

Australian/New Zealand Standard™

Pressure equipment—In-service inspection



AS/NZS 3788:2006

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee ME-001, Pressure Equipment. It was approved on behalf of the Council of Standards Australia on 27 June 2006 and on behalf of the Council of Standards New Zealand on 7 July 2006.

This Standard was published on 27 July 2006.

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This Standard was issued in draft form for comment as DR 05161.

Australian/New Zealand Standard™

Pressure equipment—In-service inspection

Originated as AS 3788—1990.
Previous edition AS/NZS 3788:2001.
Fourth edition 2006.

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Jointly published by Standards Australia, GPO Box 476, Sydney, NSW 2001 and Standards New Zealand, Private Bag 2439, Wellington 6020

ISBN 0 7337 7657 4

PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME-001, Pressure Equipment to supersede AS/NZS 3788:2001, *Pressure equipment—In-service inspection*.

The objective of the revision is to align the Standard with current equipment integrity management and assessment practices and to address some of the problems currently experienced in industry. To achieve this, the Standard has been significantly revised throughout.

While the Standard still sets out minimum inspection intervals, it now allows those intervals to be varied in response to a thorough risk-based engineering assessment. This is intended to allow the efficient use of integrity management programs by large-scale industry. As such assessments require significant resources to consider all the relevant factors, it is expected that the majority of the users of this Standard will continue using the prescribed intervals. It should be noted that the previous Clause 4.4.4.3(c), Further extended period, has been removed to ensure that variations to inspection intervals are properly assessed.

More emphasis has been placed on the responsibility to use competent bodies and personnel for all aspects of the inspection and assessment processes—a reflection of the current philosophy of occupational health and safety regulations. Guidance material is included to aid industry in assessing the competence of bodies and people for different tasks.

The Committee noted that poorly-marked or unidentifiable equipment is a significant issue facing inspectors, and has provided some guidance on dealing with such situations.

The appendices have also been revised, including a review of the normative or informative status of each. Appendix O (regarding fracture mechanics) has been significantly revised. A new appendix has been added regarding the inspection of support structures.

This Standard provides inspection requirements to assist in assuring the continued safe operation of pressure equipment. In some circumstances additional inspection may be necessary for adequate performance or safety. The material contained in this Standard may be used as an aid in the training of inspection personnel.

Users of this Standard are reminded that it has no legal authority in its own right, but acquires legal standing where adopted by government or other authority having jurisdiction, or if specified as part of a commercial contract.

Statements expressed in mandatory terms in notes to tables and figures are deemed to be requirements of this Standard.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard Pressure equipment—In-service inspection

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies the minimum requirements for the inspection, repair and alteration of in-service boilers, pressure vessels, piping, safety equipment, and associated safety controls (hereafter referred to as pressure equipment), and gives guidance in the execution of such activities. Guidance is included for the inspection of ancillary equipment such as structures. This Standard also specifies the requirements for the initial inspection after installation and prior to commissioning. The inspection flow diagram (see Figure 1.1) illustrates the various types of inspection covered by this Standard.

This Standard provides information to facilitate grounds for agreement between interested parties, and the establishment of uniform minimum requirements for in-service inspections, including inspection intervals and procedures, to assist in assuring safe and economic operation. Information is provided on mechanisms of deterioration, the assessment of defects, and the assessment of fitness for service of pressure equipment.

No rules can be written in sufficient detail to cover all aspects of the inspection of in-service pressure equipment. The owner is responsible for ensuring that the extent and frequency of inspection is appropriate and adequate for the continued safe operation of the pressure equipment. This may require the seeking of expert advice.

Duty of Care is now prescribed by Occupational Health and Safety Legislation. This Standard does not supersede such Duty of Care, but is intended to complement and contribute to it.

1.2 APPLICATION

This Standard applies to, but is not limited to, pressure equipment covered by AS/NZS 1200. Typically it includes the following:

- (a) Boilers and associated pressure parts, controls and pipe work covered by AS 1228, BS 1113, BS 2790, AS 2593 and ASME BPV-I.
- (b) Pressure vessels and associated pressure parts, controls and pipe work covered by AS 1210, BS PD 5500, EN 13445, ASME BPV-VIII, AS 2971 (serially produced pressure vessels) and EN 286-1.
- (c) Pressure piping covered by AS 4041, NZS/BS 806, ASME B 31.1 and ASME B 31.3.
- (d) Pressurized storage tanks built to API 620 or equivalent.
- (e) Fired heaters.
- (f) Heritage boilers and pressure vessels.

Although pressure equipment with Hazard Level E (to AS 4343) is within the scope of this Standard, no specific requirements have been included. To ensure safety, in-service inspection of such equipment should follow the principles of this Standard, along with good engineering practice.

This Standard does not specifically deal with the following equipment, but provides information which may be used as guidance.

- (i) Storage tanks covered by AS 1940 and built to API 650, AS 1692 or equivalent (refer API 653).
- (ii) Miniature boilers to the AMBSC codes.
- (iii) Pressurized machines, e.g. turbines, compressors, etc.
- (iv) Pipelines as per AS 2885 or equivalent.

1.3 REFERENCED AND RELATED DOCUMENTS

1.3.1 Referenced documents

A list of the documents referred to in this Standard is given in Appendix A.

NOTE: Where reference is made to a Standard by its number only, the reference applies to the current edition of the Standard including any amendments. Where reference is made to a Standard by number, year and, where relevant, an amendment number, the reference applies to that specific document.

1.3.2 Related documents

Related documents and guidance references are listed in Appendix A.

1.4 DEFINITIONS

For the purposes of this Standard, the definitions given in AS 4942 and the following apply.

NOTE: Definitions for terms such as 'owner', 'competent person' and 'inspector' may differ slightly from State OHS regulations or codes of practice.

For calculations and reports AS ISO 1000, the International System of Units, shall be applied.

1.4.1 Inspector

A person able to inspect pressure equipment for the purpose of establishing conformity with the specified requirements.

1.4.2 Inspection body

A body corporate, firm or person external to that of the owner, or an owner's inspection department, able to provide the inspection services of pressure equipment.

1.4.3 Competent person

A person who, due to their knowledge and skills, is acceptable to the owner/user/responsible person to perform a required task. The appropriate knowledge and skills may be acquired through training, experience, qualifications, or some combination of these.

NOTES:

- 1 The term 'competent person' is used in this Standard to address a variety of technical requirements. Guidance on competency requirements is provided in Appendix V.
- 2 In New Zealand the 'competent person' for inspection activities is the 'inspector' or 'design verifier'.

1.4.4 Inspection

Activities such as viewing, measuring, examining, testing, gauging, calculating, checking, verifying one or more characteristics of a product design, material, manufacture, product, service, process, plant or reports and determination of their conformity with specific requirements or, on the basis of professional judgement, with general requirements.

NOTES:

- 1 The above activities may require multiple parties.
- 2 For inspection the 'competent person' should be the 'in-service inspector' or a person with equivalent qualifications and experience.

1.4.5 Surveillance

Activities which observe the general condition of equipment, including on-line inspection, monitoring, planned or un-planned condition audits, etc.

1.4.6 Pressure equipment and ancillaries

Equipment as defined in Clause 1.2, including boilers, pressure vessels, pressure piping, and pressurized storage tanks.

In New Zealand, the regulations also include certain fired heaters, hot water boilers, gas and steam turbines, steam engines, pumps and compressors. See AS/NZS 1200.

Pressure equipment also includes ancillaries such as interconnected parts and components, valves, gauges and other fittings, headers, bolting, gaskets, supports and pressure-retaining accessories. Unless noted, it does not normally include items such as pumps, fans, and similar machinery.

1.4.7 Owner/User/Responsible person

A body corporate, firm or person who has right of title to, or management of, or control over, pressure equipment. This includes a person exercising such management or control as an agent of the owner and the user, operator and controller, as appropriate.

Where these are different parties, the owner is responsible for clarifying the respective roles, and is responsible to ensure overall compliance with this Standard.

NOTE: Control is taken to encompass the operational life cycle, ie. operation, inspection and testing, repair and alteration, maintenance, re-rating, mothballing or preservation, decommissioning and abandonment.

1.4.8 Defects

Imperfections, damage, deterioration or deficiencies in pressure equipment.

NOTE: The presence of a defect in pressure equipment does not necessarily imply that the equipment is unfit for service (see Clause 5.2).

1.4.9 In-service

The period during the life of pressure equipment from the beginning of commissioning until disposal.

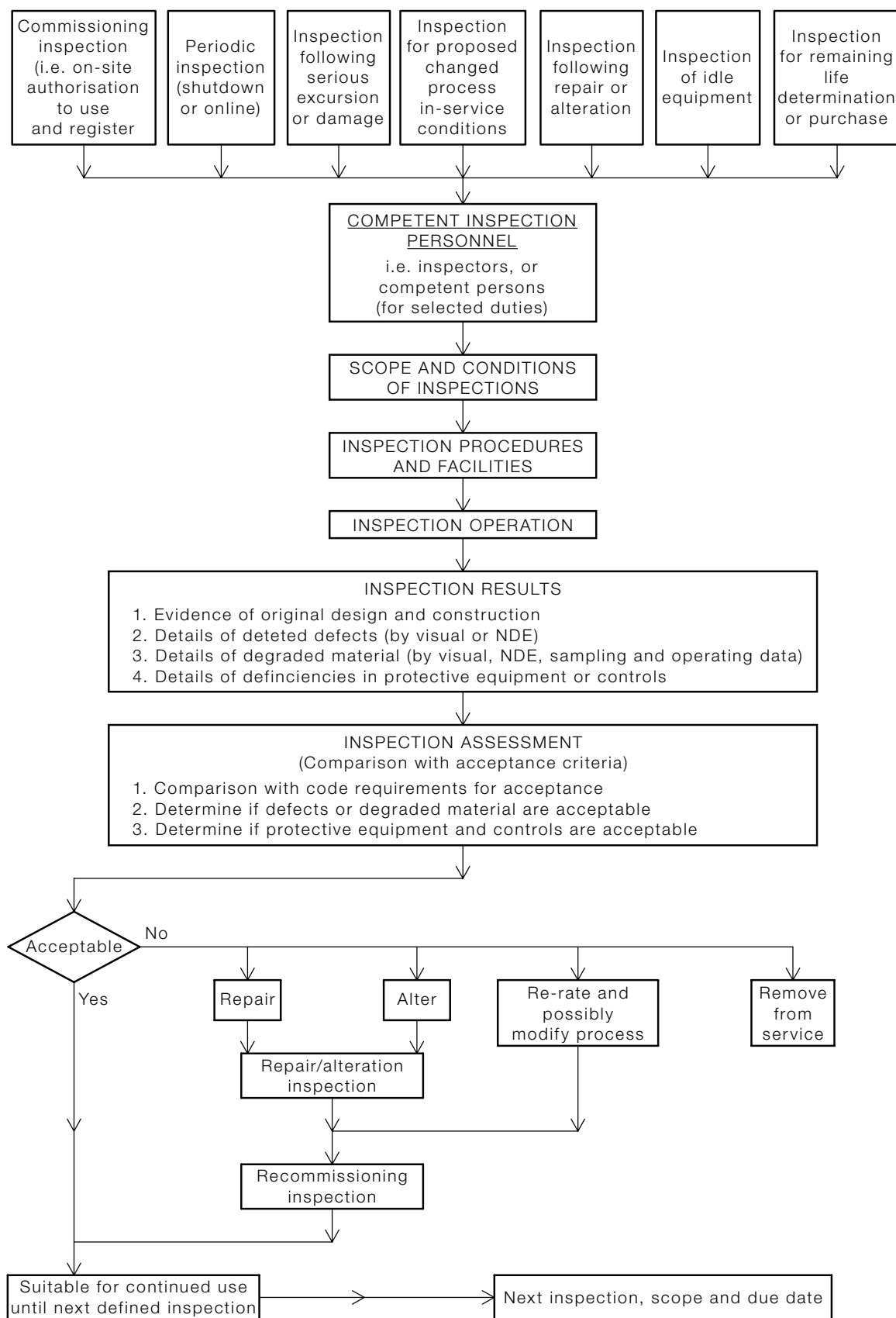


FIGURE 1.1 IN-SERVICE INSPECTION FLOW DIAGRAM

1.5 RISK MANAGEMENT AND RISK BASED INSPECTION

Risk management techniques may be used to achieve the objectives of the pressure equipment inspection program (see Clause 2.1). In order to operate pressure equipment at an acceptable level of risk, the extent and frequency of inspection, the quality of process control and monitoring and the potential consequence of failure shall be taken into account.

