

Australian Standard™

Pressure piping



S t a n d a r d s Australia

This Australian Standard was prepared by Committee ME/1, Pressure Equipment. It was approved on behalf of the Council of Standards Australia on 13 March 1998 and published on 5 July 1998.

The following interests are represented on Committee ME/1:

A.C.T. WorkCover
Australasian Corrosion Association
Australasian Institute of Engineering Inspection
Australian Aluminium Council
Australian Building Codes Board
Australian Chamber of Commerce and Industry
Australian Institute of Energy
Australian Institute of Petroleum
Australian Liquefied Petroleum Gas Association
Boiler and Pressure Vessel Manufacturers Association of Australia
Bureau of Steel Manufacturers of Australia
Department for Administrative and Information Services, S.A.
Department of Labour, New Zealand
Department of Training and Industrial Relations, Qld
Electricity Corporation of New Zealand
Electricity Supply Association of Australia
Institute of Metals and Materials, Australasia
Institution of Engineers, Australia
Institution of Professional Engineers, New Zealand
Metal Trades Industry Association of Australia
National Association of Testing Authorities, Australia
New Zealand Engineering Federation
New Zealand Heavy Engineering Research Association
New Zealand Institute of Welding
New Zealand Petrochemical Users Group
New Zealand Timber Industry Federation
Victorian WorkCover Authority
Welding Technology Institute of Australia
WorkCover N.S.W.
Work Health Authority, N.T.
Workplace Standards Authority, Tas.
WorkSafe Western Australia

Keeping Standards up-to-date

Standards are living documents which reflect progress in science, technology and systems. To maintain their currency, all Standards are periodically reviewed, and new editions are published. Between editions, amendments may be issued. Standards may also be withdrawn. It is important that readers assure themselves they are using a current Standard, which should include any amendments which may have been published since the Standard was purchased.

Detailed information about Standards can be found by visiting the Standards Australia web site at www.standards.com.au and looking up the relevant Standard in the on-line catalogue.

Alternatively, the printed Catalogue provides information current at 1 January each year, and the monthly magazine, *The Australian Standard*, has a full listing of revisions and amendments published each month.

We also welcome suggestions for the improvement in our Standards, and especially encourage readers to notify us immediately of any apparent inaccuracies or ambiguities. Contact us via email at mail@standards.com.au, or write to the Chief Executive, Standards Australia International Ltd, GPO Box 5420, Sydney, NSW 2001.

This Standard was issued in draft form for comment as DR 97114.

AS 4041—1998
(Incorporating Amendment No. 1)

Australian Standard™

Pressure piping

Originated in part as part of AS CB15—1959.
Previous edition AS 4041—1992.
Second edition 1998.
Reissued incorporating Amendment No. 1 (April 2001).

COPYRIGHT

© Standards Australia International

All rights are reserved. No part of this work may be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of the publisher.

Published by Standards Australia International Ltd
GPO Box 5420, Sydney, NSW 2001, Australia

ISBN 0 7337 1934 1

PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME/1, Pressure Equipment, to supersede AS 4041—1992, *Pressure piping*.

This Standard incorporates Amendment No. 1 (April 2001). The changes arising from the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure, or part thereof affected.

This Standard is the result of a consensus among representatives on the Joint Committee to produce it as an Australian Standard. Consensus means general agreement by all interested parties. Consensus includes an attempt to remove all objection and implies much more than the concept of a simple majority, but not necessarily unanimity. It is consistent with this meaning that a member may be included in the Committee list and yet not be in full agreement with all clauses of this Standard.

This Standard makes use of current American and British Standards such as ANSI/ASME B31.3, *Process piping*, and BS 806, *Specification for the design and construction of ferrous piping installations for and in connection with land boilers*, as well as Australian Standards. This has been done where practicable to align with international practices to provide flexibility in design and to enable current proven computer programs for either of the above Standards to be used to satisfy the design requirements of this Standard (see Clause 1.6).

Comparison of this Standard with ANSI/ASME B31.1, *Power piping* and ANSI/ASME B31.3 shows that for the same pressure and application, piping to this Standard may be thinner than piping to the two American Standards at low to medium temperatures. These two American Standards have been consulted as a major source of material, but preference has been given to BS 806 for ferrous materials. Certain subject matter either unique to BS 806 or too complex to modify has been copied direct and the source acknowledged.

The extension of scope in this edition to embrace room-temperature-safe fluids brings into contrast three different traditions of steel pipe engineering which exist side by side in Australia. All are successful in their particular scope of application.

