



Assets Planning and Delivery Group
Engineering

DESIGN STANDARD DS 30-02

General Design Criteria - Mechanical

VERSION 2
REVISION 3
JUNE 2023

FOREWORD

The intent of Design Standards is to specify requirements that assure effective design and delivery of fit for purpose Water Corporation infrastructure assets for best whole-of-life value with least risk to Corporation service standards and safety. Design standards are also intended to promote uniformity of approach by asset designers, drafters and constructors to the design, construction, commissioning and delivery of water infrastructure and to the compatibility of new infrastructure with existing like infrastructure.

Design Standards draw on the asset design, management and field operational experience gained and documented by the Corporation and by the water industry generally over time. They are intended for application by Corporation staff, designers, constructors and land developers to the planning, design, construction and commissioning of Corporation infrastructure including water services provided by land developers for takeover by the Corporation.

Nothing in this Design Standard diminishes the responsibility of designers and constructors for applying the requirements of the Western Australia's Work Health and Safety (General) Regulations 2022 to the delivery of Corporation assets. Information on these statutory requirements may be viewed at the following web site location:

[Overview of Western Australia's Work Health and Safety \(General\) Regulations 2022 \(dmirs.wa.gov.au\)](https://dmirs.wa.gov.au)

Enquiries relating to the technical content of a Design Standard should be directed to the Senior Principal Engineer, Mechanical Section, Engineering. Future Design Standard changes, if any, will be issued to registered Design Standard users as and when published.

Head of Engineering

This document is prepared without the assumption of a duty of care by the Water Corporation. The document is not intended to be nor should it be relied on as a substitute for professional engineering design expertise or any other professional advice.

Users should use and reference the current version of this document

© Copyright – Water Corporation: This standard and software is copyright. With the exception of use permitted by the Copyright Act 1968, no part may be reproduced without the written permission of the Water Corporation.

DISCLAIMER

Water Corporation accepts no liability for any loss or damage that arises from anything in the Standards/Specifications including any loss or damage that may arise due to the errors and omissions of any person. Any person or entity which relies upon the Standards/Specifications from the Water Corporation website does so that their own risk and without any right of recourse to the Water Corporation, including, but not limited to, using the Standards/Specification for works other than for or on behalf of the Water Corporation.

The Water Corporation shall not be responsible, nor liable, to any person or entity for any loss or damage suffered as a consequence of the unlawful use of, or reference to, the Standards/Specifications, including but not limited to the use of any part of the Standards/Specification without first obtaining prior express written permission from the CEO of the Water Corporation.

Any interpretation of anything in the Standards/Specifications that deviates from specific Water Corporation Project requirements must be referred to, and resolved by, reference to and for determination by the Water Corporation's project manager and/or designer for that particular Project.

REVISION STATUS						
SECT.	VER./REV.	DATE	PAGES REVISED	REVISION DESCRIPTION (Section, Clause, Sub-Clause)	RVWD.	APRV.
1	2/0	29.09.08	All	New Revision	SE	AAK
1	2/1	21.11.12	17, 18	Clause 1.1, 1.3, 1.5 amended, 1.8 added	JP	SE
All	2/3	26.06.23	N/A	Scheduled review, no change required	SE	SE
2	2/0	29.09.08	All	New Revision	SE	AAK
3	2/0	29.09.08	All	New Revision	SE	AAK
4	2/0	29.09.08	All	New Revision	SE	AAK
5	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	19	Section 5 amended	JP	SE
6	2/0	29.09.08	All	New Revision	SE	AAK
7	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	20	Clause 7.1, 7.2 amended	JP	SE
	2/1	20.11.13	20	Clause 7.1, 7.2 amended	GR	SE
8	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	22	Clause 8.2, 8.2.1, 8.2.2 amended	JP	SE
	2/1	25.08.13	21	Clause 8.2.2 amended	SE	MH
9	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	21	Clause 9.5, amended	JP	SE
10	2/0	29.09.08	All	New Revision	SE	AAK
11	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	24-27	Clause 11.1, 11.2.2, 11.7, 11.10, 11.11 added, 11.2.1, 11.2.3, 11.3, 11.4, 11.9, 11.13.3, 11.13.5, 11.13.6 amended	JP	SE
12	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	28-31	Clause 12.2, 12.3, 12.4.1, 12.4.2, 12.6, 12.7, 12.8.1 amended	JP	SE
	2/1	25.08.13	28-31	Clause 12.1, 12.2.3, 12.2.4, 12.3.3, 12.4.1, 12.4.2, 12.5, 12.6, 12.7, 12.8.3 amended	SE	MH
13	2/0	29.09.08	All	New Revision	SE	AAK

14	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	32	Table 14.1 amended	JP	SE
15	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	34	Clause 15.1, 15.2 amended	JP	SE
16	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	37	Clause 16.3 amended	JP	SE
	2/1	25.08.13	37	Clause 16.3.5 amended	SE	MH
17	2/0	29.09.08	All	New Revision	SE	AAK
18	2/0	29.09.08	All	New Revision	SE	AAK
19	2/0	29.09.08	All	New Revision	SE	AAK
20	2/0	29.09.08	All	New Revision	SE	AAK
21	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	42	Table 21.8.2 amended	JP	SE
22	2/0	29.09.08	All	New Revision	SE	AAK
23	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	45	New addition	JP	SE
24	2/0	29.09.08	All	New Revision. New section added	SE	AAK
	2/1	21.11.12	45	New addition	JP	SE
25	2/0	29.09.08	All	New Revision. New section added	SE	AAK
	2/1	21.11.12	46	Clauses 25.1 - 25.3 amended	JP	SE
26	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	46	Amended	JP	SE
27	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	47	Clause 27.3 amended	JP	SE
28	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	48	New addition	JP	SE
29	2/0	29.09.08	All	New Revision	SE	AAK
30	2/0	29.09.08	All	New Revision. New section added	SE	AAK

31	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	49-51	Clause 31.1, 31.1.1, 31.1.3, 31.2, 31.3, Table 31.1 amended	JP	SE
32	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	52	Clause 32.1.2 amended	JP	SE
	2/1	25.08.13	52	Clause 32.1.2 amended	SE	MH
33	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	67, 68	Clause 33.3, 33.5, 33.6 amended	JP	SE
34	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	69	Clause 34.2, 34.3 amended	JP	SE
35	2/0	29.09.08	All	New Revision	SE	AAK
36	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	71, 72	Clause 36.1, 36.2.1, 36.2.2, 36.2.3, 36.3 amended	JP	SE
37	2/0	29.09.08	All	New Revision	SE	AAK
38	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	73	Section amended	JP	SE
	2/2	20.02.17	73	Reference to DS36 removed and replaced with Strategic Product Register	SS	SE
39	2/0	29.09.08	All	New Revision. New section added	SE	AAK
	2/1	21.11.12	73	Section amended	JP	SE
40	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	74	Clause 40.1.2 amended	JP	SE
41	2/0	29.09.08	All	New Revision	SE	AAK
42	2/0	29.09.08	All	New Revision	SE	AAK
43	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	82	Clause 43.3 amended	JP	SE
44	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	84, 85	Clause 44.1 to 44.4 amended	JP	SE

45	2/0	29.09.08	All	New Revision	SE	AAK
46	2/0	29.09.08	All	New Revision	SE	AAK
47	2/0	29.09.08	All	New Revision	SE	AAK
	2/2	20.02.17	87	Sec 47.3 and Sec47.4: Reference to DS36 removed and replaced with DS31-01	SS	SE
48	2/0	29.09.08	All	New Revision	SE	AAK
49	2/0	29.09.08	All	New Revision	SE	AAK
50	2/0	29.09.08	All	New Revision	SE	AAK
51	2/0	29.09.08	All	New Revision	SE	AAK
	2/1	21.11.12	92	Clause amended	JP	SE
52	2/0	29.09.08	All	New Revision	SE	AAK
53	2/0	29.09.08	All	New Revision	SE	AAK

DESIGN STANDARD DS 30-02

General Design Criteria - Mechanical

CONTENTS

<i>Section</i>		<i>Page</i>
1	SCOPE AND GENERAL	17
1.1	Scope	17
1.2	Purpose	17
1.3	Design Process	17
1.4	Standards	17
1.5	Referenced Documents	17
1.6	Notation	17
1.7	Nomenclature	18
1.7.1	Engineering Definitions and Relationships.....	18
1.7.2	Classification of Major and Minor Pump Stations.....	18
1.7.3	Preferred Terminology	18
1.7.4	Abbreviations	18
1.7.5	Standard Units and Relationships	18
1.7.6	Drawing Symbols.....	18
1.8	Feedback	18
2	AIR COMPRESSORS	19
3	AIR CONDITIONING	19
4	AIR VALVES	19
5	ANCILLARY PLANT	19
6	BACKFLOW PREVENTION DEVICES	19
7	BALANCING	20
7.1	General	20
7.2	Impellers	20
7.3	Impellers for Minor Pump Stations	20
7.4	Flexible Couplings	20
7.5	Line shafts	20
7.6	Pulleys	20
8	BASEPLATES	21
8.1	General	21
8.2	Baseplate	21
8.2.1	Jacking Screws and Fasteners	21
8.2.2	Coating	21

8.3	Installation	21
9	BEARINGS	22
9.1	General	22
9.2	Anti-Friction Bearings	22
9.3	Lubrication	22
9.4	Mounting	22
9.5	Plummer Blocks	22
9.6	Seals	23
10	BLOWERS	23
11	BUILDINGS	24
11.1	Asset Protection Zones	24
11.2	Building Access	24
11.2.1	Doors	24
11.2.2	Windows	24
11.2.3	Machinery and Equipment Rooms	24
11.2.4	Control Rooms	25
11.2.5	Chlorine Facilities	25
11.2.6	Personnel Facilities	25
11.3	Cranes	25
11.4	Drainage	25
11.5	Foundation Blocks	25
11.6	Lighting	25
11.7	Materials of Construction	26
11.8	Noise Attenuation	26
11.9	Safety Signs and Identification	26
11.10	Security	26
11.11	Site	26
11.12	Stairways, Landings, Walkways and Ladders	26
11.13	Ventilation	26
11.13.1	Personnel Requirements	26
11.13.2	Equipment Ventilation Requirements	27
11.13.3	Ventilators	27
11.13.4	Velocity and Static Pressure	27
11.13.5	Dust Exclusion and Extraction	27
11.13.6	Vermin Proofing	27
11.14	Vibration Isolation	27
12	COATINGS	28
12.1	General	28
12.2	Applied Coatings	28
12.2.1	Application	28
12.2.2	Finish	28
12.2.3	Standards	28
12.2.4	Coating Repair	28

12.3	Hot-Dip Galvanizing	28
12.3.1	General	28
12.3.2	Hot-dip Galvanized Steel	28
12.3.3	Hot-dip Galvanized Coating Repair	29
12.3.4	Standards	29
12.4	Pipework	29
12.4.1	Steel and Ductile Iron Pipework	29
12.4.2	PVC Pipework and Fittings	29
12.5	Valves	30
12.6	Pumps	30
12.7	Machinery	30
12.8	Fasteners	30
12.8.1	General	30
12.8.2	Zinc Plating	31
12.8.3	Hot-dip Galvanizing	31
12.9	Non-Coated Surfaces	31
13	COMPRESSED AIR	31
14	CONDITION MONITORING AND PROTECTION	32
14.1	General	32
14.2	Condition Monitoring of Ancillary Plant	32
14.3	Bearing Temperature	32
14.4	Low Flow	32
14.5	Vibration Monitoring	33
15	CONFINED SPACE	34
15.1	General	34
15.2	Operational Practices (Informative)	34
16	CORROSION	35
16.1	General	35
16.2	Corrosion Types	35
16.2.1	Crevice Corrosion of Stainless Steel	35
16.2.2	Dealumination of Aluminium	35
16.2.3	Dezincification of Copper Alloys	35
16.2.4	Erosion-Corrosion of Corrosion- Resistant Materials	35
16.2.5	Fatigue Corrosion of Copper Pipe	35
16.2.6	Galvanic Corrosion of Metals	35
16.2.7	Graphitic Corrosion of Cast Irons	35
16.2.8	Intergranular Corrosion of Stainless Steel	36
16.2.9	Pitting Corrosion of Stainless Steel	36
16.2.10	Stray Current Corrosion	36
16.2.11	Stress Corrosion Cracking of Stainless Steel	36
16.3	Corrosion Mitigation	36
16.3.1	Design	36
16.3.2	Materials	36
16.3.3	Coatings	37
16.3.4	Stainless Steel	37
16.3.5	Cathodic Protection	37