NOTE: Guidance on risk management is given in Appendix B.

1.6 SAFETY

Appendix C sets down principles and procedures to be followed to ensure the safety of personnel during the inspection of pressure equipment.

1.7 SPECIAL CONDITIONS AND VARIATIONS

It is not possible to write requirements to cover all cases of in-service inspection of pressure equipment. In special cases there may be a need to depart from the requirements in this Standard.

Where departure from this Standard is necessary, the departure shall—

- (a) be justified and fully documented by a competent person; and
- (b) give a level of safety and quality that is no less than that specified in this Standard.

Any departure from this Standard is the subject of agreement between the parties concerned.

1.8 REFERENCED STANDARDS

Where this Standard makes reference to other Standards, these referenced Standards are not intended to be limiting or exclusive and alternative standards may be substituted for the referenced standards, where these give an equivalent level of safety and equipment quality. A list of pressure equipment Standards used in Australia and New Zealand and procedures for their use are included in AS/NZS 1200.

SECTION 2 INSPECTION REQUIREMENTS

2.1 OBJECTIVES OF INSPECTION

The objectives of in-service inspection are to—

- (a) promote the safety and health of persons in the workplace and of the public;
- (b) comply with occupational health and safety legislation;
- (c) limit the potential damage to property; and
- (d) protect the environment,

through the control, reduction or elimination of risk associated with the pressure equipment.

These objectives are achieved by—

- (i) verifying that fabrication and operation comply with design conditions;
- (ii) verifying that pressure equipment is safe and fit for service under the specified operating conditions until the next planned inspection;
- (iii) verifying that maintenance, repairs, and alterations are carried out in a manner which maintains the integrity of the pressure equipment;
- (iv) indicating repairs, replacements or alterations which may be needed, and assessing remaining safe life of the pressure equipment.

Additional inspections may be carried out for a number of reasons, including, but not limited to—

- (A) assessment of the early performance of new design, material, fabrication, and testing; and
- (B) investigation and assistance in determining the causes of failure, hazards, reduced performance, or abnormal conditions which may lead to failure, and to determine what consequent temporary or long-term action is required to ensure continued safe operation or life commensurate with commercial requirements.

2.2 ASSET INTEGRITY LIFE CYCLE

Fitness for service during the overall life cycle of pressure equipment is determined by activities at the stages listed as follows:

- (a) Concept—initially when many main decisions which affect ultimate safety (and inspection) are made.
- (b) Design—usually design review and verification.
- (c) Material—usually examination, marking and certificate correlation.
- (d) Fabrication.
- (e) Installation.
- (f) Commissioning—including identification and registration.
- (g) Operation—on line.
- (h) Periodic in-service inspection.
- (i) Maintenance.

- (j) Special in-service activity, as follows:
 - (i) Repair.
 - (ii) On-line maintenance or monitoring.
 - (iii) Alteration.
 - (iv) Idle or mothballed pressure equipment.
 - (v) Failure or changed performance.
 - (vi) Determination of remaining life.
 - (vii) Assessment of new materials and designs.

NOTE: This Standard deals only with inspection and assessment at stages (f) to (j).

2.3 INSPECTION PROCESS

The inspection scope is the subject of agreement between all parties concerned and shall be planned and executed by competent persons. The inspection scope may include items other than pressure equipment.

The overall inspection plan shall establish the equipment to be inspected, methods of inspections, requirements for surface preparation, safety requirements, and other relevant matters.

The extent and frequency of inspection elements shall be sufficient to provide a high level of assurance that the integrity of the pressure equipment is adequate.

Inspection at each stage shall provide some overlap of inspections, e.g. at the initial inspection, fabrication inspection shall be supplemented by visual inspection as a check to detect any damage in transit or installation.

Inspection personnel shall make use of personal experience, information from plant records and information from other sources.

Communication between all parties concerned shall be clear, prompt and effective at all times.

Inspection and surveillance shall be performed while the plant is operational to detect signs of deterioration, damage or evidence that suggests damage or deterioration may exist, e.g. leaks, vibration, settlement, piping movement, adequate performance of piping supports, etc.

Integrity assessment shall include review of the control system, pressure safety system, and pressure relief valves in accordance with this and other applicable Standards.

A competent person shall assess the findings of the inspections and provide a report to the owner which includes the following:

- (a) Summary of the inspections performed, the inspection methods used and the findings.
- (b) Detailed inspection reports for all inspections carried out.
- (c) The criteria for assessment of the inspection findings.
- (d) The results of the assessment of the inspection findings.
- (e) The recommended intervals to the next external and internal inspections.
- (f) Special comments, e.g. defect monitoring requirements, recommended future inspections, recommended repairs, or recommended changes to current operating practices and parameters.

Should defects be found the fitness for service of the pressure equipment shall be assessed by a competent person.

SECTION 3 INSPECTION PERSONNEL AND ADMINISTRATION

3.1 OWNER'S RESPONSIBILITIES

There shall be a management system sufficient to ensure the continuing integrity and safety of items of pressure equipment. Such a system shall be documented to a level determined to be appropriate in consultation with a person competent in pressure equipment inspection. In determining the appropriate level of documentation issues including the Hazard Level, location, physical condition, maintenance practices, service history, number of items to be covered, and any other relevant issues, shall be considered.

NOTE: For example, a complex chemical processing facility with a number of pressure vessels will warrant a comprehensive, well-developed and well-documented management system. In contrast, for a single small boiler in a commercial laundry where there is a history of good operation, maintenance and inspection, a simple management system with minimal documentation may be appropriate.

The management system should include information on all important safety issues, including:

- (a) Organization structure and defined roles and responsibilities for personnel interfacing with pressure equipment.
- (b) Safety and Risk Management policy.
- (c) Critical safety instructions.
- (d) Alterations, maintenance, and repair procedures.
- (e) Overall inspection and test plan (see Section 2).
- (f) Procedures for reporting and investigation of dangerous occurrences.
- (g) Identification of the personnel responsible for inspection.
- (h) The competency of the inspector carrying out the inspection.
- (i) The acceptability of the inspection body.
- (j) Periodic operational inspection and audit of pressure equipment, ie. compliance with Section 2.
- (k) Periodic reporting and certificates of inspection, ie. compliance with the requirements of this Standard and any regulatory requirements.
- (l) Training requirements and schedules for periodic assessment of operating, maintenance and inspection staff.
- (m) Defined limits of design and critical operating parameters (such as temperature, pressure and chemical composition) and methods for recording and reporting of any excursions and, where required, assessment of significance to integrity.
- (n) Preparation of equipment for inspection, where appropriate, in accordance with the requirements of AS/NZS 2865 (see also Appendix C).
- (o) Corrective action where non-conformances with this Standard are found.
- (p) Re-rating where undertaken.

All persons involved in undertaking inspection and assessment of the integrity of pressure equipment shall be competent.

3.2 RESPONSIBILITIES AND CAPABILITIES OF PERSONS CARRYING OUT IN-SERVICE INSPECTION

3.2.1 General

Personnel involved in in-service inspection shall be experienced, competent, trained, instructed and equipped at the level necessary for their particular task.

NOTES:

- 1 Guidance on the competency of personnel and bodies involved in in-service inspections is given in Appendix V.
- 2 In New Zealand, inspectors are required to be a signatory or be supervised by a signatory of an accredited inspection body and are required to meet the requirements of the Certification Board for Inspection Personnel (CBIP), or an equivalent body, for in-service inspectors.
- 3 In New Zealand non-destructive testing is required by legislation to be carried out by a signatory or be supervised by a signatory of an accredited inspection body.

3.2.2 Particular responsibilities

In-service inspections shall address the following items:

- (a) Performing and recording inspections in accordance with this Standard.
- (b) Acting only within areas of competency.
- (c) Being mindful of the objectives of this Standard.
- (d) Communicating clearly.
- (e) Undertaking inspection in a safe manner.
- (f) Verifying, as far as practicable, that the equipment meets the requirements of either—
 - (i) the specified Standards designated by the original design code; or
 - (ii) the Standards specified for any re-rating or modifications.
- (g) Ensuring that appropriate methods of inspection, including non-destructive testing, are provided by competent personnel.
- (h) Identifying any remedial work required to be undertaken in the interests of safety.
- (i) Issuing a certificate of inspection and report to the owner in accordance with this Standard and requirements of the owner.

3.3 RESPONSIBILITIES OF INSPECTION BODIES

Bodies managing inspection shall operate a documented system which sets down the necessary actions to be taken to ensure that the requirements of this Standard are met. Inspection bodies and personnel shall declare any conflict of interest with bodies undertaking NDT or maintenance or repair.

NOTE: In New Zealand, inspection may be undertaken by the owner only if the inspection body is accredited as a Type B or Type C accredited inspection body as set out in AS/NZS ISO/IEC 17020.

The system should comply with the requirements of AS/NZS ISO/IEC 17020 or equivalent, and, as a minimum, comprise of the following:

- (a) A statement indicating commitment to the conditions of this Standard.
- (b) An organization chart, showing the reporting line of the inspection and/or integrity management function and demonstrating its independence from operations.
- (c) The identification and duties of staff involved in in-service inspection.

- (d) Lines of communication to be followed on inspection and integrity matters including reporting procedures and interface points.
- (e) Where relevant, procedures for—
 - (i) hazard categorization to AS 4343;
 - (ii) inspection requirements for repairs, replacements and alterations for equipment not exempted by this Standard and/or the relevant regulatory requirements;
 - (iii) shut-down, preservation and storage;
 - (iv) commissioning and authorization for use;
 - (v) on-line inspection and monitoring;
 - (vi) periodic in-service inspections (internal and external), with acceptance criteria for each class of pressure equipment as per this Standard;
 - (vii) repairs, overhauling, resetting and in-service inspection of all pressure relief safety devices;
 - (viii) assessment of pressure equipment integrity; and
 - (ix) failure analysis.
- (f) The maintenance and management of pressure equipment records and data, documentation and document flow.
- (g) Definition of other relevant (e.g. company) terms and descriptions relating to pressure equipment which fall outside this Standard or other Standards.
- (h) Internal and external auditing procedures and schedules to ensure compliance.

3.4 SUPPORT ORGANIZATIONS

Internal or external organizations carrying out support activities such as design, design verification, testing, examining and measuring (e.g. non-destructive examination, mechanical tests and chemical analysis), assessment of fitness for service, maintenance and repair, or heat treatment shall comply with the appropriate specifications and Standards.

SECTION 4 PRESSURE EQUIPMENT INSPECTION

4.1 GENERAL

This Section sets out requirements for commissioning or recommissioning inspections, operational surveillance and periodic inspection of pressure equipment.

Inspections referred to in this Section shall be scoped and executed by a suitably competent person.

An in-service inspector, or person with equivalent qualifications and experience, shall certify or report that the inspections referred to in this Section have been carried out in accordance with this Standard, and that equipment is suitable for continued operation or otherwise.

Competent persons shall be used to assess the fitness for service of pressure equipment.

Table 4.1 sets out inspection intervals for pressure equipment.

4.2 COMMISSIONING OR RECOMMISSIONING INSPECTION

Pressure equipment requiring inspection as per column 2 of Table 4.1 shall be inspected—

- (a) prior to being placed in service for the first time;
- (b) following repairs (excluding minor repairs) or alterations;
- (c) following a change of duty outside the design parameters which could affect safety;
- (d) following a relocation of static (i.e. non-‘transportable’) equipment; and
- (e) prior to a return to service after being mothballed or idle.

The purpose of such inspection is to ensure that—

- (i) work has been properly executed;
- (ii) all necessary documentation has been completed; and
- (iii) the pressure equipment is safe to operate.