The first tradition is that of power and process piping using steam and other hazardous fluids. This tradition is noted for higher safety factors, thick pipe, and the greater use of pre- and post-weld heat treatment and sophisticated quality assurance.

Another tradition is the non-code tradition for room temperature safe fluids. This is more influenced by the third tradition than by the first. It uses thick or thin pipe and rarely applies postweld heat treatment and only uses limited quality assurance.

The third pipe tradition is that of petroleum and natural gas pipelines. This tradition uses lower safety factors, thin pipe, rarely applies preheat and rarely uses postweld heat treatment but has adequate quality assurance.

The extension of scope that joined tradition 1 and 2 (and possibly tradition 3 in special cases) presented the Committee with a difficulty in preventing unnecessary increases in costs for the present non-code piping systems in Australia while maintaining safety. The more conservative requirements of tradition 1, represented by BS 806 and ANSI/ASME B31.3 are not appropriate for applying these features to room-temperature safe fluids in modern low carbon equivalent pipe steels. Hence a four-tier pipe classification system is introduced to ensure adequate safety, performance and economy of piping systems for the wider range of industrial applications from critical pipe used in power stations to low hazard piping found in small industrial plant. In summary this edition will generally permit thinner steel pipe to be used for a given pressure than previously. Also there is a change to some of its pressure testing equations for steel pipe.

The traditional value of $1.5P$ applies for steam and water piping for steam boilers only.

This Standard is arranged similarly to AS 1210, *Pressure Vessels*, including Supplement 1, *Unfired Pressure Vessels—Advance design and construction (Supplement to AS 1210—1997)*, and its class system parallels that of these Standards. Without inferring equality of the safety factor, the alignment of classes is approximately as follows:

AS 4041 Class	AS 1210 Class
1	1H
2A	2H
2P	—
3	3

Australian, American, and British material and component Standards which are used to a considerable extent in Australia have been listed. This Standard now provides for a wider range of materials than previously covered. A basis for specifying non-metallic pressure piping is given by reference to ANSI/ASME B31.3 but with provision for substitution of equivalent Australian Standards.

The Standard follows in principle other Standards forming part of AS/NZS 1200, *Pressure equipment*, in providing guidance for owners, designers, manufacturers, inspection bodies and users in the form of minimum engineering requirements for the safe design, fabrication, installation, testing, and commissioning of pressure piping based on world-wide advances and experience. It also provides basic requirements and references for welding qualification, non-destructive testing, operation, maintenance and in-service inspection.

The principle objective of this Standard is clear uniform national requirements which will result in reasonably certain protection of the general public, persons installing and operating the piping, and of adjacent property and environment, which give economic piping, and which show where a margin for deterioration may be necessary to give adequate and safe service life. Additional requirements may be necessary to prevent damage from unusual conditions, third parties and abnormal forces.

The Standard provides an authoritative source of important principles, data, and practical guidelines to be used by responsible and competent persons. It is not practicable nor indeed desirable for the Standard to specify every aspect of piping design and fabrication. It is neither an instruction manual nor a complete design or construction specification. The Standard does not replace the need for appropriate experience, competent engineering judgement, and the application of fundamental engineering principles.

Users of this Standard are reminded that it has no intrinsic legal authority, but may acquire legal standing in one or more of the following circumstances:

- (a) Adoption by a government or other authority having jurisdiction.
- (b) Adoption by a purchaser as the required standard of construction when placing a contract.
- (c) Adoption where a manufacturer states that piping is in accordance with this Standard.

Acknowledgment is gratefully made to the American Society of Mechanical Engineers and the British Standards Institution for the considerable assistance provided by the above referenced national Standards.

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

The term 'normative' has been used in this Standard to define the application of the appendix to which it applies. A 'normative' appendix is an integral part of a Standard.

