures used for other pipe materials may not be suitable for PE pipe.

The following factors can affect a PE pipe pressure test:

a) Length of section and pipe diameter;

b) Test pressure, rate of pressurisation and duration of the test;

c) Presence of air (hydraulic test);

d) Level of support from pipe embedment;

e) Accuracy of test equipment;

f) Ambient temperature changes during testing; and

g) The presence of leaks.

Long test sections may incorporate a large number of joints that need to be checked for leakage. The longer the test section the harder it may be to locate a leak – this is dependent on the chosen leak test method.

The network may be tested as a whole or in sections, depending on test pressure requirements, the length and diameter of the pipe, the availability of water (if undertaking a hydraulic test), and the spacing between sectioning valves or blanking ends. The pipe (or section) shall be properly supported and, if it includes unrestrained joints, be anchored to prevent the movement of pipes or fittings during the test.

When undertaking hydraulic testing the test section shall be filled with water, taking care to purge all free air from the section. Where a motorised positive displacement pump is used for the test, consideration should be given to the installation of an effective form of pulsation damping. The pressure shall be monitored at some convenient point and the test pressure adjusted to take account of the elevation difference between the pipe's lowest point and the test rig. The adjustment shall be made by subtracting 10 kPa for every metre that the rig is elevated above the lowest part of the pipe.

The source of any leak shall then be ascertained and any defects repaired. The pipe shall then be retested.

8.4.1 Strength test

The intent of the strength test is to prove the integrity of the pipe and identify any large leaks or defects in the network being tested.

When using an increased test pressure factor of 1.38 the tested section shall be required to undergo a period of relaxation. The relaxation period shall be a minimum of 24 hours and commence upon completion of the 24-hour leak test. Upon completion of the leak test the tested section shall be depressurised and only subject to atmospheric pressure.

Table 8.4.1a Pressure test factor

Requirement	Strength pressure test factor (f_p)
Standard	1.25

Increased Test Pressure Section 4.5.2.2 (a) Rural or Rural Residential location Class	1.25 x f_{1d} / f_{1t}
Increased Test Pressure Section 4.5.2.2 (a) High Use or Sensitive Sub-location Class	1.38 x f_{1d} / f_{1t}

Where:

- f_{1d} is the factor f_1 at the design temperature;
- f_{1t} is the f_1 factor at the test temperature as per Table 4.4.1.2.; and
- In all cases f_{1d} / f_{1t} shall not be less than 1.0.

8.4.1.1 Strength test criteria – hydraulic test

The requirements for gas and water Gathering Networks have been identified below:

Table 8.4.1b Strength test criteria – gas pipe hydraulic test

Hydraulic strength test gas pipe	Acceptance criteria
Starting pressure f_p x MAOP at the highest point, the lowest point shall not exceed 1.38 x f_{1d} / f_{1t} x MAOP . Test pressure to remain between: f_p x MAOP & MAOP during test at the highest point. 6 hours minimum hold duration. P>= MAOP at highest point.	1. Structural integrity maintained for 6 hours while pressure held between f_p x MAOP and MAOP at the highest point. 2. No evidence of sudden pressure drop.

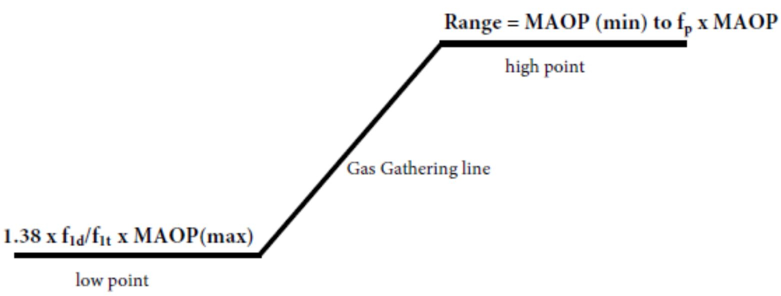


Figure 8.4.1b Test pressure range for gas pipe hydraulic test

Table 8.4.1c Strength test criteria – CSG water pipe hydraulic test

Hydraulic strength test CSG water pipe	Acceptance criteria
Starting pressure f_p x MAOP at the lowest point, the highest point shall not be less than MAOP. Test pressure to remain between: f_p x MAOP & MAOP during test at the lowest point. 6 hours minimum hold duration. P>= MAOP at lowest point.	1. Structural integrity maintained for 6 hours while pressure held between f_p x MAOP and MAOP at the lowest point. 2. No evidence of sudden pressure drop.

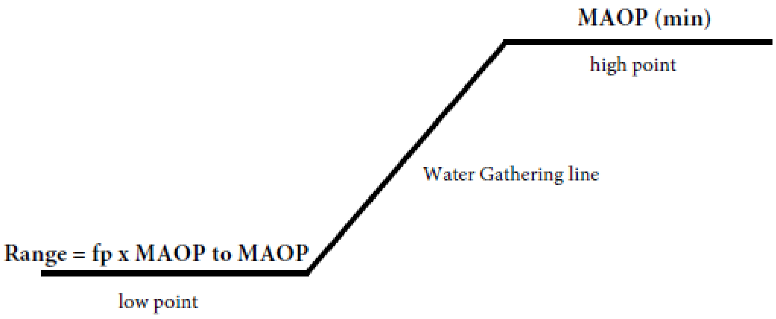


Figure 8.4.1c Test Pressure range for CSG water pipe hydraulic test

When converting a hydraulically tested water network to a gas network, consideration shall be given to the test pressures used during original construction. There may be the requirement to retest the network to ensure the test pressure acceptance criteria for gas networks, at the highest point of the test section in accordance with Table 8.4.1b.

8.4.1.2 Strength test criteria – gathering pneumatic test

For pneumatic testing, the criteria for water and gas Gathering Networks are the same.

Table 8.4.1d Strength test criteria – gas and water Gathering Networks pneumatic test

Pneumatic Strength Test	Acceptance Criteria
Starting pressure f_p x MAOP. Test pressure to remain between f_p x MAOP & MAOP during test.	1. Structural integrity maintained for 6 hours while pressure held between f_p x MAOP & MAOP.

6 hours minimum hold duration.	2. No evidence of sudden pressure drop.

8.4.1.3 Strength test method considerations

There are two primary methods of pressure testing, namely hydraulic (using water as the test medium) or pneumatic (using air as the test medium).

Care shall always be taken to ensure that the introduction of the test medium does not cause the maximum test pressure to be exceeded.

When strength tests are required to be performed in high-risk locations, hydraulic strength tests should be the preferred method of testing as opposed to pneumatic strength testing due to the incompressible nature of the test medium and hence greatly reduced stored energy. High-risk locations include the following:

- Places where other people may be working;
- Process facilities;
- Significant road crossings;
- Rail crossings;
- Populated areas;
- Third-party infrastructure; and
- Where simultaneous or conflicting operations are ongoing within the exclusion zone area.

Pneumatic strength testing in high-risk locations is not a preferred method but may be selected where:

- The pipe has tees or changes in diameter that make pigging or water filling impractical;
- There are significant changes in elevation;
- The location is remote;
- Suitable test water is not available; and
- Where a hydraulic strength preliminary test has been completed.

Specific and thorough risk assessments shall be conducted and take the necessary actions to ensure an ALARP condition.

Consideration should be given to testing in larger sections resulting in less untested (golden) welds, tie-in welds and the associated risk of these untested welds.

Disposal of the test water upon completion of the pressure test shall be considered as part of the overall pressure test process.

8.4.1.4 Test pressure for elevation changes

Care shall be taken to ensure that changes in elevation do not lead to excessive test pressures. Refer to Appendix B8 for example.

8.4.1.5 Compensation for test temperature

When performing increased strength pressure testing (Section 4.5.2.2 (a)) and where the testing pipe temperature (f1t) differs from the temperature for which the network has been designed (f1d), commensurate adjustment in test pressure shall be required in accordance with the design factors for temperature detailed in Table 4.4.1.2.

8.4.1.6 Strength Test period

The test period shall be a minimum of six (6) hours.

8.4.1.7 Type of network

All types of network categories can be tested using the Strength Test methods detailed in this Code.

8.4.1.8 Strength test constraints

There are no constraints as to the length of pipe and the diameter that can be tested in each test as long as the exclusion zone can be achieved and the parameters are followed within this Code.

8.4.1.9 Stabilising period

The stabilising period is not critical for a strength test as the intent is to determine if there are significant defects in the network. However, the temperature and material creep stabilising will have a detrimental effect on the pressure and therefore considerations should be given to temperature stabilisation of the test medium for all strength testing.

Temperature stabilising shall be required where test fluid being introduced into the network section being tested is at a different temperature to the ground temperature. A suitable time shall to be allowed for the test fluid in the network section being tested to stabilise. The Operator shall ensure that temperature stabilisation has been achieved.

As PE is an insulating material, significant time is required to ensure that the fluid inside the pipe is similar to ground temperature. This is critical for the leak test if it is being conducted as part of the strength test.

If a tracer gas leak test is being conducted, temperature stabilising is not critical.

Appropriate temperature measurements should be carried out.

8.4.1.10 Acceptance criteria

The pipe shall be considered to have passed the strength test if at the end of the test period the pressure in the test section is above MAOP and there is no evidence of a sudden pressure drop.

8.4.1.11 Strength test procedure

A strength test requires a written test procedure which shall address:

a) Installation of test equipment;

b) Pressure test requirements (test pressure, test temperature and temperature stabilising period);

c) Pressurisation of the network pipe;

d) Maximum allowable test section inlet temperature;

f) Test pass/fail assessment;

g) De-pressurisations of the test section; and

h) Test records.

The following shall be carried out while the pipe is being subjected to the pressure test:

- Following the period of temperature stabilisation, the initial pressure reading shall be taken;
- A further pressure reading shall be taken at the end of the strength test period and the apparent volume loss shall be determined. Intermediate pressure readings shall also be taken during the test period or alternatively, a continuous chart or electronic recording of the test pressures shall be taken; and
- The supervisor responsible for the pressure test shall be present at the beginning and at the end of the pressure test to witness whether or not the test section has successfully passed the test and this shall be recorded on the test certificate.

8.4.1.12 Pressurisation of piping

During pressurisation and hold period the following shall be observed:

a) The test fluid shall be introduced into the test section in a controlled manner;

b) At a low pressure (<200 kPa), after allowing a short stabilisation period at this pressure, check all above-ground components for signs of leakage;

c) While the pipe section is pressurised, no unauthorised person shall be inside the primary exclusion zone. After the initial low pressure test no persons shall enter the primary exclusion zone until the pipe has passed the test and the pressure is reduced to MAOP or lower;

d) Line valves shall not be operated; and

e) Backfilling or excavation shall not be carried out within the exclusion zone area or anywhere else along the section of network under test.

8.4.1.13 Test pass/fail assessment – strength test

The pipe shall be considered to have passed strength test if at the end of the test period the pressure in the pipe is above MAOP and that there is no evidence of a sudden pressure drop. After the successful completion of the strength test the pipe shall then be subject to a leak test process.

8.4.1.14 De-Pressurisation

8.4.1.14.1 Pneumatic test

After the strength (or leak) test, de-pressurisation will be required.

The pipe shall be de-pressurised in accordance with an approved test procedure under the supervision of a competent person.

a) The air shall be released from the test network. This process shall be controlled from the control point;

b) Due to the hazards in venting air, appropriate PPE shall be required;

c) Measures shall be taken to minimise noise generated during de-pressurising and its impact on the public and other personnel; and

d) The testing operator shall confirm that the pressure has been reduced over the entire network section under test before further work can proceed within the designated test area.

8.4.1.14.2 Hydraulic test

After testing, the pipe shall be de-pressurised and then de-watered (if required) in accordance with approved test procedures under the supervision of a competent person.

a) The water is to be released from the test head located at the control point;

b) Pressurised water is to be discharged in a controlled manner and rate as dictated by the test procedure; and

c) Considerations should be given to the discharge point.

8.4.2 Leak test

8.4.2.1 General

The intent of the leak test is to determine if there are any small leaks in the network. The leak test shall be undertaken after a successful completion of a strength test.

Exclusion zones are not normally required for leak tests as the network has been proven to have adequate structural integrity with no significant leaks. However, it is recommended that exclusion zones should still be maintained around above-ground pipe sections and testing equipment to keep unauthorised people out of the area during leak testing activities.

8.4.2.2 Leak Test Pressure

The minimum starting test pressure at which the leak test is performed shall be the nominated MAOP of the test network.

Table 8.4.2a Pneumatic leak test methods and acceptance criteria

Pneumatic Leak Test - Options	
Pneumatic Leak Test Method	Acceptance Criteria
1. Tracer Gas Test The acceptability of this method shall be approved by the operator. Further details are described in section CP-8-003 Leak Test Methods	Fails if gas detector detects leak.
2. Allowable Pressure Loss (Pneumatic pressure decay test) Details of this test method and calculations are described in CP-8-003 Leak Test Methods and Appendix B1 of this Code respectively.	The acceptable volume loss is 1 litre/hr/actual m^3 volume of test fluid. NOTE: The word 'fluid' in this context means air or other gaseous medium.
3. Other proven / approved method.	To be determined based on risk evaluation. Method to be approved by Operator.

Table 8.4.2b Hydraulic leak test methods and acceptance criteria

Hydraulic leak test - Options	
Hydraulic Leak Test Method	Acceptance Criteria
1. Constant Pressure Test	AS/NZS 2566.2 Appendix M5
2. Pressure Decay Test	AS/NZS 2566.2 Appendix M6

3. Pressure Rebound Test	AS/NZS 2566.2 Appendix M7
4. Visual test	AS/NZS 2566.2 Appendix M8: The test section shall be visually inspected for leakage at all joints, fittings, valves and all connections. If no leaks are present then the section shall be deemed acceptable.
5. Other proven / approved method.	To be determined based on risk evaluation. Method to be approved by Operator.

Additional information on above tests can be found in appropriate Companion paper. Consideration should be given to tightening the minimum acceptance criteria depending on the type of fluid (e.g. tighter acceptance criteria may be selected for brine pipes). In addition, consideration should be given to the minimum acceptance criteria for built up locations (T1 - High Use or Sensitive).

8.4.2.3 Constraints per type of test

The type of test to be used is to be identified in the inspection and test plan (ITP); consideration should be given to the criteria set out in Section 8.3. Network volumes are divided into three categories:

- Low volume;
- Medium volume; and
- High volume.

Each category is defined as follows:

- <u>Low volume networks</u> consist of components, road crossings, horizontal directional drill strings and short sections of buried pipe. They also include all pipe work that can be visually inspected;
- <u>Medium volume networks</u> consist of long above-ground pipe strings, buried pipe work with volumes approximately up to 50 cubic metres for pneumatic tests, and up to 250 cubic metres for hydraulic tests; and
- <u>High volume networks</u> consist of volumes above 50 cubic metres for pneumatic testing and over 250 cubic metres for hydraulic tests.

Leak test methods suitable for these networks are:

a) Low volume:
   - Hydraulic visual test;
   - Hydraulic rebound test; and
   - Pneumatic test methods – all (including tracer gas leak testing).

b) Medium volume:
   - Hydraulic rebound test;

- Hydraulic pressure decay test; and
- Pneumatic test methods – all (including tracer gas leak testing).

c) High volume:

- Hydraulic pressure decay test;
- Constant pressure test; and
- Pneumatic test methods – all (including tracer gas leak testing).

8.4.2.4 Other proven / approved methods

Other methods of leak detection including acoustic testing are available or are being developed. In order to use any of these methods, the acceptable criteria shall be approved by the Operator including verification of contractor competency as well as method verification by technical assessment and testing.

8.4.3 Component testing

8.4.3.1 Component Pre-test

Numerous manufactured components are used in Gathering Networks, including valve manifold assemblies, risers, low point drains, T-sections, high point vents and riser sections (e.g. for pressure testing). These components may include materials other than PE.

Components that are pre-fabricated and not subjected to a field pressure test, shall be required to have a test duration of a minimum of 6 hours at the required test pressure in accordance with Section 8.4.1.

8.4.4 Hot tapping and emergency response pressure testing

When performing a hot tap on a live PE pipe, in the course of an emergency response or providing a new connection, the hot tap assembly shall be tested prior to cutting of the coupon. Testing of a hot tap assembly shall be performed using a combined strength and leak test using hydraulic methods only. Components and assemblies which are installed or replaced due to failure (in the case of an emergency repair or scheduled maintenance), and not be subjected to a field pressure test, shall be tested in accordance with this clause.

The test duration shall be a minimum of 6 hours at the required test pressure in accordance with Section 8.4.1. During the test period, a minimum exclusion zone of five (5) metres shall apply.

The test section should encompass the branch saddle, isolation valve and tapping equipment. The exceptions are small bore tapping saddles (OD≤63 mm), normally used for bleed or drain purposes. The test time for such components during emergency response can be reduced if a risk assessment is completed and approved by the Operator.

8.5 Test records

Test report sample sheets can be found in Appendix B7.

Details of test records requirements are included in Section 9.

8.6 Pressure test failure

The Constructor shall ensure that any failure which occurs during pressure testing shall be communicated to the Operator and investigated, repaired and subjected to a repeat test prior to being commissioned. All records shall be provided to the Operator.

8.7 Qualification and assessment of a pressure test procedure

The pressure testing procedure for testing PE networks shall be approved by the Operator. The test procedure shall be based on this Code and address all operational and safety issues.

Quality and WHS specialists of or contracted by the Operator shall have input into the development of the pressure test procedure. This is to ensure that all hazards associated with pressure testing have been mitigated to as low as reasonably practicable (ALARP) through the implementation of identification, evaluation and control methods.

The Operator shall provide sufficient resources to ensure that relevant information, instruction, training and supervision are available to conduct all work activities safely. The test procedure shall be assessed and monitored to ensure that it conforms to the requirements of this Code. It shall be reviewed on a regular basis.

8.8 Qualification of pressure test personnel

The pressure testing personnel who are included in the work permit shall pass an approved pressure test course before being permitted to conduct a pressure test. This course shall cover all relevant elements of this Code.