Commissioning or re-commissioning inspections shall include, but not be limited to, the following:

- (A) Checking all necessary safety devices are fitted and operate correctly.
- (B) Supervision, witnessing or verification of pressure tests.
- (C) Checking that each item of pressure equipment is clearly identified by marking and or stampings, as required by Section 8 and as required by other relevant Standards, such as AS 1210. This identification shall, where appropriate, consist of a nameplate with a registered number (as issued by the relevant regulatory authority) and functional description and shall be prominently displayed and permanently fixed to the pressure equipment.
- (D) Updating existing pressure equipment files or setting up new files, as appropriate.
- (E) Establishing that all statutory and relevant Standard requirements for inspection during design, manufacture and installation have been completed and that evidence of the design identification (where required by regulations) is readily available.
- (F) Checking that the correct corrosion management system has been applied.
- (G) Checking that no extraneous material is left in the pressure equipment.

- (H) Where appropriate, ensuring that the pressure equipment has been inspected.
- (I) For pressure equipment designed to operate in the temperature creep range, carrying out an accurate 'base line' dimensional check and metallurgical assessment for future reference.
- (J) Verifying that all operational and performance tests specified by the manufacturer and owner have been successfully completed.
- (K) Verifying, as far as practicable, the accuracy and completeness of the manufacturer's data report (MDR) and piping fabrication and construction quality assurance documentation.

Consideration should be given to checking original thickness measurements of new pressure equipment to obtain baseline data. Where there is a delay between installation and commissioning, there may be deterioration of the equipment which is inconsistent with the deterioration mechanisms and rates when in service, and this should be allowed for.

4.3 OPERATING SURVEILLANCE AND MONITORING

Regular operational surveillance is an essential part of the operation of all pressure equipment to detect deterioration so that remedial action can be taken at an early stage. This shall be carried out by the person responsible for the operation of the pressure equipment and shall consist of periodic visual observation of pressure equipment and ancillaries. Operating conditions should be monitored to detect and record any significant change which may affect the integrity of the pressure equipment, see Clause 5.4.3. Any abnormality such as operation outside the limits of the design criteria, unusual odors or noise, and extremes of temperature or vibration shall be investigated and reported to the owner.

NOTE: AS 3873 covers the operation and maintenance of pressure equipment.

For some pressure equipment, an understanding of the corrosion mechanisms and rate of corrosion around the plant is paramount in order to maintain integrity. A variety of on-line inspection, monitoring techniques and/or devices may be required. Information gained by thickness testing, chemical sampling, radiography, thermal imaging, defect growth monitoring, metallurgical on-line analysis (replications), or corrosion rate monitoring using corrosion probes or coupons, should be combined as appropriate to achieve overall integrity management.

On-line monitoring offers the potential of correlating process events (such as start ups) and process chemistry (iron count, pH, CO₂ content, etc.) with corrosion rate so that adjustment in operating parameters or addition of inhibitor may be made to modify shutdown intervals, maintenance scope or operational life.

4.4 PERIODIC INSPECTION

4.4.1 Basis and types of inspection

4.4.1.1 General

Pressure equipment shall be periodically inspected to assist in assuring safe operation until the next scheduled inspection. These inspections shall assess the condition of the pressure equipment for integrity and its fitness for service until the next scheduled inspection at the design conditions and normal operational parameters.

Inspection may be both internal and external and may include supplementary non-destructive techniques or pressure tests. Inspection may be performed when the pressure equipment is operating or depressurized. As a result of periodic inspection, a certificate or report of inspection shall be issued to the owner.

4.4.1.2 External inspection

An external inspection gathers information about the condition of external surfaces of pressure equipment and includes inspection of fittings, protective devices, protective coatings, insulation, bolting, supports, pressure equipment identification and attachments. The purpose of external inspection is to detect anomalies or defects such as corrosion, leaks, bulging, signs of excessive heat or cold, or signs of cracking. External inspection requires comprehensive visual inspection, which may be supplemented by non-destructive examination methods such as dye penetrant or magnetic particle inspection. Appendix D provides requirements and information on methods of inspection.

Periodic external inspection and on-line non-destructive examination may be carried out while pressure equipment is in operation to obtain information for future maintenance or to save time when the plant is shut down.

4.4.1.3 Internal inspection

An internal inspection gathers information about the condition of internal surfaces and usually requires confined space vessel entry or visual inspection using equipment such as boroscopes or video scopes. However, internal inspection may also be executed by appropriate non-intrusive means (e.g. ultrasonic or radiographic testing), where a high degree of confidence can be demonstrated in the reliability of such techniques. Care is needed to ensure that sampling is truly representative of the condition of equipment. Where practical internal inspection may be carried out whilst the equipment is operating.

4.4.2 Periodic inspection of pressure equipment

Requirements for the periodic inspection of specific types of pressure equipment are given in the following appendices:

- (a) Heritage boilers and pressure vessels Appendix Y.
- (b) Unfired pressure vessels:
 - (i) Transportable vessels.....Appendix E.
 - (ii) Vessels with quick actuating openings Appendix Q.
 - (iii) Deaerators.....Appendix S.
 - (iv) Drums for transport of liquefied gas..... Appendix W.
- (c) Buried or mounded vessels Appendix R.
- (d) Storage tanks.....Appendix T.

Guidelines for the periodic inspection of specific types of pressure equipment are given in the following appendices:

- (A) Boilers—General.....Appendix F.
- (B) Unfired pressure vessels:
 - (i) Stationary vessels Appendix G.
 - (ii) Heat exchangers Appendix H.
- (C) Pressure piping.....Appendix I.
- (D) Fired heaters..... Appendix J.
- (E) Pressure relief valves.....Appendix P.
- (F) Structures.....Appendix Z.

NOTE: Typical check lists to assist in the inspection of pressure equipment are given in Appendix K.

4.4.3 First in-service inspection

When indicated by Column 3 of Table 4.1, new pressure equipment shall be inspected internally and externally after its first year of service. The purpose of the first yearly inspection is to confirm the suitability of the design and materials used for the service conditions and to pick up any quality assurance defects that may have been either overlooked during fabrication or construction, or which may have developed or become significant during operation. The interval to the next inspection shall then be determined.

Alternatively, the first in-service inspection may be deferred if it is determined safe to do so by using a Risk Based Inspection (RBI) process (refer also Clause 4.5 and Paragraph B5). The maximum interval between commissioning and the first in-service inspection shall be the nominal inspection interval given in Table 4.1. Any deferment shall be documented in a transparent and auditable manner.

4.4.4 Intervals for periodic inspection

4.4.4.1 Inspection intervals

Inspection intervals are shown in Table 4.1.

Inspection intervals may be varied by the in-service inspector, or persons with equivalent qualifications and experience, in consultation and agreement with all parties concerned. Requirements for determining shortened or extended inspection intervals are given in this Clause (4.4.4).

For non-typical pressure equipment not identified in Table 4.1, the inspection interval shall be determined by a competent person, and agreed by the parties concerned.

Nominal external inspection intervals are listed in Table 4.1, Column 4. Where external inspection intervals are extended in accordance with Clause 4.4.4.4, they shall not exceed the internal inspection interval (as determined using either Table 4.1 or RBI analysis).

The internal inspection intervals listed in Table 4.1 are as follows:

(a) *Nominal interval*

The internal inspection intervals (Column 5) define nominal maximum inspection intervals based on industry experience. These intervals should be used only when operating experience or condition monitoring gives confidence that no significant deterioration will occur in that period.

(b) *Extended interval*

The intervals shown in Column 6 shall only be used after at least one 'nominal interval' inspection has been undertaken in addition to the first yearly inspection (if applicable) and assessment has clearly demonstrated that such extended intervals are safe. Such a change shall be justified and documented with respect to the correct operating parameters. Changes to these parameters should be preceded by review of the proposal with a competent person. Refer also to Clause 4.4.4.4.

Operating with extended inspection intervals requires a formal process to be in place which advises changes to process conditions which impact on pressure equipment integrity, such as operating temperature, process fluid composition or process fluid velocity. The information justifying an extended inspection interval shall be documented by a competent person.

An alternative to the inspection intervals listed in Table 4.1 is to use Risk Based Inspection (RBI, alternatively known as Risk Directed Inspection, RDI). RBI is discussed in Clause 4.5 and Appendix B.

RBI may also be used to optimize the scope and extent of the inspection program for groups of pressure equipment of the same or equivalent design and materials which are installed in parallel, in series, or otherwise operated under similar process conditions and with similar process environments. An inspection program based on inspection of sample equipment selected from those at the site may be used if soundly based on competently applied risk based inspection techniques, and on adequate historical data regarding corrosion and other active causes of deterioration.

4.4.4.2 *Wastage rate*

Where the observed wastage rate is the controlling factor for pressure equipment life, due to mechanisms such as corrosion or erosion, the maximum interval between inspections based on measured wastage rates shall typically not exceed half the calculated remaining life of the pressure equipment. Determination of the actual interval shall also take into account other time dependent mechanisms such as hydrogen attack, stress corrosion and fatigue, which may influence pressure equipment life.

The adoption of a procedure to monitor the condition of a wasting vessel ensures that the frequency of inspection increases as the pressure equipment approaches the end of its service life. For example, where the calculated remaining life of a vessel is four years, the maximum inspection interval is 2 years. Following that inspection, if the calculated remaining life is now 2 years the maximum inspection interval is 1 year.

The wastage rate and corrosion mechanism may be determined directly by thickness testing or visual inspection and measurement or indirectly by using corrosion probes or coupons.

TABLE 4.1
INSPECTION INTERVALS

1		2	3	4	5	6
Pressure equipment		Commissioning inspection required? (see Clause 4.2)	First yearly inspection required? (see Clause 4.4.3)	Inspection interval, years		
				External inspection (see Notes 2 and 3 and Clause 4.4.4.1)	Internal inspection	
					Nominal interval (see Clause 4.4.4.1)	Extended interval (see Clause 4.4.4.1)
1	BOILERS (see Note 12)					
1.1	Electric boilers	Y	N	2	4	8
1.2	Coil-type forced circulation boilers	Y	N	2	(see Note 15)	
1.3	All other boilers	Y	Y	1	1	4 (see Note 4)
2	STEAM PRESSURE VESSELS					
2.1	Jacketed vessels				(See Note 14)	
	$pV \leq 30$ MPa.L	N	N			
	$pV > 30$ MPa.L	Y	Y	2	4	8
2.2	Other steam pressure vessels (see Appendix S for deaerators)					
	$pV \leq 30$ MPa.L	N	N	(See Note 14)	(See Note 14)	
	$30 < pV \leq 100$ MPa.L	Y	N	(See Note 14)	(See Note 14)	
	$pV > 100$ MPa.L	Y	Y	2	4	8
3	VESSELS WITH QUICK-ACTUATING CLOSURES					
3.1	Containing gases (including steam)				(See Note 14)	
	$pV \leq 15$ MPa.L	N	N			
	$pV > 15$ MPa.L	Y	Y	2	4	8
3.2	Containing liquids				(See Note 14)	
	$pV \leq 100$ MPa.L	N	N			
	$pV > 100$ MPa.L	Y	Y	2	4	8
4	FIRED HEATERS OR CONVECTION BANKS	Y	Y	2	4	8
5	WATER HEATERS	Y	N	4	12	12
6	COMPRESSED AIR CONTAINING VESSELS					
	$pV \leq 100$ MPa.L	N	N		(See Note 14)	
	$100 < pV \leq 150$ MPa.L	Y	N		(See Note 14)	
	$pV > 150$ MPa.L	Y	N	2	4	12
7	STATIC STORAGE VESSELS (see Notes 5 and 17)					
7.1	Gases (non-corrosive condition) including above-ground LPG storage vessels	Y	N	2	10	12
7.2	Gases (other conditions) including anhydrous ammonia	Y	Y	2	2	4
8	STORAGE TANKS TO API 620 OR EQUIVALENT	(See Appendix T)				

(continued)

TABLE 4.1 (continued)