16.4	Pickling and Passivation of Stainless Steel.....	37
16.4.1	Pickling	37
16.4.2	Passivation	37
17	CRANES	38
18	DIESEL ENGINES	38
19	ENVIRONMENT	38
19.1	Environmental Protection Act	38
19.2	Environment Branch	38
20	FANS	38
21	FASTENERS FOR STRUCTURAL APPLICATIONS	39
21.1	General.....	39
21.2	Standards	39
21.2.1	PC 4.6 Bolts and PC 5 Nuts	39
21.2.2	PC 8.8 Bolts and PC 8 Nuts	40
21.3	Design, Manufacture and Quality	40
21.3.1	Design and Manufacture	40
21.3.2	Quality.....	40
21.4	Marking.....	41
21.5	Fastener Minimum Size.....	41
21.6	Bolt Holes for Structural Fasteners.....	41
21.7	Fastener Bearing Surfaces.....	42
21.8	Fastener Coatings.....	42
21.8.1	Bolted Joints.....	42
21.8.2	Galvanized High-Strength Nuts	42
21.9	Washers.....	42
21.9.1	General.....	42
21.9.2	Locking Washers.....	43
21.9.3	Static Equipment.....	43
21.9.4	Dynamic Equipment	43
21.9.5	Self-locking Nuts and Thread Locking Compounds.....	43
21.10	Fastener Lubrication	43
21.10.1	General.....	43
21.10.2	Galvanized or Plated Fasteners	43
21.10.3	Pre-Applied Lubricant.....	44
21.10.4	Lubricant Applied During Assembly	44
21.10.5	Recommended Lubricant	44
21.11	Structural Bolting Guidelines	44
21.12	Miscellaneous Fasteners	44
21.12.1	Capscrews	44
21.12.2	Dowelling.....	44
21.12.3	Fitted Bolts.....	44
21.12.4	Self-Tapping Screws	44
21.12.5	Spring Clips.....	44
21.12.6	Stainless Steel Fasteners	44

22	FINANCIAL IMPACT STATEMENT.....	45
23	FLANGED CONNECTIONS	45
24	FLOWMETERS.....	45
24.1	Mechanical.....	45
24.2	Electronic.....	45
25	FOUNDATION BLOCKS.....	46
25.1	General.....	46
25.2	Pumpsets	46
25.3	Ancillary Equipment.....	46
26	GENERATING SETS.....	46
27	GUARDS.....	47
27.1	General.....	47
27.2	Design	47
27.3	Construction	47
28	HANDOVER	48
29	INSTRUMENTATION	48
30	INSTALLATION.....	48
31	LUBRICATION.....	49
31.1	Grease Lubrication	49
31.1.1	General.....	49
31.1.2	Local Semi-Automatic System	49
31.1.3	Centralised Manual System.....	49
31.1.4	Centralised Automatic System	49
31.1.5	Automatic Gas Lubricators	49
31.2	Oil Lubrication.....	50
31.3	Lubricants Chart.....	50
32	MATERIALS	52
32.1	General.....	52
32.1.1	Alternative Materials.....	52
32.1.2	Contamination of Water.....	52
32.2	Elastomers.....	52
32.2.1	Elastomeric Gaskets and O-Rings.....	52
32.2.2	Elastomeric Application Guide	52
32.2.3	Elastomer Types.....	53
32.2.3.1	Polychloroprene (CR)	53
32.2.3.2	Etylene Propylene Diene Monomer (EPDM)	53
32.2.3.3	Vinelidene Fluoride Copolymer (FPM)	53
32.2.3.4	Synthetic Polyisoprene Rubber (IR)	54
32.2.3.5	Nitrile Rubber (NBR).....	54
32.2.3.6	Natural Rubber (NR).....	54
32.2.3.7	Poly Tetra Fluoro Ethylene (PTFE)	54
32.2.3.8	Styrene Butadiene Rubber (SBR)	54
32.2.4	Reference Standards.....	54
32.3	Metals	54
32.3.1	Aluminium Alloys.....	54
32.3.2	Copper Alloys	54

32.3.2.1	Copper Alloy Application Guide	54
32.3.2.2	Silver Brazing	55
32.3.3	Grey Cast Iron and Ductile Cast Iron.....	55
32.3.3.1	General.....	55
32.3.3.2	Grey and Ductile Cast Irons Application Guide	56
32.3.4	Stainless Steel	56
32.3.4.1	General.....	56
32.3.4.2	Corrosion Mitigation.....	56
32.3.4.3	Stainless Steel Application Guide	56
32.3.4.4	Galling of Stainless Steel	58
32.3.4.5	Welding of Stainless Steels.....	58
32.3.4.6	Pickling	58
32.3.4.7	Passivation	58
32.3.5	Steel.....	58
32.3.5.1	General.....	58
32.3.5.2	Structural.....	58
32.3.5.3	Engineering Steel Products	59
32.3.6	Galling of Materials	59
32.3.6.1	General.....	59
32.3.6.2	Galling Mitigation Strategies	60
32.3.7	Corrosion Resistant Metal Designation	60
32.4	Materials for Sea Water Service.....	61
32.4.1	General.....	61
32.4.2	Resistance to Pitting and General Corrosion in Seawater.....	61
32.4.3	Stainless Steel	62
32.4.4	Carbon Steel.....	62
32.4.5	Cast Iron and Cast Steel.....	62
32.4.6	Copper Alloys	63
32.4.7	Galvanic Effects.....	63
32.4.7.1	General.....	63
32.4.7.2	Anodic or Cathodic Selection	63
32.4.7.3	Body and Trim Combinations.....	63
32.4.8	Material Combinations in Seawater.....	63
32.4.9	Galvanic Series of Metals and Alloys in Seawater	64
32.4.10	Valves and Pumps in Seawater	65
32.4.10.1	Butterfly Valves	65
32.4.10.2	Ductile Iron versus Austenitic Iron Gate Valves	66
32.4.10.3	Seawater Pump Components.....	66
33	NOISE.....	67
33.1	General.....	67
33.2	Daily Noise Dose for Personnel.....	67
33.3	Neighbourhood Noise Levels.....	67
33.4	Acoustic Enclosures	67
33.5	Sound Level Measurements	67
33.6	Noise Reduction Strategies.....	67
33.7	Sound Pressure versus Sound Power Levels (Informative)	68
33.7.1	Sound Pressure.....	68
33.7.2	Sound Pressure Analogy	68
33.7.3	Sound Power	68
33.7.4	Sound Power Analogy	68
33.7.5	Sound Pressure and Sound Power Relationship.....	68

34	OCCUPATIONAL SAFETY AND HEALTH	69
34.1	General.....	69
34.2	Safety Standards	69
34.3	Duty of Care	69
35	PIPEWORK	70
36	PITS AND CHAMBERS	71
36.1	General.....	71
36.2	Pit (Chamber) Requirements	71
36.2.1	Access	71
36.2.2	Flooring.....	71
36.2.3	Drainage.....	71
36.2.4	Lighting, Ventilation and Sunlight.....	72
36.2.5	Instrumentation, and Labelling	72
36.3	Lifting Requirements	72
37	PUMP STATIONS.....	73
38	PREFERRED EQUIPMENT.....	73
39	QUALITY.....	73
39.1	Quality Assurance	73
40	SEALS.....	74
40.1	Packed Glands	74
40.1.1	General.....	74
40.1.2	Advantages of Pump Packed Glands	74
40.1.3	Disadvantages Pump Packed Glands	74
40.1.3.1	Maintenance	74
40.1.3.2	Wear	74
40.1.3.3	Power Consumption.....	74
40.1.3.4	Product Leakage.....	74
40.1.4	Packed Gland Requirements	74
40.2	Mechanical Seals	75
40.2.1	General.....	75
40.2.2	Inside-Mounted Single Rotating Mechanical Seals	75
40.2.2.1	Arrangement.....	75
40.2.2.2	Features	75
40.2.2.3	Disadvantages	75
40.2.3	Multiple Seals	75
40.2.3.1	Arrangement.....	75
40.2.3.2	Features	75
40.2.3.3	Back-to-Back and Face-to-Face Seals	76
40.2.4	Cartridge Seals	76
40.2.4.1	Arrangement.....	76
40.2.4.2	Features	76
40.2.4.3	Cost Comparison.....	76
40.2.5	Split seals	76
40.2.5.1	Arrangement.....	76
40.2.5.2	Features	76
40.2.5.3	Life Cycle Cost	76
40.2.6	Unbalanced Seals	76
40.2.6.1	Arrangement.....	76
40.2.6.2	Limitations	76
40.2.6.3	Disadvantages	76

40.2.7	Balanced Seals	77
40.2.8	Seal Materials.....	77
40.2.8.1	Metallic Components	77
40.2.8.2	Springs	77
40.2.8.3	Seal Faces.....	77
40.2.8.4	Elastomers.....	77
40.2.9	Seal Flushing.....	77
40.2.9.1	Suction Recirculation	77
40.2.9.2	Discharge Recirculation.....	77
40.2.9.3	External Flushing	78
40.2.10	Seal Venting.....	78
40.2.11	Cyclone Separators for Seals	78
40.2.12	Summary of Mechanical Seals Requirements.....	78
41	SECURITY	79
42	SIGNAGE AND LABELS.....	80
42.1	General.....	80
42.2	Safety Signs.....	80
42.2.1	Hazchem Signs.....	80
42.2.2	Statutory Requirements.....	80
42.2.3	Hazard Identification.....	80
42.2.4	Electric Interlocks	80
42.2.5	Automatic Equipment	80
42.3	Labelling of Equipment and Pipework	81
43	SITE CONDITIONS AND SELECTION.....	82
43.1	General.....	82
43.2	Temperature	82
43.3	Operating Periods	82
43.4	Site Selection and Design.....	82
43.4.1	Selection.....	82
43.4.2	Design	83
43.4.2.1	Surface Treatment	83
43.4.2.2	Access	83
43.4.2.3	Security and Protection	83
44	STAIRWAYS, WALKWAYS AND LADDERS	84
44.1	General.....	84
44.2	Materials	84
44.2.1	Steel.....	84
44.2.2	FRP	84
44.2.3	Stainless Steel	84
44.2.4	Aluminium	84
44.3	Ladders versus Stairways.....	85
44.3.1	Ladders versus Stairways.....	85
44.3.2	Step Iron Ladders.....	85

45	STATUTORY AUTHORITIES.....	86
46	SURGE VESSELS	87
47	TESTING.....	87
47.1	General.....	87
47.2	Engines	87
47.3	Pumps.....	87
47.4	Valves	87
48	TRANSMISSION DRIVES.....	88
48.1	General.....	88
48.2	Flexible Couplings.....	88
48.3	Lineshaft Drives	88
48.4	Vee-Belt Drives	89
48.4.1	Drives	89
48.4.2	Pulleys	89
48.4.3	Belts	89
48.5	Reduction Gearboxes	89
48.5.1	Rating and Service Factors.....	89
48.5.2	Case Construction	89
48.5.3	Bearings and Seals	89
48.5.4	Lubrication	90
48.5.5	Cooling Fans	90
49	VALVES	90
50	VIBRATION.....	91
50.1	Torsional Vibration.....	91
50.2	Translational Vibration.....	91
50.3	Equipment Vibration Limits.....	91
50.3.1	Machinery	91
50.3.2	Pumps.....	91
50.3.3	Submersible Sewage Pumps	91
50.4	Vibration Isolation	91
50.4.1	Structural Vibration Mitigation Strategies	91
50.4.2	Pumpsets	92
50.4.3	Generating Sets, Ventilating Fans and Air Compressors	92
50.5	Vibration Monitoring and Protection	92
51	WATER AND WASTEWATER TREATMENT PLANTS	92
52	WELDING.....	92
52.1	Metal Arc Welding.....	92
52.2	Brazing	92
53	WORKMANSHIP.....	92

1 SCOPE AND GENERAL

1.1 Scope

DS 30-02 is the third part of a three part standard which provides mechanical engineering information with a water industry bias to aid designers in the mechanical design process and use of the Corporation's DS 30 series of mechanical standards. The other parts of the Standard comprise

- DS 30 Mechanical Design Process,
- DS 30-01 Glossary - Mechanical.

This Standard details the Corporation's general mechanical design standards, guidelines and preferred engineering practices for water supply, wastewater and drainage applications. Section topics have been arranged in alphabetic order to assist the reader in finding relevant information.

1.2 Purpose

The Corporation's mechanical design standards are documented in its DS 30 Standards series. Designers shall comply with these standards for the design and specification of mechanical components of assets being acquired for the Corporation.

The purpose of the DS 30 Standards series is to provide:

- (a) Standards and guidelines applicable in the design of Corporation assets,
- (b) Explanatory or specific design information,
- (c) Information relating to Corporation preferences and practices which have evolved from over a century of experience in the water industry.

1.3 Design Process

The mechanical design process to be followed by Designers is documented in the Corporation's Engineering Design Manual and DS 30.

1.4 Standards

All materials and workmanship shall comply with latest revisions of the relevant codes and standards.

Water Corporation Strategic Product Specifications (SPS), or in their absence the latest editions of Australian Standards, or Water Services Association of Australia (WSAA) Codes, shall be referenced for design and specification. In the absence of relevant Australian Standards or WSAA Codes, relevant international or industry standards shall be referenced.

1.5 Referenced Documents

Standards and documents referred to in the DS 30 Standards series are listed in Appendix A of DS 30-01.

1.6 Notation

Statements expressed by the use of the word 'shall' are mandatory or 'normative' requirements of the Standard. Statements expressed by the use of the words 'should' or 'may; are 'informative' but not mandatory and are provided only for information and guidance. Notes in Standards text are informative however notes that form part of the Standards tables are normative.

1.7 Nomenclature

1.7.1 Engineering Definitions and Relationships

Definitions relating to terminology used in the DS 30 Standard series are contained in Section 2 “Engineering Definitions and Relationships” of DS 30-01.

1.7.2 Classification of Major and Minor Pump Stations

Major and minor pump stations are typically designated in accordance with Figure 1.1 and as further detailed in the Glossary of DS 30-01.