9 Records Management

9.1 Basis of section

Primarily, the purpose of records is to preserve:

a) Historical information required for the safe operation and maintenance of the network over the network's life;

b) Objective evidence of conformance with, and effectiveness of, the network management system (NMS) and safety management system; and

c) Records of decision-making and approvals.

9.2 Design, construction, testing and commissioning records

During the design stage, receipt of materials for the network, and network construction, the Operator shall obtain, prepare and keep current, records of the following:

a) Safety management studies or risk assessments conducted (including location class);

b) Hazard and operability study records;

c) Design basis;

d) Project specifications and data sheets;

e) Specification and traceability of all materials and components including all test results, inspection reports, names and process of manufacture;

f) All tests and inspections that are required to verify the integrity of the network in accordance with this Code;

g) Required MAOP;

h) All drawings, as built and alignment (developed in accordance with AS 1100.401) relating to the network and facilities;

i) Condition of the internal and external surfaces;

j) Operation procedures that form part of the design;

k) List of the authorities that have granted operating permits, and land-holders through whose land the network passes, including contact history and title information;

l) List of other easements (especially easements for other networks, power lines and communications cables) through which the network passes, their contact details and other relevant information;

m) Records of network sections or components identified as potentially high-risk in an emergency;

n) Commissioning records;

o) Welding records;

p) Quality assurance and control records including traceability;

q) Safety and environment records;

r) Approvals and correspondence with regulatory authorities;

s) All associated inspection records and test results that are required to verify the integrity of the network in accordance with this Code;

t) Any construction information that may be relevant to maintenance of the network; and

u) Commissioning records including as a minimum all records from commissioning activity relevant to the ongoing operation and maintenance of the Gathering Network.

9.3 Pressure testing records

A test report shall include as a minimum the following details:

a) Test limits and identification of the section of network being tested including location, length, diameter, SDR and material;

b) Date and times the test was performed;

c) Specified MAOP;

d) Test pressure at the start and at the end of the strength test;

e) Pressure recorder chart or data logger readings;

f) Details of hold periods and stabilisation times;

g) Temperature of the pipe where relevant;

h) Statement that the section of network under test has passed or failed the strength and leak test method requirements showing relevant calculations; and

i) Name and signature of the person validating the test.

9.4 Operation and maintenance records

The Operator shall prepare a records management plan. The plan shall detail the records to be obtained, the records to be retained, storage methods and procedures to maintain currency of the records, until the abandonment of or removal of the network. The plan shall be approved.

Records that shall be included in the plan are the following:

a) Records required due to operating condition changes;

b) Historical NMS plans and procedures;

c) Any approved change to operating conditions, engineering investigations and any work carried out in connection with any changes to operating conditions;

d) Any modifications to the maps, charts, plans, drawings and procedures, which are required to allow the procedures to be properly administered (e.g. exposure to the public, changes in design and operating conditions including brownfield tie-ins and gathering extensions);

e) Details of any deformation, damage or other anomalies;

f) Details of any leaks, ruptures or other loss of containment events;

g) Routine inspections, and inspections and testing carried out when cutting into a network or making hot taps;

h) Repairs and maintenance work to networks;

i) Details of inspections of internal or external network condition;

j) Correspondence with statutory and regulatory authorities;

k) Safety management study or risk assessment reviews;

l) Incidents and subsequent preventive actions;

m) Operation and maintenance personnel competency details and training records;

n) MAOP review documents;

o) Location class review documents;

p) Reports on landholder and third-party liaison and the information given;

q) Records of emergency response exercises, the actions arising, and the completion of those actions; and

r) Records of any pressure excursions as a result of fit-for-purpose design under Section 4.6 including the location, time, date and duration of the excursion and any effect on network life.

The following records shall also be prepared and retained for a minimum of five (5) years:

- Necessary operational data; and
- Network surveillance patrol reports.

NOTE: Legislative obligations may result in increased record retention durations.

9.5 Abandonment records

The Operator shall document the archiving or disposal of records associated with an abandoned network.

A record should be kept of all abandoned networks that remain in-situ, to prevent possible mistakes in identifying an abandoned network as an operational network.

The following minimum information should be recorded:

- Location;
- Network identification number;
- Abandonment plan details;
- Pipe diameter and SDR;
- Type of service;
- Date constructed; and
- Date abandoned or decommissioned.

9.6 Records management and document control

The Operator shall establish procedures for the identification, collection, storage and disposal of records pertinent to the NMS and to the achievement of the objectives of this Section. Procedures shall cover electronic as well as paper-based records. As a minimum the following shall be addressed:

- Records to be retained;
- Retention period of each record type;
- Records storage and preservation methods (e.g. paper based, electronic storage, GIS etc);
- Record update and maintenance procedures; and
- Audit schedule.

The Operator should ensure that appropriate records are identified, retained, managed and recorded in the records management plan. In addition to the requirements of Section 9.3, the records management plan should address the above requirements as a minimum.

The Operator shall obtain and maintain records that are necessary to:

- Safely operate and maintain the network;
- Demonstrate conformance with this Code and relevant legislation;
- Identify decisions made and actions taken by the Operator; and
- Confirm the fitness for purpose of the network at any stage of the network operating life.

10 Commissioning

10.1 Basis of section

Commissioning shall be the responsibility of the Operator, and shall always be preceded by acceptance pressure testing of the relevant network section (refer Section 8) and all associated components.

Commissioning is broadly defined as the range of activities that are required between mechanical completion of the plant or network and its handover for operation; it involves the introduction of process fluids, and the functional and performance testing of all related equipment and systems prior to handover.

10.2 Commissioning strategy and plans

The Operator shall develop a strategy which shall be based upon generic commissioning plans to be executed by competent staff. As each gas field comprises numerous gas and water Gathering Networks (and transfer pipes at some locations), the Operator should ensure that the commissioning strategy reflects the following aspects:

- While the water and gas Gathering Network(s) is normally constructed and tested simultaneously, the commissioning may often be conducted separately, such as in instances where the water Gathering Network is used to deliver drilling water supply.
- Gas Gathering Network commissioning is normally performed in conjunction with the wellsite facilities, as the over-pressure prevention and pressure relief facilities protect both asset facilities.

10.3 Commissioning personnel

The Operator shall ensure the availability of an appropriate number of experienced, competent personnel, including suitably qualified Commissioning Supervisors, who shall be responsible and direct each separate commissioning process.

For commissioning Gathering Networks, the nominated Commissioning Supervisor shall ensure that all personnel responsible for commissioning activities and tasks are suitably experienced, competent and take all relevant precautions. The Commissioning Supervisor shall conduct a simultaneous operations (SIMOPS) assessment and ensure all relevant stakeholders are engaged.

10.3.1 Commissioning manager

The Operator shall appoint a suitably qualified manager to direct the commissioning processes.

The appointed manager shall ensure that all personnel responsible for commissioning are suitably experienced and take relevant precautions required when working on the live gas network facilities.

The appointed manager is also responsible for coordinating activities between all associated groups involved with the commissioning process including communication and interaction with other contractors and operating plant, and has sighted that all pre-commissioning documentation is completed prior to commissioning.

10.4 Plans and procedures

The Operator shall ensure that a generic commissioning plan and procedures are developed covering all details of key personnel (in particular Commissioning Supervisors), inspections required by this Code and referenced documents. For each specific Gathering Network, a site-specific risk workshop (or equivalent) shall be conducted and reviewed.

Commissioning procedures shall require all pre-commissioning documents identified during the pre-planning process to have been completed and signed off prior to the commencement of commissioning.

Commissioning involves a phased approach, which shall consist of:

a) Pre-commissioning, following pressure testing;
b) Component testing and commissioning; and
c) Full network commissioning.

The nominated Commissioning Supervisor shall have the responsibility for each discrete section of the Gathering Network.

If at any time during the Commissioning process, any unforeseen risks are encountered the work shall cease, the Commissioning Supervisor informed and appropriate remedial action taken; the Commissioning Supervisor shall advise the work teams of permission to proceed.

10.5 Health, safety and environmental precautions

Commissioning of Gathering Networks, or transfer pipes shall be performed in a safe and efficient manner with precautions taken to ensure the continued safety of all personnel, property and equipment, and that no losses of containment of process fluids occur.

All operations conducted during the course of commissioning shall be in accordance with the requirements of the following documents:

- Relevant government regulations;
- The Construction and Operations Network Management System (NMS) for the relevant part, and process fluid, of the network where the commissioning is occurring; and
- Environmental Licence and Plan.

The Operator shall be responsible to ensure that all personnel involved are competent and experienced.

'Safety toolbox meetings' should be conducted regularly during any commissioning program by the appropriate Commissioning Supervisor.

A permit system shall be implemented during the commissioning process, comprising as a minimum the following procedures:

- Permit to work, including JHA/JSA system; and

- Lockout and tag system.

The Operator shall ensure that written procedures are developed to ensure that all relevant stakeholders and commissioning team members are fully aware of the hazards associated with the Gathering Network, and what measures are necessary to make all such activities safe to perform. The procedures shall also consider:

- Appropriate valve line-ups and sequencing (for both isolation valves and gathering facilities including HPVs and LPDs); and
- SIMOPS activities within the Gathering Network.

The Operator shall ensure that all commissioning operations are conducted in accordance with the approved Environmental Licence and Plan.

10.5.1 Safety

Each member of the commissioning team shall clearly understand that the existing installation or other infrastructure associated with the new network is critical to the safe and secure operation of the whole network. All personnel involved in the commissioning operations shall be adequately trained and experienced with the relevant tasks.

To ensure all sites involved in the commissioning process remain safe and secure during natural gas purging and pressurising procedures, all other work activities associated with the network being commissioned shall normally be suspended until final commissioning of the section has been completed. Any exceptions shall only occur under strict permit conditions.

10.6 Readiness for operation

The Commissioning Supervisor shall ensure that for all Gathering Networks, both the PE pipes and all associated facilities are checked and verified by a competent and qualified inspector to ensure that they are fit for purpose for the nominated operating envelopes. Such facilities shall include valves, flanges, protective devices (pressure safety valves), electrical and instrumentation equipment where applicable.

10.6.1 Contaminants

No network or section of network shall be placed in service before it has been cleaned of contaminants, before it has satisfied test requirements and, in the case of CSG water pipes, before the quality of water supplied from the pipe has met the Operator's standards.

Possible contaminants include:

a) Materials that enter the pipes and fittings during storage and transport;

b) Construction debris;

c) Materials introduced during construction, e.g. lubricants used with elastomeric seal joints; and

d) Bacterial contaminants, which often colonise other contaminants.

10.6.2 Actions

All actions arising from the commissioning and/or pre-commissioning risk assessment shall be implemented in a timely manner and the implementation documented. Where ongoing action is required, a reporting mechanism to demonstrate action shall be established, implemented and audited.

Safety management documentation shall be transferred from the design and construct phase of the project to the operating phase of the project in a form that enables operations to be undertaken in a safe manner from the time that operation commences.

For new networks, all actions that are considered necessary for the safe pressurisation of the pipes shall be completed prior to the commencement of commissioning.

10.6.3 Communication of commissioning procedure

The Operator shall ensure that an adequate procedure is developed to communicate commissioning activities to all relevant parties in a timely manner.

10.7 Purging and filling the Gathering Network

10.7.1 General

The Operator shall be responsible to initiate suitable integrity management activities to maintain the safe operation of all newly commissioned Gathering Networks.

The network shall not be considered ready to commence or recommence operation until, as a minimum, the following checklist has been completed:

a) The network safety management study has been reviewed and network determined as ready for operation;

b) The strength and leak test requirements have been achieved and documented;

c) The MAOP has been established;

e) If tie-in welds to existing facilities have not been subjected to b) above, then such welds have been subjected to the requirements of Section 7.5.1, 7.7.1, 7.8 and 7.9;

f) All components have been tested for satisfactory operation; and

g) Sufficient operating, maintenance, and emergency personnel have been trained and qualified as competent.

NOTE: Refer to Appendix C for further details regarding testing of tie-in welds.

10.7.2 Filling a gas network

Prior to filling a gas network, a commissioning plan shall be prepared, which shall contain all relevant supporting calculations.

Ensure all necessary pre-commissioning punch-list items from all field installation checklists (FICs) are complete before proceeding with commissioning.

When a network is being purged of air with gas, prior to filling, consideration shall be given to the safety and operational consequences of the formation of an explosive mixture at the gas/air interface.

A direct purge of produced (coal seam) gas may be used provided the approved procedures meet the conditions and requirements of AS/NZS 4645.3 or AGA Purging Manual, Catalogue No, XK1801. If the conditions and requirements for direct purging cannot be satisfied, then the Commissioning Supervisor shall ensure that an approved procedure, using an alternative technique, purges the network in a safe manner.

10.7.3 Filling a water network

In most CSG Gathering Networks, the source options are likely to include the following, which may require different techniques:

- Wellhead lease facilities;
- Water bores, either Landholder, stock route or industry drilled for development purposes;
- Storage ponds or dams, Landholder owned; and
- Industry (nodal) ponds or dams, containing de-gassed PFW. This category can include fracking-water and regional gathering water storage ponds.

Typical contents within the water include a combination of the following:

- Entrained gas (bubbles) such as methane, hydrogen sulphide or carbon dioxide;
- Varying concentrations of dissolved salts;
- Solids such as coal fines, sand and grit;
- Bacteria and/or other organic matter; and
- Pure water devoid of any minerals such as reverse osmosis water (un-buffered).

The composition of the water to be carried in the network shall be established and specific risks considered in the development of the commissioning procedures.

Post introduction of water into the Gathering Network, a visual verification at the outlet is required.

10.8 Function testing of associated gathering equipment

10.8.1 Protective devices

All associated upstream and downstream protective devices shall have their compliance plate/tag verified by a competent person. The competent person shall also safely test (if current test records are not already available) the device by simulating a trip or activation event as per its design to an approved procedure. All equipment used as testing protective devices shall have a valid calibration tag certified by a recognised and certified testing agency conforming with the relevant Australian Codes and Standards. Upon successfully passing activation or trip testing, the device shall be reset, checked that it is in good condition and fully functional for introduction of gas.

10.8.2 Mechanical equipment

All valves, flanges and associated up and downstream equipment shall be verified by a competent person to ensure that they are properly aligned, lubricated, installed, in good condition and fully functional for introduction of gas or CSG water.

10.8.3 Electrical and instrumentation equipment

All electrical and instrument devices shall be checked and verified by a competent and qualified inspector that they are fully functional for the introduction of gas or CSG water into the facilities being commissioned.

10.8.4 Changed operating conditions

Prior to commencing operation at a new MAOP, a commissioning and testing plan shall be developed to manage the safe implementation of the changed operating conditions. The plan shall address at least:

a) The setting and testing of each instrument and control;

b) The number and magnitude of pressure increments used in the transition from the original operating condition to the new condition; and

c) The requirements for leakage testing during the transition.

10.9 Records management

The Operator shall ensure that all relevant records are prepared at the conclusion of each commissioning task within the Gathering Network and managed in accordance with the requirements of Section 9.

11 Operations

11.1 Basis of Section

This section provides important principles, practices and guidelines for use by competent persons and organisations involved in the operation and maintenance of CSG gas and water Gathering Networks. The network facilities are an integral component of the field operations, and are normally covered by the overall network management system and related plans, rather than having a specific individual plan.

The fundamental principles on which this Section is based are the following:

a) Safety, engineering design, materials, testing, inspection and operation are reviewed and approved by the Operator;

b) Network management system is implemented to provide for continued integrity, monitoring and safe operation of the CSG field Gathering Network in its entirety; and

c) Where the Code does not provide detailed requirements appropriate to a specific item, the principles and guidelines set out in the Code are the basis on which an engineering assessment is made by competent persons. Specific requirements of the Code do not replace the need for appropriate experience and engineering judgement.

NOTE: While CSG Gathering Networks primarily involve PE pipes, also included are manifolds, valves and low point drains (for gas networks) high-point venting facilities (for CSG water networks) and other installations.

11.2 Safety and operation

There are fundamental requirements that shall be met before a new Gathering Network can be considered ready for operation, and to ensure an existing network remains fit for operation.

The primary goal is to manage the safety and integrity of the Gathering Network to provide a safe and reliable operation for the life of the asset, and also to ensure that the operation and maintenance of the Gathering Network does not impact on the health and safety of personnel, the public or have an unacceptable impact on the environment.

To achieve these objectives the Operator shall ensure:

- That the network management system (Section 2) is implemented to properly include the Gathering Network facilities and incorporates risk assessment and an integrity management process;
- A CSG field environmental management plan, when developed and implemented, includes provision for the Gathering Network, in particular the storage, processing and beneficial of CSG water;
- A compliant Gathering Network exists and is fit for operation;
- An effective handover process as specified in Section 10 is in place;

- An operating philosophy ensuring the ongoing fitness for purpose of the Gathering Network has been prepared; and
- An effective CSG field emergency response plan for the Gathering Network is documented and implemented.

Relevant records to enable investigations and analysis to be carried out are retained and updated as required by the network management system.

NOTE: Refer to the appropriate Companion Paper for further information.

11.3 Network operation and controls

11.3.1 General

Network operation shall be continually monitored by reviewing both operating data and external factors to ensure that the integrity is maintained in accordance with the requirements of the IMP. The review shall assess the effectiveness of the implemented control and monitoring processes during the design life of the network. The major areas in operation controls include operating parameters, maximum allowable operating pressure (MAOP) and maximum operating pressure (MOP) adjustment.

In order to maintain structural integrity, the Operator shall ensure that a network meets the following applicable requirements:

a) Operate a network only when it conveys the fluid or fluids under the conditions (including subsequent changes) for which it was designed, constructed, tested, and approved;

b) Ensure that during normal operation, the operating pressure at any point in the network does not exceed the MAOP; and

c) Ensure that the average temperatures are such that the design life is not reduced and the thermal stress limits used in the network design are not exceeded.

11.3.2 Operation and maintenance procedures

The Operator shall have procedures for the normal operation and maintenance of the Gathering Networks, including those necessary for maintaining integrity in accordance with this Code.