1		2	3	4	5	6
Pressure equipment		Commissioning inspection required? (see Clause 4.2)	First yearly inspection required? (see Clause 4.4.3)	Inspection interval, years		
				External inspection (see Notes 2 and 3 and Clause 4.4.4.1)	Internal inspection	
					Nominal interval (see Clause 4.4.4.1)	Extended interval (see Clause 4.4.4.1)
9	PROCESS VESSELS (see Note 6)					
9.1	Hazard Level A	Y	Y	2	4	8
9.2	Hazard Level B	Y	Y	2	4	12
9.3	Hazard Level C	Y	Y	2	4	12
9.4	Hazard Level D	Y	N	4	(See Note 14)	(See Note 14)
10	AUXILIARY VESSELS (see Note 7 and 17)					
10.1	Accumulators					
	$pV \leq 100$ MPa.L	N	N		(See Note 14)	
	$100 < pV \leq 200$ MPa.L	Y	N		(See Note 14)	
	$pV > 200$ MPa.L	Y	Y	2	12	12
10.2	Other auxiliary vessels containing corrosive, toxic or flammable contents and except those covered Note 19.	Y	Y	2	4	12
10.3	Particular auxiliary vessels (See Note 19)	Y	Y		(See Note 19)	
11	REFRIGERATION AND AIR-CONDITIONING VESSELS (see Note 13)					
11.1	Group A1 refrigerants to AS/NZS 1677.1					
	$pV \leq 100$ MPa. L	N	N		(See Note 14)	
	$100 < pV \leq 200$ MPa.L	Y	N		(See Note 14)	
	$pV > 200$ MPa.L	Y	Y	2	12	12
11.2	Groups A2, A3, B1 and B2 refrigerants to AS/NZS 1677.1	Y	Y	2	12	12
12	STATIC LOW TEMPERATURE VESSELS (BELOW -10°C) (See Clause 4.12)					
12.1	Insulated, non-vacuum, non-jacketed, non-toxic contents	Y	N (see Note 14)	4	12	12
12.2	Insulated non-vacuum, non-jacketed, toxic contents	Y	N	4	12	12
12.3	Vacuum insulated:					
	(a) inner vessel	Y	N		(see Clause 4.12.1)	
	(b) outer vessel	Y	N	4	(see Clause 4.12.1)	
12.4	Jacketed non-vacuum vessels:					
	(a) inner vessel	Y	N		(see Clause 4.12.2)	
	(b) outer vessel	Y	N	4	(see Clause 4.12.2)	

(continued)

TABLE 4.1 (continued)

1	2	3	4	5	6
Pressure equipment	Commissioning inspection required? (see Clause 4.2)	First yearly inspection required? (see Clause 4.4.3)	Inspection interval, years		
			External inspection (see Notes 2 and 3 and Clause 4.4.4.1)	Internal inspection	
				Nominal interval (see Clause 4.4.4.1)	Extended interval (see Clause 4.4.4.1)
13 BURIED OR MOUNDED PRESSURE EQUIPMENT	Y	(see Paragraph D6.2.2 and Appendix R)		In accordance with Table 4.1 for particular type of vessel	
14 PRESSURE PIPING (see Notes 20 and 21)					
14.1 Hazard Level A	Y	Y	2	4	8
14.2 Hazard Level B or C confirmed to be in corrosive, vibrating or elevated temperature service after 1st yearly inspection	Y	Y	2	4	8
14.3 Hazard Level D piping (See Note 14); or Hazard Level B or C piping confirmed to be in non-corrosive, non-vibrating service and non-creep service after 1st yearly inspection	Y	Y	8		
15 TRANSPORTABLE VESSELS (see Appendix E and Notes 1, 8, 9, 10, 11, 16, and 17)					
15.1 Service conditions					
15.1.1 Cargo (Refer to AS 4343)					
15.1.1.1 Lethal	Y	Y	1	2	2
15.1.1.2 Very harmful	Y	Y	1	5	5
15.1.1.3 Harmful	Y	Y	1	5	5
15.1.1.4 Non-harmful	Y	N	3	6	9
(a) Non-harmful powder discharge vessel. (Aluminium construction)	Y	N	2	2	4
(b) Non-harmful powder discharge vessel. (Steel construction)	Y	N	3	6	9
(c) Non-harmful powder discharge vessel. (Other material construction)	Y	Y	1	5	5
15.1.2 Low-temperature (<-10°C) (see Clause 4.12)					
15.1.2.1 Non-vacuum insulated, non-jacketed	Y	Y	1	6	6
15.1.2.2 Vacuum insulated (see Note 15)					
(a) Inner vessel	Y	N			
(b) Outer vessel	Y	Y	1		

(continued)

TABLE 4.1 (continued)

1	2	3	4	5	6
Pressure equipment	Commissioning inspection required? (see Clause 4.2)	First yearly inspection required? (see Clause 4.4.3)	Inspection interval, years		
			External inspection (see Notes 2 and 3 and Clause 4.4.4.1)	Internal inspection	
				Nominal interval (see Clause 4.4.4.1)	Extended interval (see Clause 4.4.4.1)
15.2 Material of construction					
15.2.1 AS 1210 Group G steels (see Notes 9 and 10)	Y	Y	1	3	6
15.2.2 Austenitic alloy steels					
15.2.2.1 Stabilized grades (such as 316Ti, 321 and 347)					
(a) Non-vacuum insulated (see 15.1.2.1 of this table)					
(b) Vacuum insulated (see 15.1.2.2 of this table)					
15.2.2.2 Non-stabilized grades (such as 302 and 304)					
(a) Non-vacuum insulated	Y	Y	1	6	6
(b) Non-vacuum insulated cold 'stretched'	Y	Y	1	3	3
(c) Vacuum insulated (see 15.1.2.2 of this table)					
15.2.3 Other materials	Y	Y	1	5	5
15.3 Liquefied gas transport drums (chlorine and ammonia)			(See Appendix W)		
15.4 Other transportable vessels (see Note 10)	Y	Y	1	5	5
16 Pressure relief devices	Y	Y	1	(See Note 18)	
17 Heritage boilers and pressure vessels	(See Appendix Y)				

LEGEND:

p	=	Design pressure, in megapascals
V	=	Maximum volume and liquid space, in litres
Y	=	Yes
N	=	No

NOTES:

- The designated inspection date (as shown on the certificate of inspection) may be deferred by a maximum of three months to allow the inspection to be scheduled during a shutdown or maintenance period. A deferral is the subject of agreement between the owner and the competent person or in-service inspector. The justification for a deferral shall be documented by the owner, and included with the inspection records for the equipment concerned. The following inspection date shall be determined by the original designated date, not the deferred date. In New Zealand it is the responsibility of the inspection body to decide on the extension of inspection intervals.
- External inspection covers the visual confirmation of the condition of fittings, protective devices, protective coatings, insulation, fireproofing, bolting, supports, pressure equipment identification and security of attachments and the absence of defects, such as corrosion, leaks, bulging, signs of heat or cold, signs of cracking, e.g. at exposed welds particularly those adjacent to supports, excessive dents and integrity of supports and clamps.
- The rate of external corrosion may be governed by the atmospheric environment. AS/NZS 2312 classifies the environment into mild, moderate, severe industrial and very severe. Pressure equipment located in severe industrial and very severe environments may need to have the external inspection interval reduced.

- 4 Extended interval is available only to boilers which have adequate water treatment facilities and have demonstrated reliability and have not been subjected to a change of fuel types (e.g. gas to solid fuel) outside the original design parameters.
- 5 Gases may be stored in either the liquefied or gaseous state. These vessels exclude low-temperature vessels normally operating below -10°C and buried static storage pressure equipment.
- 6 Process vessels are those which form part of a process train and which are subject to changes in temperatures, pressure and/or contents during the process cycle. Process vessels exclude other pressure equipment specifically referred to in Table 4.1. Where the type of vessel used in the process is specifically referred to in another part of Table 4.1, then the more stringent of the two internal inspection intervals shall be applied.
- 7 Auxiliary vessels are those which form part of a package or part of a subsystem, e.g. suction/discharge vessels, filters, knock-out vessels, intercoolers and hydraulic accumulators.
- 8 When a transportable vessel used for the carriage of anhydrous ammonia is permanently removed from anhydrous ammonia service, a further annual internal inspection is required 12 months after the last period during which ammonia was carried.
- 9 All transportable vessels constructed to AS 1210 group G steels (quenched and tempered) and all other transportable vessels in liquefiable gas service (other than vacuum-insulated vessels) having a volume exceeding 14000 L shall be non-destructively examined both internally and externally in accordance with Appendix E, Paragraph E3.3 after the first year of service.
- 10 Where required by Note 9, non-destructive examination of external welds on non-vacuum insulated vessels may be carried out using the ultrasonic method permitted in Appendix E, Paragraph E3.3.
- 11 For these insulated vessels, at the 6-yearly internal inspection, the insulation is to be removed locally to allow all welds which are subject to cyclic bending stress during the operation of the vessel (see Note 1 to Table E1) to be examined.
At 12-yearly intervals all insulation shall be removed from the vessel for a complete external examination.
- 12 For boilers, the inspections given in this Table (4.1) are not to be confused with the inspections listed in AS 2593. The listed intervals apply regardless of attendance category. All boilers with hazard levels D and E and miniature boilers complying with AMBSC do not require inspection to this Table (4.1).
- 13 For Group A1 refrigerants, internal inspection is not required on the refrigerant side. Toxicity, flammability and combustibility of refrigerants are not included in this lower pressure grouping.
- 14 This equipment is sometimes considered as low risk when operated in accordance with good engineering practice and process control. Despite this low risk, the pressure equipment and control equipment shall be maintained in a fit and safe condition for service, including regular operating surveillance. Any major repairs or alterations to pressure equipment shall be subject to compliance with Section 6.
- 15 Normally cannot be inspected internally, see Clause 4.12.
- 16 Where a transportable vessel fits into more than one type defined in Table 4.1, the most stringent of the requirements for inspection is to be applied.
- 17 Conditions may only be considered non-corrosive based on demonstrated experience in identical service. For example, the storage of anhydrous ammonia in a carbon steel vessel would in general be considered as a corrosive condition due to the possibility of stress corrosion cracking. However, proven effective control of the risk of stress corrosion cracking by selection of steel, post-weld heat treatment, dosing with water and control of oxygen and other contaminant ingress may allow the service to be deemed non-corrosive.
- 18 See Clauses 4.7 and 4.8.
- 19 Some auxiliary vessels are designed for intervals between internal access in excess of 10 years, eg high voltage electricity circuit breakers. Where such vessels contain no known deterioration mechanism and there is a significant population of such vessels, the interval between inspections may be determined by a competent person and agreed to by the parties concerned.
- 20 Appendix I gives guidance on piping integrity and inspection. Hazard level is determined by AS 4343.
- 21 Refer to Clause 4.13. Internal inspection refers to obtaining information on the condition of the internal surface by either internal inspection or use of non-destructive inspection (e.g. radiography or ultrasonic thickness testing or pulsed eddy current techniques).

4.4.4.3 *Determination of inspection interval*

4.4.4.3.1 *General*

Determination of inspection intervals, including extension of inspection intervals, shall be carried out by a competent person and shall consider the following:

- (a) Materials of construction and possible damage mechanisms.
- (b) Process and mechanical design.
- (c) Possible manufacturing or construction shortfalls.
- (d) Effectiveness of inspection techniques for anticipated damage mechanisms.
- (e) Condition of pressure equipment as revealed by inspection.
- (f) Effectiveness of process control.
- (g) Consequences of failure

NOTE: Consideration of consequences may include the leakage or rupture location, consequences for people or the environment, cost of shutdown (business interruption or effect on reputation), and regulatory or public reaction. Calculation of Hazard level by use of AS 4343 may be used to assess relative consequences of failure.

4.4.4.3.2 *Criteria*

The following criteria are not exhaustive and other factors may be considered when determining the inspection intervals:

(i) *Internal and external corrosion*

Some considerations are as follows:

- (A) Possibility of pitting or general corrosion, for example due to:
 - (1) Chloride ions being dissolved in water above 50°C.
 - (2) Carbon dioxide combining with water.
 - (3) Organic acids operating near their boiling points.
 - (4) Acid solutions forming.
 - (5) Corrosion from sulphur and its compounds.
 - (6) Cooling water corrosion.
 - (7) Increased oxygen in process fluids due to mixing or turbulence.
- (B) Condition and effectiveness of corrosion mitigation measures, such as protective coatings, corrosion inhibitors, cathodic protection, etc.
- (C) Condition of the surfaces under insulation, fire proofing and refractory linings (particularly for insulated parts of the pressure equipment operating between -10°C and +120°C or operating intermittently).
- (D) Possibility of intergranular corrosion.
- (E) Possibility of stress corrosion cracking.
- (F) Possibility of caustic embrittlement.
- (G) Possibility of hydrogen embrittlement or hydrogen attack.
- (H) Possibility of corrosion fatigue.
- (I) Possibility of liquid metal embrittlement from sources such as copper, mercury, cadmium, zinc or lead.
- (J) Possibility of galvanic or electrolytic corrosion.