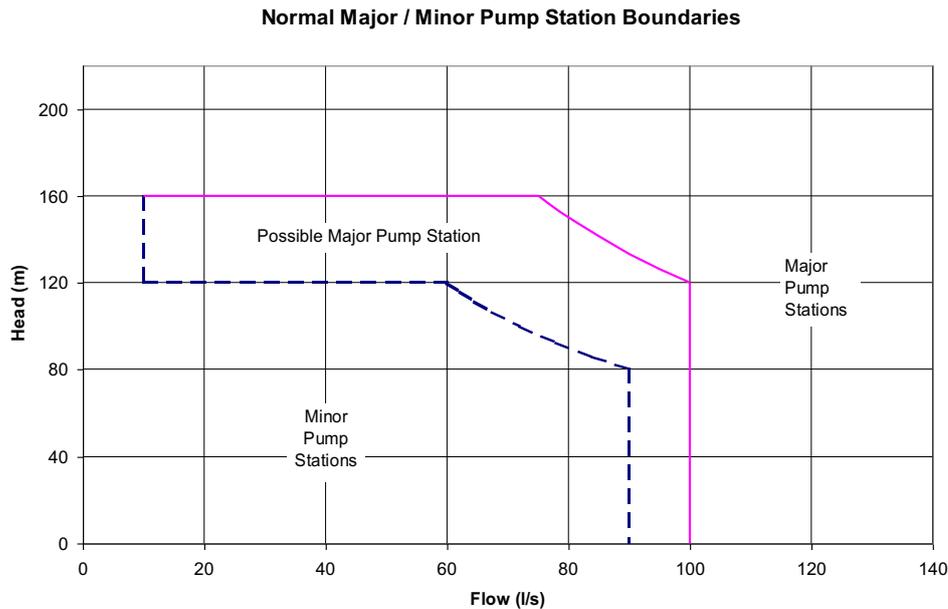


Figure 1.1 – Designation of Major and Minor Pump Stations

1.7.3 Preferred Terminology

Preferred mechanical terminology used in the DS 30 Standard series is contained in Section 3 “Preferred Terminology” of DS 30-01.

1.7.4 Abbreviations

Acronyms and symbols used in the DS 30 Standard series are contained in Section 4 “Acronyms and Symbols” of this DS 30-01.

1.7.5 Standard Units and Relationships

The units and relationships used for mechanical designs shall be in accordance with those specified in Section 5 “SI Units, Relationships and Prefixes” section of DS 30-01.

1.7.6 Drawing Symbols

A comprehensive list of mechanical drawing symbols for pipework and valves is referenced in DS 80.

1.8 Feedback

The mechanical standards are live documents that require regular review and revision in accordance with changes in associated standards, latest knowledge, operational experience and technology. Users of these standards are encouraged to provide feedback on their content to the Principal Engineer Mechanical Section, Infrastructure Design Branch.

2 AIR COMPRESSORS

For information relating to air compressor and compressed air design criteria the Designer should refer to the relevant sections contained in DS 35.

3 AIR CONDITIONING

For information relating to air conditioning design criteria the Designer should refer to the relevant section contained in DS 35.

4 AIR VALVES

For information relating to air valves refer to DS 31-02.

5 ANCILLARY PLANT

For information relating to ancillary plant design criteria associated with Corporation infrastructure the Designer should refer to DS 35 and DS 35-01. The following represents a list of the ancillary plant items contained in DS 35 and DS 35-01:

DS 35

- Air compressors
- Air conditioning
- Blowers
- Cranes – bridge and monorail
- Cranes – Jib
- Diesel engines
- Diesel engine driven plant
- Fans
- Generating sets (Stand-alone)
- Pits and Chambers
- Air cushions and surge vessels

DS 35-01.

- Surge vessels

6 BACKFLOW PREVENTION DEVICES

For information relating to backflow prevention devices refer to DS 31-02.

7 BALANCING

7.1 General

The Corporation standard for balancing the rotating elements of machinery such as pumps, fans and blowers shall be in accordance with ISO 1940/1. Corporation balancing requirements for specific rotating components are detailed below.

7.2 Impellers

In Corporation applications the term impeller is normally associated with pumps but it can also be applied to large blowers, fans or other large rotating machines.

Impellers shall be statically and dynamically balanced to ISO 1940/1 in accordance with the following criteria:

- (a) Any removal of material during the balancing process shall not interfere with either the structural integrity or the hydraulic performance of the impeller.
- (b) The impeller shall be initially statically and dynamically balanced to a balance grade of G6.3 at the maximum operating speed of the machine, with material being removed from, or near, the periphery of the rotor or impeller.
- (c) Where the maximum rotational speed of the machine is greater than 1000 rpm the impeller shall then be dynamically (two-plane) balanced to achieve a balance grade of G2.5 at the maximum operating speed of the machine with material removal limited to the area immediately around the seal rings for pump impellers.
- (d) The balancing speed shall be no less than 500 rpm and balance certificates shall be supplied.

NOTES:

1. The balance grade of G2.5 exceeds the minimum grade specified by ISO 1940/1 for pump impellers. In most cases this higher grade is easily obtainable and the resultant reduced imbalance and improved vibration levels would generally justify the small additional cost incurred.
2. In special cases such as single vane or relatively light impellers a balance grade of G2.5 can be too restrictive. In these instances approval should be sought from the Corporation to achieve the balance grade G6.3.
4. Care should be taken where a stepped key is being used in the shaft keyway that the equivalent half key length is used when balancing the shaft otherwise unacceptable pump vibration may result.

7.3 Impellers for Minor Pump Stations

Impellers for minor pump stations shall be dynamically (two-plane) balanced to achieve a balance grade of G6.3 at the maximum operating speed of the pump.

7.4 Flexible Couplings

Couplings shall be dynamically (two-plane) balanced with half keys to achieve a balance grade of G6.3 at the maximum operating speed.

7.5 Line shafts

Line shafts shall be dynamically balanced to achieve a balance grade of G6.3 at the maximum operating speed.

7.6 Pulleys

Vee belt pulleys shall be dynamically (two-plane) balanced with a half key with the key stepped down to the diameter of the shaft where it extends beyond the coupling to achieve a balance grade of G6.3 at the maximum operating speed.

8 BASEPLATES

8.1 General

Long-coupled machinery which is horizontally oriented shall be mounted onto a common baseplate that is designed for installation onto a concrete foundation block. Vertically oriented machinery shall be mounted onto a support stool or separate stools (in the case of line-shaft drives) designed for installation onto a concrete foundation block or separate blocks. The baseplate (or stool) shall comply with the following:

8.2 Baseplate

- (a) The baseplate shall be of rigid construction, and fabricated from standard rolled steel (or stainless steel) sections and plate;
- (b) The baseplate shall be fully seal-welded and braced to prevent misalignment or flexing under load. Welding shall be in accordance with Technical Specification WS – 1;
- (c) The baseplate shall incorporate foundation bolt holes and also access holes to facilitate grouting and concrete filling;
- (d) The baseplate shall be designed to accommodate a flexible coupling guard (where applicable), which shall comply with the Guards section of this Standard.
- (e) Individual mounting pads shall be provided on the baseplate for the driver and driven machine;
- (f) The mounting pads shall be machined after hot-dip galvanizing of the baseplate;
- (g) For pumpset baseplates the motor mounting pads should be machined to allow the motor shaft height to be 5 mm below the pump shaft height when mounted on the pads with no shims;
- (h) The baseplate shall incorporate specifically designed lifting lugs.

NOTE: The baseplate section should be read in conjunction with the Foundation Blocks section of this Standard.

8.2.1 Jacking Screws and Fasteners

- (a) Horizontal baseplates shall incorporate jacking screws comprising four per driver unit for direct-coupled electric motors exceeding 15 kW rating, to assist in moving the driver laterally and longitudinally for alignment purposes;
- (b) Jacking screws are not applicable for machinery mounted on vertical stools;
- (c) All holding down bolts shall be fitted with lock nuts;
- (d) Baseplate holding down bolts shall be readily accessible without the use of specialised tools and shall be set vertically;

8.2.2 Coating

- (a) Baseplates, coupling guards and fasteners subject to an outdoor or corrosive environment (wetting or high humidity conditions) shall be hot-dip galvanized in accordance with the Coatings section of this Standard. Alternatively the coating shall comprise a Zinc Rich Epoxy Primer, Epoxy Mastic Coat, Polyurethane Top Coat on Steel or Cast Iron complying with Coating Specification C2. The topcoat colour shall be N43 to AS 2700 or RAL7001 to European standards.
- (b) Baseplates and coupling guards subject to an indoor non-corrosive environment (no wetting or high humidity) shall be painted in accordance with Coating Specification E3. For more information on coating requirements refer to DS 95.

8.3 Installation

Baseplate installation shall comply with the relevant sections of DS 38-01.

9 BEARINGS

9.1 General

Bearings should be of the anti-friction type. Sleeve and babbitt bearings may be used on equipment as required but are not covered in this Standard (refer to the 'Glossary' contained in DS 30-01 for information on each type).

9.2 Anti-Friction Bearings

Rotating shafts shall be supported by ball or roller type bearings selected for a minimum L10 life of: 100,000 hours for equipment rated at ≥ 150 kW; or 40,000 hours for equipment < 150 kW. Bearings shall comply with AS 2729 and be designed to accommodate all loads they may be subjected to at the operating and future duties. High grade selected industrial bearings or precision bearings shall be used. Balls and rollers shall be retained in metallic cages. Ball bearing retainers shall be of one piece pressed steel or bronze construction. Riveted retainers are not acceptable. Bearings shall conform to ISO Standard Metric dimensions.

9.3 Lubrication

Bearings shall be oil or grease lubricated in accordance with the manufacturer's recommendations. All grease lubricated bearing housings shall be fitted with grease nipples, or where specified single point automatic gas lubricators in accessible locations where appropriate. Oil lubricated bearings shall be fitted with an oil level sight glass and shall be marked to indicate the level of oil both under running and stationary conditions. Further information is contained in the 'Lubrication' section of this Standard.

9.4 Mounting

Bearings shall be mounted directly on shafts using cylindrical or taper bores. All bearing housings, including those for electric motors, shall be fitted with a labyrinth bearing isolator seal. For taper bore bearings the use of adaptor sleeves is preferred for shafts over 80 mm diameter. Withdrawal sleeves with taper bores and cylindrical bores should only be used where recommended by the manufacturer.

9.5 Plummer Blocks

- (a) Plummer blocks shall be of the split type, incorporating grease lubricated bearings with tapered bores and adaptor sleeves.
- (b) Bearings for sizes up to 38 mm shaft diameter should be sealed for life. Larger bearings shall have grease lubrication with provision for regreasing e.g. a grease nipple for each bearing housing. The grease point(s) shall be extended to an accessible location to allow safe regreasing under operating conditions.
- (c) The bearing housing material shall be ductile iron, or cast steel.
- (d) Plummer blocks shall be located sufficiently clear of adjacent casings, pulleys or couplings so as to enable the split seal housings to be removed for examination of the seal without any other disassembly.
- (e) When a plummer block is at a dead end of a shaft, a suitable steel blanking plate shall be provided.
- (f) All openings of plummer blocks where shafts protrude should be fitted with taconite type seals comprising a flexible seal to exclude dust together with a triple labyrinth. Each taconite seal assembly shall incorporate a grease nipple. Where seal housings are split, the split shall lie in the same plane as the plummer block split.
- (g) Housings shall be set square to the shaft such that the radial gap measured between the labyrinth seals at any two diametrically opposite points do not vary by more than 0.5 mm.
- (h) Each pair of bearings supporting a shaft shall have one fixed and one floating bearing and the fixed bearing shall be adjacent to the drive.

- (i) Plummer block installation shall comply with the relevant sections of DS 38-01.

9.6 Seals

Bearings seals should be elastomeric lip type or elastomeric spring lip type, which shall retain lubricant whilst excluding dirt and foreign matter and rain or water spray from high pressure hoses. Replaceable wear sleeves or plates should be provided for rubbing type bearing seals.

Where possible the seal shall be protected by an annular grease ring and multi-labyrinth seal (taconite) in arduous dusty environments as specified above.

10 BLOWERS

For information relating to blower design criteria the Designer should refer to the relevant section contained in DS 35.

11 BUILDINGS

The following mechanical related requirements (listed in alphabetical order) shall be considered during design of Corporation buildings.

11.1 Asset Protection Zones

Buildings located in bushfire-prone areas shall comply with the Corporation's Instruction "Fire – Assets Protection Zones – for Critical Assets" and AS 3959.

11.2 Building Access

11.2.1 Doors

- (a) Generally external access to buildings such as pump stations should, for security reasons, be via a single personnel access door. In the case of a pump station, the personnel access door for external access should open into a safe part of the pump station area such as the pump loading bay.
- (b) All other doors should be locked from the inside and fitted with emergency escape crash bars where required.
- (c) Double doors for vehicular tray access shall be manufactured from double-skinned foam-filled colorbond steel for acoustic attenuation (as required). Roller doors may be a suitable alternative for small installations as applicable. Doors should be located away from the prevailing weather if practicable.
- (d) Swing doors and related architecture (e.g. crash bars) for access and escape shall be provided for:
 - (i) High voltage switch room
 - (ii) Transformer room
 - (iii) Telemetry room
 - (iv) High hazard rooms e.g. chlorine and fluorosilicic acid equipment and storage etc.
- (e) Use of roller shutter access doors shall only be used where neighborhood noise considerations have been satisfied. Dead-man type controllers shall be provided for remote controlled roller doors.

NOTE: If there is no reason to have an automatic controller for remote controlled roller doors then a dead-man controller should always be specified. This requires that the door closure is monitored by the operator. An automatic door controller will cut out when an obstacle is encountered, however it is not generally appreciated that the force applied can be very high e.g. 280 kg.

11.2.2 Windows

External windows should be eliminated, minimized or provided with security treatment to reduce potential vandalism and security risk.