CONTENTS

	<i>Page</i>
SECTION 1 SCOPE AND GENERAL	
1.1 SCOPE	7
1.2 RESPONSIBILITIES	8
1.3 CLASSIFICATION OF PIPING	8
1.4 CLASSIFICATION OF FLUIDS	8
1.5 SELECTION OF PIPING CLASS	12
1.6 ALTERNATIVE STANDARDS	14
1.7 DEFINITIONS	14
1.8 NOTATION	17
1.9 NON-SI UNITS	18
1.10 REFERENCED DOCUMENTS	18
1.11 REPORTS AND CERTIFICATES	18
1.12 NOT ALLOCATED	18
1.13 NOT ALLOCATED	18
1.14 NON-METALLIC PIPING	18
1.15 INTERPRETATION OF STANDARDS	18
1.16 NEW DESIGNS, MATERIALS AND FABRICATION METHODS	18
1.17 DIMENSIONAL AND MASS TOLERANCES	19
1.18 ALTERNATIVE DESIGN OF ACCESSORIES	19
SECTION 2 MATERIALS AND COMPONENTS	
2.1 GENERAL	20
2.2 QUALIFICATION OF MATERIALS AND COMPONENTS	20
2.3 LIMITATIONS ON MATERIALS AND COMPONENTS	24
2.4 PROPERTIES OF MATERIALS	24
2.5 IDENTIFICATION OF MATERIALS AND COMPONENTS	25
2.6 LIMITATIONS ON APPLICATION	25
2.7 MATERIALS AND COMPONENTS FOR CORROSIVE SERVICE	28
2.8 DISSIMILAR MATERIALS	29
2.9 BACKING RINGS AND FUSIBLE INSERTS	29
2.10 BRAZING MATERIALS	29
2.11 MATERIALS FOR LOW TEMPERATURE SERVICE	29
SECTION 3 DESIGN	
3.1 GENERAL	50
3.2 DESIGN PRESSURE	50
3.3 DESIGN TEMPERATURE	50
3.4 DESIGN LIFE	51
3.5 STATIC AND DYNAMIC LOADS AND FORCES	51
3.6 RISK ANALYSIS	52
3.7 THERMAL EFFECTS	52
3.8 EFFECTS OF MOVEMENT AT SUPPORTS, ANCHORS AND TERMINALS	52
3.9 DESIGN PRESSURE AND TEMPERATURE FOR PIPING ASSOCIATED WITH STEAM BOILERS	52
3.10 DESIGN CRITERIA	56
3.11 DESIGN STRENGTH	57
3.12 DESIGN FACTORS	60
3.13 ALLOWANCES	61
3.14 WALL THICKNESS OF STRAIGHT PIPE	62

	<i>Page</i>
3.15 PIPE BENDS	64
3.16 REDUCERS	69
3.17 BIFURCATIONS, SPECIAL FITTINGS AND CONNECTIONS	70
3.18 EXPANSION FITTINGS AND FLEXIBLE HOSE ASSEMBLIES	70
3.19 BRANCH CONNECTIONS AND OPENINGS	71
3.20 WELDED BRANCH CONNECTIONS	86
3.21 DESIGN OF CLOSURES FOR PIPE ENDS AND BRANCHES	86
3.22 DESIGN OF OTHER PRESSURE-RETAINING COMPONENTS	86
3.23 ATTACHMENTS	87
3.24 PIPING JOINTS	89
3.25 DESIGN REQUIREMENTS PERTAINING TO SPECIFIC PIPING	107
3.26 NOT ALLOCATED	110
3.27 FLEXIBILITY, STRESS ANALYSIS AND SUPPORT DESIGN	110
3.28 PIPE SUPPORTS	122
3.29 INFORMATION TO BE SUPPLIED	126
3.30 INFORMATION TO BE SUPPLIED BY THE OWNER	126
 SECTION 4 FABRICATION AND INSTALLATION	
4.1 SCOPE	127
4.2 FABRICATION	127
4.3 INSTALLATION	127
4.4 THERMAL INSULATION	128
4.5 IDENTIFICATION	128
 SECTION 5 WELDING AND ALLIED JOINING PROCESSES	
129	
 SECTION 6 EXAMINATION AND TESTING	
6.1 SCOPE	130
6.2 RESPONSIBILITY	130
6.3 QUALIFICATION OF WELDING PROCEDURES AND WELDERS	130
6.4 NON-DESTRUCTIVE EXAMINATION	130
6.5 ALTERNATIVES TO NON-DESTRUCTIVE TESTING	131
6.6 PRESSURE TESTS	132
6.7 HYDROSTATIC TEST	132
6.8 ALTERNATIVE TO HYDROSTATIC TEST	133
6.8A INITIAL SERVICE LEAK TEST	134
6.9 TESTING PRESSURE-LIMITING DEVICES, RELIEF VALVES, PRESSURE REGULATORS, AND CONTROL EQUIPMENT	135
6.10 REPORT	135
 SECTION 7 PROTECTIVE SYSTEMS AND DEVICES	
7.1 GENERAL	136
7.2 PRESSURE AND TEMPERATURE CONTROL SYSTEMS	136
7.3 PRESSURE RELIEF SYSTEMS	136
7.4 CORROSION PROTECTION	137
7.5 FIRE PROTECTION	137
7.6 EARTHING	137
7.7 PROTECTION FROM IMPACT	137
7.8 LIGHTNING PROTECTION	138
7.9 HUMAN CONTACT PROTECTION	138
7.10 NOISE CONTROL	138
7.11 ISOLATION PROTECTION (FOR INTERCONNECTED PIPING)	138
7.12 NOT ALLOCATED	138