- (K) Possibility of wet hydrogen sulphide blistering and or cracking.
- (L) Microbiological induced corrosion.

(ii) *Thermal effects*

Some considerations are as follows:

- (A) Possibility of operation in the creep-rupture range for the material, e.g. due to blockage, loss of refractory or deposits on heated surfaces.
- (B) Possibility of thermal fatigue due to frequent temperature transients or unstable flow.
- (C) Effects of thermal differential expansion, such as flange leakage and bolt relaxation.
- (D) Possibility of flame impingement.
- (E) Possibility of creep crack initiation or creep fatigue due to temperature transients or excursions.
- (F) Possibility of thermal shock.

(iii) *Erosion/abrasion*

Some considerations are as follows:

- (A) Possibility of erosion due to high velocity or sudden change in direction (including that from loss of baffles).
- (B) Possibility of abrasion due to abrasive solids.
- (C) Possibility of cavitation erosion.
- (D) Possibility of wear and erosion plates becoming ineffective or baffle failure leading to adverse flow change.
- (E) Possibility of flow accelerated corrosion or erosion corrosion.

(iv) *Process-related problems*

Some considerations are as follows:

- (A) Possibility of contamination by corrosive products due to a process upset, excursion, or carry over.
- (B) Possibility of the pressure equipment being subjected to overpressure or operated above or below its design temperature or suffering other process upsets which may have an adverse effect.

(v) *Mechanical problems*

Some considerations are as follows:

- (A) Effect of vibration or fatigue.
- (B) Effect of a material or design error, or fabrication defects.
- (C) Occurrence of any mechanical damage since the last inspection, e.g. due to collision.
- (D) Effect of creep or corrosion.
- (E) Effects of repairing in-service equipment or materials, e.g. welding creep affected material or introduction of residual stresses.

(vi) *Condition monitoring*

The extent and results of any non-destructive testing, corrosion monitoring or condition monitoring that has been carried out should be considered.

(vii) *Reported incidents and risk assessment*

The considerations are as follows:

(A) Reported incidents involving similar or associated pressure equipment.

(B) Results of recommendations of a risk assessment.

NOTE: For details of risk management see Appendix B.

4.4.4.4 *Extension of inspection intervals*

The inspection interval for pressure equipment may be extended after consideration of the issues listed in Clause 4.4.4.3 and after establishing the following:

- (a) The wastage rate, or rate of deterioration of mechanical properties, is predictable.
- (b) The equipment is to remain in the same service, or the service and operating conditions are to remain unchanged.
- (c) The equipment is installed so that it is not subject to inadvertent corrosion by contamination, or loss of protective system.
- (d) No defects are present which would give rise to premature failure.

Extensions shall be justified, supported by a risk assessment, and shall be documented in an auditable manner.

NOTES:

- 1 For information on risk assessment, refer to Appendix B and AS/NZS 4360.
- 2 In New Zealand, the inspection body decides whether there will be any extension of the inspection interval.

Where equipment is withdrawn from service for any reason during an extended interval, its internal and external condition shall be inspected.

Where two or more items of pressure equipment (except transportable vessels) of similar design and materials are installed in parallel or in identical service and the operating conditions, degradation mechanisms and any actual degradation have been deemed to be identical over a period of four years, the internal inspection of one may be taken as representative of the group. The information underlying such an assumption shall be assessed and documented by a competent person.

Where two or more items of pressure equipment (except transportable vessels) are installed in series and no potentially corrosive contaminants are introduced at an intermediate point in the train, or become present as the result of operating conditions in any part of the train, and provided that at least four years corrosion history has been accumulated, the inspection of one vessel (preferably the worst case) may be taken as representative of the whole train. The information underlying such an assumption shall be assessed and documented by a competent person.

4.4.4.5 *Special cases*

In the following special cases, the inspection interval shall be varied from those indicated in Table 4.1:

(a) *Internally lined vessels*

Where part or all of the vessel wall has a protective lining, the maximum interval between inspections shall be determined from a consideration of previous history for the lining material for similar service conditions, as well as the following:

- (i) The wastage allowance on the protected metal in case of lining failure.
- (ii) The remaining corrosion allowance on the parent metal where it is not protected by a lining.
- (iii) The possibility of damage to the base metal, by atomic diffusion through the lining.

(b) *Vessels of advanced design*

Pressure equipment designed to AS 1210 Supplement No. 1 (Pressure vessels of advanced design and construction), and AS 1210 Supplement No. 2 (Cold stretched stainless steel pressure vessels) or vessels of a similar category designed to other National Standards, may involve higher design stresses for the materials of construction (than those noted in AS 1210).

The normal inspection procedure for in-service inspection of such vessels shall include review of the operating conditions. The operating conditions that might affect the integrity of such vessels include—

- (i) full range pressure cycles (start up, shutdown);
- (ii) pressure and temperature excursions;
- (iii) fluctuations in the temperature differences between the extremities of a vessel (e.g. a column where the bottom operates at 30°C and the top operates at –80°C);
- (iv) fluctuations in temperature for vessels that are constructed of materials with different thermal expansion (e.g. austenitic stainless steel nozzles in a carbon steel shell);
- (v) process-induced vibration (e.g. cavitation or vibration in supply pumps and compressors); or
- (vi) any vibrations or displacements caused by other forces (e.g. cyclonic winds, earth tremors, impact, unstayed nozzles).

The inspection interval of these vessels shall be in accordance with Table 4.1 unless the operating history indicates to the competent person that more frequent inspection is required. In the inspection of such vessels, particular attention shall be given to areas that could be subject to fatigue cracking.

When the operating history shows that the design life of the vessel has been reached, the integrity of the vessel shall be re-evaluated by a competent person (in accordance with Section 5) before further use.

(c) *Pressure equipment in creep range*

Pressure equipment operating at elevated temperatures close to or within the creep range of the materials of construction (e.g. high temperature process vessels, some boiler components or fired heater coils) may require more frequent inspection than normal pressure equipment.

The inspection interval shall be established by a competent person.

NOTE: See Appendix U for guidance on inspection requirements at various remaining life fractions.

(d) *Sealed units*

Vessels which are prevented from being exposed to external corrosion (such as by being installed in a cold box in which atmosphere is purged with an inert gas, or by the temperature being consistently maintained sufficiently low or sufficiently high to preclude the presence of water) need not have the insulation removed for periodic external inspection. However, the condition of the insulating system or the outer jacketing, such as the cold box casing, shall be inspected periodically and repaired if necessary.

If the condition of cold or hot surface temperature is intermittent, the likelihood of atmospheric corrosion under insulation, vibration, crack sensitivity and other operational issues shall be assessed, and inspection intervals established accordingly.

(e) *Pressure equipment similar to failed pressure equipment*

Where experience indicates a class or type of pressure equipment is susceptible to failure, the frequency and type of inspection shall be suitably adjusted.

4.5 RISK BASED INSPECTION

An alternative to the inspection intervals listed in Table 4.1 is to use Risk Based Inspection (RBI, alternatively known as Risk Directed Inspection, RDI). Understanding the risks associated with varying the intervals identified in Table 4.1 is essential. RBI may be used, subject to—

- (a) agreement between the owner and the inspection body;
- (b) preparation of risk assessment and management documentation, justifying any variation of inspection practice from this Standard in a clear, transparent and auditable manner (see Appendix B);
- (c) the involvement of a multidisciplinary team (e.g. inspector, corrosion engineer, process engineer, mechanical engineer, operations representative, etc.);
- (d) consideration of the effects and risks associated with possible fabrication and construction defects; and
- (e) consideration of the effects and risks associated with the actual service conditions on the equipment design and materials of construction.

4.6 INSPECTION OF IDLE PRESSURE EQUIPMENT

When pressure equipment is shut down for an extended interval with the possibility of recommissioning at a later date, a preservation plan shall be drawn up to prevent deterioration of the pressure equipment while idle. The preservation plan shall include controlled decommissioning and storage procedures.

NOTE: 'Layed-up' and 'mothballed' are also terms used for equipment removed from service with the possibility of recommissioning.

If the pressure equipment is out of service for an extended period, the effect of the external and internal atmospheric conditions during the period shall be considered in determining the date of the next inspection. Where pressure equipment has been stored for extended periods both an internal and an external inspection of the pressure equipment shall be carried out prior to recommissioning to ensure that the preservation plan has been effective.

Guidelines for the preservation and inspection of idle pressure equipment are given in Appendix G, Appendix L, and AS 3873.

4.7 PRESSURE-RELIEF DEVICES

4.7.1 General

This Clause (4.7) applies to all pressure relief devices such as safety valves, relief valves, safety relief valves, pressure relief valves, pilot operated safety relief valves and thermal relief valves as referenced in AS 1210, AS 1271, AS/NZS 1677.2, AS 1228, AS 2593, AS 2671 and AS 4041. Refer to AS 4942 for definitions of various pressure relief devices.

Inspection and testing (where applicable), provide means of determining the in-service integrity and adequacy of a pressure relief device for service. Such devices are the primary safety mechanism for safe guarding a system from over pressure and are fitted to:

- (a) Pressure equipment and auxiliary equipment.
- (b) Piping systems, to prevent overpressure due to expansion of liquids and gases.

A documented system shall be set in place that includes controls and procedures for each pressure relief device. The system shall include as a minimum the following information on each pressure-relief device:

- (i) Manufacturer's data (e.g. type, serial number, size, set point).
- (ii) Identification of valve (e.g. unique plant number).
- (iii) Location.
- (iv) Inspection records.
- (v) Maintenance intervals.
- (vi) Record of adjustments and authorizer.

Where operation of the device is determined to be outside the set parameters or outside the manufacturer's specification, the cause shall be investigated and one or more of the following actions shall be taken:

- (A) Eliminate the root cause.
- (B) Decrease the inspection/test interval.
- (C) Install a device of more appropriate specification.

A 'clean' service is one involving fluids such as nitrogen, methane, or hydraulic or lubricating oil. Clean fluids are characterized by the condition of the device on removal, where it is necessary only to wipe over the components, with no particles of matter attached to the valve. This is not to say there will be no signs of wear or damage.

'Non-clean' or 'dirty' or 'corrosive' service is, in effect, the opposite of clean. There will be pick-up of operating fluid or particles of material adhering to device components, and this will usually imply that the condition of the device is more likely to result in its performance being impaired. Such service is characterized less by its actual effects on the pressure relief device (which should have been specified so that key components are corrosion resistant) than by the capability of the fluid to corrode parts of the associated system.

Where a fluid is prevented, under normal conditions, from being in contact with the pressure relief device components, usually by means of a bursting disc or bellows, then the application may be considered a 'clean' duty. However, confidence in this method shall be proven before 'clean' duty is categorized.

NOTE: Use of the terms 'clean', 'non-clean', 'dirty' and 'corrosive' is a matter of judgement and is always qualitative. Absolute consistency may not be achieved in practice.

4.7.2 Commissioning and re-commissioning

The installation of pressure relief devices shall comply with relevant pressure equipment Standards (these may include AS 1210, AS 3892, or other Standards), and should comply with the manufacturer's recommendations.

Pressure relief devices that are not attached to flare or vent systems shall discharge to, or be piped to a safe, visible area. Any discharge piping shall be arranged to prevent accumulation of water, fouling and blockage by vermin.

NOTE: Refer to AS 3892 for discharge piping requirements.

Each pressure relief device shall be given a unique identification and its location shall be recorded. Section 8 of this Standard details identification requirements.

New or serviced pressure relief devices shall be inspected by the in-service inspector, or persons with equivalent qualifications and experience, prior to installation or process start up, to ensure that the integrity of the device has not changed during transport or storage, and that any gags, plugs and other such items have been removed. It may be appropriate for the device to be retested prior to installation, to verify its settings.

New pop action relief valves with soft seats, which are fitted to vessels used for the storage or transport of liquefiable gases, do not require pre-installation testing other than that carried out in the manufacturer's works as witnessed by the stamping on each valve. Where the valve is not used within five years of the manufacturer's test date, the valve may be preconditioned, prior to retesting in accordance with Appendix X.