11.2.3 Machinery and Equipment Rooms

Safe and adequate access shall be provided around all equipment for operation and maintenance purposes and shall include:

- (a) Provision of a minimum access of 1000 mm around all major equipment;
- (b) Provision of a minimum of 800 mm width for all equipment access platforms.
- (c) Space for vehicular access shall be provided in the building in order to remove major items of equipment e.g. particularly in the case of large pump stations.

11.2.4 Control Rooms

Control rooms for treatment plants and large pumps stations shall be enclosed, air conditioned with filtered air.

11.2.5 Chlorine Facilities

Chlorine building design shall comply with DS 70-01. The requirements outlined in DS 70-01 shall take precedence over the 'Building' section of this Standard.

11.2.6 Personnel Facilities

Office and ablution facilities should be provided in accordance with client requirements.

11.3 Cranes

Lifting equipment shall be provided within a building where large items of machinery or their components are required to be installed or removed for service e.g. a gantry crane in a large pump station.

Where a gantry crane is required for lifting machinery, it shall traverse the vehicle loading area.

The height of the building shall be sufficient to accommodate safe lifting of equipment. There shall be adequate vertical clearance under the crane, allowing for clearance beneath equipment being lifted over installed equipment and of sufficient height to allow placement of equipment onto a service vehicle.

Outdoor pump stations and machinery facilities shall have a lifting strategy developed as part of the design, which shall provide for access roadways for mobile crane and service vehicles.

Ceiling eyebolts shall not be used for lifting purposes.

For crane design criteria refer to the 'Cranes – Bridge', and 'Monorail and Cranes – Jib' sections contained in DS 35.

11.4 Drainage

Where a building incorporates pump sets installed below the surrounding natural surface and therefore subject to potential flooding, drainage of the pit via a drainage sump and drainage pump set shall be provided.

Floors subject to water spillage or having a regular cleaning requirement shall be graded to a sump.

Machinery or equipment within a building that would be vulnerable to flood damage e.g. in the event of pipework failure, shall be raised above the potential flood level.

The external site shall be provided with proper drainage to avoid flooding. External pit walls e.g. valve pits shall be raised above ground level to prevent flooding from run off.

11.5 Foundation Blocks

For design information relating to foundation blocks and grouting refer to the 'Foundation Blocks' section of this Standard and 'Grouting' section of DS 38-01 respectively.

11.6 Lighting

Where practicable the opportunity to use natural lighting should be considered for daytime activities providing that security and vandalism issues can be satisfactorily addressed. Adequate lighting shall be provided to all areas requiring personnel access in accordance with DS 22. Lighting operation should be timed or otherwise arranged to reduce power where feasible.

11.7 Materials of Construction

Buildings shall be constructed from materials complying with:

- (a) Local council or shire requirements;
- (b) Security requirements;
- (c) In keeping with the surrounding environment;
- (d) Other factors such as noise minimization and bush fire risk etc.

Corporation buildings are normally steel or brick with a concrete floor.

11.8 Noise Attenuation

Design of sound level emissions generated from equipment within a building shall not exceed the neighborhood noise level requirements as required in the Noise section of this Standard.

11.9 Safety Signs and Identification

For safety signs and identification relating to the site and building refer to 'Signage and Labels' section of this Standard.

11.10 Security

For security of the building and site refer to the 'Security' section contained in this Standard.

11.11 Site

For information relating to site requirements refer to the 'Site Conditions and Selection contained in this Standard.

11.12 Stairways, Landings, Walkways and Ladders

Access stairways, landings, walkways and ladders shall comply with the Stairways, Landings, Walkways and Ladders section contained in this Standard.

11.13 Ventilation

Adequate ventilation shall be provided to all areas requiring personnel access and as further specified in the following. Forced ventilation may be required for cooling of electric motors however natural ventilation should be assessed for feasibility before deciding on forced ventilation.

11.13.1 Personnel Requirements

Rooms in buildings which are not air-conditioned shall be provided with a fresh air ventilation system.

Areas served by a ventilation system shall be provided with an appropriate means of allowing outside make-up air to enter at a low level and exit at a high level for the spaces to be ventilated. Openings for inlets shall consist of weatherproof and vermin proof louvered panels in doors and/or wall to permit air flow. External louvers shall incorporate acoustic damping and security features.

All ventilation systems shall conform to the relevant requirements of AS/NZS 1668.

11.13.2 Equipment Ventilation Requirements

Unless otherwise required, ventilation systems shall provide a minimum of 8 air changes per hour.

The ventilation system shall limit the temperature within the building to a 6°C rise above ambient temperature when taking into account the maximum reject heat load of all equipment likely to be present within the design life of the facility. Temperature switches shall be provided for all rooms where high temperature may affect equipment operation, including switch rooms. The heat generated by electric motors shall be calculated and forced ventilation provided for cooling as required.

Natural ventilation is preferred over mechanical ventilation as it does not require redundancy considerations do not incur running costs.

11.13.3 Ventilators

Ventilators shall be of the static continuous ridge or flat mounting type in conjunction with low level inlet louvers fitted with security features as appropriate (e.g. considering bushfire risk). Ventilators shall be of high capacity, acoustically dampened type for hot air discharge. Ventilators shall be designed for the relevant wind loading region and terrain category in accordance with AS/NZS 1170.2.

NOTE: Rotary ventilators are not preferred as over time they tend to suffer bearing failure leading to squeaking, failure to rotate and toppling of the rotor in extreme cases where bearings collapse.

11.13.4 Velocity and Static Pressure

Ventilation duct velocities shall not exceed 8 m/s in main ducts and 4 m/s in the inlet ducts. Static pressure of ventilated spaces shall not be less than -50Pag.

11.13.5 Dust Exclusion and Extraction

Where sensitive equipment or machinery is to be installed within a building Designers shall treat the building or sensitive area to exclude entry of dust from the external environment.

11.13.6 Vermin Proofing

All permanent openings in the building such as static ventilators, low level louvers, eaves etc. shall be treated to prevent the entry of birds, vermin and insects. Mesh apertures shall comply with the requirements of AS 3959 if the building is located in a bushfire-prone area.

11.14 Vibration Isolation

For isolation of vibration in buildings refer to the 'Vibration' section of this Standard.

12 COATINGS

12.1 General

Product supplied to the Corporation that is subject to corrosion shall be provided with a protective coating. The Designer shall ensure the coating is appropriate for the product and service conditions.

All coating materials in contact with drinking water shall comply with the 'Contamination of Water' section of this Standard.

Product components subject to continuous immersion in water shall be fully and effectively coated including the internal wetted surfaces of ferrous gland, seal housings for pump, valve or other components. Interfaces between components subject to ingress of moisture shall be provided with coating returns and properly radiused edges.

Product components that are subject to corrosion that cannot be fully and effectively coated shall be manufactured from corrosion resistant materials.

NOTE: For more information on coating requirements refer to DS 95.

12.2 Applied Coatings

12.2.1 Application

Preparation of substrate surfaces and the application procedures for protective coatings shall be in accordance with the relevant Corporation coating standards and the manufacturer's requirements.

12.2.2 Finish

Finished coatings shall be of uniform thickness, colour and appearance. Coatings shall be fully cured, adherent, coherent and free from holidays, laps, sags, checking, overspray, patchiness and any other defect that may impair the performance and/or appearance of the coating.

12.2.3 Standards

Designers shall select appropriate coatings in accordance with relevant Corporation standards and the Coating Specifications for coatings as listed in Appendix A: Referenced Documents section of DS 30-01.

12.2.4 Coating Repair

The extent of coating damage shall be assessed as outlined in Criteria for Assessment and Repair section in DS 95. If the coating damage is extensive i.e. if the rust percentage is 50% and greater, it may be more cost effective to completely recoat the structure.

12.3 Hot-Dip Galvanizing

12.3.1 General

The hot-dip galvanizing process, which involves immersion of pre-treated ferrous products into a bath of molten zinc, provides an adherent corrosion-inhibiting coating on the exposed surfaces. The inhibiting mechanism is produced because of the characteristic of zinc to form a protective zinc carbonate film when exposed to air. Hot-dip galvanizing produces a durable heavy duty corrosion-resistant coating suitable for long-term outdoor service in wet or high humidity environments.

12.3.2 Hot-dip Galvanized Steel

The following requirements shall apply (where applicable):

- (a) Prior to coating, the surface to be galvanized shall be cleaned with a solvent to remove all oil, grease, wax, dirt, and other foreign matter.

- (b) The surface to be galvanized shall be prepared by etching with an etching solution in accordance with the manufacturer's recommendations.
- (c) The etched surface shall be free of oxides and exhibit a surface profile that will provide a satisfactory anchorage for the coating and be otherwise compatible with the coating to be applied.
- (d) Hot-dip galvanized surfaces shall exhibit finishes that are clean, smooth, continuous, and free from acid spots, cracks, laminations, runs and drips.
- (e) Closed sections to be hot-dip galvanized shall be provided with adequate venting holes.
- (f) Distortion of components caused by the galvanizing process shall be corrected without damage to the coating surface.
- (g) Strain aging effects resulting from cold working shall be avoided.
- (h) Hot-dip galvanized items that are to be cast into concrete shall be passivated in a 0.2% sodium dichromate solution or its equivalent.

12.3.3 Hot-dip Galvanized Coating Repair

For repair of hot-dip galvanized coatings refer to the Coating Specifications H1 and H2.

12.3.4 Standards

Steelwork shall be prepared for the hot-dip galvanizing process by cleaning, degreasing and pickling in accordance with AS 1627.5.

The following table details the hot-dip galvanizing standards applicable for the relevant products and material shapes and sections:

Table 12.1 – Hot-dip Galvanizing Products and Standards

Material Section	Standards	Applications
Threaded fasteners	AS 1214	Bolts, studs and nuts
Ferrous fabricated articles	AS/NZS 4680	Fabricated steel products
Ferrous open sections	AS/NZS 4791	Inline process application for channels, angles etc.
Ferrous hollow sections	AS/NZS 4792	Inline process application for pipe and tube etc.

12.4 Pipework

12.4.1 Steel and Ductile Iron Pipework

Decorative coatings for exposed steel or ductile cast iron pipework and equipment shall be applied in accordance with Surface Preparation A1 and Coating Specification C2 and as follows:

- (a) Water supply items shall be painted Jade Green (G21) to AS 2700,
- (b) Sewage items shall be painted Black (N61) to AS 2700,
- (c) Installed pipework shall be identified in accordance with AS 1345 and the Corporation's 'Guidelines for Planset Creation, Drawing Registration and General Drawing' Reference – Drawing EG71-1-1 for colour coding of pipework for water and wastewater treatment plants.
- (d) Long runs of pipework e.g. treatment plants (other than exposed PVC) should be identified via colour banding and not fully painted with the identifying colour.

12.4.2 PVC Pipework and Fittings

Exposed PVC pipework shall be painted in accordance with Coating Specification K1 in order to prevent ultraviolet degradation. Paint colour shall be in accordance with Section 5 'Standard Colour Coding for Pipework' contained in DS 80.

12.5 Valves

Acceptable coatings for ductile cast iron or steel valves and appurtenances shall be either:

- (a) Thermal-bonded (polymeric) in either thermoplastic or thermosetting epoxy in accordance with AS/NZS 4158, or Corporation Specification G2,
- (b) Liquid applied epoxy high-build, 2-pack solventless (refer Note 1 below), unless otherwise approved by the Corporation.

Bituminous type or coal tar epoxy coatings shall not be used in any event.

NOTES:

1. A polymeric coating should be specified as a first preference. However where there are valid reasons for departing from this a coating in accordance with Surface Preparation A1 and Coating Specification D1 may be approved by the Corporation.
2. The above coatings are suitable for flow velocities up to 10 m/s.

12.6 Pumps

- (a) Cast iron or ductile iron pumps shall be coated in accordance with the specific requirements detailed in the relevant strategic product specifications unless otherwise stated. Generally the coatings shall comply with the following:

Table 12.2 – Pump Coatings

Pump Type	Coating Colour	Internal Coating	External Coating
Water	AS 2700 G21 Jade Green	Chesterton ARC 855 [®] , Belzona 1341 Super Metal Glide [®] , Peerless Epigen 1311 [®] or equivalent (Clause 12.6(b))	Preparation shall be in accordance with Surface Preparation A1 and the manufacturer's standard [Clause 12.6(c)].
Sewage	AS 2700 Black		

- (b) Application of the internal coating shall be in accordance with Surface Preparation A1 and Coating Specification F3.
- (c) Minimum total dry film thickness of the external coating shall be 250 µm.

12.7 Machinery

Machinery and equipment shall be coated in accordance with Surface Preparation A1 and Coating Specification B2. The final coating colours shall be in accordance with AS/NZS 2700 unless otherwise approved by the Corporation.

12.8 Fasteners

12.8.1 General

Fasteners (bolt, nuts, screws, clips, washers, rivets, etc.) used where corrosion protection is required, shall have a corrosion resistance equivalent to the metal or alloy they are in contact with so that they will not suffer preferential corrosion.

Brass, Monel[®] metal and stainless steel is generally an acceptable fastener material. Hot-dip galvanized mild steel fasteners may be acceptable providing the surface coating would not be damaged (e.g. bolts and nuts sized for galvanizing, washers but not self-tapping screws, speed clips, rivets).

Cadmium plated fasteners shall not be used.

12.8.2 Zinc Plating

Zinc plating is a process which produces a light duty zinc corrosion-inhibiting coating of uniform appearance on the fastener surface. Corrosion resistance for outdoor/ use is only short-term e.g. 12 months and therefore zinc plated fasteners shall be restricted to indoor use for fasteners not subject to corrosive service.