The procedures shall include detailed instructions for persons responsible for the operation and maintenance of the network during normal operation and maintenance and be documented within the network integrity management plan (IMP). The IMP shall also contain a summary of the operational and maintenance processes and procedures.

The Operator shall:

a) Have written procedures which shall be approved and reviewed at nominated intervals for the operation and maintenance of the Gathering Network;

b) Document and record the interval between reviews of the network management system, the environmental management plan, the emergency response plan and the operating and maintenance procedures; and

c) Operate and maintain the Gathering Network in accordance with these procedures.

11.4 Environmental and cultural heritage management

11.4.1 CSG field environmental management plan

The Operator shall establish procedures to identify environmental aspects and ensure impacts on the environment are maintained at an acceptable level.

The Operator shall have an approved environmental management plan in place prior to commissioning the total Gathering Network and during the life of the asset to ensure that operation and maintenance requirements are effectively applied. Measures to mitigate environmental impacts shall be documented in the plan

Relevant government authorities regularly publish revised guidelines related to the treatment of PFW and its by-products, so ongoing attention is suggested to ensure full conformance with statutory requirements.

Environmental matters are key items in pre-operational planning particularly in respect of the PFW pipes; however normal good practice adequately controls their impacts. Regular liaison with landowners and other stakeholders regarding environmental matters may also reduce many of the third-party interference threats.

The *Australian Pipelines and Gas Association Code of Environmental Practice – Onshore Pipelines* should be referred to by the Operator for guidelines on environmental management of networks.

11.4.2 Heritage sites

A register of heritage sites should be held and used during pre-planning and design of the gas field facilities. Heritage sites are protected by law and shall be identified during pre-planning and protected during construction. Operators should also be aware of the locations in the vicinity of the network and shall ensure that they are protected with appropriate permissions obtained prior to working in those locations.

11.5 Water management

11.5.1 Surface Water management

Management of surface water flows and streams are major issues which can lead to wash-aways, integrity risks and major expense. Routine surveillance is necessary, particularly after heavy downpours, to monitor the condition of the network corridor and the access tracks.

11.5.2 Water transfer handling

Water Gathering Networks, especially flow/spur sections, may be used to transfer treated water for drilling or workover activities; site-specific procedures should be developed.

11.5.3 Spill prevention and response

CSG Water Gathering Networks contain various categories of water requiring appropriate spill responses. Specifically, networks containing PFW and saline water require suitable spill prevention and response planning to contain any spills and minimise the environmental impact. The impact of these spills can be significant and specific training and review of all regulatory requirements is necessary.

11.6 Gathering Network integrity management

Integrity is achieved when the network is leak tight, operating within the design parameters and able to safely withstand all identifiable forces to which it may be subjected during operation, including the MAOP.

The Operator shall establish systems and processes that ensure integrity for the design life of the network. The Operator should be able to demonstrate that appropriate systems are established, implemented and maintained.

The objective of maintaining integrity of the network is to ensure that the operation and maintenance will not cause injury to the public, personnel, unacceptable damage to the environment or disruption of production.

11.6.1 Network integrity management plan

The Operator shall prepare, approve and implement a network integrity management plan (IMP) for the Gathering Network.

Monitoring, inspection and mitigation of the identified threats shall be based upon assessment of risk where the frequency of monitoring, inspection, and mitigation of each threat is based upon the risk level posed by that threat. The adequacy of the IMP shall be reviewed at intervals not greater than five (5) years, or immediately upon a failure event.

The Plan shall also detail the operating philosophy including design parameters of the network, specifying operational limits, including the MAOP, overpressure excursions, temperature limits and design life.

Integrity management procedures shall be maintained for each monitoring, inspection or mitigation action that ensure the Gathering Network infrastructure remains fit for purpose at all times. This is achieved by implementing a systematic approach to operation, maintenance, testing and inspection activities and the application of sound engineering principles with due regard to safety and the environment.

Activities may include:

- Right of way inspection;
- Leak detection surveys;

- Critical function testing (CFT) of over pressure protection devices; and
- Checks to ensure the average temperature is not exceeding the maximum average temperature applicable for the selected design life.

Procedures shall be developed to ensure structural integrity of the network infrastructure is retained during operation and maintenance activities. The procedures shall be approved.

The structural integrity issues of at least the following elements shall be addressed in accordance with the approved IMP:

- Pipe joints (flanges, butt welded and EF welded joints, compression joints, etc); and
- Metallic elements of the network (e.g. risers, metallic flanged joints, metallic valves, transition joints, LPD and HPV metallic elements).

Over-temperature effects shall be addressed where these have been determined by risk assessment as potentially impacting the network at specific locations (e.g. at above-ground piping locations, subject to solar heating, which may potentially be subjected to over-pressure at the increased temperatures upon start-up of upstream pumps-including downhole pumps).

Structural integrity assurance may be achieved by means of testing and/or inspecting representative samples at locations and frequencies identified by risk-based assessment. The structural integrity issues may be addressed when opportunity arises, for example during replacements, extensions, scheduled repairs or emergency response activities.

Where the integrity procedural measures have been specified in accordance with Section 4.5.2.2 Increased QA/QC, the IMP shall document the method, equipment and frequency of inspection to achieve the required procedural control in accordance with the design.

Gathering Network integrity shall continually be assessed and maintained by reviewing network operating conditions both time-dependent and time-independent factors through integrated operation controls and maintenance activities.

The data and information identified and collected for the assessments and reviews should form the basis for ongoing assessment of the risk and integrity of the network. The findings of such a program will determine actions necessary to ensure the continuous safe and reliable operation of the network.

11.6.2 Condition assessment

Condition assessment in accordance with the IMP can provide improved integrity and safety assurance by assessment of joint failure or slow crack growth (SCG) as appropriate and remediation of the issue before failure.

Options should include:

- Completion of oxidation induction time (OIT) and Fourier transform infrared spectroscopy (FTIR) tests on targeted pipes and fittings (by external scrapings) to verify conformance with the prescribed pipe and fittings standards.

- Direct external inspection of selected buried joints, especially EF joints based on risk;
- Mechanical testing of extracted fittings, joints and saddles;
- Leak detection surveys and investigation of leakage; and
- Corrosion assessment of any metal components.

For condition assessment to be effective, the results shall be documented with the associated actions implemented by competent personnel, in an appropriate timeframe, in accordance with the associated risk level.

11.6.3 Leak detection surveys

The IMP shall be modified where new or current modes of failure having an increased risk are identified. Leak detection shall be carried out by the operator to ensure a network is free from identifiable leaks. The type of surveillance and the frequency required for safe network operation varies and should be determined by IMP and operational leak management plan.

11.7 External interference management

The network integrity can be affected by unauthorised external interference or during an encroachment incident. These incidents can directly impact on the network integrity with the result of loss of containment

The Operator shall establish and implement protection systems to ensure that all external interference threats to the Gathering Network identified in the network management system are managed. The effectiveness of the control measures implemented to manage all identified threats and the corresponding risks shall be continually reviewed and monitored.

To adequately manage risk, the Operator shall develop, implement and monitor the threat mitigation measures and risk management procedures that have been identified in the network management system.

The minimum should include the following:

a) Marking;

b) Community and stakeholder awareness;

c) Maintaining pipe separation for greenfield and subsequent installations;

d) Protection methods and load limits;

e) External interference detection;

f) Permit to work; and

g) Physical measures— depth of cover or barriers.

11.7.1 Network corridor management

Maintenance programs can be very visible to the community and regular routine operations should seek to manage the maintenance works with a minimal disturbance. Every care should be taken to meet relevant regulations and avoid at all times the spread of disease and weed infestations between properties by vehicle and shoe transfer of soils and seeds.

Corridor maintenance generally involves:

a) Monitoring easement conditions particularly after heavy rain;

b) Maintaining access tracks; and

c) Monitoring third party activities.

11.7.2 Gathering Network marking

Signs shall be maintained along the route so that the network can be properly located and identified, as appropriate to each particular situation and as identified in the network management system.

Maintenance of network marking shall ensure the following:

a) Legible signs are maintained at spacing as predefined in the design documentation and in any case at inter-visible distances;

b) Signs or other markers are placed at each change of direction, at each side of permanent watercourses, at each side of road and rail crossings and at crossings of each property boundary;

c) Signs exist at all above-ground facilities;

d) Any other signs needed to identify the location of the network are placed and maintained; and

e) Conformance with the requirements set out in Section 5 Network Marking.

11.7.3 Communication

The Operator shall identify people and organisations outside the Operator's organisation with a legitimate interest in the safe operation and maintenance of the network.

These may include landowners, local and emergency authorities as well as technical regulators or other government agencies.

The Operator shall establish procedures for regular consultation with, communication and reporting to these identified stakeholders. These procedures shall include statutory reporting requirements.

11.7.4 Community and stakeholder awareness

The Operator shall take all reasonable steps to inform people and organisations that may in any way rely upon the safety of the Gathering Network as follows:

a) Informing the appropriate authorities and other relevant bodies of the hazardous properties of the fluid and the effects of any accidentally discharged fluid on the safety of the public or the environment so that, in the event of an emergency, prompt joint cooperative action can be taken;

b) Informing landowners and other occupiers of land through which the Gathering Network passes of the methods of recognising risks to the Gathering Network and an emergency situation. They should be supplied with 24-hour contact telephone numbers of the appropriate responsible persons or organisations to be notified in the case of an emergency;

c) Warnings should be issued concerning the dangers of interference with the Gathering Network and its appurtenances; and

d) Operator staff visits, at approved regular intervals, to provide landowners and other occupiers of land through which the Gathering Network passes with information to ensure that their activities do not endanger the Gathering Network and its appurtenances.

To ensure the integrity of the Gathering Network and the safety of the public and the environment, it is critical that identified groups such as property and service designers, owners and operators, construction organisations, excavators, drillers and borers and the general public take into account the presence of the Gathering Network in their intended activities. Appropriate regular communication with these and with the relevant authorities is required to raise and reinforce awareness of the presence of a Gathering Network and the constraints with respect to the use of the land on and near the Gathering Network.

Where the Gathering Network occupies public land, consideration should be given to including these sections of the network on the 'Dial Before You Dig' database.

NOTE: AS 2885.6 E4.3 provides guidance on developing an effective third-party liaison program

11.7.5 Gathering Network pipe separation

The minimum clearance from a Gathering Network to any buried structure shall be as per Section 4.12.

The minimum clearance for parallel installation shall be such that future maintenance can be conducted, but shall not be less than those detailed in Table 4.12.1 Minimum Separation distances.

The Operator shall consider protection when determining appropriate separation distances of Gathering Network to other buried structures.

The Gathering Network and associated crossings should be designed to ensure that seismic activities do not affect the Gathering Network.

11.7.6 Protection methods and load limits

Ground cover is the primary protection against external loadings on the Gathering Network. The pipe cover shall be maintained at all locations where vehicles are traversing the Gathering Network. Loads imposed by these vehicles on the Gathering Network shall be assessed to ensure that they do not exceed the design conditions of the Gathering Network at the specific location. Refer to Section 4 Design for external loads for further information regarding design for external loads.

11.7.7 External interference detection

11.7.7.1 Surveillance Programme

Gathering Network surveillance shall be undertaken at a frequency and in a form determined or validated by an SMS process, the network management system and relevant management plans, but not less than annually.

Surveillance activities can include physical patrols (e.g. by driving or on foot), aerial patrols (including by fixed wing, rotary or unmanned aerial vehicles) or the use of other surveillance tools (such as aerial photography or satellite imagery).

The frequency of surveillance may need to be adjusted or additional surveillance conducted based on:

a) The assessed likelihood of external interference;

b) How regularly currently-identified external interference threats are managed;

c) How regularly new threats are likely to be able to be identified;

d) Effectiveness of other layers of protection in place;

e) The Gathering Network environment; and

f) The location class.

The boundaries (including routes for aerial and ground patrols) and responsibilities for surveillance activities shall be clearly defined to eliminate any gaps in coverage.

NOTE: Patterns of third-party activities near the Gathering Network should be regularly examined to inform and provide guidance of specific threats to personnel conducting the surveillance activities on an ongoing basis.

Factors to be considered when developing a surveillance program shall include the following:

- Operation of a ‘one-call system’;
- Whether the Gathering Network is above or below ground;
- Third-party activities that could affect the Gathering Network;
- Locations in a built-up area or where there is a high potential for exposure to the public in the event of a failure event;
- Locations close to environmentally sensitive areas;
- Provision of a leak-detection system;
- Regularity of use;
- Nature of the fluid carried;
- Design and operating pressure and temperature;
- Specific requirements such as at bridge crossings; and
- The environmental and terrain context (included propensity for flood, earthquake and landslip).

11.7.7.2 Surveillance Activities

The following shall be identified during the surveillance of Gathering Network. These may be achieved through a range of surveillance activities:

a) Variations to surface conditions such as erosion or earth movement or seismic activity, which may need engineering assessment for induced stress and strain;
b) Changes to watercourse, steep terrain and crossings that might render the network unsupported or exposed;
c) Indications of leaks such as dead vegetation, frozen ground or evidence of liquid;
d) Construction activity or evidence of construction activity on or near the network;
e) Deteriorating condition, visibility, adequacy and correctness of route markers and signs installed in accordance with the relevant requirements of Clause 7.7;
f) Security of sites and evidence of unauthorised entry;
g) Any factors likely to initiate a review of location class such as new urban developments and land use change; and
h) Excessive growth of vegetation within the easement area (See Clause 7.12.4).

During surveillance, attention shall be given to activities involving excavation, directional drilling, blasting operations, boring activities, including the use of an auger, and drains or ditches that are maintained and cleaned by an independent party.

Natural events such as flood, earthquake and ground slips are also sources of external interference which have the potential to affect the networks integrity. Uncontrolled ground movement can impact or displace the pipe, and may increase pipe stress to unacceptable levels. This may result in a failure or coating damage on steel risers.

Surveillance activities can also contribute to operational monitoring and general network corridor management monitoring not specific to external interference, and can be used to identify:

- Impediments to access to stations, and communication installations;
- Any other factors affecting the safety and operation of the network; and
- Potential effects of the network on the environment.

The person conducting the surveillance shall:

- Be issued with written patrolling procedures;
- Be appropriately trained and competent in the procedures; and
- Know the extent of the network easement and the location of the network.

Records should include a surveillance log incorporating the specific consideration of relevant issues as detailed above. Surveillance records shall be available to determine procedural measure effectiveness during future SMS reviews. Nil reports should be considered valid methodology.

All surveillance records shall be retained for a minimum period of ten (10) years and maintained as specified in the record management plan.

A level of assurance appropriate to the surveillance activities should be implemented, and document related assurance plans in the management system.

11.7.7.3 Remote intrusion monitoring and alternative surveillance methods

Using available technology, real time monitoring and detection of interference, leakage and ground movement can be considered along the network for threats such as third-party interference, landslides, floods, erosion in river crossings, and tectonic hazard zones. Advanced intrusion and surveillance technology such as the following may be applied to complement the effectiveness of the surveillance:

- Installation of remote monitoring such as CCTV, motion sensors and alarms for third-party interference;
- Infra-red laser gas leak detection system that can be mounted on a vehicle, a helicopter, or a drone;
- Gas leak detection system based on video and optical gas telemetry mounted on a robot for areas with restricted accessibility;
- Drone mapping and inspection for closer examination of threats, such as landslides in harsh terrain;
- Satellite monitoring using high resolution imagery to detect third-party intrusion and ground movement;
- Optical fibre sensors and strain meters for detection and monitoring of leakage, third party interference, strain, bending and deformation;
- 3D laser scanning and visualisation including recording and monitoring of ground movement and others;
- Strong motion instrumental system and sensors for monitoring ground motion and topographic or GPS measurements for permanent ground displacement; and
- Advanced flow and pressure instrumentation in the network that correctly alarm any leak for effective leak detection.

NOTE: More guidance on the selection and application of monitoring methods for land instability THREATS can be found in AS 2885.1 K6.8.

The reliability and effectiveness of any alternate surveillance method adopted shall be periodically evaluated, taking into account the ability of the operator to respond or mobilise to the location of the alarm.

11.8 Operating changes

11.8.1 Design condition changes

Design condition changes shall be subject to management of change procedures and may require the modification and re-approval of operating, maintenance and emergency procedures and to the MAOP and design life.

The following list is given as a guide to items of change that should initiate an assessment:

a) Process fluid (gas, CSG Water);

b) Pressure and temperature;

c) Land use location class;

d) Network damage;

e) Physical Gathering Network modifications such as lowering, additional compression/pumping stations or replacement of major components (with non-like for like items);

f) Mode of operation such as direction of flow or service;

g) Network modification (the addition of a branch, the inclusion of a pressure-containing component etc.);

h) Modifications to HPVs and LPDs;

i) Pressure control and protection systems including logic changes;

j) Design life extension; or

k) An upgrade in MAOP.

The assessment shall include, as appropriate, a review of the following:

- The location or sub-location class;
- The design pressure (specifically where the change is to risk based design in accordance with Section 4)
- The change in the required physical or procedural measures resulting from the change to location class or sub-location class;
- The safety management study;
- The average fluid temperature as determined from records of the operation and maintenance;
- The boundaries of the location class and the location of physical barriers or other features that could restrict the movement of these boundaries;
- The physical condition of the network as determined from records of the operation and maintenance and from reports of examinations, inspections and monitoring, including those pertinent to corrosion mitigation; and
- Validation of pressure test.

11.8.2 Review of maximum allowable operating pressure (MAOP)

The MAOP of each network shall be reviewed and approved whenever there are changes (including pipe damage or failures; or location class change) that could adversely affect the safety of the public, the operating personnel or the integrity of the network. Investigations, tests and calculations shall be made during the review to establish the current condition of the network and to determine an MAOP in accordance with this Code.

11.8.3 Review of operating temperature

At approved intervals not exceeding ten (10) years the operating temperature shall be assessed to confirm conformance with the design average temperature, the design MAOP and design life. If required, appropriate corrective action including a reduction in MAOP or design life shall be carried out in accordance with the requirements of this Code.