NOTE: Soft seated valves suffer from a memory effect and sticking is common. This may result in excessive over pressure lifts.

4.7.3 On-line external visual inspection

On-line external visual inspection of pressure relief devices shall be carried out by a competent person, at a nominal interval of 1 year. Regular operating surveillance should be carried out in addition to this.

The actual inspection interval shall be determined with due consideration of issues such as the consequences of failure, the pressure relief device history, and specific local conditions such as operating environment and the possible effect of nearby construction or maintenance activities.

An on-line inspection shall examine each device to ensure the following:

- (a) The correct device is installed.
- (b) Identification provides means to establish the correct set pressure for the equipment protected by the device.
- (c) No gags, blinds or closed valves would prevent the device functioning correctly.
- (d) There is no unacceptable external mechanical damage.
- (e) The bonnets of non-balanced valves are plugged.
- (f) The bonnets of balanced valves are vented to a safe location, and the vent is clear and not discharging process fluid.
- (g) Vent stacks, discharge piping and receiving vessels are properly supported.
- (h) Upstream and downstream block valves (where applicable) are secure, and interlocks are managed appropriately.

NOTE: AS 1210 includes requirements for the use of interlocks with pressure relief devices, for pressure vessels.

- (i) Any lifting lever is operable and positioned properly.

- (j) External corrosion is not excessive.
- (k) There is no evidence of device tampering.
- (l) Blockage in the outlet or discharge piping has not occurred, nor in any drains fitted to the relief valve or its discharge piping (where possible).
- (m) The device is leak-tight.
- (n) Adequacy and condition of weather protection (where applicable).
- (o) Where discharge piping terminates outdoors, or where ingress of water, dust, debris or vermin is possible, control measures are in place to prevent ingress, accumulation, damage, fouling or blockage.

Where weather protection has failed, the device should be externally examined, and assessed for continued service.

Pressure relief devices with easing gear should be manually operated, unless there is significant risk that this will—

- (i) compromise plant integrity;
- (ii) damage the device; or
- (iii) create a hazard for personnel in the vicinity.

Where a pressure relief device is found to be not functioning correctly, it shall be repaired and tested in accordance with Clauses 4.7.4 to 4.7.9.

4.7.4 Scheduled testing and maintenance

4.7.4.1 General

At appropriate intervals each pressure relief device shall be tested for operation and, if necessary, removed and overhauled.

AS 1271, ANSI/API 527 and ANSI/API 576 provide guidance in determining testing procedures. The terms ‘pass’ and ‘fail’ refer to the acceptance criteria provided in these Standards.

Pressure relief device maintenance which involves dismantling or repairs and testing shall be carried out by a competent person.

NOTE: In New Zealand, the repair, adjustment and testing of pressure relief devices should be carried out only by accredited testing facilities.

A maintenance report shall be prepared and provided to the owner for each pressure relief device tested. All pressure relief devices, other than soft seated pop action valves, shall be subject to a pre-test to measure set pressure and leakage rate before being dismantled. Results of this test should be reported in the pressure relief device maintenance report, and should be taken into consideration in setting the intervals between subsequent tests.

NOTES:

- 1 Resilient seat type valves normally require replacement of the seat after an extended interval of operation.
- 2 For details of a suggested type of maintenance report, see Figure P1.

Springs are the ‘working element’ of a spring operated safety or relief valve, and may be susceptible to fatigue, corrosion, relaxation, etc. Springs should be periodically tested and inspected for performance, wear and defects. Each end of a helical compression spring shall present a flat bearing of not less than 75 percent of the circumference at right angles to the axis, so that, when placed on end on a horizontal plane, the spring is within the tolerances recommended for Class A springs in Appendix A of BS 1726-1:2002.

Where pressure relief devices with complex settings are serviced and tested, all necessary information (e.g. required ring settings, the pressure conditions on both sides of the valve, etc), shall be supplied to the service and test facility. It shall be the responsibility of the owner to ensure that those servicing the device have the required information to apply the correct settings for the cold set pressure and adjustment ring settings.

Balanced valves should be cold set at the desired relief pressure using the manufacturer's recommendations. Non-balanced valves should be set to account for both the static back pressure, and any flow-induced back pressure expected during relief. When discharging to a lower pressure system, the low pressure relief system shall take into account the flow from the high pressure system in addition to the requirements of the low pressure system alone. All the correct settings for the various adjustment rings shall be provided to the service and test facility to allow correctly reassembly or testing.

Where appropriate means are provided pressure-relief devices may be tested in-situ, while in operation, to determine their set pressure. The risks involved shall be considered, and suitable contingency plans made in case the device fails to re-seat.

NOTES:

- 1 One method of in-situ testing involves applying an additional hydraulic or pneumatic force to the valve stem with appropriate detectors to determine the point of lift. This method has the advantage of measuring the actual load required to lift the stem under operating conditions, with the device undisturbed. The disadvantage is that the device is not inspected visually.
- 2 Note that on most modern test rigs the actual movement of the stem is very small so neither this in-situ test, nor the bench test, actually proves that the device is able to open fully in discharge conditions. This needs to be ascertained by inspection of components.

4.7.4.2 Test interval

Following commissioning, pressure relief devices shall be tested at a nominal interval of one year. Test intervals may be varied if a competent person determines that the variation is appropriate, based on the type of service experienced (clean, sticky, corrosive, etc), the contents of the pressure equipment, prior experience with similar devices (similar design, application, service manufacturer, etc), common industry practice, the results of any previous tests, and any other relevant factors. The assessment shall include a full risk assessment of the safety and environmental consequences of leakage or failure, and shall be fully documented and retained in the information file for the relevant pressure equipment.

NOTE: Guidance on risk management may be obtained from AS/NZS 4360 and similar overseas documents.

The test interval shall not exceed the internal inspection interval for the item of equipment that the pressure relief device is designed to protect, as listed in Table 4.1. Extended intervals may be applied as per Note 1 to Table 4.1.

If the pressure relief device passes the first year test or subsequent 'as received' tests, and the valve is in clean service, the next test interval may be extended to the lesser of—

- (a) the requirements of other applicable standards (e.g. AS 2593); or
- (b) the internal inspection of the item of pressure equipment that it protects; or
- (c) 5 years.

Where the internal inspection interval of the associated pressure equipment is greater than five years and the service is clean, non-sticking and non-corrosive the test interval of the pressure relief device may be extended up to the internal inspection interval of the associated pressure equipment. Such extension is subject to—

- (i) justification by the in-service inspector or persons with equivalent qualifications and experience in consultation;
- (ii) agreement between all parties concerned; and

- (iii) risk assessment and documentation in a manner that provides an auditable trail for the inspection process.

It may be possible to use risk-based techniques to optimize both test and overhaul intervals. Such an approach requires—

- (A) detailed knowledge of the equipment and the plant environment, the likely consequences of failure and reliable historical data; and
- (B) application of mandatory reduced test intervals in ‘fail to danger’ situations.

Where there is insufficient site and company data, such an approach shall not be undertaken. The use of risk-based techniques for setting of test and overhaul frequencies shall only be undertaken by competent persons. All requirements relating to the use of risk-based inspection in Section 4 shall apply.

Guidance on typical test intervals for valves in different service is provided in Table P1.

NOTE: AS 2593:2004, Clause 6.5.2 specifies that at least once per year, the boiler and its operating and safety systems be thoroughly checked and overhauled in accordance with the procedure for annual maintenance.

If the pressure relief device fails under testing or inspection (i.e. inspection reveals problems, or the tested relief pressure is not within tolerance) the next test interval shall be set to a maximum of one year and shall require resetting or overhaul of the valve. Pressure relief devices in ‘dirty’ service shall use a maximum test interval of one year.

NOTE: There are situations where additional provisions should be applied or inspection intervals shortened because of operational conditions. There are many cases where valves in ‘dirty service’ need to be cleaned more frequently than once a year.

Table 4.2 sets out the ‘as-received’ test requirements, to determine the subsequent test interval for a pressure relief device which has been in service. The number of asterisks in the right hand column indicates the relative degree of confidence to extend the test interval, based on the test results.

TABLE 4.2
DETERMINING TEST INTERVALS FOR PRESSURE RELIEF DEVICES

Result of tests	Degree of confidence
'As Received' pass pressure between set pressure and acceptance criteria limit (Note 2)	***
Valve reseats but not within tolerance (Note 3)	*
Leak rate above tolerance (Note 3)	*
Fails back-pressure test (Note 3)	
Failure to reseat (Note 3)	
Corrosion, damage or parts failure (Note 4)	

NOTES:

- 1 More * indicates a higher level of confidence to extend the test interval.
- 2 If the relief (pop) pressure was between the operating pressure and the acceptance criteria limit then the next test interval may be set to a maximum of 5 years.
- 3 If the valve was seen to reseat then the next test interval may be set to the lesser of the next inspection of the protected equipment, or the requirements of other applicable Standards, to a maximum of 5 years. If the leak rate is inside the acceptable tolerance but still measurable then the next test interval may be set to a maximum of 5 years. The potential health safety and environmental consequences of leakage should be considered (e.g. fluid type to AS 4343).
- 4 Where repair is required, the root causes shall be established. If the root cause is understood, the test frequency may be extended. If the visual condition of the inlet, outlet and components was good then the next test interval may be set to a maximum of 5 years.
- 5 These requirements may be modified by an engineering review and assessment. For example, corrosion that builds to an unacceptable level after a number of inspections may not be cause to re-set the inspection interval to one year. Interval shall be set according to the components affected.

4.7.5 Testing and maintenance documentation

Maintenance and repair procedures shall cover at least the following items:

- (a) Dismantling, including a visual inspection which records critical measurements such as the position of adjusting rings and lifting pressure (if appropriate).
- (b) Overhaul and repair of pressure relief devices, including reassembly.
- (c) Testing and resetting if necessary considering critical dimensions, spindle, run out, leak testing, set pressure and blow down pressure.
- (d) Sealing, nameplate, records and certification.
- (e) The repairers tag shall be wired to the body of the valve (separate from adjusting screw) stating the repairer, bench set pressures, date overhauled, date of next scheduled inspection and valve identity.

4.7.6 Re-adjustment and testing

After reassembly, each valve shall be readjusted for set pressure, leakage tested and any blow-down ring reset as indicated on the pressure-relief valve maintenance report.

Seals shall be installed in a manner to prevent changing the adjustment without breaking the seal. One seal is normally located on the body sealing the position of the adjusting ring locking pins. A second seal is normally located on the valve cap and lever assembly sealing the position of the compression screw used to adjust the valve set pressure.

Where practicable, valves fitted to steam boilers shall be tested in situ after reinstallation or overhaul. Any seals which are broken to effect adjustment shall be replaced by the owner on completion of the test. Rebuilt relief valves fitted to steam boilers should be subjected to a live lift to confirm the correct operation of the valve and the blowdown. This is recommended as there may be changes to the valve operation due to the repairs, and the adjustments noted during disassembly (eg blowdown ring position) may not work correctly on the repaired valve. If the valve is not checked for correct operation, it may simmer, chatter, etc. when required to operate.

4.7.7 Bursting discs

Rupture discs or other non re-closing devices may be used as sole relieving devices or in combination with a pressure relief device. Bursting discs shall be selected in accordance with AS 1358, BS 2915 or another relevant Standard.

Bursting discs and other non-closing relief devices shall be connected to the vessel in the vapour space above any contained liquid, or to piping connected directly to the vapour space in the vessel which is to be protected. With vessels containing viscous liquids, special precautions shall be taken to place pressure relief devices in a position where contact with fluid will not prevent the valve from performing satisfactory.

Inspection and any necessary maintenance shall, where practicable, coincide with the inspection of the associated pressure equipment or pressure-relief valve (where the bursting disc is installed in series with the pressure-relief valve). Inspection shall include—

- (a) Review of rupture disc nameplate information, including stamped burst pressure and coincident temperature, to ensure the device is compatible with the vessel design and/or pressure relief device.
- (b) Checking for any leakage between bursting disc and pressure-relief valve and any deposits or signs of corrosion.
- (c) Careful checking of the markings indicating direction of flow, as some rupture disks when installed incorrectly may burst well above the stamped pressure.

The service life of a bursting disc is a function of the—

- (i) type of bursting disc;
- (ii) creep strength of bursting element; and
- (iii) operating conditions.