12.8.3 Hot-dip Galvanizing

Hot-dip galvanizing on fasteners produces a heavy duty zinc coating with very good corrosion resistant characteristics and is suitable for long-term outdoor service. Hot-dip galvanized nuts shall be tapped oversize in accordance with AS/NZS 1214 to accommodate the relatively thick galvanized coating on the bolts. Hot-dip galvanized structures shall be assembled using hot-dip galvanized fasteners.

12.9 Non-Coated Surfaces

The following surfaces shall not be subject to blast cleaning or other cleaning and coating, unless otherwise specified:

- (a) Machined faces of flanges for vessels, pumps, pipework and valves,
- (b) The contact surfaces of earthing bosses,
- (c) Stainless steel pipework and components,
- (d) Self finished surfaces such as glass and plastic laminates,
- (e) Plastic including GRP, plastic pipe and fittings, and cables other than those exposed to UV radiation requiring protection e.g. PVC-U and ABS,
- (f) Machinery identification and marking plates,
- (g) Nuts and bolt threads for flanges, general threads and adjusting screws,
- (h) Field weld margins,
- (i) Flexible or resilient components e.g. duct connections, rubber hoses and mountings and non-metallic flexible fittings,
- (j) Wire ropes,
- (k) Galvanized or zinc coated pipe, conduit, sheet metal and fasteners where normally hidden from view,
- (l) Self-coloured PVC-U conduits and fittings e.g. electrical,
- (m) Exterior thermal insulation on ductwork where not clad with metal sheathing,
- (n) Air conditioning dampers except where visible through grilles.

13 COMPRESSED AIR

For design information related to air compressors and compressed air the Designer should refer to the relevant 'Air Compressors' and 'Compressed Air' sections contained in DS 35.

14 CONDITION MONITORING AND PROTECTION

14.1 General

Major machinery including pumps, blowers and ancillary equipment should be designed to incorporate condition monitoring and protection equipment as recommended by the manufacturer or considered necessary by the client for the protection of the asset as follows.

14.2 Condition Monitoring of Ancillary Plant

Condition monitoring of ancillary plant should be as a minimum in accordance with the table below.

Table 14.1 - Condition Monitoring of Ancillary Plant

Ancillary Equipment	Condition Monitoring Requirement
Bearing housings < 100 kW – oil lubricated	Oil level sight glass
Bearing housings > 100 kW – oil lubricated	Oil level sight glass, oil temperature, oil pressure for circulation systems
Bearing housings > 100 kW – grease lubricated	Bearing temperature
Centrifugal blowers > 500 kW	Tapping points for pressure and flow measurement, bearing temperature and vibration monitoring
Compressors < 150 kW	Oil level/oil pressure
Compressors > 150 kW	Oil pressure and oil temperature
Diesel engines	Refer to the Engines section of DS 35
Electric motors	Depending on motor size refer to the relevant parts of DS 21 and DS 22
Fans and blowers > 100 kW (General)	Tapping points for pressure and flow measurement and bearing temperature
Gearboxes < 100 kW – oil lubricated	Oil level sight glass
Gearboxes > 100 kW – oil lubricated	Oil level sight glass, oil temperature, oil pressure for circulation systems
Pumps	Refer to the condition monitoring sections of DS 32, DS 32-01, DS 32-02,
Vacuum sewage pump stations	Refer to the Vacuum Sewage Pump Stations section of DS 32

14.3 Bearing Temperature

Bearing temperature alarm and protection equipment shall be provided for all major machinery in order to detect increases in temperature above acceptable operating levels e.g. pumps, blowers, compressors etc.

14.4 Low Flow

Low flow alarm and protection equipment for critical water, wastewater, and air or other process fluids and compounds shall be provided via:

- (a) Flow switch or,
- (b) Non return valve fitted with an extended spindle and cam actuated limit switch or,
- (c) Magnetic flow meter or,
- (d) Pressure switch or,

- (e) Other approved pressure or low flow detecting device.

14.5 Vibration Monitoring

Normally this would only be a requirement for large sewage pump stations and ancillary equipment such as high speed blowers e.g. >500 kW. However the Designer should examine specific requirements for each design to determine whether vibration monitoring is appropriate.

Considerations in deciding whether vibration monitoring is appropriate are as follows:

- (a) The likelihood of preventing catastrophic failure by vibration monitoring and the cost and consequence of failure compared to the cost of the monitoring equipment.
- (b) The mean time between failure of the equipment bearings. For some axially split pumps for example, this may be greater than the life of the monitoring equipment.
- (c) Alternative methods of condition monitoring: e.g. bearing temperature.
- (d) The reliability and likelihood of nuisance alarms from the monitoring equipment and associated operating costs.

For wastewater applications, the frequent passage of debris through the pump generally means that (d) is prohibitive.

For clearwater pumps, considering (a), (b) and (c) above, generally means that only large (~>500kw) pumps would be suitable for vibration monitoring.

For rotational speeds below 500 rpm displacement transducers shall be provided as velocity type are ineffective.

15 CONFINED SPACE

15.1 General

Designs incorporating confined spaces that may require access by personnel shall comply with the requirements of:

- (a) Corporation's WC-OSH 108 Safe Working in Confined Spaces Procedure;
- (b) Corporation's WC-OSH 109 Tagging and Isolation Procedure;
- (c) Requirements of AS 2865;
- (d) Types of valves acceptable for single point isolation of confined space as detailed in the 'Confined Space Isolation' sub section of the 'Isolating Valves' section of DS 31-02.

Isolation of confined spaces should take into account the following operational strategies in any proposed works as outlined in the following.

15.2 Operational Practices (Informative)

The following risk minimisation strategies should be implemented for isolation of confined spaces:

- (a) Use double isolation methods wherever possible,
- (b) Identify all the valves to be isolated including branch main valves,
- (c) Assess the condition of the valves to be isolated,
- (d) Conduct a risk assessment of the confined space isolation,
- (e) Conduct a job safety analysis (JSA) and implement risk minimisation strategies,
- (f) Use of a properly maintained sluice valve as a suitable method of single point isolation,
- (g) Use of a properly maintained butterfly valve as a suitable method of single point isolation. (Although perceptions exist regarding the security of their operation in practice),
- (h) Compulsory condition assessment and maintenance of sluice or butterfly valves that are over 20 years old, other than seal-on-body butterfly valves, which are used to isolate a main (based on a sliding scale with an increasing requirement with age).

NOTE: This information is based on the results of an investigation and report "Confined Space Entry – Single Point Isolation Devices" dated January 2000

16 CORROSION

16.1 General

All materials in contact with water shall be either manufactured from corrosion resistant materials such as stainless steel or bronze; or coated in accordance with the relevant Corporation Technical Specification; or hot-dip galvanized (where appropriate) in accordance with the Coatings section of this Standard.

The Designer should refer to the 'Engineering Definitions and Relationships' section of DS 31-01 for further information regarding each of the following corrosion types (which have been arranged in alphabetic order).

NOTE: For general information on corrosion refer to the Water Corporation's "An Introduction to Corrosion Control – Guidelines".

16.2 Corrosion Types

16.2.1 Crevice Corrosion of Stainless Steel

Designs shall avoid shielding the surface of stainless steel, such as would occur at crevices that may lead to exclusion of oxygen and subsequent breakdown of the passive chromium rich film leading to crevice corrosion in a corrosive environment.

Accordingly stainless steel shall not have any coating or markings applied to it if it is to be subject to moisture or immersion.

16.2.2 Dealumination of Aluminium

Aluminium alloy components shall be manufactured from dealumination resistant materials e.g. aluminium bronze to minimum Grade C95810 to AS 1565.

16.2.3 Dezincification of Copper Alloys

Copper alloy components shall be dezincification resistant in accordance with AS 2345.

16.2.4 Erosion-Corrosion of Corrosion- Resistant Materials

Designers shall ensure materials subjected to the combined effects of erosion or abrasion and corrosion are resistant to these effects e.g. use special protective coatings, or stainless steels. Copper is particularly sensitive to erosion-corrosion at water velocities in excess of 1.0 m/s particularly if the water contains entrained air.

16.2.5 Fatigue Corrosion of Copper Pipe

Corrosion fatigue commonly occurs in copper pipes containing hot water installed directly in a concrete slab where the coefficient of thermal expansion and contraction has not been allowed for. To avoid the problem copper pipework for water services shall be installed in ducts within a concrete slab.

16.2.6 Galvanic Corrosion of Metals

Designers shall ensure that differing materials such as grey cast iron, ductile iron materials, mild steel, copper alloy, stainless steel and aluminium when subject to moisture and immersion shall, be protected from galvanic corrosion e.g. provide insulation strategies or use more compatible materials that are closer together on the galvanic series. Composite pipework (e.g. SS pipe with an MS flange welded and bolted to a HDG MS pipe and flange) shall be provided with appropriate isolation at flanges.

16.2.7 Graphitic Corrosion of Cast Irons

Graphitic corrosion rates of grey and ductile cast iron immersed in water varies from 0.2 mm per year for general corrosion to 0.5 mm per year for the worst case scenario. Accordingly grey cast iron and ductile iron components subject to immersion or moisture shall be fully coated with an appropriate

protective coating/lining, in accordance with Corporation Technical Specifications PA and PH, to prevent the onset of graphitic corrosion.

NOTE: The water industry has generally phased out grey cast iron in favour of ductile cast iron where practicable.

16.2.8 Intergranular Corrosion of Stainless Steel

Intergranular Corrosion is also known as weld decay or weld sensitivity. Designers and contractors shall ensure that welded stainless steel components are manufactured from low carbon e.g. 316L or stabilised stainless steel grades if they are to be subject to immersion or moisture (in conjunction with pickling and passivation), in order to avoid intergranular corrosion in the adjacent zone to the weld.

16.2.9 Pitting Corrosion of Stainless Steel

Designers and Contractors shall select stainless steel alloys that are resistant to pitting corrosion in instances where high levels of chloride ions are likely to be present causing breakdown of the passive chromium rich oxide film.

16.2.10 Stray Current Corrosion

Is corrosion of buried assets caused by direct currents that have deviated from their designed path e.g. from an impressed current cathodic protection system.

16.2.11 Stress Corrosion Cracking of Stainless Steel

Austenitic stainless steels e.g. Grade 304 and 316 shall not be used where conditions are likely to cause stress corrosion cracking. Such conditions occur in combination and are:

- (a) Where tensile stress will be present e.g. a fastener, or where residual stress is present in a component as a result of its manufacture,
- (b) Neutral chloride solutions at temperatures $> 10^{\circ}\text{C}$,
- (c) Where water temperatures exceed 60°C and 100 ppm chlorides,
- (d) Where chloride ions are present.

Alternative materials, which provide high resistance to stress cracking corrosion, are ferritic stainless steels, duplex stainless steels, and stainless steel alloys.

16.3 Corrosion Mitigation

The Designer shall employ the following design strategies where relevant in order to minimise the effects of corrosion:

16.3.1 Design

- (a) Components shall be free from water-trapping pockets in castings or fabrications (e.g. free draining) and unsealed cavities;
- (b) Crevices shall be avoided in uncoated or crevice corrosion prone materials;
- (c) Lap joints shall be avoided in ferrous materials unless they are sealed along the joint sides.

16.3.2 Materials

- (a) Use corrosion resistant materials in lieu of coatings. Refer to the designation of Corrosion Resistant Metals in the Materials section of this Standard for appropriate selection;
- (b) Avoid dissimilar metal contact;
- (c) Insulate components from each other where dissimilar metal contact cannot be avoided;
- (d) Component surfaces shall be smooth and free from foreign inclusions likely to occur during manufacture or other cause;
- (e) Use appropriate materials for the environment, operating conditions and fluids being considered;

- (f) Copper alloy materials shall not be used in sewage applications due to their susceptibility to corrode in the presence of hydrogen sulphide.

16.3.3 Coatings

Coating of product shall comply with the requirements of the 'Coatings' section of this Standard.

16.3.4 Stainless Steel

- (a) For continuously immersed surfaces, stainless steels shall comply with a relevant recognized standard and grade which has a PREN ≥ 22 e.g. a minimum grade 316 or 316L for fabricated parts (refer note);
- (b) Stainless steels shall be subject to pickling and passivation as required depending on the effects of any fabrication processes undertaken;
- (c) Stainless steel fasteners used for bolting stainless steel components should be the same or a higher grade as the material they are in contact with.

NOTE: Grade 431 stainless steel shall be exempted from this requirement.

16.3.5 Cathodic Protection

Utilise cathodic protection systems where the service conditions dictate e.g. sacrificial anodes or impressed current as appropriate. For more information on Cathodic Protection refer to DS 91.

16.4 Pickling and Passivation of Stainless Steel

16.4.1 Pickling

Stainless steel fabricated products which have been subject to the application of heat sufficient to produce high temperature scale, and adjacent layers of low chromium shall be subject to a pickling process in order to restore the original passive quality of the surface. Failure to do so may result in corrosion of the affected area.

Further information regarding pickling is contained in the 'Engineering Definitions and Relationships' section of DS 30-01.

16.4.2 Passivation

Manufacturing processes shall be avoided that may cause embedding of carbon steel into the surface of stainless steels e.g. using the same tools for carbon and stainless steels. Embedding of carbon steel or other impurities on a stainless steel surface will break down the passivating characteristics of the material causing pitting corrosion where chloride ions are present.