11.8.4 Review of network management system

As part of any design review for change of use or extension of design life and at a period not exceeding five (5) years, an identification shall be made of the threats that could result in hazardous events affecting the network. Threat mitigation procedures, failure analysis and risk evaluation shall be reviewed at those times.

11.8.5 Key review intervals

The following table outlines the maximum permissible review intervals applicable to key network operating plans and reviews.

Table 5 Key operating plans review frequency

Review Activity	Frequency (maximum)*
Integrity management plan review	5 years
Pressure control and over-pressure protection systems review	Prior to system / ops change
Location class review	5 years
SMS review	5 years
Remaining life review, operating temperature and MAOP review	10 years
Isolation plan review	5 years
Network operating procedures	2 years

* The periods outlined in the above table shall not be exceeded. However, reviews may be triggered earlier as advised in the relevant sections of this code. In this instance, the review period should begin from the date of the latest review.

11.8.6 Network service conversion (repurposing)

Networks can be converted from one service to another (eg gas to CSG water and vice versa) provided the adequate reviews and assessments are conducted to evaluate additional and different risks resulting from this process. Alternative or additional methods of network marking shall be assessed and implemented as required. The network conversion shall be approved and the records updated.

11.8.7 Upgrading of MAOP

The MAOP section of the Gathering Network can be upgraded, provided that the following conditions are met:

a) The section had been pressure tested to the strength test pressure equal or greater than the value of new MAOP multiplied by 1.25;

b) The new MAOP is not higher than the design pressure as per Section 4.3.5;

c) An engineering assessment as per Section 11.8.1 is completed and approved; and

d) The new MAOP shall not exceed the pressure rating of the lowest rated component in the network.

If pressure testing records are not available, or the strength tests pressure that had been applied in past testing is not corresponding to the new MAOP, the section shall be pressure tested to the new MAOP as per Code requirements.

11.9 CSG field emergency response

11.9.1 Emergency planning and preparation

The Operator shall plan and prepare for emergency events resulting not only from the Gathering Network operation and maintenance but also from external events, which may affect the safe and reliable operation of the network.

In the event of an emergency, the Operator shall ensure that response to any emergency is performed in a planned and safe manner.

11.9.2 Emergency response and recovery

The Operator shall ensure that the activities associated with operation and maintenance of the network do not cause harm to personnel, contractors, and the public. During such activities the Operator shall minimise the impact to the environment.

The Operator shall develop and implement emergency response and recovery plans and procedures to address all emergency events including:

a) CSG water network leaks and spills;

b) Full bore rupture;

c) Gas leaks;

d) Fires, (especially bushfires);

e) Natural events;

f) Environmental remediation; and

g) Damage, or suspected damage, by external interference activities.

11.9.3 Emergency Response Plan

A CSG Field Emergency Response Plan shall be developed to ensure that response to any identified emergency situations is coordinated and appropriate. Emergency plans and procedures shall be documented to address the following:

a) The number of experienced operative and supervisory staff shall be adequate at all times to respond to any reported emergency event;

b) Incident management procedures, covering the necessary planning and preparation to implement responses to the emergency event may include the following:

- Prompt and expedient remedial action for the safety of the public and operating personnel, minimising damage to property and protecting the environment.
- Liaising with the appropriate authorities, including the regulatory authority, and other relevant bodies.
- Liaising with relevant stakeholders including landowners.
- Limiting the quantity of and controlling any discharged CSG water.

c) Isolation plans;

d) Prohibition of road traffic, low-flying aircraft and the isolation of electrical power in any areas that may be hazardous to safety, to reduce any risk of ignition and resultant dangers; and

e) Expeditious transport of repair equipment, materials and personnel to the site.

Personnel required to implement emergency procedures shall be fully trained in their application including any action required under such procedures.

Emergency response exercises and plan rehearsals shall be carried out on a regular basis (to validate the plans, to maintain the proficiency of designated response personnel and to ensure that external agencies are familiar with the plans and their potential involvement. The period between the exercises shall not exceed two (2) years for full-scale field exercise, and minimum one (1) year for desktop exercise (review of the emergency response plans, emergency scenarios, personnel and equipment etc.).

A debrief should be conducted as part of the exercise or rehearsal to identify any shortcomings or amendments that may be necessary to enhance the effectiveness of the emergency response plan.

Planned exercises and rehearsals may not need to be undertaken where an emergency or emergencies, of the same nature and scale, have actually occurred and been reviewed.

11.10 Significant incidents and significant near misses

All significant incidents and significant near misses shall be recorded. Significant incidents and significant near misses shall be investigated and analysed where the event has new learnings or where failures of controls have occurred.

Investigation and analysis may be undertaken for an individual event or for a collection of similar events. Corrective actions to minimise either the likelihood or consequence of any similar future incidents shall be implemented.

Management processes, for significant incidents and significant near misses, shall be established and implemented. The processes should incorporate the following:

a) Incident definition and / or classification;
b) Incident identification and reporting;
c) Logging of events during an incident;
d) Preservation of evidence for incident investigation;
e) Investigation appropriate to the incident;
f) Analysis of incident trends;
g) Establishment of follow up actions to prevent a recurrence;
h) Follow up to ensure that actions are closed out;
i) Feedback of results of investigations completed actions to appropriate stakeholders; and
j) Notification of statutory authorities as prescribed for various types of incidents.

11.11 Network assessment, repair and refurbishment

11.11.1 Initial assessment and remedial action

Where the integrity of a network, or a section of a network, is assessed as being inadequate or at imminent risk, the Operator shall immediately take steps to prevent failure until the integrity of the network is restored.

Interim measures shall be taken to mitigate the risk of a leak or failure. This may include a pressure reduction, or shutdown.

A permanent repair shall be planned and implemented, and shall reinstate the integrity of the network for the service conditions.

11.11.1.1 Pipe surface cracks

Crack-like anomalies found on the pipe surface are to be considered defects. Crack-like defects shall be removed by pipe replacement or removal of pipe material/reinforcement if the depth of the cracks exceeds 10 per cent of wall thickness.

11.11.1.2 Anomalies on field welds

Anomalies found on field welds shall be removed unless the anomaly existed at the pressure test and can be shown to be dormant by subsequent monitoring.

11.11.1.3 Metallic components and HPV/LPD assemblies

The metallic components may be inspected visually and/or using NDT methods to assess the defect (mechanical damage, corrosion, manufacturing defects etc). The assessment shall consider the pressure containment and the structural (load bearing) capacity of the components, in particular the risers.

The repair may consist of coating refurbishment, reinforcing by composite sleeve or similar, or replacement of the metallic component.

11.11.2 Pipe Repairs

The objective of repair is to ensure that the repaired pipe is fit for service over the remaining life and having sufficient structural integrity to withstand all the identifiable forces to which it may be subjected during operations including the MAOP and cyclic pressure fluctuations with an acceptable safety margin.

11.11.2.1 Pre-repair preparation

Where a pipe, which has been purged, filled with air and is connected to a source of hydrocarbon fluid that cannot be completely isolated, jointing or repair operations shall not be permitted unless the flow of hydrocarbon fluid toward the work site is prevented and the pipe contents at the work site are tested continuously to ensure that an unsafe concentration of hydrocarbon fluid does not occur. This may require:

- The generation of airflow away from the work within the pipe, by the operation of air movers at suitable locations; or
- The flow stopping techniques (refer Section 11.11.3) with bleed vents on each side of the work site, ensuring this does not prevent adequate airflow as required.

Purging of gas networks shall be carried out in accordance with this Code.

11.11.2.2 Repair methods

Defects in pipes may be repaired by a number of methods.

Consideration in selecting the appropriate repair method should be based upon risk-assessment considering factors such as the integrity of the pipe, location, pressures, and the extent of the damage to the asset.

Primary repair methods shall be as follows.

a) Replacement

Where a section of pipe is identified to have significant damage the total replacement of the defective section of pipe may be desirable. The pipe used for replacement shall be compatible with the existing pipe. It should be equal to or have greater than original wall thickness. The section of the pipe used for replacement can be pressure pre-tested in accordance with the Code.

The Operators can determine whether they wish to pre-test pipe and keep it for emergencies. This should be documented in their repair management strategy. This is especially valuable for long delivery pipe (and fittings).

Alternatively, untested pipe can be sourced for emergency repairs and installed when required as required. In this event, effective in- service leak monitoring methods (for example gas detection, and/or non-burial for a period to monitor for leaks) shall be adopted.

b) Reinforcement

Where a squeeze-off is placed on a section of pipe or a section of pipe is identified as having defects which compromise the integrity of the asset, but such defects are not in the vicinity of the pipe joints or other fittings, repair may be achieved by a compression sleeve. These sleeves are designed so when applied the repaired or squeezed-off section of the pipe is placed into compressive hoop stress at the operating pressure.

This repair method is unsuitable for longitudinal or circumferential crack-like defects.

The full encirclement reinforcement sleeve or clamp shall be designed for the application, rated for the service, and approved by the Operator.

Installation of reinforcement devices shall be as per manufacturer's recommendations. The device shall be compatible with the pipe material (particularly adhesives used with composite sleeves)

c) Leak repair

A clamp, or sleeve may be installed to mitigate loss of containment until provisions are made for a permanent repair. The device shall be suitably pressure rated and consideration shall be given to the seal of this device ensuring compatibility with the pipe material and the fluid being transported.

d) Pressure containment sleeves

A clamp, sleeve, or electro-fusion repair sleeve/patch may be installed to mitigate the potential loss of containment due to a defect in the pipe (e.g. gouge or crack). The device shall be suitably pressure rated and consideration shall be given to the seal of this device ensuring compatibility with the pipe material.

11.11.3 Flow-stopping methods

During the life of an operational Gathering Network, isolations are required for many purposes, including shutdowns, maintenance and emergency response operations, suspensions and water transfers. The isolation is normally a valve. Alternative isolations such as squeeze-off, flow stop bags and stoppling are used where one of the following is applicable:

- Valve isolation is not possible/ present;
- Valve failure; and/ or
- Secondary isolation requirement.

Pre-qualification methods used for flow stopping devices, clamps, reinforcement sleeves and repair devices shall first be documented in an approved plan covering:

- The approved procedure;
- Equipment; and
- Pipe material (PE100, DN, SDR, Age).

Only competent personnel shall undertake operation of specialist equipment having first undergone an approved pre-qualification process in order to meet the above criteria.

The following are examples of flow-stopping techniques; refer to appropriate Companion Paper.

11.11.3.1 Squeeze-off

Squeeze-off is a technique used to temporarily control or stop the flow of gas or liquid in a polyethylene pipe by compressing the pipe between parallel bars with a mechanical or hydraulic squeeze-off device until the inside surfaces make contact.

Squeeze-off operations shall require pre-qualification on pipe diameters greater than DN315. Pre-qualification conducted on the lowest SDR (thickest walled) pipe shall pre-qualify the operation for higher SDR (thinner walled) pipes for that particular pipe diameter.

Following the completion and removal of a squeeze-off, the pipe shall be reinforced with a reinforcing clamp at the location where the squeeze-off was placed unless an engineering review shows that stress relief is not necessary. The reinforcing clamp shall be in accordance with Section 11.11.2.2 b) Repair Methods.

Squeeze-off location shall be recorded and physically marked up on the pipe. Premature pipe failures at squeeze-off site shall be investigated. The investigation should identify any sites requiring remedial action where similar materials may exhibit premature failure and confirm current procedural practices.

11.11.3.2 Bagging-off

Bagging-off flow stop technique uses an existing or a welded branch saddle connected to the pipe with an isolation valve. An inflatable bag is inserted into the pipe; when the bag is in the required position it is inflated to stop the flow. Bags are deflated and withdrawn once flow is reinstated.

Using vents between bags shall be considered to prevent pressure build up and to act as a double block and bleed.

Use of a flow stop bag for a primary isolation shall be prequalified and approved. Manufacturer's recommendations should be consulted in using bagging-off flow stop techniques.

As a minimum, pre-qualification shall address:

- Maximum flow stop differential pressure for each pipe medium;
- Burst pressure; and
- Insertion methodology.

11.11.3.3 Plugging

Plugging is a specialist technique used to stop or control flow by mechanically installing plugs in the pipe.

As a minimum, pre-qualification shall address the following:

- Maximum flow stop differential pressure for each pipe medium; and
- Insertion methodology.

Using a hot-tapping machine, a hole is cut in the pipe through the tapping fitting and a valve. A plugging machine is then bolted on to install the plug assembly. Consideration should be given to the use of vents between stopple plugs to prevent build-up of pressure and to act as a double block and bleed.

11.11.3.4 Freezing

Freeze-off is a technique when isolation is achieved by forming an ice plug on gathering pipes from water present or inserted in the pipe. It can be achieved by applying liquid nitrogen, CO_2 or other refrigerant coolers. The effect of the low temperature on the pipe at the given pressure and flow conditions shall be evaluated and the procedure shall be qualified. The risks from asphyxiation from refrigerant fluids shall be assessed.

11.11.4 Hot tapping

Hot tapping is a method that can be used for providing a branch connection to a live or non-operational pipe, and can also be used in conjunction with flow stopping techniques.

Hot tapping operation shall only be conducted by qualified, trained and competent personnel. The hot tap technique shall be pre-qualified for use ensuring the length of the drill and cutter are suitable for executing the coupon.

Refer to relevant Companion Paper for detailed requirements.

11.11.5 Refurbishment

Where the remaining life of a network component has been evaluated as less than its design life (for example due to over-temperature operation) or is assessed not adequate for continuous safe operation, a component refurbishment program shall be planned and implemented to reinstate the structural integrity. The materials for the refurbishment shall be confirmed and approved.

The refurbishment shall be carried out in accordance with approved procedures, performed by trained and experienced persons, and assessed to meet all WHS and network management system requirements.

Materials used for replacing existing pipe and associated fittings shall conform with the latest material specifications subject to further requirements of this Code.

11.12 Changes to an established operating pressure within the MAOP

During the life of a Gathering Network the operating pressure may be increased from a previously long-standing level by the addition of compression or similar. Whilst this modified operating pressure may still be within the MAOP of the Gathering Network, consideration should be given to the impact the pressure increase may have on the integrity of the network. Any such modification to the normal operating envelope of the Gathering Network shall be managed in accordance with the change management procedures.

The following items should be considered where appropriate:

- Past pressure history with respect to the proposed pressure;
- Past fluid temperature history with respect to the proposed new fluid temperature;
- Effectiveness of inspection, patrolling and surveillance activities to have identified or stopped damage occurring;
- Whether conditional assessment could be carried out prior to the pressure increase;
- The consequence of a failure in all location classes during the pressure increase; and
- Additional monitoring following the change of operating pressure.

11.13 Remaining life review

The integrity and remaining life of an existing network shall be assessed at regular intervals or following a network failure.

The remaining life review is a periodic process for demonstrating that a Gathering Network can be safely operated and is fit for purpose until the next review.

The first review shall be completed not later than ten (10) years after commissioning with an approved interval of subsequent reviews to be determined by the preceding assessment with a maximum interval of ten (10) years.

The remaining life review includes a review of the current condition and an assessment of the degradation of the Gathering Network against the operating requirements. The data required for the review should include the following:

a) Integrity reviews; consideration should be given to condition assessment, previous incidents, integrity management records;

b) Operating records such as operating pressure, temperature cycles and fluid properties;

c) Reviews of pressure and temperature control/protection systems;

d) Corrosion protection records for steel components where used including coating system condition, CP monitoring, corrosion coupon / probe data where used, and corrosion inhibition;

e) New threat assessment and changes to location classifications as per the SMS review;

f) Change in environmental factors;

g) Equipment functionality and reliability; and

h) Outcomes from any root cause analysis undertaken for any failure event.

The output of the remaining life review shall be to document the following:

- Confirmation that the Gathering Network can continue to safely operate at MAOP in accordance with this code;

- Where (a) cannot be achieved without corrective actions, details of the necessary operating strategy and the timing for any necessary corrective actions, see section below for Corrective Action Determination; and
- Determination of the timing for the next remaining life review if less than 10 years.

11.13.1 Corrective action determination

Where the remaining life review process determines that corrective actions are necessary to achieve and maintain safe operations, these shall be delivered and re-assessed annually to ensure:

a) The consolidated plan of activities required for continued safe operation at MAOP until the next assessment will be deliverable; and

b) Any changes required from the integrity management programs have been implemented through the IMP and are effective.

11.14 Suspension and abandonment

11.14.1 Operation of a suspended network

The operation of a Gathering Network shall be considered suspended when the Gathering Network is taken out of service (placed into a state of "no flow") and the Gathering Network is no longer available for normal operation as defined in the NMS.

The primary aim of Gathering Network suspension activities is to preserve the integrity of the Gathering Network for future use.

Where a Gathering Network is suspended for a period of over 12 months, the following conditions apply primarily to address potential for corrosion of metallic components:

a) Where the Gathering Network is considered as not being subject to internal or external corrosion, the hydrocarbon contents of the network may be stored, at reduced pressure within the Gathering Network for the duration of the suspension;

b) Where the Gathering Network is considered to be subject to internal corrosion, the Gathering Network shall be purged or flushed to remove all hydrocarbons, and filled with a corrosively inert fluid (with inhibition as necessary) to an above-atmospheric pressure. Where the fluid is water, the period of suspension should not exceed 18 months, after which the Gathering Network should be purged, dried and re-suspended with a corrosively inert gas unless engineering assessment confirms continued suspension with inhibited liquid is appropriate. Where inhibited fluids are used (e.g. inhibited water) an engineering assessment should consider the long-term impact and effectiveness of the inhibited fluids within in the Gathering Network;

c) Suspended Gathering Networks containing saline water shall have this fluid removed;

d) Where the hydrocarbon contents are to remain in the Gathering Network, the pressure shall be reduced such that the pressure is maintained at less than 100kPa;

e) The suspension of above-ground Gathering Network sections shall be subject to a risk assessment;

f) If any changes are to be made to the surveillance and monitoring controls conducted during normal operation (e.g. reducing frequency of patrols, integrity tests, facility maintenance (e.g. HPV)), the SMS shall be reviewed to determine the appropriate modified frequency for the suspended state; and

g) A suspension plan detailing, as a minimum, the following items shall be documented and approved:

   - Current (operating) contents of the Gathering Network and the controls for internal corrosion management.
   - Anticipated suspension period (continued suspension is to be reviewed prior to the expiry of this date).
   - Suspension methodology and required activities.
   - Any changes to or additional controls identified in the suspension SMS.
   - Requirements for returning the network to service.

h) The implementation of the approved suspension plan shall be documented. These records shall include were appropriate;

   - Cleaning records.
   - Water and debris sampling results.
   - Suspension fluid properties.
   - Level of pressurisation.

i) The level of pressurisation shall be monitored at approved intervals throughout the duration of the suspension period.

j) The suspension shall be subject to periodic review at approved intervals to determine if continued suspension is appropriate or if the Gathering Network should be abandoned.