Fluctuating loadings, alternating loadings, temperature changes, corrosion and erosion may considerably reduce the life. The bursting disc shall be changed at the interval recommended by the manufacturer, and should be changed sooner under adverse operating conditions.

4.7.8 Rupture pin valves (buckling pin non-reclosing pressure relief device)

Rupture pin pressure relief valves shall be in accordance with the requirements of AS 1210 or equivalent. Installation of rupture pin pressure relief devices shall be in accordance with the requirement of the manufacturer's recommendations and AS 3892.

Inspection of rupture pin pressure relief valves should coincide with the inspection of the associated pressure equipment. This inspection should include—

- (a) that the correct rupture pin is selected and correctly installed;
- (b) inspection of local piping to check that distortion has not affected the intended performance of the rupture pin
- (c) a check of the piston seal and seat surfaces.

Where manufacturer's recommendations for inspection are available they shall be followed.

4.7.9 Fusible plugs

Fusible plugs shall be inspected at each internal inspection. If deterioration is detected they shall be replaced. Further guidance is provided in AS 1732.

4.8 CONTROLS CRITICAL FOR SAFEGUARDING EQUIPMENT

4.8.1 Pressure-actuated devices

Pressure-actuated devices shall be regularly tested and maintained by a competent person at intervals not exceeding the pressure equipment's internal inspection interval.

4.8.2 Temperature-actuated devices

Temperature-actuated devices shall be regularly tested and maintained by a competent person at intervals not exceeding the pressure equipment's internal inspection interval.

4.8.3 Excess flow and back check valves

Excess flow and back check valves shall be inspected and maintained by a competent person at intervals not exceeding the pressure equipment's internal inspection interval.

4.8.4 Quick-actuating closure interlocks and swing bolt doors

Quick-actuating closure interlocks and swing bolt doors shall be regularly inspected, tested and maintained by a competent person, following the requirements and guidance provided in Appendix Q. Quick-actuating closures on equipment below the $P \times V$ limits set by Table 4.1 shall be inspected, tested and maintained by a competent person in accordance with a program set by the owner. Others shall be inspected as set out in Table 4.1.

4.8.5 Relief valve isolation

Where an interlock is installed in accordance with AS 1210 or permanent locks are fitted to control the operation of block valves fitted to relief valves, the system shall be inspected by a competent person on a scheduled basis to establish that it is operable, cannot be overridden, and is suitable for continued service.

4.9 INSTRUMENTATION AND CONTROLS

Instruments and control equipment critical to the safety of pressure equipment shall be periodically inspected, tested (critical function testing) and maintained by a competent person.

NOTE: Guidance on such equipment is provided in AS 61508.

For required maintenance and testing of the boiler control systems for unattended and limited attendance boilers, see AS 2593 or New Zealand OSH approved Code of Practice for the design, safe operation, and maintenance and servicing of boilers (in Australia and New Zealand respectively).

4.10 EMERGENCY SHUTDOWN SYSTEMS

Instrumentation that triggers a sequence of events that can put a system or equipment into a safe condition shall be tested on a regular basis. The emergency shutdown system shall be fully exercised at an interval not exceeding the internal inspection interval of the prime pressure equipment in the system. Computer or functional checks should be performed at more regular intervals.

4.11 AUTOMATIC FIRE-FIGHTING SYSTEMS USED TO PROTECT PRESSURE EQUIPMENT

Automatic fire-fighting systems used to protect pressure equipment may include alarms, deluge, foam, carbon dioxide, or other fire-fighting or cooling fluids that are discharged automatically in the event of a flammable release, a rise in temperature, or smoke or a fire being sensed. These systems shall be checked on a regular basis. Discharge of fluids should be avoided or controlled during testing to avoid damage to the equipment and the environment. A log of these checks shall be kept.

NOTE: AS 1851 provides guidance on maintenance of fire protection equipment.

4.12 LOW TEMPERATURE VESSELS

4.12.1 Vacuum-insulated vessels

A vacuum reading shall be taken at—

- (a) intervals not exceeding six years;
- (b) when the vessel is commissioned or recommissioned; and
- (c) whenever a cold spot is located or heat gain becomes excessive.

Inspection of the inner vessel shall only be required when a loss of vacuum occurs due to leakage from the inner vessel or its appurtenances or the integrity of the inner vessel is suspect, e.g. when the inner vessel is dented or leakage through the cladding is detected. Leakage from piping between the inner and outer vessel is not a cause for inspection of the inner vessel.

Additionally, for transportable vessels the inner vessel shall be pneumatically tested for leak-tightness (see Paragraph D18.2) at the vessel's highest service pressure, after the first six years and then every twelve years.

4.12.2 Insulated, non-vacuum, non-jacketed vessels

Where ice or condensation is evident on the external insulation surface and vessel surface deterioration is likely, inspection of the surface shall be carried out (by either removing insulation or by other means).

4.12.3 Transportable vessels

Where baffles are welded directly to the shell, the welds shall be inspected annually.

4.13 PRESSURE PIPING

4.13.1 General

This Clause (4.13) describes the general requirements for the inspection of pressure piping.

NOTE: Detailed guidance on pressure piping inspection and integrity management is provided in Appendix I.

Pressure piping includes the pipe and all valves and fittings that form the pressure retaining parts. It also includes the piping support components such as hangers, guides and shoes.

Pressure piping shall be periodically inspected to assist in ensuring safe and reliable operations until the next scheduled inspection. This inspection shall assess the condition of the piping in order to judge its suitability to continue to operate.

Inspection may be both internal and external and may include supplementary non-destructive techniques or pressure tests. An inspection may be performed when the piping is operating or depressurized. As a result of periodic inspection, a certificate or report of inspection shall be issued to the owner

4.13.2 Intervals for periodic inspection of piping

4.13.2.1 *External inspection interval—Piping*

The external inspection interval for piping is given in Table 4.1.

4.13.2.2 *Internal inspection interval—Piping*

It is not possible to specify a universal minimum internal inspection interval for piping as piping systems operate in a very wide range of service conditions. The internal inspection interval shall be determined by a person competent to identify and assess the failure mechanisms and deterioration rates. It shall take into account any data from previous inspections to provide information on the current condition and past performance.

In the absence of previous inspections, the piping shall be internally inspected in accordance with the requirements of Table 4.1.

It is often impractical to carry out internal inspection using direct visual examination of the internal surfaces of the piping systems. Internal inspection shall be carried out by methods appropriate to detecting the modes of failure as identified by a competent person.

NOTE: Information on inspection methods is provided in Appendix I.

SECTION 5 ASSESSMENT OF PRESSURE EQUIPMENT INTEGRITY

5.1 GENERAL

5.1.1 Scope of Section

This Section provides requirements for the assessment of fitness for service of pressure equipment by determination of the—

- (a) acceptability of defects which are located in pressure equipment and which fall outside the fabrication acceptance limits of the appropriate pressure equipment design, manufacturing or fabrication Standard;
- (b) safe remaining life of pressure equipment which operates in an environment likely to cause progressive deterioration (e.g. creep, fatigue or corrosion);
- (c) maximum allowable working pressure or temperature when re-rating pressure equipment; and
- (d) operating criteria to ensure that equipment satisfies the design parameters.

Whenever the criteria in this Section are used to justify continued operation of the pressure equipment or remaining life, the course of action is the subject of agreement between the parties concerned.

5.1.2 Responsibility

The determination of fitness for service is subtle and complex, and all calculations used for the assessment of fitness for service shall be carried out by a competent person.

5.1.3 Documentation

Whenever the criteria given in this Section are used to justify the operation of pressure equipment the assessment shall be adequately stated, documented and filed, together with any supporting calculations, assumptions and drawings. The file shall be placed in the system described in Section 8 so as to draw immediate and continuing attention to the pressure equipment throughout its remaining operating life.

5.2 FITNESS FOR SERVICE ASSESSMENT

5.2.1 Introduction

The normal approach to determination of pressure equipment integrity is to accept only those imperfections which are within the limits specified in the appropriate pressure equipment design, manufacturing or fabrication Standard. Fitness for service assessment is carried to assess defects outside such limits, and is intended to prevent unnecessary retirement or repairs of pressure equipment.

This Clause (5.2) sets out conservative criteria for the preliminary or simplified assessment of defects that may be accepted as safe for a specified period of continued service. If defects exceed the criteria given in this Clause, a more detailed study shall be undertaken prior to continued operation to determine whether the equipment is fit for continued service.

Defects which occur in pressure equipment include, but are not limited to, deformation (e.g. out-of-roundness), reduced wall thickness, weld defects, corrosion, pitting, erosion, cracks, gouges, leakage, bulges, dents, and metallurgical deterioration (such as microstructural change or embrittlement).

NOTES:

- 1 See Appendix M for common modes of deterioration.
- 2 Worked examples of determination of pressure equipment integrity are given in Appendices N and O.
- 3 References to facilitate more detailed assessment of defects using alternate methods are provided in Appendix A, Paragraph A2.

5.2.2 Initial review

When defects are observed which fall outside the limits of the original pressure equipment design, manufacturing or fabrication Standard, the equipment shall be retired or the continued safe operation shall be ensured by the following methods:

(a) *Repair of defects or replacement of defective components*

Repair procedures are covered by Clause 6.2. Repair or replacement is the normal and preferred method where practical and economic.

NOTE: It is possible that repairs may lower the pressure equipment integrity more than the presence of an unrepaired defect.

(b) *Determine acceptability of defect*

Undertake an investigation to establish if the defect can be safely tolerated for an interim period, either unrepaired or with only a minor repair, to provide time for major repair and replacement.

NOTE: This action may be preferable where a comprehensive repair is not possible, not practical or not economic.

(c) *Re-rate the pressure equipment*

A re-rating procedure is given in Clause 6.3.

NOTE: Re-rating may be used in addition to or as an alternative to the options in Items (a) and (b).

5.2.3 Investigation of defects

As part of the overall assessment of the equipment, an inspection and investigation shall be carried out which is sufficiently searching to locate all significant defects. The defects shall be located and assessed by experienced, competent personnel using techniques demonstrated to have a high probability of detection, and an appropriately high level of accuracy. The following shall be investigated and documented:

- (a) Extent, location, orientation, position and type or nature of defects.
- (b) Materials in the region of the defect and their probable or actual mechanical properties.
- (c) Temperatures and stresses occurring in the region of the defect.
- (d) Most probable cause(s), factors and conditions contributing to defect initiation and development.
- (e) Feasibility of changing service parameters or process stream conditions, such as pressure, temperature, cycles, temperature differences and rates of change and process composition.
- (f) Prognosis of the defect and fitness for service of the pressure equipment and the required actions to reduce future degradation.

- (g) Anticipated time in service before repair or replacement.
- (h) Proposals to ensure safety against abnormal conditions, e.g. significant cracking of furnaces or tube plates of fire tube boilers is permitted provided added precautions are taken to prevent a low water condition which could result in catastrophic rupture at the cracked area.

NOTE: Additional requirements may exist for the continued operation of transportable vessels with defects.

5.2.4 Thinning of walls

If the thickness of a shell is reduced below the minimum value specified in the original pressure equipment design Standard, such reduced thickness may be considered acceptable provided that—

- (a) the material loss is within calculated acceptable limits; or
- (b) the pressure equipment is suitably de-rated (see Clause 5.4).

NOTES:

- 1 Acceptance limits should be soundly based on the design philosophy incorporated in AS 1210. Thus, if an area of reduced thickness is smaller in extent than the area of a perforation (or hole or nozzle) that AS 1210 would allow by design then the area of reduced thickness is acceptable, provided the remainder of the pressure equipment is sound.
- 2 Methods to assess equipment with localized wall thickness loss are provided in Appendix N.
- 3 Appendix N does not apply to operation in the creep regime but may be used for assessment of equipment operating at elevated temperatures below the creep regime provided appropriate elevated temperature mechanical property data is used.
- 4 The incidence of higher stress associated with areas of local thinning is not considered to be re-rating.

5.2.5 Cracking and crack-like defects

5.2.5.1 General

Cracks and crack-like defects arising during fabrication or service may be detected during periodic inspections. Fitness for service assessment involves determination of the critical size of crack that is unacceptable (e.g. by using fracture mechanics), assessment of all defects actually present, and acceptance of only those defects that are insignificant relative to the critical size.