Stainless steel fabricated products which have been subject to contamination resulting from fabrication and machining processes or mechanical damage shall be subject to a pickling process, in order to restore the original passive quality of the surface. All stainless steel components except for fasteners shall be passivated in accordance with ASTM A380. Failure to do so may result in corrosion of the affected area.

Further information regarding passivation is contained in the 'Engineering Definitions and Relationships' section of DS 30-01.

17 CRANES

For information relating to crane design criteria the Designer should refer to the ‘Cranes – Bridge and Monorail’, and ‘Cranes – Jib’ sections contained in DS 35.

18 DIESEL ENGINES

For information relating to diesel engine and diesel engine driven plant design criteria the Designer should refer to the related sections contained in DS 35.

19 ENVIRONMENT

19.1 Environmental Protection Act

All designs and work performed for Corporation infrastructure shall comply with the requirements of the Environmental Protection Act.

19.2 Environment Branch

All environmental approvals and queries should be referred to the Corporation’s Environmental Branch.

20 FANS

For information relating to fans design criteria the Designer should refer to the Fans section contained in DS 35.

21 FASTENERS FOR STRUCTURAL APPLICATIONS

21.1 General

This section primarily covers structural fasteners and washers used on Corporation infrastructure. It includes requirements for the design and construction of bolted connections, and for the procurement of acceptable quality of structural fasteners. Fasteners and connection design shall comply with the requirements of AS 4100.

Correct bolting practices are a critical part of a structural joint and accordingly they shall comply with the 'Bolting Structural Joints' section contained in DS 38-01.

Coating of fasteners is covered in the Coatings section of this Standard.

Information relating to miscellaneous fasteners e.g. stainless steel fasteners, capscrews, self-tapping screws, spring clips and dowelling has been included in this section.

NOTE: Flange fasteners are not covered in this Standard however relevant information is contained in DS 38-02.

21.2 Standards

21.2.1 PC 4.6 Bolts and PC 5 Nuts

Property class (PC) 4.6 bolts with PC 5 nuts shall comply with the Australian Standards referenced in the following table.

Table 21.1 – Plain Carbon Steel Fastener Standards

Item	PC/HV ¹	Items	Standards	Comments
Bolt	4.6	Dimensions, tolerances, material requirements	AS 1111.1	Covers sizes ≤ M64, Product grade C ³
		Mechanical properties, marking	AS 4291.1	Covers sizes ≤ M39
		Threads	ISO 724	Basic dimensions
		Hot-dip galvanizing	AS 1214	Covers sizes ≤ M36
Nut	5	Dimensions, tolerances, material requirements	AS 1112.3	Covers sizes ≤ M64, Product grade C
		Mechanical properties, marking	AS/NZS 4291.2	Covers sizes ≤ M39
		Hot-dip galvanizing	AS 1214	Covers sizes ≤ M36, tapped oversize after galvanizing
Flat washer	300 HV ²	Mechanical properties	AS 1237.1	Covers sizes ≤150 mm; <39 mm, < 6 mm is Product grade A; >39 mm, > 6 mm is Product grade C
		Tolerances	AS 1237.2	
		Hot-dip galvanizing	AS/NZS 4680	

NOTES:

1. PC refers to property class - HV refers to hardness (Vickers)
2. Washer hardness of 300 HV shall be selected
3. Product grade A refers to high quality with the most precise tolerances through to product grade C being lowest quality with the least precise tolerances.

21.2.2 PC 8.8 Bolts and PC 8 Nuts

Property class (PC) 8.8 bolts with PC 8 nuts shall comply with the Australian Standards referenced in the following table.

Table 21.2 – High-Strength Fastener Standards

Item	PC/HV ¹	Items	Standards	Comments
Bolt	8.8	Dimensions, material, marking	AS/NZS 1252	Covers sizes M16 to M36
		Mechanical properties	AS 4291.1	Covers sizes ≤ M39
		Threads	AS 1275	Coarse thread series
		Hot-dip galvanizing	AS 1214	
Nut	8	Dimensions, material, marking	AS/NZS 1252	M16 to M36
		Mechanical properties	AS/NZS 4291.2	Property class
		Threads	AS 1275	Coarse thread series
		Hot-dip galvanizing	AS 1214	Covers sizes ≤ M36, tapped oversize after galvanizing
Flat washer	300 HV ^{1,2}	Dimensions, material, marking, hardness	AS/NZS 1252	Hardness should be 35-45HRC ¹ in lieu of hardness specified in AS/NZS 1252
		Tolerances	AS 1237.2	
		Hot-dip galvanizing	AS/NZS 4680	

NOTES:

1. PC refers to property class; HV and HRC refer to Vickers and Rockwell hardness respectively
2. Washer hardness of 300 HV shall be selected

21.3 Design, Manufacture and Quality

21.3.1 Design and Manufacture

The following requirements shall apply:

- (a) Fasteners shall be of the correct property class for the application.
- (b) Fasteners shall be hot-dip galvanized (unless otherwise specified).
- (c) Fasteners shall be of sound manufacturing quality, free from manufacturing or coating defects and nuts should run freely on the threads.
- (d) Bolts selected shall be of the correct length such that a minimum of 2 and a maximum of 5 threads protrude past the nut after fitting.
- (e) At least one flat washer (for fitting under the turned fastener component) shall be supplied with the fastener assembly and washers should be a similar hardness to the fasteners

21.3.2 Quality

Fastener and associated packaging shall be marked to confirm that:

- (a) The bolt head and nut markings are clearly and properly marked, and high-strength washers incorporate circumferential nibs, in accordance with the relevant Australian Standards (refer clause on fastener 'Marking' below),

- (b) The supplier shall be able to provide valid certification relating to the fastener design and manufacture, which has been issued by an authorised certification body that certifies compliance with the relevant Australian or international standards.

21.4 Marking

Marking of bolts, nuts and washers shall be in accordance with the following table which is a summary based on the markings requirements contained AS 1252, AS 4291.1 and 4291.2.

Table 21.3 – Fastener Markings

Item	PC	Marking	Standards	Comments
Property Class 4.6				
Bolt	4.6	Property class and manufacturer's trademark	AS 4291.1	Fully marked on top of the bolt head ¹
Nut	5	Property class and manufacturer's trademark	AS/NZS 4291.2	PC should be marked on nut side, bearing surface or chamfer ²
Washer	-	No marking required	AS 1237.1	Round plain faced washer
Property Class 8.8				
Bolt	8.8	Property class, 3 radial lines on bolt head and manufacturer's trade-mark ²	AS/NZS 1252	PC 8.8 bolt heads are larger than equivalent PC 4.6 bolt heads and may be stepped
Nut	8	Property class, 3 circumferential lines on bolt head and manufacturer's trade-mark ³		
Washer	-	3 nibs on external circumference	AS 1252	Nibs are 120° apart

NOTES:

- Fully marked normally on top of the bolt head or otherwise if limited space available by using the abbreviated clock face system
- Marking of nut located on a hexagon flat, or the bearing surface, or an external chamfer

21.5 Fastener Minimum Size

Where there exists the potential for over-torquing general fasteners, structural fasteners and foundation bolts shall be of minimum size M16 regardless of the design load.

21.6 Bolt Holes for Structural Fasteners

Bolt holes shall comply with the following:

- Bolt holes shall be drilled (e.g. gas burning of holes shall not be permitted) and associated fastener seating faces should be fully machined.
- Holes shall be drilled oversize and shall be no larger than 2 mm for bolt diameters up to and including 24 mm and 3 mm larger for bolts larger than 24 mm diameter as specified in AS 4100 Clause 14.3.5.2.
- Baseplate holding down bolt holes and slotted holes shall comply with AS 4100 Clause 14.3.5.2.

21.7 Fastener Bearing Surfaces

The quality of mating surfaces of fasteners is very important as most of the variation in the torque to induced tension of threaded fasteners is due to the effect of friction under the head or nut during tightening (depending upon which item is turned). Therefore the following issues should be considered:

- (a) Propagation of damage or galling between the bearing surface of a nut or bolt head and its mating surface can cause increased resistance during tightening. The additional torque associated with increased galling resistance will reduce the induced tension in the fastener thus reducing the clamping force.
- (b) Accordingly it is very important when high tensile strength fasteners are used that optimal mating surfaces are provided. This should be achieved by using a hard flat washer to provide a durable surface for the nut or bolt head to tighten against.
- (c) Most high-strength fasteners incorporate a step under the head or on the nut bearing face in order to optimise the torque to induced tension relationship, however this can be destroyed if galling propagates. Therefore it is necessary to provide a hard flat washer under the turned item.
- (d) Also where the flange surfaces has a protective coating that requires its integrity to be maintained, a flat washer shall be provided under the fastener head and nut otherwise the coating will suffer damage during tightening.
- (e) Where it is necessary to tighten by rotating the bolt head rather than the nut extra torque is required to overcome any friction that may be caused by contact between the bolt shank and the bolt hole. Accordingly the nut should be the preferred fastener component to be rotated during tightening but this may not always be the case where restricted access exists for the torque wrench. Lubrication of the fastener is essential under these circumstances.

21.8 Fastener Coatings

For coating of fasteners refer to the 'Coatings' section of this Standard.

Hot-dip galvanized bolted joints and fastener components can introduce particular issues that should to be addressed by the Designer and Manufacturer as detailed below.

21.8.1 Bolted Joints

The following factors resulting from the effect of galvanizing shall be considered in the joint design:

- (a) Higher bolting torque requirements due to galling potential as previously mentioned,
- (b) Variable torque to induced tension for bolts associated with a particular joint,
- (c) Bolt relaxation,
- (d) Slip factors of mating surfaces associated with friction type bolted joints.

These factors mitigate against developing the correct induced tension in the fastener.

21.8.2 Galvanized High-Strength Nuts

Hot-dip galvanizing of bolts causes over sizing of their threads. To accommodate this it is necessary to tap the nuts oversize in accordance with AS/NZS 1214. High-strength galvanized nuts should be manufactured from higher specified hardness steel than would otherwise be required to ensure that the stripping strength is acceptable.

21.9 Washers

21.9.1 General

Washers shall be provided under nuts or under bolt heads where the latter are rotated during bolt tightening and the following:

- (a) Hardened compatible washers shall be used for high-strength fasteners e.g. PC 8.8 bolts and PC 8 nuts. They shall comply with the requirements of AS/NZS 1252 except for hot-dip galvanized washers which should be of hardness 35-45 HRC.
- (b) Where locking washers are required they shall be substituted for the plain washers except where washers are located over slotted holes.
- (c) Taper washers shall be fitted to surfaces where the surface slope exceeds 3°.
- (d) In addition to the above requirements, washers shall be provided at all slotted holes (e.g. baseplates).
- (e) Flat washers shall be provided under bolt heads and nuts to protect coated surfaces.

21.9.2 Locking Washers

Thread locking shall be used where structural fastening is subject to dynamic loads, vibration or relative movement between components in order to prevent the nut from unscrewing from the bolt or stud and as further detailed in the clauses relating to static and dynamic equipment below.

Lock washers are generally of the square section spring or serrated spring types. Lock washers tend to bite into the component metal, which can destroy coating integrity if that is important.

21.9.3 Static Equipment

For normal static equipment applications, a lock washer should be provided under each nut for PC 4.6 bolts. In such applications, lock washers need not be used where PC 8.8 bolts are tightened to a pre-determined torque.

21.9.4 Dynamic Equipment

- (a) On dynamic applications PC 4.6 and 8.8 bolts shall have lock washers fitted except for fully tensioned property class 8.8 bolts where lock washers are not mandatory. PC 4.6 bolts are non-preferred for dynamic applications.
- (b) Dynamic applications shall include all bolted joints on or within moving machinery and bolted joints connecting moving machinery or its mounting brackets, to static plant or structural supports. Thus, for example, all bolts connecting plumper blocks or conveyor idler roller brackets to their supports are considered to be dynamic applications.

21.9.5 Self-locking Nuts and Thread Locking Compounds

Where bolted connections are subject to heavy vibration, self-locking metal nuts shall be used. In addition all bolts, screws etc. (assembled into blind holes) shall have their threads treated with Loctite or other approved thread locking compound before assembly.

21.10 Fastener Lubrication

21.10.1 General

Approximately 90% of the applied bolting torque is used to overcome friction in threads, bearing surfaces and rotating components; (stainless steel fasteners can be even higher). A reduction in friction by use of lubrication can significantly increase the induced tension in the fastener and improve the clamping force i.e. 10% torque reduction could increase tension 80-90%.

21.10.2 Galvanized or Plated Fasteners

Hot-dip galvanized or plated coatings require applied torque of the order 10% higher than the dry torque values because of the effects of galling of the thread coating under high stress which makes the use of pre-applied lubrication an imperative. There is also the issue of galling on the fastener and washer galvanized bearing surfaces, which is likely to produce significant variability in the applied torque to induced tensions in the bolting system. Anti-seize lubricants may be useful in addressing this issue.

21.10.3 Pre-Applied Lubricant

For PC 5 nuts after tapping, the oversize galvanized nut threads are required to be oiled for corrosion protection in accordance with Clause 5.1 of AS 1214.

In accordance with Clause 3.2.5.4 of AS/NZS 1252, all hot-dip galvanized PC 8 nuts require a dry film lubricant to be pre-applied by the manufacturer, in order to prevent seizure during assembly.

NOTE: Refer to the Stainless Steel Fasteners clause regarding use of anti-seize compounds.

21.10.4 Lubricant Applied During Assembly

During assembly of fasteners they should be additionally lubricated and the torque values used should be the lubed values (which are of the order 0.8% of dry torque values).