The suspension and preservation of associated plant shall also be completed and documented.

11.14.2 Return to service

A suspended Gathering Network should only be returned to service after confirmation of the following;

- The condition of the Gathering Network is suitable for the required MAOP and operating life;

- Review of the latest SMS and Integrity Management Plan to ensure Gathering Network inspection; maintenance and monitoring controls are adequate for a return to service. This review is to consider changes to the surrounding land use which may have occurred during the suspension period; and
- The return to service is Approved.

NOTE: Where records of the suspension method and subsequent management are not available or are not complete the Gathering Network should be subject to inspection and/or testing to confirm its condition prior to a return to service.

Where the Gathering Network is known to have deteriorated to the point where repair is required a fitness for service assessment shall be completed.

The suspension of a Gathering Network should be reviewed after a five-year period to determine if the Gathering Network should be abandoned, except where the Gathering Network is in a multiple pipe trench, in which case the suspension of the Gathering Network shall be reviewed five years after all pipes in the trench are suspended.

11.14.3 Abandonment records

11.14.3.1 General

When a network is to be abandoned, an abandonment plan, including an environmental rehabilitation plan, shall be compiled and approved. The sequence of decision making that is required to develop and implement the plan should be in accordance with Figure 11.13.3 Flow Chart – Network Abandonment.

When a network is abandoned, it shall be disconnected from all sources of hydrocarbons or CSG water that may be present in other pipes and other appurtenances, and shall be purged of all hydrocarbons and vapour with a non-flammable fluid. Disposal of the purging fluid shall meet all relevant environmental and safety requirements.

If the section to be abandoned is to be transferred to a third party for further use, a different and specific abandonment process may need to be developed and approved.

11.14.3.2 Abandonment in place

When abandoned in place, the Gathering Network section shall be abandoned in such a way to ensure that future ground subsidence and the risk of contamination of the soil or groundwater is minimized and any impacts to ongoing land uses (e.g. cropping and agricultural activities etc.) are identified and mitigated.

Where engineering assessment identifies subsidence to be an unacceptable risk, suitable measures shall be put in place. Such measures might include;

1. Filling the network sections with concrete or other similar materials
2. Continuation of ROW monitoring programs and implementation of remediation activities.

11.14.3.3 Segmentation of an abandoned Gathering Network

In developing the abandonment plan of a buried Gathering Network, a segment analysis should be completed to identify lengths of network that should be abandoned by removal or left in place. This analysis should consider;

- Features sensitive to subsidence (e.g. road ways, water courses);
- Requirements of landholder agreements;
- High use areas (e.g. common infrastructure corridors) and
- Environmentally sensitive areas.

The most appropriate abandonment method should be selected to minimise the impact of the abandonment.

11.14.3.4 Abandonment of above-ground pipes

Above-ground pipes or networks shall be abandoned by removal of the pipes or networks.

11.14.3.5 Additional requirements for abandonment

When a network is abandoned, the following additional requirements shall be completed:

a) The cutting of all buried pipes at a minimum of 750 mm below natural surface or at the pipe depth, whichever is the lesser;

b) The removal of all equipment;

c) The removal of all signage associated with the network on completion of the post abandonment maintenance period; and

d) Obtaining landowner releases for the completed abandonment.

11.14.3.6 Additional requirements for abandonment

On the completion of the abandonment of the network section in place, the records identifying and locating sections of the abandoned network, shall be prepared as part of the relinquishment procedure.

These records shall be made publicly available to prevent possible mistakes in identifying an abandoned network as an operational network.

Records of approved changes of operating conditions, all engineering investigations and work carried out in connection with any change in the operating conditions shall be maintained until the network is abandoned or removed.

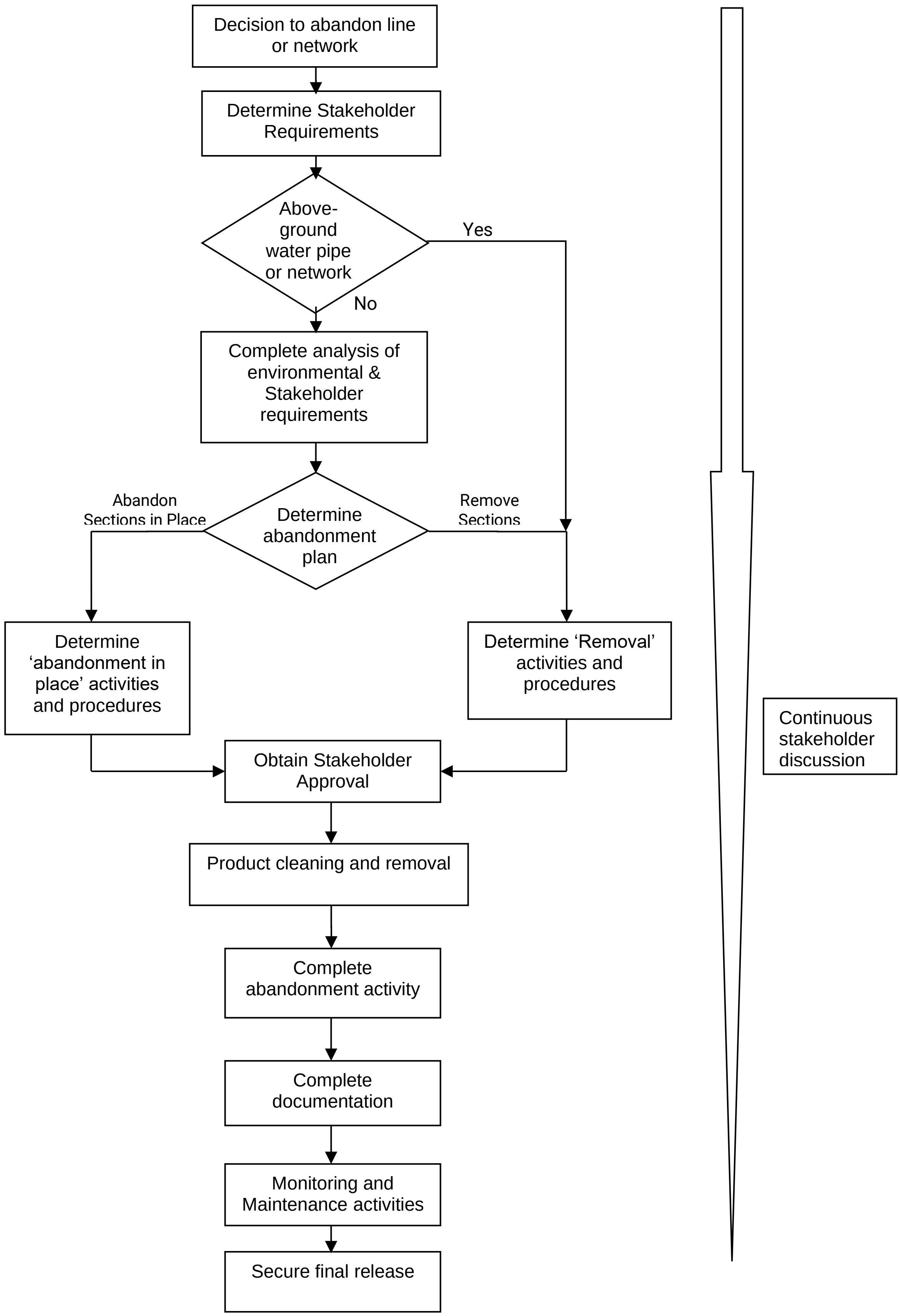


Figure 11.13.3 - Flow Chart – Network Abandonment

• APPENDIX A – Safety Management Process (Normative)

A1 General

The network safety management process required by this Code is of fundamental importance to the network design, its operation and maintenance. It is the means by which network safety is demonstrated. It also forms the basis for all operations and maintenance of the network.

The safety management process is integrated and continuous. It requires consideration of design aspects and operating procedures in a combined, holistic way so that the network can be operated safely. Analysis is updated and refined using information as it becomes available throughout the life cycle of the network.

The essential outcomes of a management process are:

a) Assurance that the threats to the network and associated risks are identified and understood by those that are responsible for addressing the threats and risks; and

b) Appropriate plans are made to manage these risks.

The network safety management process requires the application of multiple independent controls to protect the network from each identified threat.

Physical (route selection, barrier or exclusion), procedural and design methods should be applied to all threats with the objective of preventing failure of the network, minimising the consequence to the public (including the Operator's personnel and Contractors) and the environment.

Those threats that, with controls in place, may result in a failure of the network should be subject to a risk assessment in accordance with the requirement of AS 31000, and the risk mitigated to ALARP. The Operator may determine the appropriate risk matrix to be used, with preference for the 5 x 5 matrix detailed in Section A6.

A2 Whole of life network safety management

Network safety management to this Code is an integral component of the planning, design, construction, operation and abandonment of the network.

A2.1 Whole of life phases

Safety management studies should be undertaken at intervals during the network design and operational phases to facilitate periodic reassessment of the threats and the implementation of controls as knowledge of the threats is gained over time.

As a minimum, the safety management study should be undertaken during the following phases.

a) Design – A detailed safety management study that conforms with this Code should be undertaken in parallel with the design and should consider at least the following:

- Class location or land use;
- Generic threats;
- Location-specific threats;

- Basic network design parameters;
- The radiation intensity contour radius of 4.7 kW/m^2 and 12.6 kW/m^2 in the case of a full diameter failure (gas); and
- Drainage contours based upon topography, soil type and the presence of significant watercourses (PFW or saline water).

b) Pre-commissioning: A review of the detailed safety management study that conforms with this Code should be undertaken prior to commissioning the network and should consider at least the following:

- Any design or route change;
- Land use change, specifically changes within the radiation contour;
- Any change to location or non-location threats;
- Construction defects or deviations from specification; and.
- Testing defects and pressure test failures.

c) Operation: A review of the detailed safety management study that conforms with this Code should be undertaken at least every five (5) years and should consider at least the following:

- Any loss or degradation of integrity.
- Land use change, specifically changes within the radiation contour.
- Any change to location-specific or non-location-specific threats.
- Construction defects or deviations from specification.
- Testing defects and pressure test failures.
- The previous safety management studies.

The review should also be completed:

- When operating conditions change, outside of the network design envelope;
- Before recommencement of operation following a pipe failure where such failure has resulted from a mechanism not previously included in preceding studies;
- At any time when new or changed threats including land use occur;
- At any time where there is a change of knowledge affecting the safety of the network; and
- If design life is extended.

d) Suspension or abandonment: A review of the detailed safety management study that conforms with this Code should be undertaken when the network or a part of the network is suspended or abandoned and should consider at least the following:

- The possibility of the suspended or abandoned network causing environmental harm (e.g. water conduiting); and

- The threat of mistaken asset (e.g. network extension being tied into a suspended or abandoned pipe or network and hydrocarbons being introduced).

A3 Prerequisites for safety management studies

A3.1 Extent of safety management studies

A3.1.1 Gas networks

The detailed management study should cover all threats and land use within the area bounded by the radiation intensity contour radius of 4.7 kW/m^2 on each side of the centre line of each gas pipe in the network. Where multiple pipes of different diameters or service are laid in a common trench, the area under study should be the outermost 4.7 kW/m^2 radiation intensity contour radius on each side of the common trench.

A3.1.2 CSG Water or saline water networks

The detailed management study should cover all threats and land use within the area bounded by the drainage contours on each side of the centre line of the network.

A3.2 Safety management study information

A robust safety management system requires detailed preparatory information and analysis to provide the correct consistency of approach across the network and to provide all of the tools necessary to correctly identify all threats and to facilitate assessment and control.

The safety management study should be undertaken by personnel with the expertise in each component of design, construction, commissioning and operation of the network, including the support of personnel familiar with the land use and environments along the entire route of the network. The safety management study should be chaired by an independent person deemed competent in the conduct of such a study.

The following information should be generated and used for the detailed safety management study:

a) Design basis including network properties, engineering design for non-standard construction, design calculations, and typical design drawings;

b) The threat analysis of common threats;

c) The network alignment and class location identification;

d) The assessment of current land use, and if known, future land use plans;

e) Documented external threats from third parties (landowners, public authorities and contractors) and from existing networks or other infrastructure in the vicinity of the network;

f) List of the construction and landowner constraints;

g) Environmental constraints;

h) HAZOP and other design reviews relevant to the network including pressure control system design;

i) Scenarios under which full diameter leaks may occur;

j) Consequence modelling which will:

- Assess the impacts of a fluid release on people, property and the environment;
- Provide the radiation intensity contour radius of 4.7 kW/m^2 and 12.6 kW/m^2 in the case of a full diameter failure (gas networks); and
- Provide release rates and drainage contours based upon topography, soil type and the presence of significant watercourses (PFW or saline water).

In the case of the operational review of the safety management plan, the following information should also be included:

k) Network management system;

l) Integrity management plan;

m) Land use changes;

n) Sections added to the network;

o) Inspection and integrity management history;

p) Maintenance history;

q) Loss of control events – failure of pressure control or loss of integrity;

r) Previous safety management studies; and

s) Close out reports relating to previous risk mitigation actions.

A4 Threat identification

A4.1 General

Threat identification consists of the identification of all threats to the network including the following threat categories:

a) Generic threats: Threats that could occur at any point or at multiple discrete locations along the network and may include external interference (from general construction or agricultural activities), material or construction defects; and

b) Location-specific threats: Threats which become apparent from a detailed length by length review of the route of the network, which may include generic threats which have a unique assessment (e.g. high point vent under a power line).

In all cases the details for the threat analysis needs to be sufficient such that the appropriate design, controls or risk mitigation actions can be implemented.

A4.2 Description of Threats

Typical threats include, but are not limited to:

A4.2.1 External Interference

a) Excavation, such as occurs during construction or maintenance of buried services, roads, and mining;

b) Power augers, screw piles, drilling operations (vertical, horizontal and directional), and installation of power poles;

c) Ripping or blade ploughing for agricultural use;

d) Augers for fence installation or maintenance;

e) Land use development, such as grading of land and dam construction;

f) Excessive external loads from backfill or traffic;

g) Blasting; and

h) Trenching for new pipes.

A4.2.2 Corrosion

a) External corrosion of the metallic components due to environmental factors, such as the type of soil and moisture content; and

b) Internal corrosion of the metallic component from free water and carbon dioxide, present in the gas.

A4.2.3 Natural events

a) Earthquake;

b) Ground movement, due to land instability;

c) Bushfires;

d) Lightning;

e) Water course damage resulting in tunnel or table drain erosion and excess span; and

f) Inundation, leading to flotation.

A4.2.4 Operations and maintenance

a) Exceeding network MAOP;

b) Insufficient or incorrect maintenance;

c) Fatigue from cyclic service;

d) Failure due to surge pressure; and

e) Excessive external loadings.

A4.2.5 Design defects

Failure to define the correct range of operating conditions -leading to incorrect settings on control or protective devices, or unacceptable pressures, temperatures and loads.

A4.2.6 Material defects

a) Manufacturing defects; and

b) Lack of adequate inspection and test procedures to confirm the acceptability of material and equipment.

A4.2.7 Construction defects

a) Inadequate testing of defects.

A4.2.8 Intentional damage

a) Terrorism; and

b) Malicious damage from vandalism.

A4.2.9 Other threats

a) Seismic survey, resulting in blast or equivalent external pressure loads;

b) Flange/monolithic joint failure;

c) Failure of threat controls; and

d) Failure of all controls at worst possible location (highest risk and/or highest consequence).

A5 Threat mitigation general

Threat mitigation may be achieved by:

a) Change in route;

b) External interference protection; or

c) Use of procedural controls.

A5.1 Change in route

Change in route for parts of the network can reduce the risk from and to external parties. Examples of this may include locating pipes and ancillary structures (manifolds, low point drains and vents) away from roads, away from areas of congregation (plants, camps, administration buildings and maintenance areas) and the selective crossings of waterways.

A5.2 External interference protection

Options for external interference protection which provide an effective physical control by separation may include:

a) Depth of burial – provided the depth exceeds the maximum normal working depth of the equipment under consideration plus a margin, and is significantly greater than the minimum depth of cover specified in this Code.

b) Exclusion – fences or barricades; or

c) Barrier – The installation of barrier slabs.

A5.3 Procedural controls

Procedural controls may include:

a) Landowner or third-party liaison;

b) Community awareness;

c) One-call services;

d) Network marking using signage;

e) Buried marker tape, tracer wires, or detectable marker products;

f) Agreements with other entities using shared lands or infrastructure corridors;

g) Planning notification zones;

h) Patrolling of the network; and

i) Remote monitoring.

A6 Qualitative risk assessment

A6.1 General

This section provides the requirements for qualitative risk assessment in accordance with AS 31000.

Where a failure event of the network may have several outcomes, the consequence and frequency of each outcome should be considered. Full evaluation of every outcome may not be necessary, but sufficient outcomes should be evaluated to identify the outcome with the highest risk ranking.

For Rural class locations, the risk assessment outcomes for the generic threats of that particular network may be used generically for any new pipes in the network. Within the Rural class location, threats such as minor road or network crossings may be assessed as generic threats, provided the design of the road or network crossing has the same risk profile.