	<i>Page</i>
7.13 PROTECTION AGAINST INTERFERENCE	138
SECTION 8 QUALITY ASSURANCE AND INSPECTION	
8.1 GENERAL	139
8.2 REVIEW OF DESIGN	140
8.3 MATERIAL AND COMPONENT INSPECTION	140
8.4 GENERAL INSPECTION OF FABRICATION	140
SECTION 9 COMMISSIONING AND OPERATION	
9.1 COMMISSIONING	141
9.2 OPERATION	141
APPENDICES	
A LIST OF REFERENCED DOCUMENTS	142
B NOMINAL SIZES AND OUTSIDE DIAMETERS OF PIPE	153
C NOT ALLOCATED	156
D MATERIAL PROPERTIES, DESIGN PARAMETERS AND TENSILE STRENGTHS	157
E LINEAR EXPANSION	182
F YOUNG MODULUS	184
G DESIGN TENSILE STRENGTH FOR FLANGE BOLTING	186
H LODMAT ISOTHERMS	190
I DETERMINATION OF DESIGN STRENGTH	191
J DESIGN PRESSURE FOR SAFETY VALVE DISCHARGE PIPING	195
K TYPICAL FORGED BRANCH FITTINGS	199
L REINFORCEMENT OF A BRANCH AND AN OPENING	200
M TYPICAL BRANCH WELDS	210
N WELD DETAILS	218
O FILLET-WELDED SOCKETS	226
P SLEEVE JOINT	227
Q NOTES ON PIPING STRESS ANALYSIS	228
R METHOD OF ASSESSING FLEXIBILITY	231
S EXAMPLE OF STRESS CALCULATION IN A SECTIONALIZED PIPING SYSTEM	253
T STANDARD PIPING DESIGN	263
U HYDROSTATIC TEST PRESSURE	267
INDEX	272

STANDARDS AUSTRALIA

Australian Standard

Pressure piping

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE This Standard sets out minimum requirements for the materials, design, fabrication, testing, inspection, reports and pre-commissioning of piping subject to internal pressure or external pressure or both. Specific requirements are given for piping constructed of carbon, carbon-manganese, low alloy and high alloy steels, ductile and cast iron, copper, aluminium, nickel, titanium and alloys of these materials. General requirements and reference to Standards for non-metallic piping are included.

A1 | The Standard makes extensive use of AS/NZS 3992, AS 4037 and AS 4458.

Piping complying with BS 806, ANSI/ASME B31.1, ANSI/ASME B31.3 and ANSI/ASME B31.5 are deemed to meet the requirements of this Standard (see Clause 1.6).

This Standard applies specifically to pressure piping, i.e. piping which may present a significant risk of injury to people, property or the environment owing to hazards arising from—

- (a) the effects of pressure, either as a result of internal pressure causing an explosion or projectile, or as a result of external pressure causing buckling and collapse;
- (b) release of contents which are lethal, toxic, harmful to human tissue (e.g. hot, cold, corrosive) flammable, combustible or are otherwise hazardous; or
- (c) release of contents which directly or indirectly result in injury or damage e.g. piping for pollutants, fire-fighting purposes or cooling purposes.

This Standard is intended to apply to the following piping except when varied by the relevant Standard:

- (i) Piping for land steam boilers, prime-movers, refrigerant and other industrial plant except where the piping forms an integral part of a boiler or pressure vessel and the requirements of AS 1210 or AS 1228 apply.
- (ii) Hydraulic piping, water piping (including feed water piping), process piping, hot water piping exceeding 99°C and water piping forming part of a fire protection system (see AS 3689 and AS 4118). See also Items (A) to (G) of this Clause.
- (iii) Piping within boundaries of chemical manufacturing or processing installations, petroleum refineries, petrochemical plant, gas process plant, refinery tank farms, terminals and bulk handling plants.
- (iv) Oil fuel piping within the scope of AS 1375, AS 1692 and AS 1940.
- (v) Liquefied petroleum gas piping within the scope of AS 1596.
- (vi) Anhydrous ammonia within the scope of AS 2022.
- (vii) Low-temperature and refrigeration piping within the scope of AS 1677.
- (viii) Piping for road tank vehicles within the scope of AS 2809.
- (ix) Compressed air piping, the design pressure of which exceeds 70 kPa (internal) or 32 kPa (external).
- (x) Piping for low pressure gas systems complying with AG 601.
- (xi) Other piping covered by Standards Australia Standards which require compliance with this Standard.