Planar type weld defects, such as incomplete penetration, lack of fusion and lamellar tearing shall be assessed in the same manner as cracks.

The following aspects shall be considered to assess the significance of cracks:

(a) *Causes of cracking*

The most common causes of cracking encountered in-service are due to—

- (i) weld defects created during fabrication, repair or alteration;
- (ii) cyclic operation, particularly in components subjected to high thermal stresses or excessive vibration;
- (iii) corrosive environments;
- (iv) metallurgical degradation as a result of fabrication and heat treatment, or occurring during service;
- (v) operation outside of design;
- (vi) design deficiencies;
- (vii) imperfections in the material used for fabrication; or
- (viii) inadequate maintenance.

(b) *Mode of cracking*

The most common modes of in-service cracking are—

- (i) environmental cracking due to—
 - (A) stress corrosion, corrosion fatigue or other types of corrosion;
 - (B) hydrogen embrittlement; or
 - (C) liquid metal embrittlement.
- (ii) high stress (caused by excessive pressure, temperature, temperature differences, or external loads including inadvertent impact during transport to site or in-service);
- (iii) fatigue;
- (iv) creep; or
- (v) temperature related embrittlement and subsequent loss of ductility.

NOTE: Embrittlement may occur due to low temperature or elevated temperature exposure. Appendix M provides information on damage mechanisms.

(c) *Fracture characteristics*

The fracture characteristics of the pressure equipment depend on—

- (i) the static and dynamic stress around the crack, which is a function of operating pressures, temperatures and local geometry;
- (ii) the shape and size (length and depth) and position (orientation, internal or surface breaking, or in weld or heat-affected zone) of crack;
- (iii) the materials mechanical properties both local and away from the crack such as material toughness and tensile properties at the operating temperature; and
- (iv) the operating environment.

(d) *Prognosis of cracking*

To assess the significance of the crack on the integrity of the pressure equipment, the following shall be assessed:

- (i) Comparison of the actual crack dimensions with the assessed critical crack size.
- (ii) Whether the crack, if it grows, will penetrate the pressure equipment wall and cause a leak before fracture occurs (usually referred to as ‘leak before break’).
- (iii) The anticipated rate of growth of the crack while in service.

5.2.5.2 *Assessment of fitness for service*

A simplified and conservative analysis may be used to adequately demonstrate that the pressure equipment is safe. If the simplified method does not clearly indicate pressure equipment safety, or where its use is inappropriate, a more rigorous study or other action shall be undertaken. The assessment of crack-like defects is subtle and shall be undertaken by competent personnel.

NOTE: A simplified and conservative fracture mechanics approach is outlined in Appendix O, which also provides references for more rigorous methods, guidance on data requirements, and guidance on repair options.

5.2.6 *Volume type weld defects*

Volume type defects such as porosity and inclusions may also be assessed conservatively by treating such defects as wall thinning.

5.2.7 Dents

For small diameter pressure equipment (diameter not greater than 500 mm and diameter to thickness ratio greater than 50 mm) dents in ductile materials shall be evaluated using criteria in AS 2337.1. (This does not apply to glass-lined vessels or vacuum vessels.)

For larger pressure equipment the dent shall be treated as a thinned area with the wall thickness being taken as one-half of the actual thickness with the criteria given in Clause 5.2.4 then being applied.

For the inspection of dents in drums, see Appendix W.

For sharp and deep dents, in addition to the above, the maximum dimension of the dent shall be equated to a crack halfway through the wall, and the criteria given in Clause 5.2.5 applied to evaluate acceptability of the assumed 'equivalent' crack.

NOTE: This 'equivalent' crack method ensures that recognition is given to strain hardening or other metallurgical or mechanical effects that may have taken place within the dented area.

Where deep dents are associated with surface gouges at the base of the dent, the damaged area shall be repaired by welding or grinding to remove stress concentration.

NOTE: References are given in Paragraph A2 to facilitate more detailed fitness for service assessment of equipment containing dents and dent gouge combinations.

5.2.8 Metallurgically damaged material

Depending on the type of damage suffered by the material, the damaged area shall be assessed as follows:

- (a) Treat as a thinned wall having a mean thickness (t_m) calculated thus:

$$t_m = \frac{\text{strength of affected material}}{\text{specified minimum tensile strength of original material}} \times \text{actual thickness}$$

The criteria given in Clause 5.2.4 are then applied.

- (b) In cases where ductility or fracture toughness is doubtful, treat as an equivalent crack or as an area of reduced fracture toughness with the criteria given in Clause 5.2.5 being applied.
- (c) In cases where metallurgical damage is only partly through the wall, treat as in Items (a) and (b) and correct for reduced affected thickness.

5.2.9 Leakage

Leakage due to any reason, including any combination of the abovementioned defects at or remote from mechanical joints, shall be investigated immediately in accordance with Clause 5.2.3 to establish—

- (a) the maximum probable leak rate;
- (b) the effect of such leakage on nearby personnel and the environment; and
- (c) the effect of such leakage on the immediate and future structural performance.

Leakage shall not be accepted unless it is clearly established that the risk of injury to persons or damage to plant or environment will be negligible.

5.2.10 Bulging

Bulging may indicate creep or overpressurization. The cause of bulging shall be thoroughly investigated in accordance with Clause 5.2.3.

5.3 DETERMINATION OF REMAINING LIFE

Pressure equipment which is subject to an environment likely to cause deterioration by fatigue, creep or wastage corrosion will have a finite lifetime. Appendix U provides direction for assessment of the condition of pressure equipment in order to establish safe remaining life. Remaining life assessment shall be carried out by competent personnel. Due care shall be taken to consider the significance of inaccuracies involved in assessment (e.g. temperature, geometry or stress inputs). All calculations and assumptions shall be fully documented. The extent and accuracy of investigations will influence the confidence in the estimate of safe remaining life.

NOTES:

- 1 Common damage mechanisms are described in Appendix M.
- 2 A remaining life assessment procedure is described in Appendix U.

5.4 DE-RATING

5.4.1 General

In some circumstances pressure equipment may require a reduction in the maximum allowable operating pressure to allow continued safe operation, for example due to—

- (a) the presence of defects;
- (b) changed operating conditions.

This process is known as de-rating. A fitness for service assessment shall be used to determine the maximum allowable working pressure.

5.4.2 Presence of defects

If the defect assessment (undertaken in accordance with Clause 5.2) shows that the pressure equipment is not fit to operate within the current operating conditions, operating parameters shall be revised or repair shall be undertaken.

In the assessment of the effect of defects, the pressure or operating temperature (or both) may have to be changed in order to maintain the safety margin on—

- (a) crack size, position, shape and direction;
- (b) material thickness; or
- (c) rate of crack growth.

NOTES:

- 1 Increase in operating temperature may result in increase of K_{IC} (fracture toughness, see Appendix O) for some materials which will increase the critical crack size.
- 2 If operating temperature exceeds the design temperature, this may reduce the allowable stress according to the design Standard, which may reduce the allowable operating pressure.
- 3 Decrease in pressure will decrease stress which will allow an increase in critical crack size, and also decrease the rate of crack growth in situations where fatigue or creep is a concern.

5.4.3 Changed operating conditions

Even without physical defects, the integrity of pressure equipment may be affected when operating conditions are changed. If a significant change occurs a fitness for service assessment shall be undertaken in accordance with Clause 5.2. The maximum allowable operating pressure could change for the following reasons:

- (a) The temperature is lowered to that where the full stress condition is not permitted by the design Standard.
- (b) The pressure equipment is subject to thermal or mechanical shock.

- (c) The temperature is increased, resulting in lower permissible stress or creep (see Paragraph U5.3).
- (d) The environmental operating conditions are changed resulting in accelerated wastage or metallurgical degradation.
- (e) Cyclic operations are changed to those which could exhaust previously estimated fatigue life (see Paragraph U5.2). This would normally be associated with AS 1210 Supplement 1 (or equivalent) vessels.
- (f) Change to service with lethal contents will require welded joints to be assessed to ensure the absence of unacceptable defects.

SECTION 6 REPAIRS, ALTERATIONS AND RE-RATING

6.1 GENERAL

6.1.1 General requirements

This Section relates to control of repairs, alterations, modifications and re-rating of pressure equipment.

Cognizance shall be taken of the conformity assessment requirements for design verification and fabrication inspection according to AS 3920.1, including requirements for the repair of pressure equipment.

Repair, modification, alteration and re-rating work shall use—

- (a) personnel of the same competency; and
- (b) the same fabrication and manufacturing Standards,

as required for the design and fabrication of new pressure equipment.

NOTE: Typically, alterations involve a change to the original design, and may require re-registration of the design. Typically, repairs do not involve a design change.

The following requirements apply:

- (i) Repairs, alterations, modifications and re-rating shall be competently designed (see Clause 6.2.1).

NOTE: Where appropriate, these may require agreement by the parties concerned.

- (ii) The work shall be carried out by a competent person(s), satisfy all inspections and tests required and shall result in equipment that meets applicable design Standards.
- (iii) The work done shall be recorded and relevant documentation shall be retained.
- (iv) Before the methods of repair or replacement are decided, the cause or causes of any defects shall be investigated and documented.
- (v) Proposals for repairs, replacements or alterations shall be reviewed by a competent person.

6.2 REPAIRS

6.2.1 Procedure and design

For boilers and pressure vessels hazard levels A, B and C, and piping hazard level A and B (according to AS 4343), repairs and alterations shall be carried out only after review by a competent person, after documentation has been completed, and with the agreement of the parties concerned. All repairs shall be carried out in accordance with the relevant design and fabrication Standards, the manufacturer's established procedures as appropriate, and to comply with AS/NZS 3992 and AS 4458.

NOTE: Repairs and alterations may be affected by requirements for design registration or verification under State and Territory regulations. These requirements may differ between jurisdictions.

No welding shall be carried out on any pressure equipment unless a repair procedure including a qualified welding procedure has been developed. The repair procedure shall include visual inspection and appropriate NDT, e.g. ultrasonic testing, magnetic particle examination, radiography, dye penetrant, and pressure testing, prior to return to service.

Care shall be taken to ensure that the materials used are in accordance with design requirements.

In the case of alterations and/or repairs, the hydrotest may be waived if it can be demonstrated that all work meets the requirements of the relevant design and fabrication Standards.

6.2.2 Minor repairs

Examples of minor repairs are as follows:

- (a) Replacement or weld repair of tubes or pipes and associated attachments.
- (b) Weld build-up, provided the actual thicknesses to be welded are within the allowable limits of the qualified welding procedure. The total surface area of the build-up should not exceed 5% of the original surface area of the individual plate, casting, or pipe/tube section. Pad welding of pressure parts should not exceed 1 m² in total area.
- (c) Addition of corrosion-resistant weld overlay.
- (d) Addition of non-pressure attachments to pressure parts.
- (e) Replacement or plugging of boiler and heat exchanger tubes.
- (f) Re-welding or replacing heat exchanger channel partition plates.
- (g) Addition or replacement of nozzles or branches without alteration.
- (h) Replacement of flanges without alteration.

Clamps for piping repairs or innovative repair techniques such as composite fibre wraps are not classed as minor repairs and require engineering assessment.

6.2.3 Welder qualifications

Welders shall be qualified in accordance with appropriate requirements e.g. AS/NZS 3992. Special qualification tests, which closely duplicate actual repair welding, may be necessary in complex or critical cases or where material degradation or contamination has occurred. Welders' names and qualifications shall be filed for future reference. Should a welder's work decline in weld quality that welder shall be retested to AS/NZS 3992, or other Standards required by the manufacturing standard, before being allowed to carry out any further welding.

6.2.4 Retrospectivity

A repair or alteration shall be carried out in accordance with current requirements of design and fabrication or manufacturing standards. For pressure equipment that has been in satisfactory service for some time the owner need not retrospectively apply all requirements of the current applicable Standards, however compliance with current Standards is mandatory where Standards have changed:

- (a) to address matters of safety;
- (b) to reflect changes in community expectation; or
- (c) due to new engineering knowledge.

Examples of changes to Standards which shall be addressed include increase of design wind velocity, reduction of specified minimum allowable materials properties, etc.

A decision not to adopt the requirements of the current applicable design Standard shall be based on a risk assessment and the justification for each specific requirement not adopted shall be documented.