A6.2 Consequence analysis

The severity of the consequences of each failure should be assessed. Consequences to be assessed should include the potential for:

a) Human injury or fatality;

b) Economic impact due to loss of production;

c) Environmental damage; and

d) Equivalent range of cost (defined per Operator).

A severity class shall be assigned to each failure event based on the consequences at the location of the failure. The severity class may be selected from Table A6.2.

Where necessary to make the severity classes applicable to the Gathering Network under study the measures of severity in Table A6.2 may be modified with the agreement of the stakeholders—modification should be minimised. Any modification of the severity classes shall be undertaken so that consistency with Table A6.4 is maintained.

The reasons for any changes to the measures of severity shall be documented and approved.

Table A6.2 Severity class

	Severity Class				
	Catastrophic	**Major**	**Severe**	**Minor**	**Trivial**
People	Multiple fatalities result	At least one fatality, with several life-threatening injuries	Injury or illness requiring hospital treatment	Injuries requiring first aid treatment	Minimal impact upon health and safety
Production	Long term interruption of production	Prolonged interruption or long-term restriction of production	Short term interruption or prolonged restriction of production	Short term interruption of production, but shortfall met from other sources	No impact, no restriction of production.
Environment	Determine environmental limits for each severity class based upon the respective State's Environmental Protection legislation, the Operator's Environmental License and the APGA Code of Environmental Practice.				
Equivalent Range of Cost	(defined per Operator)	(defined per Operator)	(defined per Operator)	(defined per Operator)	(defined per Operator)

A6.3 Frequency analysis

A frequency of occurrence of each failure event should be assigned for each location where risk estimation is required. The following table provides a recommended frequency selection.

The contribution of operations and maintenance practices and procedures to the occurrence or prevention of the failure events should be considered in assigning the frequency of the occurrence.

The frequency for a threat that exists for a limited period should be assessed against the exposure period rather than the life of the network.

Table A6.3 Frequency Class

Frequency	Frequency Description
Frequent	Expected to occur once per year or more
Occasional	May occur occasionally in the life of the network
Unlikely	Unlikely to occur with the life of the network, but possible
Remote	Not anticipated for this network at this location
Hypothetical	Theoretically possible, but has not occurred on a similar network

A6.4 Risk ranking

The results of the consequence and frequency analysis should determine the risk associated with the failure event.

Risks determined to be low or negligible or demonstrated to be ALARP are acceptable risks.

Table A6.4 Risk Matrix

	Catastrophic	Major	Severe	Minor	Trivial
Frequent	Extreme	Extreme	High	Intermediate	Low
Occasional	Extreme	High	Intermediate	Low	Low
Unlikely	High	High	Intermediate	Low	Negligible
Remote	High	Intermediate	Low	Negligible	Negligible
Hypothetical	Intermediate	Low	Negligible	Negligible	Negligible

A6.5 Risk mitigation

Action to reduce risk should be taken in accordance with Table A6.5 based on the risk rank determined. The action(s) taken and its effect on safety management should be documented and approved.

Where the risk rank cannot be reduced to 'Low' or 'Negligible', action should be taken to:

a) Remove the threat, reduce the frequency or consequence of the threat to the extent practicable; or

b) Demonstrate ALARP.

Table A6.5 Required Actions

Risk rank	Required action	Timing of action for an operational network
Extreme	Modify the threat, the frequency or the consequence so that the risk rank is reduced to 'Intermediate' or lower	Immediate
High	Modify the threat, the frequency or the consequence so that the risk rank is reduced to 'Intermediate' or lower	Within a month
Intermediate	Repeat the threat identification and risk evaluation to verify and where possible quantify the risk estimation. Where the risk rank is confirmed as 'Intermediate' modify the threat, the frequency or the consequence so that the risk rank is reduced to 'Low' or 'Negligible'.	Within 6 months
Low	Determine the management plan for the threat to prevent occurrence and monitor changes that could affect the risk rank.	
Negligible	Review at the next review interval.	

A6.6 ALARP

A risk cannot be demonstrated as ALARP until consideration has been given to:

a) Means of further reducing the risk; and

b) Reasons these further means have not been adopted.

ALARP is achieved when the cost of further risk reduction measures is grossly disproportionate to the benefit gained from the reduced risk that would result.

There is a need to show that a range of options were considered, and that those chosen actually reduce the risk to a level that is as low as reasonably practicable. Cost benefit analysis to determine the maximum justifiable spend is only one factor in demonstration of ALARP.

Determining if the risk from a specific threat has been reduced to ALARP involves a comparison between the assessment of the risk to be avoided and the effectiveness and cost of the measure(s) involved in avoiding the risk. The cost ranges provided in Section A6.2 may be used as the basis of determining the cost of the risk. The measure of whether ALARP has been achieved is if the cost of reducing the risk is grossly disproportionate to the benefit gained.

The concept of ALARP contains an implicit assumption that there are alternative designs or measures that can reduce the risk but some of the alternatives may not be practicable. There is always one alternative: abandon the project or shutdown the network or that part of the network to which the threat is applied.

The formal ALARP assessment shall be documented. Formal ALARP assessment is required when:

a) The risk level is Intermediate;

b) The Location Classification is High Use / Sensitive and the network does not conform with the risk control measures specified in Table 4.5.1; and

c) The SMS identifies an uncontrolled threat arising from proposed construction works in the network corridor.

For in-service networks, the risk reduction measures listed below should be considered as part of formal ALARP assessment:

a) Pipe replacement (with the new pipe designed to mitigate the identified risks);

b) Network relocation (to a location where the consequence is eliminated);

c) Modification of land use (to separate the people from the network); and

d) Implementing physical and procedural protection measures that are effective in controlling threats capable of causing the network to leak.

For other formal ALARP assessments, the above risk reduction measures may also be applicable together with any other measures that are appropriate to the nature of the threat and the consequences of failure.

A7 Gas radiation contour

A7.1 General

The Code requires consideration of the consequence distance in terms of the radiation intensities of 4.7 kW/m^2 and 12.6 kW/$m^{2.}$ This section provides guidance on the method of calculation of the radiation contour of gas networks.

Where there are sensitive receptors in close proximity to the gas network, it may be necessary to consider the potential consequence of people within the 12.6 kW/m^2 contour or potentially even higher heat intensity radiation contours such as the 37.5 kW/m^2 radiation area. Refer to the appropriate Companion Paper, for further guidance on how to assess radiation contours.

NOTE: A thermal radiation level of 4.7 kW/m^2 will cause injury, at least second-degree burns, after 30-seconds exposure. A thermal radiation level of 12.6 kW/m^2 represents the threshold of fatality, for normally clothed people, resulting in third degree burns after 30-seconds exposure.

The radiation contour may be calculated based on the estimated release rate (MJ/s) and the calculations provided in API 521 'Pressure-relieving and Depressuring Systems'.

As the hole size increases relative to the pipe diameter the release rate and radiation distance will be controlled by the capacity of the network to deliver gas to the release point.

PE pipe is not normally subject to rupture although full diameter leaks may occur as a result of a pipe joint failure.

The following radiation contour curves are informative based upon full diameter leaks and the leak expected to result from a 120 mm hole due to penetration by a 35-ton excavator (the maximum size machine normally used in CSG operations) at various pressures up to the limit of this Code.

The calculation of the radiation contour should be completed at the maximum allowable operating pressure (MAOP) of the network.

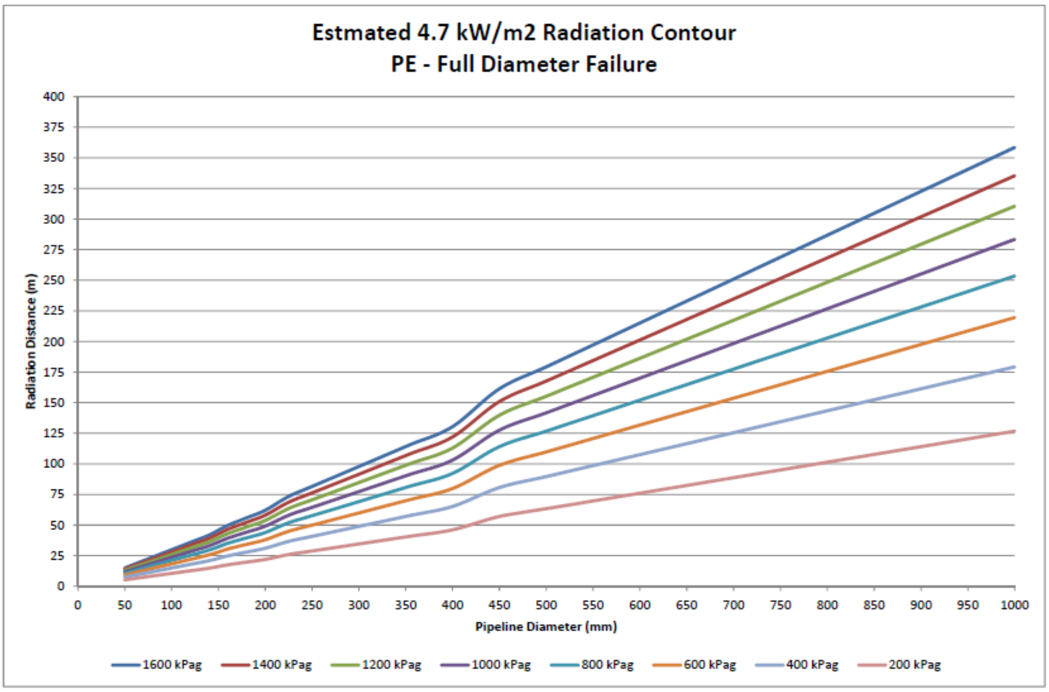


Figure A7.1a - Radiation Contour Radius – Full Diameter

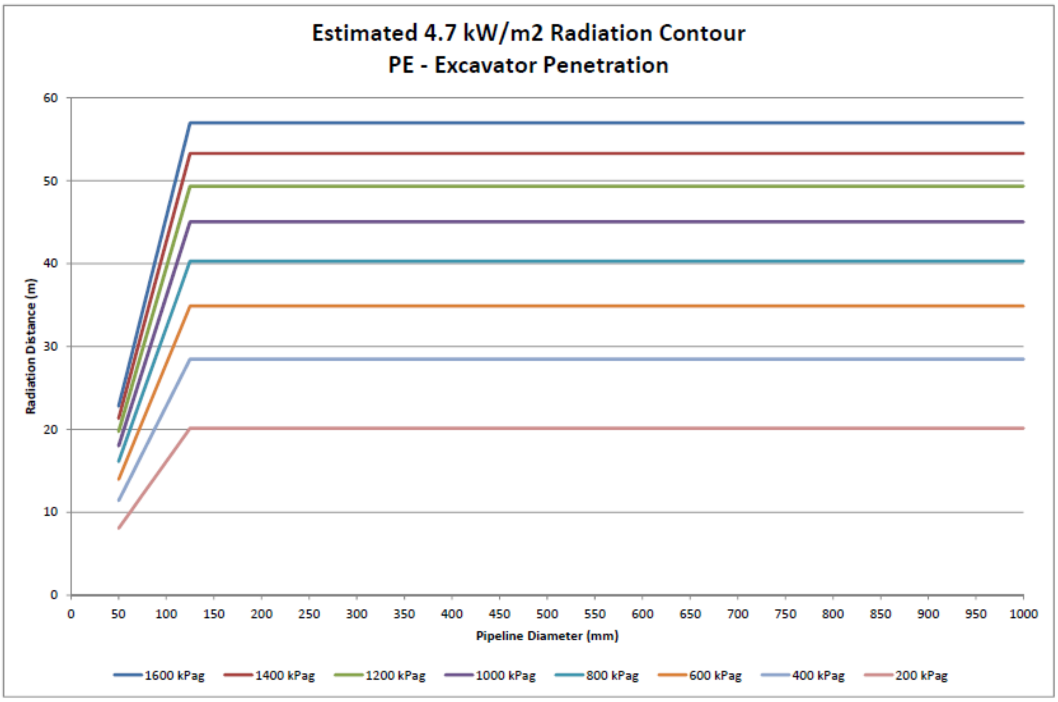


Figure A7.1b - Radiation Contour Radius – Penetration

A8 CSG Water network leaks

A8.1 General

For CSG water network pipes the impact upon the environment requires specific consideration of the following:

a) Water characteristics – PFW, saline water or treated water;

Note: entrained gas should be considered.

b) Topography of the land;

c) Proximity of surfaces of water – watercourses, rivers, dams or billabongs;

d) Soil types in the vicinity of the network segments;

e) Potential penetration hole sizes in the network pipes, (see below);

f) Elevation profile of the network;

g) Maximum spill volume; and

h) Proximity of environmentally significant locations or protected location of flora and fauna.

The water release rate from the pipe may exceed the normal design flowrate or pump rate depending upon the change in elevation of the section.

The calculation of the water release rate should be completed at the maximum allowable operating pressure (MAOP) of the network.

A8.2 Penetration hole size

An approximate hole size of 120 mm is suggested for a 35-tonne excavator. (This is the equivalent hole size for penetration of all general-purpose teeth on the standard bucket for this machine). The approximate hole size is based on steel pipeline testing, and is considered conservative for PE.

• APPENDIX B – Pressure Testing (Normative)

Contents

B1 Pneumatic pressure decay method

In order to achieve an acceptable pneumatic pressure decay test the volume should be kept as low as possible as leaks will be more apparent. All tests on pipes with large volumes shall be held to a minimum leak test period of 24 hours. This will result in a full temperature cycle of the test section to be completed.

The longer the test period, the more certain the detection of leaks, so for very large volume networks the duration of the test may need to be extended.

B1.1 Leakage effects

Any leak on a pipe results in a loss of pressure. However, the effect of small leaks can be masked by creep and temperature effects. Therefore, the duration of the test shall be of sufficient duration determine if any leaks are present.

B1.2 Acceptance criteria

The total pressure loss or gain over the test period is related to the temperature change, creep and leakage of the test fluid. When leak testing over long durations, pressure normally follows the trend of the barometric pressure and internal pipe temperature as the elasticity of the pipe is significantly less at lower pressures.

B1.2.1 Allowable pressure loss calculation

A method of calculation for the allowable pressure loss in the pneumatic pressure decay test is:

D = the outside pipe diameter in a uniform test section, in mm

L = the length of a uniform test section, in metres

t = the wall thickness of the pipe in a uniform test section, in mm

P_a = absolute atmospheric pressure, in kilopascals, 101.3 kPa

P_1 = test pressure, in kilopascals

Loss = Acceptable loss rate per hour per cubic metres
= l /hr/act m^3 (See Companion Paper CP-08-003)

T = test period, in hours, normally 24 hours

V = total volume under test pressure, in cubic metres
= $(L \times \pi \times (D - 2 \times t)^2) / (4 \times 1000000)$ cubic metres

V_1 = Starting volume – actual cubic metres
= $V \times (P_1+P_a) / P_a$

V_{loss} = Acceptable loss – litres/hr
= $V_1 \times$ Loss

$V_{losstest}$ = Acceptable loss in test – m^3/test
= $T \times (V_{loss} / 1000)$

$P_{losstest}$ = Acceptable pressure loss in the test – kPa
$= (P_1 + P_a) - [(P_1 + P_a) \times (V_1 - V_{losstest}) / V_1]$

P_2 = Acceptable pressure at end of test period – kPa
$= P_1 - P_{losstest}$

B2 Stored energy and safe distance calculation: pneumatic tests

The following method is from ASME PCC-2. The stored energy of the equipment or network should be calculated and converted to equivalent kilograms of TNT (Trinitrotoluene) using the following equations.

A method of calculation of stored pneumatic energy is:

D = the outside pipe diameter in a uniform test section, in mm

L = the length of a uniform test section, in metres

t = the wall thickness of the pipe in a uniform test section, in mm

k = ratio of specific heat for the test fluid, 1.4 for air.

P_a = absolute atmospheric pressure, in kPa, 101.3 kPa

P_{at} = absolute test pressure, in kPa

TNT = equivalent kilograms of TNT (Trinitrotoluene)

V = total volume under test pressure, in litres
$= \{L \times \pi \times (D - 2 \times t)^2\} / (4 \times 1000)$ litres

To calculate the stored energy (SE)
$SE = [1/(k-1)] \times P_{at} \times V \times [1 - (P_a/P_{at})^{[(k-1)/k]}]$ Joules

When using air or nitrogen as the test medium (k = 1.4), this equation becomes

$SE = 2.5 \times P_{at} \times V \times [1 - (Pa/P_{at})^{0.286}]$ Joules

Equivalent kilograms of TNT (Trinitrotoluene)

TNT = SE/4266920 kg

Safe distance calculation: pneumatic tests

This safe distance calculation is based on the stored energy calculation detailed above and the safe distance calculation adapted from ASME PCC-2.

This calculation details the minimum distance required for a pneumatic test. An R_{scaled} number of 20 is recommended for the distance from the pipe to the limited boundary access (primary exclusion zone).

A method of calculation of safe distance is:

R = safe distance, in meters

R_{scaled} = safe distance scaled consequence factor from ASME PCC-2 Article 5.1, Mandatory Appendix III, Table III-1.
Refer Table B3, Appendix B3.

R_{scaled} = 20 (minimum)

For pneumatic testing, the minimum distance between all personnel and the equipment being tested shall be:

(a) R = 30 m for SE ≤ 135 500 000 J
(b) R = 60m for 135 500 000 J < SE ≤ 271 000 000 J
(c) $R = R_{scaled} \times (2TNT)^{1/3} = 20 \times (2TNT)^{1/3}$ m for SE > 271 000 000 J

B3 Stored energy and safe distance calculation: hydraulic tests

NOTES:

1. This method is based on the calculation in AS 2885.5 - 2012 and adapted for PE. For further information refer to this standard.
2. This equation assumes a maximum residual air content of 0.2 per cent. The test shall be conducted by a competent operator by means of a controlled fill to ensure the maximum residual air content does not exceed the value assumed in the stored energy calculation. Verification of actual volume may be performed during the filling operation.