21.10.5 Recommended Lubricant

The minimum lubrication required would be light oiling. The oily residue on plain finish mild steel and high tensile bolts is usually sufficient, but all plated fasteners such as hot-dip galvanized should be oiled and stainless steel products can benefit from a high quality solid type lubricant such as molybdenum disulphide.

21.11 Structural Bolting Guidelines

Installation of structural bolted joints shall comply with the Bolted Structural Joints section of DS 38-01.

21.12 Miscellaneous Fasteners

21.12.1 Capscrews

All capscrews shall comply with the dimensions, material requirements, and mechanical properties specified in AS 1420.

21.12.2 Dowelling

Equipment including motors, gearboxes and plummer blocks, shall not be dowelled into position unless recommended by the manufacturer and authorized by the Corporation. However, on completion of lining up snugs should be welded to sub-frames to effectively locate the equipment. Where sub-frames are required to be stress relieved, welding of snugs shall preferably be carried out prior to stress relief.

21.12.3 Fitted Bolts

Fitted bolts shall comply with AS 1111.1 property class 8.8 unless otherwise specified. Holes for fitted bolts shall be reamed within the tolerance range for an H7/K6 transition fit in accordance with Table 1 in AS 1654.2. Nuts shall be of property class 8 to AS 1112.1.

21.12.4 Self-Tapping Screws

Self-tapping screws and tapped holes in sheet metal shall not be used except where used for attaching sheet metal to heavy section framework, provided they are not used in areas subject to vibration, shock, impulse or other dynamic loads.

21.12.5 Spring Clips

Carbon steel spring clips shall not be used in corrosive or outdoor environments.

21.12.6 Stainless Steel Fasteners

Where stainless steel fasteners are used they shall comply with AS 1111.1, AS 1112.3 and AS 1275.

Grades 316 and 431 stainless steels are equivalent to property classes 4.6 and 8.8 respectively.

The galling potential between fastener mating threads shall be addressed preferably by use of grade 431 bolts and studs with grade 316 nuts, or by use of anti-seize “nickel based” compounds where similar grade stainless steel mating threads are used. Refer also to stainless steel in the Materials section of this Standard.

22 FINANCIAL IMPACT STATEMENT

Planning, Preliminary Design, Engineering and Detailed Design options that have varying capital, environmental (Carbon) and operating cost impacts shall be evaluated using a Financial Impact Statement spreadsheet.

The Corporation’s current Financial Impact Statement (FIS) is the standard financial evaluation tool for comparing the whole-of- life costs of design options and is available on the Financial Evaluation Branch’s website. The spreadsheet requires input of capital and various operating costs and calculates the Net Present Value of the various alternatives including a dollar equivalent of Carbon footprint.

23 FLANGED CONNECTIONS

For information on requirements for flange design, manufacture and installation refer to DS 38-02.

24 FLOWMETERS

24.1 Mechanical

Mechanical flow meters shall comply with the requirements of the Mechanical Flow meters section contained in DS 31-02.

24.2 Electronic

Electronic flow meters shall comply with the requirements of the ‘Flow Meters’ section of DS 25-01 which covers:

- Magnetic flow meters (refer Note);
- Head loss flow meters e.g. orifice plates and venture tubes;
- Open channel flow meters;
- Thermal mass flow meters.

NOTE: The regulatory requirements of abstraction flow meters (magnetic flow meters) are contained in the Abstraction Flow meter section of DS 32-01.

25 FOUNDATION BLOCKS

25.1 General

Machinery foundation blocks shall:

- (a) Provide a permanent rigid mass to support the machinery mounted on it;
- (b) Provide full support to the baseplate footprint;
- (c) Withstand all forces generated by the rotodynamic machinery over its operating range;
- (d) Dampen vibrations generated by the rotodynamic machinery to acceptable levels in accordance with the 'Vibration' section of this Standard;
- (e) Ideally, be placed into virgin ground;
- (f) Incorporate blockouts for the baseplate holding down bolts. Blockouts should be sized at least 3 times larger than the holding down bolt diameter;
- (g) Provide for an allowance to accommodate grouting between the foundation block surface and the underside of the baseplate – refer to the section on 'Grouting' contained in DS 38-01;
- (h) Where required, shall incorporate reinforcing bar complying with AS/NZS 4671;
- (i) Be constructed from concrete complying with AS 1379.

25.2 Pumpsets

- (a) Each pumpset shall be rigidly mounted onto a concrete foundation block without vibration isolators;
- (b) The foundation block and building floor shall be rigid e.g. they shall have a fundamental natural frequency that is at least 140% of the highest speed of the pumps or any other significant rotating equipment. (A rigid structure is one that has a fundamental natural frequency of magnitude greater than 125% of the maximum rotational speed of the machine);
- (c) The foundation block should have a mass of between 3.5 to 5.0 times the total mass of the pumpset. The mass of a building floor, providing it is integral with the foundation block, may be used in the total mass calculations providing that the section of floor being considered contributes towards vibration damping.

25.3 Ancillary Equipment

Generating sets, ventilation fans and air compressor units, unlike pumpsets, should be mounted on vibration isolators, either as part of the unit baseplate or retro-fitted between the baseplate and foundation block as detailed in 'Vibration' section of this Standard.

26 GENERATING SETS

For information relating to generating set design criteria the Designer should refer to the Generating Sets section contained in DS 35 and Electrical Type Specification DS 26-05.

27 GUARDS

27.1 General

Safety guards shall be provided to cover all moving parts including couplings, exposed rotating shafts, belts, openings in machinery, housings, cooling fans or for protection from high temperature components (above 60°C) in accordance with the requirements of Work safe Western Australia and relevant parts of AS 4024.1.

27.2 Design

Safety guards shall be:

- (a) Designed to resist deformation in the event of inadvertent forces being applied e.g., person leaning or standing on the guard as relevant;
- (b) Securely fixed to the machine or supporting structure;
- (c) Removable as required for access to serviceable components;
- (d) Totally enclosed for moving or dangerous components;
- (e) Weatherproof and ventilated as required;
- (f) Designed so as not to trap moisture where exposed to weather.

Coupling guards shall not adversely restrict cooling air flows to the equipment e.g. engine, alternators etc.

Inspection covers shall be designed to be readily opened without the use of tools. Grilles, bars or mesh shall be provided behind covers where moving equipment may be reached and where required by Work safe Western Australia. Alternatively, interlocks shall be provided to stop equipment in the event that covers are opened. Mesh or grille openings shall be sized so as to prevent access by hands or fingers to dangerous parts of the machinery through the grille openings.

Guards for vee-belt drives shall be designed to allow for a 50% increase in the diameter of the driven and drive pulleys and allow motor adjustment to the limit of the motor slide rails. Items driven by vee-belt drives shall, where possible, have the guards supplied with provision for checking the speed safely when using a hand held tachometer, without having to remove the guard. If a cover is provided over the shaft end and has to be opened to use a tachometer, then additional protection shall be provided inside the cover so that opening the cover does not require the machine to be shut down.

27.3 Construction

Coupling guards shall be of either rigid mild steel welded construction or stainless steel. Where the mild steel guard is likely to be subject to wetting or outdoor service it shall be hot-dip galvanized after fabrication. Hot-dip galvanizing shall comply with the requirements of the Coatings section of this Standard

Welding shall comply with WS-1.

28 HANDOVER

Handover of assets, which includes commissioning, is subject to agreement between the Service Delivery Representative and Project Manager following the Handover Process guidelines and is facilitated by use of the Handover Checklists.

29 INSTRUMENTATION

Electronic field instrumentation shall comply with the requirements of DS 25-01.

30 INSTALLATION

Installation of mechanical plant and equipment shall comply with the Installation section of DS 38-01.

31 LUBRICATION

31.1 Grease Lubrication

31.1.1 General

Lubricants and lubrication frequencies shall comply with machinery and equipment manufacturer's requirements. Grease lubricating systems shall be designed to permit safe lubrication of the machinery while it is operating.

Points requiring manual grease lubrication shall be provided with 1/8" or 1/4" BSP "Tecalemit" screwed hydraulic nipples suitable for use with "Tecalemit" type HF4048 hydraulic connectors or equivalent. Nipples shall be remotely mounted with connections where necessary to bring the nipple within safe reach of an access point.

Tubing fittings required for connection of remote mounted grease nipples shall be rated to withstand a maximum operating pressure of 34.5 MPa. Tubing shall be copper, steel or high temperature/high pressure rated nylon in 6 mm size maximum as appropriate.

Except for pre-packed bearings all other grease packed bearing housings and labyrinth seals shall be fitted with individual grease points.

31.1.2 Local Semi-Automatic System

Local semi-automatic systems comprising a screw-on spring loaded canister type lubricators may be used subject to approval of the Corporation. These systems require follow up checking regularly to ensure that canisters are replaced before they become depleted of grease.

31.1.3 Centralised Manual System

For machinery components with several lubrication points, and in particular with difficult or hazardous access, the grease points shall be piped to an approved location for safe access. The grease lines shall terminate at Farval "Multival" lubrication blocks, or at individual nipples. All grease lines shall be of adequate size and permanently marked for identification.

31.1.4 Centralised Automatic System

For large and complex machinery where the lubrication interval is less than one month, an automatic distribution system should be installed. This should consist of a grease reservoir, pump and metering device. Pumps and reservoirs shall be located at easy access points with due consideration being given to the ready replenishment of grease to the reservoir. The size of the reservoirs shall be adequate to allow the equipment to be operated continuously for two months minimum without recharging. Reservoirs comprising standard grease packages requiring changeover in lieu of filling, are preferred.

Auto lubrication systems shall be of the dual line type, and shall be provided with condition monitoring equipment connected to the control PLC.

31.1.5 Automatic Gas Lubricators

Automatic gas lubricators shall comply with the following requirements:

- Single point, high capacity, compact type, incorporating a transparent lubricant container,
- Hermetic sealing to protection class IP 68 of AS 60529,
- A lubricant drive mechanism comprising a gas-cell containing inert gas,
- An adjustable time setting period ranging between 1 and 12 months,
- A reliable, accurate dispense rate that allows a low grease dispense rate,

- Ambient temperature range of -10 to 60 °C and a maximum operating pressure of 5 bar,

- A temporary deactivation facility and storage life of 2 years.

31.2 Oil Lubrication

Lubricants and lubrication frequencies shall comply with machinery and equipment manufacturer's requirements.

Oil reservoirs shall be fitted with sight glasses or dipsticks and shall be marked to indicate the level of oil both under running and stationary conditions.

Bearings provided with circulatory oil systems shall be designed to incorporate line filters of an approved type, and which can be cleaned in service without isolation and without the use of special tools. Oil flow sight glasses or indicators of an approved type shall be installed in the return line from each oil lubricated bearing.

Where pressurised oil lubrication is provided, a low pressure cut out switch suitable for the operating pressure range and a pressure gauge with isolation valve shall be provided.

31.3 Lubricants Chart

The following lubrication chart summarises the latest standards applicable to lubricants used by the Corporation. The chart is provided for information and as a guide. **In all instances the lubricants required for vehicles, plant, machinery and equipment shall comply with the original equipment manufacturer (OEM) requirements.**

Table 31.1 – Lubricants Standards Charts

Application	Standard/ Specification	Status	Service	Comment	
Petrol Engines	API SN	Current	For 2011 and earlier petrol vehicles to	1.API Classification 'S' relates to spark ignition or petrol engines 2. For temperatures down to 0°C typical viscosities for passenger cars would be 0W-20, 0W-30, 5W-20, 5W-30, 10W-30, 10W-40, 20W-50 3. For temperatures down to -18°C typical viscosities for passenger cars would be as above except for 20W-50 which would not apply. 4. provide improved high temperature deposit protection for pistons and turbochargers, more stringent sludge control, improved fuel economy, enhanced emission control system compatibility, and protection of engines operating on ethanol-containing fuels to E85	
	API SM	Current	For 2010 and older automotive engines		
	API SL	Current	For 2004 and older automotive engines		
	API SJ	Current	For 2001 and older automotive engines		
	API – SH to SA	Obsolete	N/A		
Diesel Engines	API CJ-4	Current	For high-speed 4-stroke cycle diesel engines designed to meet 2010 model on-highway and Tier 4 non-road exhaust emission standards as well for previous model year diesel engines.	1.API Classification 'C' relates to compression ignition or diesel engines 2. Exceeds the performance criteria of API CI-4, CH-4, CG-4 and CF-4 and can effectively lubricate engines of these API Service Categories. 5. CJ-4 oils are especially effective at sustaining emission control system durability where particulate filters and other advanced after-treatment systems are used. Optimum protection is provided for control of catalyst poisoning, particulate filter blocking, engine wear, piston deposits, low and high-temperature stability, soot handling properties, oxidative thickening, foaming, and viscosity loss due to shear	
	API CI-4	Current	For high-speed, four stroke diesel engines designed to meet 2004 exhaust emission standards implemented in 2002.		1. Can be used in place of CD, CE, CF-4, CG-4, and CH-4 oils 2. CI-4 oils are formulated to sustain engine durability where exhaust gas recirculation (EGR) is used and intended for use with diesel fuels ranging in sulphur content up to 0.5% by weight
	API CI-4	Current	For high-speed, four stroke diesel engines		

Application	Standard/ Specification	Status	Service	Comment
				2. Can be used in place of CD, CE, CF-4 and CG-4 oils
	CG-4, CF-4, CF-2, CF, CE, CD-11, CD, CC, CB, CA	Obsolete	N/A	N/A
Gears: Spiral bevel gears, worm gears and manual non-synchronised gearboxes	API GL-1	Current	For manual transmissions operating under mild conditions.	1. API MT-1 has improved performance over API GL-1 and is generally preferred. 2. Friction modifiers and extreme pressure additives are not used but others can be used e.g. oxidation and rust inhibitors, de-foamers etc
Gears: Spiral bevel gears, hypoid gears and axles	API GL-4	Current	For spiral bevel gears and axles operating under moderate to severe speeds and loads, and hypoid gears operating under severe speeds and loads	GL-4 and GL-5 are gear oil classifications not transmission oil classifications
Gears: Hypoid gears	API GL-5	Current	For hypoid gears in axles operating under high speed/shock loading or low speed/high torque conditions	GL-5 is not a replacement for GL-4 and its use in lieu of GL-4 will cause damage to the transmission
Gears: Manual transmissions	API MT-1		For non-synchronised manual transmissions	Higher specification of API GL-1
Automatic transmissions and torque convertors	N/A	N/A	There are no specific standards for automatic transmission fluids (ATFs) and transmission manufacturers utilize fluids that best serve their specific requirements.	The transmission OEM recommended lubricant shall apply
Brakes	A high temperature brake fluid meeting AS/NZS 1960.1 Grade 3 and AS/NZS 1960.2 (Grade 4)	Current	All hydraulic brake systems designed for non-petroleum (AS/NZS 1960.1) or silicone (AS/NZS 1960.2) brake fluids.	Braking systems designed for non-petroleum brake fluids may suffer reduced performance with silicone brake fluids. Accordingly the different fluids should not be mixed or interchanged.
Bearings and grease points	Grease meeting specification NLGI Grade 2	Current	General use in earthmoving equipment plant and equipment, trucks, motor vehicles, for ball joints, wheel bearings and general purpose applications	The OEM recommended lubricant shall apply

32 MATERIALS

32.1 General

32.1.1 Alternative Materials

Alternative materials to those referred to in this Standard may be used providing they are equivalent or superior in performance and authorized by the Corporation.