A method of calculation of stored energy is:

D = the outside pipe diameter in a uniform test section, in mm

L = the length of a uniform test section, in metres

p = the test pressure, in kilopascals

SE = total stored energy, in Joules

t = the wall thickness of the pipe in a uniform test section, in mm

T = average temperature of test section, in °C

Vo = the total initial volume of water in the test section, in litres
$= \{L \times \pi \times (D - 2 \times t)^2\} / (4 \times 1000)$ litres

A = Compressibility of testing medium, in kPa^{-1}
$= (3.897\times10^{-3} \times T^2 - 0.3133 \times T + 50.65) \times (1 - p/411844) \times 10^{-8}$

TNT = equivalent mass of TNT (Trinitrotoluene), in kilograms

$\%_{air}$ = 0.2% (assuming a maximum residual air content of 0.2%)

V_{air} = Vo × $\%_{air}$ = Vo × 0.002 volume of air in litres

V_{H2O} = Vo × (1 − $\%_{air}$) = Vo × (1 − 0.002) volume of water in litres

v = 0.4
= Poisson's ratio

E = Young's Modulus
= 800,000 kPa

NOTE: 800,000 kPa is used for the purpose of this calculation; typically 600,000 to 1,400,000 kPa for PE.

To calculate stored energy in a water-filled section of a network (assuming a negligible temperature change).

$\Delta V = V_{H2O} \times \{(1 - v^2)/E \times D/t + A\} \times p$

where the stored energy (SE_{H2O}) is the volume under the PV curve:

SE_{H2O} = stored energy of water, in Joules
= $0.5 \times p \times \Delta V$ Joules

The method contained within AS/NZS 3788 and ASME PCC-2 to calculate stored energy in residual air may be applied:

$SE_{air} = 2.5 \times (p + 101.3) \times Vair \times \{1 - [101.3/(p + 101.3)]^{0.286}\}$ Joules

Total stored energy:

$SE = SE_{air} + SE_{H2O}$ Joules

Equivalent kilograms of TNT (Trinitrotoluene)

TNT = SE/4266920 kg

Safe distance calculation: hydraulic tests

This safe distance calculation is based on the stored energy calculation detailed above, known hydraulic energy release mechanism during pressure testing rupture events, and the safe distance calculation adapted from ASME PCC-2.

This calculation details the minimum distance required for a hydraulic test. A minimum R_{scaled} number of 20 is recommended for the distance from the pipe to the limited boundary access (primary exclusion zone).

A method of calculation of safe distance is:

R = safe distance, in metres
R_{scaled} = safe distance scaled consequence factor from ASME PCC-2, Article 5.1, Mandatory Appendix III, Table III-1 below.
R_{scaled} = 20 (minimum)

TNT = equivalent mass of Trinitrotoluene as calculated above, in kg

Table B3 – R_{scaled} Consequence Factor – extract from ASME PCC-2

R_{scaled} m/kg$^{1/3}$	**Biological effect**	**Structural failure**
20	. . .	Glass windows
12	Eardrum rupture	Concrete block panels
6	Lung damage	Brick walls
2	Fatal	. . .

For hydraulic testing, the minimum distance between all personnel and the equipment being tested shall be the greater of:

(a) R = 5m
(b) $R = R_{scaled} \times (2TNT)^{1/3} = 20 \times (2TNT)^{1/3}$ m

NOTE: The risk of blast wave, present during pneumatic tests, is only applicable to the minimal residual air component during hydraulic tests which enables reduction in the safe distance used.

B4 Test Pressure for Elevation Changes - Example

Example:

Pipe MAOP is 250 kPa. Test factors is 1.25. Test pressure is 250 x 1.25 = 312.5 kPa.

Maximum difference allowable between the highest and lowest point in the test section is 62.5 kPa. This relates to 6.25m in elevation between the lowest and highest point in the section being tested. Multiple tests are required for elevations > 6.25m.

NOTE: It is recognised that the above criteria are not consistent with traditional steel pipeline testing. Further note that fractions of kPa are not to be used in performance of the test. They are only included here for demonstration purposes.

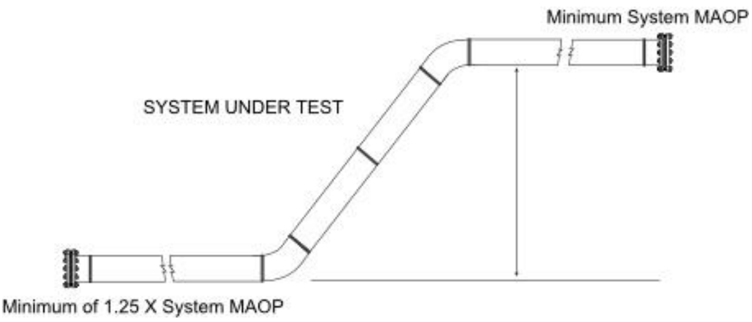


Figure B4-Elevation Diagram

This results in several tests being required when pipes are located in hilly terrain (unless pipe of increased MAOP is utilised in places at a lower elevation).

Above-ground test sections can be affected by high ambient and test fluid temperatures. Consideration should be given to shading the test section or completing the test outside hot periods of the day. The test pressure may need to be adjusted depending upon the measured temperature.

B5 Typical Test Forms

TEST NOTIFICATION FORM					
PROJECT TITLE:			**PROJECT NUMBER:**		
CLIENT:			**CLIENT ID NUMBER:**		
TEST PARK DESCRIPTION:			**TEST PACK NUMBER:**		
SECTION:		**FROM:**		**TO:**	
LOCATION:			**RELATED ITP:**		
SYSTEM NUMBER:			**SYSTEM TYPE:**		
P&ID NO:					
DRAWING NO:					
DATE SUBMITTED:					
TO THE ATTENTION OF:					
DATE OF PROPOSED TEST:			**TEST DURATION:**		
START TIME:			**FINISH TIME:**		
SITE CONTACT:			**CONTACT TELEPHONE NO:**		
EMERGENCY CONTACT:			**EMERGENCY TELEPHONE NO:**		
TEST TYPE:	*Hydraulic/Pneumatic		**TEST MEDIUM:**		
MAXIMUM TEST PRESSURE:	**KPA**		**EXCLUSION ZONE *(Meters/Map No.):**		
ADDITIONAL COMMENTS:					

CONTRACTOR

Approved by:

Name:

Position:

Signature:

Date:

CLIENT

Approved by:

Name:

Position:

Signature:

Date:

PRESSURE TEST CERTIFICATE

CLIENT:			
CLIENT ADDRESS:			
CLIENT CONTRACT NUMBER:			
TEST PACK NUMBER:			
TEST PACK DESCRIPTION:			
DRAWING NUMBER:			
FACILITY:			
TEST DATA			
TEST MEDIUM:		**PRESSURE START:**	KPA
TEST PRESSURE:	KPA	**PRESSURE FINISH:**	KPA
TEST DURATION:		**PRESSURE LOSS:**	KPA
TEST DATE:			
PIPE VOLUME:	m3	**TIME START:**	
AIR CONTENT:	%	**TIME FINISH:**	
PERMISSIBLE LOSS:	LITRES	**TEMPERATURE START:**	
ACTUAL LOSS:	LITRES	**TEMPERATURE FINISH:**	
CALIBRATION DATA:	**SERIAL NUMBER**	**DATE OF CALIBRATION**	**MODEL**
TEST GAUGE:			
TEST RECORDER:			
DATA LOGGER:			
TEMPERATURE RECORDER:			

CONTRACTOR

Witnessed by:

Name:

Position:

Signature:

Date:

CLIENT

Witnessed by:

Name:

Position:

Signature:

Date:

• APPENDIX C – Testing of Final Construction and Repair Tie-ins (Informative)

Final butt or electrofusion tie-ins or 'golden welds' connecting pipe sections that have already been pressure tested, shall be installed in accordance with the requirements of Section 7.5. To ensure correcting welding parameters, where practicable, pipe should be constructed such that an overlap occurs at the tie-in point so that excess pipe can be cut in order to provide a production weld on completion of the tie in (see Figure C1).

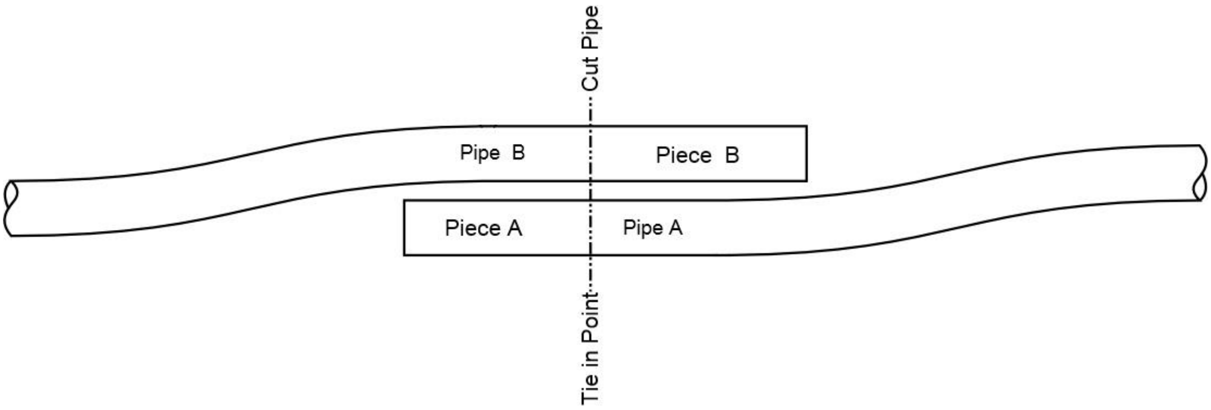


Figure C1 - Pipe overlap

With reference to Figure C2, the production weld should be completed on site in the same field conditions, using the same procedure, equipment and welder used for the final tie-in weld. The production weld should be completed prior to the final tie-in in order that this joint can undergo a destructive test.

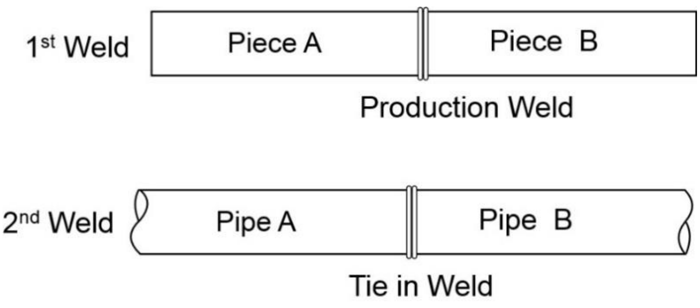


Figure C2 - Production weld/joint

Where it is not practicable to overlap pipes, where an insertion of pipe (or pup piece) is required as shown in Figure C3, two production welds should be conducted prior to the final tie in as shown in Figure C4.

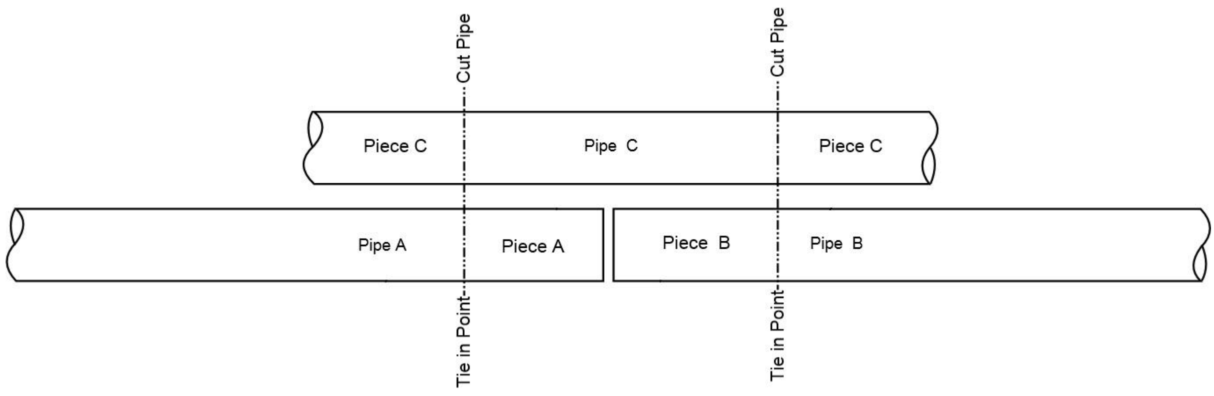


Figure C3 - Pup insertion

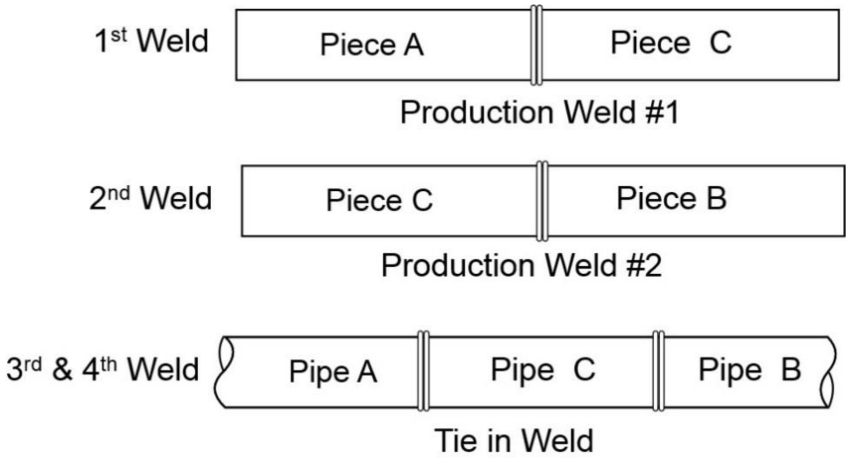


Figure C4 - Production and tie-in welds

NOTE: Where Pipe A and Pipe B are from the same continuous pipe material, only one production tie-in weld is required.

On completion of the tie-in, the production welds should undergo a destructive test. Destructive testing shall be in accordance with Section 7.9. Test samples may include NDT identified defects to ensure the quality control of the weld. If the production weld(s) is a failure, final tie in welds should be cut out and repeated. The network should not be commissioned until a satisfactory destructive test is confirmed.

Where a final tie-in or 'golden' weld is to be performed on a pipe already in operation, it might not be practical to wait for completion of the production weld(s) test before reintroducing the pipe into service. In these circumstances, any assemblies to be inserted into the network should be successfully pressure tested in accordance with Section 8 prior to insertion. 'Production' welds should also be prepared using samples of the new pipe assembled under the proposed conditions to be applied to the tie-in welds. On satisfactory completion of the 'production' weld tests, the tie-in welds can be performed under the same conditions. Any failure of the 'production' weld(s) should be investigated.

- # APPENDIX D – Definitions and Standards

Definitions

Term	Definition
Above-ground	Installed on or above ground level
Adequately trained	The provision of sufficient skills or knowledge to perform tasks safely and without harm to the environment or to plant.
ALARP	As low as reasonably practicable
APGA	Australian Pipelines and Gas Association.
Approved	Approved by the Operator and/or by statutory officer as applicable. Refer to Section 1.6 for more information.
Brownfield	A facility or network which is in operation and requires modification or upgrade is referred to as a brownfield project. This is in contrast to greenfield projects.
CFT	Critical function testing
Control Point	The location where the test personnel conduct pressure tests
Construction	Activities required to fabricate, construct and test a Gathering Network, and to restore the right of way of a Gathering Network.
Constructor	The entity approved by the Operator to conduct construction activities
CSG	Coal seam gas
CSG Water	Produced formation water (PFW), permeate, saline water and treated water
CTP	Calculated test pressure. (The acronym CTP 'calculated test pressure' is used instead of STP 'stipulated test pressure' as this can be confused with 'standard temperature and pressure' which is universally recognised as 101.325 kPa (Abs) and 15 deg C.)
Design Pressure	The maximum pressure for which a network has been designed to ensure for pressure containment (excluding transient conditions).
Easement	A section of land registered on a property title which gives the easement holder the right to use the land for specific purposes, documented in the easement usage approval, even though the easement holder may not own the property. Refer also to 'right of way'.
EF	Electrofusion
Electrofusion	Fusion of PE induced by the application of electric current.
EMP	Environmental management plan
Exclusion Zones	Defined areas established to protect public and personnel from an unforeseen discharge event during testing pressure testing. There are two exclusion zones: primary and secondary. Primary exclusion zone: This is the area identified as hazardous around the test section. Secondary exclusion zone: This is the area identified as hazardous around the test equipment.
FIC	Field installation checklist
Fluid	In the context of this Code, 'fluid' refers to gaseous or liquid substances transported through PE pipes or utilised in the pressure testing of PE pipes.
FRCS	Fibreglass reinforced compression sleeves
FTIR	Fourier transform infrared spectroscopy
Gauge Pressure	Pressure measured above atmospheric pressure
Golden weld	A final joining weld which cannot be fully tested (also known as 'closure weld')
GRE	Glass reinforced epoxy
Greenfield	A new facility or network which is built from the very beginning, without making use of or relying on any previous work for assistance, or interacting with previously constructed facilities or networks is called a greenfield project. This is in contrast to a brownfield project.
HAZOP	Hazard and operability study

Hydraulic Testing	Testing using a liquid medium, almost always water. NOTE: This term replaces the earlier term 'hydrostatic testing' which, in some quarters, is now used to define both liquid and gaseous testing processes.
HDPE	High density polyethylene. NOTE: While PE materials historically are commonly referred to as high density (HDPE), medium density (MDPE), low density (LDPE) or linear low density (LLDPE) these descriptors are not appropriate for the PE pipe compounds used for the CSG industry. There is no universally accepted delineation between MDPE and HDPE and density alone does not adequately describe the material. The term PE100 should always be applied to the PE pipes used for CSG as it ensures all of the appropriate performance requirements have to be met rather than simply a density range. Refer to the appropriate Companion Paper for further information.
HPU	Hydraulic power unit
HPV	High point vent
IBC	Inside bolt centre
IMP	Integrity management plan
ITP	Inspection and test plan
JSA	Job safety analysis; also commonly called job hazard analysis (JHA), and job hazard and environmental analysis (JHEA).
LoF	Lack of fusion
Leak Test	The leak test determines if there are any small leaks in the test system. The leak test shall be undertaken after a successful completion of a strength test.
Limited access boundary	An area which extends beyond the exclusion zone, and includes the control point and pressurising equipment.
LDPE	Low density polyethylene. Refer to HDPE above and the appropriate Companion Paper for further information regarding the use of this term.
LLDPE	Linear low-density polyethylene. Refer to HDPE above and the appropriate Companion Paper for further information regarding the use of this term.
LPD	Low point drain
Major highways	High capacity roads managed by State and Territory government agencies.
MAOP	Maximum allowable operating pressure: the maximum pressure at which a network may be operated in accordance with the design criteria and provisions set out in this code, Section 4.3.5. MAOP should not be confused with the PN rating of the pipe.
MDPE	Medium density polyethylene. Refer to HDPE above and the appropriate Companion Paper for further information regarding the use of this term.
MOP	Maximum operating pressure – an interim adjustment representing the highest pressure a piping system may be subjected to during an interim operating period.
MRS	Minimum required strength for the material in MPa at 20°C.
NDT	Non-destructive testing
NMS	Network management system
OH&S	Any reference to workplace health and safety (WHS) should be taken to mean OH&S in Victoria and WA.
OHS&E	Any reference to workplace health and safety and the environment (WHS&E) should be taken to mean OHS&E in Victoria and WA.
OIT	Oxidation induction time
Operator	The term refers to the entity that the regulatory authority holds accountable for the network.
P&ID	Piping and instrumentation diagram
PE	Polyethylene
PFD	Process flow diagram
PFW	Produced formation water
PIPA	Plastics Industry Pipe Association of Australia Ltd

PN	Pressure nominal - nominal working pressure at 20 degrees C designated in bar. Refer AS/NZS 4130.
Pneumatic testing	Testing using a gaseous medium, almost always air.
Preliminary test	A test that is undertaken on a section of a network that will be subsequently exposed to a further strength test pressure when included in the main network test section.
Pre-test	A pressure test of a network section or component that is undertaken separately from the network and is not re-tested after installation. (eg. network section with a closure weld.)
Pressure test	A pressure test consists of a strength test followed by a leak test
Production Test	Destructive testing of a production weld.
Production weld	Weld undertaken external to the network installation, using the same material as the associated pipe tie-in materials, for destructive testing purposes.
QA/QC	Quality assurance and quality control
Right of way (ROW)	Network route and work area, along the network centreline, approved for construction, operation or maintenance purposes (usually temporary). Refer also to 'easement'.
Strength test	The strength (or proof) test is a means by which the integrity of a test section is assessed, this is carried out by filling with a fluid, sealing and subjecting to a calculated test pressure. The strength test is used to validate integrity and to detect any construction or mechanical defects and also defective materials.
PSV	Pressure safety valve
QA	Quality assurance
QC	Quality control
RO	Reverse osmosis
RTO	Registered training organisation
Safety management study	A process that identifies threats to the network and applies controls to them, and (if necessary) undertakes assessment and treatment of any risks to ensure that residual risk is reduced to an acceptable level.
SCG	Slow crack growth
SDR	Standard dimension ratio
Shall	A mandatory requirement.
Should	A recommended action or guideline.
STP	Stipulated test pressure or Standard temperature and pressure; refer to the acronym CTP 'calculated test pressure' for more information.
TDS	Total dissolved salts
Test Section	The network or portion of network being subjected to a pressure test.
Test System	The network being subject to a pressure test.
Threat	Any activity or condition that can adversely affect the network if not adequately controlled.
UV	Ultraviolet
VOC	Verification of Competency.
WHS	Workplace health and safety. Any reference to WHS should be taken to mean OH&S in Victoria and WA.
WHS&E	Workplace health and safety and the environment. Any reference to WHS&E should be taken to mean OHS&E in Victoria and WA.

Referenced Standards and Documents

Standard/Document	Title
AGA-XK1801	Purging Manual
ANSI/ASTM B16.5	Pipe flanges and flanged fittings
API 521	Pressure-relieving and Depressuring Systems
AS 1319	Safety signs for the occupational environment
AS/NZS 1020	The control of undesirable static electricity
AS 1100.401	Technical drawing - Engineering survey and engineering survey design drawing
AS1463	Polyethylene pipe extrusion compounds
AS/NZS 2033	Installation of polyethylene pipe systems
AS 2129	Flanges for pipes, valves and fittings
AS2187.2	Explosives – storage and use – use of explosives
AS 2566.2	Buried flexible pipelines - Installation
AS 2885.1	Pipelines - Gas and liquid petroleum - Design and construction
AS 4041	Pressure piping
AS 4087	Metallic flanges for waterworks purposes
AS/NZS 4129	Fittings for polyethylene (PE) pipes for pressure applications
AS/NZS 4130	Polyethylene (PE) pipes for pressure applications
AS/NZS 4131	Polyethylene (PE) compounds for pressure pipes and fittings
AS/NZS 4158	Thermal-bonded polymeric coatings on valves and fittings for water industry purposes
AS/NZS 4331.1	Metallic flanges - Steel flanges
AS 4343	Pressure equipment – hazard levels
AS/NZS 4645.1	Gas distribution networks - Network management
AS/NZS 4645.3	Gas distribution networks - Plastics pipe systems
AS/NZS/ISO 31000	Risk management - Principles and guidelines
AS/NZS 60079	Electrical apparatus for explosive gas atmospheres
ASME B31.3	Process piping
ASME PCC-2	Repair of Pressure Equipment and Piping
ASTM D1598	Standard Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
ASTM F905	Standard Practice for Qualification of Polyethylene Saddle-Fused Joints
ASTM F1041	Standard guide for squeeze-off of Polyolefin Gas Pressure Pipe and Tubing
ASTM F1055	Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing.
ASTM F1563	Standard Specification for Tools to Squeeze-Off Polyethylene (PE) Gas Pipe or Tubing
ASTM F1598	Standard Test Method for Determining the Effects of Chemical/Solvent Exposure to a Membrane Switch/Graphic Overlay (Spot Test Method)
ASTM F1734	Standard Practice for Qualification of a Combination of Squeeze Tool, Pipe, and Squeeze-Off Procedures to Avoid Long-Term Damage in Polyethylene (PE) Gas Pipe
ASTM F1962	Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings
ASTM F2620	Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
ASTT CPJP8029-GUI-C-001	Guidelines for Horizontal Directional Drilling, Pipe Bursting, Microtunnelling and Pipe Jacking
BS EN 805	Water supply. Requirements for systems and components outside buildings
BS EN 1555-3	Plastics piping systems for water supply, and for drainage and sewerage under pressure. Polyethylene (PE). Fittings.

Standard/Document	Title
BS EN 12201-4	Plastics piping systems for water supply, and for drainage and sewerage under pressure. Polyethylene (PE). Valves.
BS EN 13185:2001	Non-destructive testing- Leak testing- Tracer gas method
Evisive Paper	HDPE Butt Fusion Weld Inspection and Imaging Using Evisive ScanTM Technology
Evisive Paper	HDPE Pipe Electro-Fusion Coupling Inspection and Imaging Using Evisive ScanTM Technology
GIS/E4:2006	Inflatable, self-centring bag stoppers for use on distribution pipes of a nominal size up to and including 300 mm (12 in)
ICONE17-75742	Microwave based NDE inspection of HDPE pipe welds.
ISO/AS/NZS 9001	Quality management systems - Requirements
ISO/IEC 31010.	Risk management - Risk assessment techniques
ISO 4437	Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE).
ISO 7005.1	See AS/NZS 4331.1
ISO 11413	Plastics pipes and fittings - Preparation of test piece assemblies between a polyethylene (PE) pipe and an electrofusion fitting
ISO 11414	Plastics pipes and fittings. Preparation of polyethylene (PE) pipe/pipe or pipe/fitting test piece assemblies by butt fusion
ISO 13953	Polyethylene (PE) pipes and fittings - Determination of the tensile strength and failure mode of test pieces from a butt-fused joint
ISO 13954	Plastics pipes and fittings - Peel decohesion test for polyethylene (PE) electrofusion assemblies of nominal outside diameter greater than or equal to 90 mm
ISO 13955	Plastics pipes and fittings - Crushing decohesion test for polyethylene (PE) electrofusion assemblies
ISO 13956	Plastics pipes and fittings - Decohesion test of polyethylene (PE) saddle fusion joints - Evaluation of ductility of fusion joint interface by tear test
ISO 13957	Plastics pipes and fittings -- Polyethylene (PE) tapping tees -- Test method for impact resistance
ISO 14236	Plastics pipes and fittings - Mechanical-joint compression fittings for use with polyethylene pressure pipes in water supply systems
ISO 21307	Plastics pipes and fittings - Butt fusion jointing procedures for polyethylene (PE) pipes and fittings
ISO 21751	Plastics pipes and fittings - Decohesion test of electrofusion assemblies - Strip-bend test
PIPA TN016	Non-Destructive Examination of PE welds – Emerging Techniques
PIPA TP005	Flexible Pipe Design
POP 001	PIPA Guideline: Electrofusion Jointing of PE Pipe and Fittings for Pressure Applications
POP 010A	PIPA Guideline: Polyethylene pressure pipes design for dynamic stresses
POP 003	PIPA Guideline: Butt fusion jointing of PE pipes and fittings - recommended parameters
POP 004	PIPA Guideline: Polyethylene pipe compounds
POP 005	PIPA Guideline: Packaging, handling and storage of polyethylene pipes and fittings
POP 006	PIPA Guideline: Derating requirements for fittings
POP 007	PIPA Guideline: Metal backing flanges for use with PE pipe flange adaptors
POP 016	PIPA Guidelines High stress crack resistant PE100
POP 202	PIPA Guideline: PVC and PE pressure pipe installation on curved alignments
PIPA TN016	PIPA Guideline: Non-Destructive Examination of PE welds – Emerging Techniques.
PPI Handbook	Handbook of Polyethylene Pipe
WIS 4-24-01	Specification for mechanical fittings and joints for polyethylene pipes for nominal sizes 90 to1000

Standard/Document	Title
WIS 4-32-08	Specification for the fusion jointing of polyethylene pressure pipeline systems using PE80 and PE100 materials.
WSA 109	Industry standard for flange gaskets and O-rings – Water Services Association of Australia

• Amendments from Previous Versions

The list below shows where many of the significant amendments from Version 3.0 and Version 4.0 were made. However, users should not assume that these details are complete and should refer to this version in all cases.

Version 3.0 Supplementary amendments

Section 1.1
Scope clarification has been made regarding environmental management requirements detailed within the Code. Similar adjustments, in accordance with the clarification, have been made throughout the code where applicable.

Section 4.18
Improvements made to provide clarity around overpressure protection requirements.

Section 5.11
Qualifications made to signage requirements where PE networks are located in cultivated fields.

Version 4.0 Amendments

Section 1.1
An increase of the maximum design pressure for gas from 1000 kPag to 1600 kPag as a direct result of the incorporation of risk-based design.

Section 1.5
The incorporation of Companion Papers 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.

Section 1.6
Details of items requiring *approval*, and the associated meaning of term as used in this Code, moved to Section 1.6 from Section 11 *Operation* where the information was previously located.

Section 2.2.1
The meaning of the term Operator, as used by this Code, was changed from referring to an individual (dependent upon Code context) to "the entity that the regulatory authority holds accountable for the network".

Section 3.3.2.2
Added requirements for enabling an increase in pressure rating for fittings.

Section 3.4.2
Added requirements for enabling an increase in pressure rating for valves.

Section 4
Incorporation of risk-based design in lieu of a fixed 'risk' design factor based on the use of physical and procedural measures for risk mitigation in accordance with the location or sub-location class.

Inclusion of the limited application of 'composites' in accordance with this Code;

Section 4.16
Clarification of the scope applicability of ASME B31.3 and AS4041.

Section 4.3
Introduction of the *pressure test factor* and removal of the *risk factor*.

Section 4.5
Introduction of the risk control and mitigation details into the body of the Code.

Section 4.8.2
Change to the location class to incorporate 'High Use' and 'Sensitive' sub-location classes.

Section 4.13.1
Additional requirements added for the use of above-ground pipe subject to internal pressures greater than 80 kPag.

Section 4.25
Requirements added for the use of alternative materials for sections of CSG water pipes where the pressure at the lowest point exceeds 2500 kPag due to elevation head differences.

Section 5
This Section covering Construction has been consolidated and re-written in parts to improve ease of usability. Much of the descriptive details of construction methods, found in the previous version of this Code, has been removed.

Section 5.11.1.3
Updated to recognise detectable marker products in lieu of tracer wire

Section 8.2
The information previously provided, regarding methods of reducing the amounts of pneumatic stored energy in the network test section, has been removed.

Section 8.4
Incorporation of risk-based design in lieu of a fixed 'risk' design factor based upon the use of physical and procedural measures for risk mitigation in accordance with the location or sub-location class.

Changes to pressure testing requirements updated to incorporate the pressure test factor introduced in this version of the Code. Details were also added for component testing and preliminary testing as well as hot tapping and emergency response pressure testing for components.

Section 9.4
Additional details provided to clarify the minimum information that should be recorded as part of abandonment records.

Section 11
Previous details, around meaning and use of *approvals* in this Code, moved to Section 1.6.

Section 11.5.1
Adjustments made clarifying the structural integrity issues that are required to be covered in the integrity management plan.

Section 11.5.2
Further flow-stopping options now detailed in the body of this Code. Much of the information was provided in an Appendix of the previous version of this Code.

Details previously provided - discussing clamps, sleeves and pipe reinforcement devices - have been removed.

Section 11.9.5
Additional requirements have been added for the use of reinforcement sleeves and pressure containment sleeves.

Appendices
The following Appendices have been removed which were previously contained in *Version 3.0* of the Code (as well as contained in *Version 3.0 Supplementary*):

- System Design Considerations;
- Assessment of PE Welds;
- PE Materials Selection and Quality
- Maintenance, Modifications and Emergency Response;
- Sidewall Fusion Welding;

Some content removed from previous versions of this Code may be found in Companion Papers.

Refer to the appropriate Companion Papers for further information.

Version 4.0 Supplementary amendments

Section 1.3
New definition of objective of the Code.

Section 3.3.1
New method of service identification provided.

Section 4.5.2
Updated Table 4.5.2 to provide a summary of interference controls.

Section 4.8.2.2 a) and b)
Clarification in sub location High Use and Sensitive area definitions.

Section 4.13.1

Revision of use of above ground pipe use.

Section 4.18
Definition of excursion times for pressure testing.

Section 5.5.3
Removal of reference to suitability of striped pipes for above ground use and consolidation into Section 4.13.1.

Section 5.11.3
Clarification note added for location of signs.

Section 8.4.1.5
Revised definition of test temperature compensation.

Section refer to 11.11.2.2 b)
Re-definition of compression sleeve.

Appendix B2
Correction to minimum distance formula.

Appendix D
Inclusion of CSG Water definition and global use of term in Code.

Version 5.0 Major Amendments

Global
In the interests of clarity:

- Reference to “Code of Practice” changed to “Code”.
- Reference to “Pipelines” and “Flowlines” changed to Gathering Networks” to match title of Code.
- Reference to “PFW” or Drilling Water” changed to CSG Water.
- Review of “shall” and “should” statements to ensure they match industry practice.

Section 2.2.1
Section clarified to define requirements for connection of independently operating Gathering Networks.

Section 2.2.2.2 e)
Expanded scope of damage repair.

Section 2.2.2.4
Changed frequency of review of Network management System from 2 years to 5 years, in line with industry practice.

Section 2.6.6
New section covering “ALARP” added to match industry experience.

Section 2.9
Section covering “Site Safety” expanded re JSA’s to match industry experience.

Section 3.3.2.2
Section covering “Rating requirements for fittings”, expanded to clarify intent.

Section 3.3.2.5 / 3.3.2.6
Sections covering “Mechanical compression fittings” and Mechanical couplings”, expanded to clarify intent.

Section 3.3.2.7
New section covering “Backing flanges” added clarify intent and allow use of non-metallic component.

Section 3.3.3
Section covering “Previously used pipe” expanded to permit re-use of pipe in temporary service.

Section 3.4.2
Section expanded to cover example of pressure rating of PE valves.

Section 3.4.3
New section added covering standards applicable to thermoplastic valves.

Section 4.1
Section expanded to encourage use of advances in resin technologies in Gathering Network design.

Section 4.3.1/4.3.1.1/4.3.1.2
Section expanded and split to clarify use of Design Basis and design requirements

Section 4.3.3 / 4.3.4
Factors to be taken into consideration in network and process design expanded in line with industry experience.

Section 4.4.1.4
In Note 2, numerical value offered to distinguish between pipes designed for PFW use and gas use.

Section 4.4.1.4
In Note 2, numerical value offered to distinguish between pipes designed for PFW use and gas use.

Section 4.5.1 / 4.5.2
Clarification of risk control requirements for integrity and external interference, in line with industry practice.

Section 4.6.3
Under Fitness for purpose, added examples of use of Miners rule and advanced resin properties.

Section 4.7
Added additional considerations, for when undertaking route selection.

Section 4.9
Under “Isolation” added consideration for transportation of water for drilling and workovers. In addition, added consideration of other than carbon steel risers as part of well head facilities.

Section 4.10
Clarified “Depth of Cover” and introduced “reduced cover”.

Section 4.18
Section clarified to define requirements.

Section 4.13.1
Introduced ability to install temporary above ground water lines, in non-fenced-off locations.

Section 5
Section related to construction re-worded to clarify intent.

Section 6.2 / 6.3
Clarified welding requirements and revised SDR transition step limitations.

Section 6.5
Clarified welders training requirements in line with industry availability of courses.

Section 7.5
Intent of welding procedure qualification groupings clarified.

Section 8.2.8 / 8.2.9
Sections renumbered and material moved to Companion papers.

Section 8.4
Strength test factor modified to match intent of Code. Material moved to Companion papers.

Section 8.4.4
Pressure test time requirements for emergency response incidents clarified.

Section 11
Sub sections re-numbers and intent clarified.

Section 11.8
Key document review dates revised in line with industry practice.