32.1.2 Contamination of Water

All materials in contact with drinking water shall have been approved as being suitable for use with potable water by the Health Department of Western Australia and be in accordance with AS/NZS 4020.

For potable water approved products refer to Schedule 5.0 published by the Department of Health Western Australia.

Designers should also refer to the Memorandum of Understanding for Drinking Water Schedule 10 for Approved Materials and Schedule 11 for Water Treatment Agents (MoU is available for internal use on www.waternet.watercorporation.com.au/corporate/agreements/health/schedule%2010).

32.2 Elastomers

32.2.1 Elastomeric Gaskets and O-Rings

The following factors shall always be considered when selecting gasket types for successful sealing:

- (a) Temperature of the media to be contained,
- (b) Pressure of the media to be contained,
- (c) Corrosive nature of the application.

Further information regarding gaskets and O-rings is contained in DS 38-02.

32.2.2 Elastomeric Application Guide

The following guide is provided for reference for Designers.

Table 32.1 Elastomer Application Guide

Elastomer Designation	Alternative Names	Recommended For	Not Recommended For
CR	Neoprene, Chloroprene	Medium concentration chemicals and acids, ozone, fats, greases, selected oils and solvents, refrigerants (freons, ammonia)	Strong oxidising acids, esters, ketones, chlorinated aromatic and nitro hydrocarbons, phosphate esters
EPDM	Nordel, Royalene, Vistalon, Epcar	Animal and vegetable oils, ketones, alcohols, ozone, concentrated chemicals, oxidising chemicals, water	Mineral oils, solvents, aromatic hydrocarbons
FPM ¹	Viton [®]	Hydrocarbons, silicone fluids and greases, acids, selected phosphate esters, chlorine gas and chlorine solutions	Ketones, amines, esters and ethers of low molecular weight
IR	Synthetic Polyisoprene	Similar to NR but exceeds its performance	Similar to NR
NBR	Nitrile, Buna N	Selected hydrocarbons, fats, oils, greases, chemicals, water, silicone greases and oils, ethylene glycol fluids, sewerage	Ozones, ketones (MEK and acetone), esters, aldehydes, chlorinated and nitro hydrocarbons, strong acids, brake fluids, phosphate ester hydraulic fluids
NR	Cyan acryl, Hycar, Krynac, Thiacril	Medium concentration chemicals, organic acids, alcohols, ketones, aldehydes, brake fluid, water	Hydrocarbons, oils, greases, ozones, strong acid and alkalies, fats, sunlight
PTFE	Sigma	High degree of chemical resistance, water, food	Molten alkaline metals and certain fluorine compounds at elevated temperatures
SBR	Buna S	Same as for NR	Same as for NR

NOTE:

For specific chemicals and fluids the applications should be selected from chemical resistance charts for the particular product in conjunction with the manufacturer's recommendations.

32.2.3 Elastomer Types

The following elastomers are used in water industry applications for diaphragms, seals, gaskets and O-rings. The information is provided in alphabetic acronym order as a summary to assist Designers in selection of appropriate materials.

32.2.3.1 Polychloroprene (CR)

CR are homopolymers of chloroprene and is suitable for low temperature applications e.g. < 60 °C.

32.2.3.2 Etylene Propylene Diene Monomer (EPDM)

EPDM is a polymer comprising essentially ethylene, propylene and diene monomers and is suitable for low temperature applications e.g. < 60 °C. EPDM is widely used for water and wastewater service applications providing the wastewater does not contain high levels of hydrocarbons.

32.2.3.3 Vinelidene Fluoride Copolymer (FPM)

FPM (Viton[®]) elastomers should be used in high temperature applications or where there is the presence of chlorine gas or chlorine solutions. Viton[®] materials used in hypochloride applications shall be stabilized with carbon black.

32.2.3.4 Synthetic Polyisoprene Rubber (IR)

Synthetic polyisoprene rubber is similar to natural rubber in structure and properties. However it exceeds NR in product consistency, cure rate, processing and purity. It also has superior mixing, moulding and calendaring process properties to NR.

32.2.3.5 Nitrile Rubber (NBR)

NBR is a copolymer comprising butadiene and acrylonitrile. The percentage of nitrile content for NBR varies from 20% to 50%. The higher the nitrile content the greater resistance to hydrocarbon products. NBR is largely used in seal applications. NBR is widely used for water and wastewater service applications and is tolerant of high levels of hydrocarbons that may occur in sewage and sewage sludges.

32.2.3.6 Natural Rubber (NR)

NR elastomers are manufactured from crude natural rubber. Use of natural rubber in water supply applications is now not preferred because of its susceptibility for promoting microbial growth. Synthetic elastomers have generally replaced NR because of their superior properties.

32.2.3.7 Poly Tetra Fluoro Ethylene (PTFE)

PTFE is inert to most chemicals and stable to 260 °C. However use of virgin PTFE sheet as a sealing material is limited because it suffers creep and cold flow when subject to compression. This can lead to stress relaxation and leakage. PTFE composites have now been developed to reduce creep and improve stress retention properties. Pressures from 8.5 Mpa to vacuum can now be accommodated to 260 °C.

32.2.3.8 Styrene Butadiene Rubber (SBR)

Originally developed in the 1940's as a substitute for natural rubber and has similar applications as for NR.

32.2.4 Reference Standards

Elastomers shall comply with the requirements of AS 1646, WSA 109, AS/NZS 4020 and ASTM D3187.

32.3 Metals

32.3.1 Aluminium Alloys

The following aluminium casting alloys are considered corrosion-resistant: grades CA 401, AA 601, AA 603, and AA 607 complying with AS 1874.

32.3.2 Copper Alloys

32.3.2.1 Copper Alloy Application Guide

The following copper alloys are commonly used in Corporation assets:

Table 32.2 – Copper Alloy Standards and Applications

Standard	Min Grade	Material/Product	Application
AS 1565	C83600A	Leaded gunmetal castings	Pump and valve components – (4% - 6% lead)
	C90250	Phosphor bronze castings	Pump components – impellers, wear rings. Valves.
	C90710	Phosphor bronze castings	Gears, worm wheels
	C92710	Leaded tin bronze	Pumps, valves, bearings
	C93500	Leaded tin bronze castings	Pump components, bearings ¹
	C93700	Leaded tin bronze castings	Pump components, bearings ¹
	C92410A	Gunmetal castings	Pump components
	C95810	Aluminium bronze castings	Valve components, pump components
AS/NZS 1567	C48600	Leaded arsenical brass bar and rod	Valve components ²
AS/NZS 1568	C35200	Leaded arsenical brass wrought or cast forging stock	Valve components

NOTES:

1. C93500 copper alloy material should only be used for pump components where they are not in contact with potable water because of the high lead content e.g. 8% - 10%.
2. The comments regarding the copper/zinc ratio referred to in AS/NZS 1567 should be complied with.
3. C95210 copper alloy (AB1 – not shown above) should not be used for continuous immersion as it suffers dealuminification.

32.3.2.2 Silver Brazing

This section covers the filler metals referred to as silver brazing alloys (SBA) used in the brazing of copper alloy components for Corporation infrastructure. In this Standard the term silver brazing will be used in preference to silver soldering as the latter term tends to refer to low temperature soldering.

SBA used on Corporation infrastructure shall comply with the following:

- (a) Filler metal for brazing work shall be silver brazing alloy containing not more than 0.05% cadmium complying with Table 1 of AS/NZS 1167.1, or copper phosphorous brazing alloy containing at least 5% silver and complying with Table 2 of AS/NZS 1167.1.
- (b) All SBA and components which will be in contact with drinking water shall comply with AS/NZS 4020.

NOTE: The use of soft solders complying with AS 1834 is generally not permissible on Corporation water services.

32.3.3 Grey Cast Iron and Ductile Cast Iron

32.3.3.1 General

There has been a progressive trend in the water industry to replace grey cast iron (CI) pipe and fittings with ductile cast iron or steel. This is because cast iron's flake graphite micro-structure tends to produce stress raisers in tension making it brittle and susceptible to cracking. Further bare CI subject to internal and external immersion results in graphitic corrosion and the formation of tuberculation. The corrosion reduces the wall thickness which increases the pipe wall stress resulting in catastrophic longitudinal cracking. Tuberculation results in reduced waterways and aesthetic water quality issues. Ductile iron on the other hand is not susceptible to catastrophic cracking because of its ductility but has similar

corrosion characteristics in terms of corrosion rate and formation of tubercles requiring it to be fully polymeric coated for immersed service.

32.3.3.2 Grey and Ductile Cast Irons Application Guide

The following cast and ductile irons are commonly used in Corporation assets:

Table 32.3 – Cast and Ductile Iron Standards and Applications

Standard	Designation	Material	Application
AS 1830	ISO 185/JL/250	Grey cast iron ^{Note}	Pump casings, valve bodies and covers, gearboxes and general castings
AS 1831	ISO 1083 /JS/400-15S ISO 1083/JS/450-10/S ISO 1083/JS/500-7S	Ductile cast iron	Pump casings, valve bodies, pipes and fittings, and pressure containing castings
AS 1833	L-NiCuCr 15-6-3	Austenitic cast iron	Pump casings, wear rings, valve bodies and covers and pressure containing castings for sea water, salt solutions, alkalis and dilute acids
AS 2027	1985	Nickel chromium iron	Pump wear rings

NOTE: Gate valve and butterfly valve body components are required to be ductile cast iron (in lieu of grey cast iron) to provide structural integrity when used in pipelines where confined space issues require risk minimisation strategies to be implemented.

32.3.4 Stainless Steel

32.3.4.1 General

Stainless steel is available in five different types namely austenitic, ferritic, duplex (and super duplex), martensitic and precipitation hardening. Generally, duplex stainless steels have a PREN ≥ 30 and ≤ 40 , and super duplex stainless steels have a PREN > 40 .

Stainless steel castings, plate and bar subjected to welding during repair or manufacture of components shall be of low carbon or stabilised grade. Stainless steel castings shall be heat treated in accordance with AS 2074. All stainless steel components except for fasteners shall be passivated in accordance with ASTM A380.

32.3.4.2 Corrosion Mitigation

Graphite greases, graphite packing and graphite compounds shall not be used in contact with stainless steel.

Protective or decorative coatings shall not be applied to stainless steel when exposed to moist or corrosive environments.

Designers should ensure that stainless steel applications comply with the requirements for corrosion mitigation as detailed in the Corrosion section in this Standard.

32.3.4.3 Stainless Steel Application Guide

As there are no longer any manufacturers of stainless steel products in Australia (apart from castings) stainless steel products and components shall conform to ASTM Specifications and would typically be as shown in the following table.

Table 32.4 – Typical Stainless Steel Applications

Specification	Grade	Product	Application
AS 2074	H3B, H3C, H5C, H6B	Cast	Pump casings, impellers and wear rings, valve components
ASTM A182M	304 ² , 316	Cast	Flanges and pipe fittings
ASTM A240M	304 ² , 316	Plate, sheet, strip	Pressure vessels
ASTM A269	304 ² , 316 ³	Pipe and tube	General purpose pipework
ASTM A276	316	Bar, round, hollow	Shafts, studs, fasteners, shaft sleeves
	316L	Bar	Welded components
	431	Bar	Small fasteners, pump and valve shafts
ASTM A312M	316	Pipe	General purpose pipework
ASTM A313M	304, 316	Wire and spring	Springs
ASTM A351M	CF3M ¹	Castings	Corrosive environments for pressure containing components e.g. valve bodies, valve discs, valve balls
	CF8M ¹	Castings	AS for CF3M plus pipe fittings
	CN7M (Alloy 20)	Castings	AS for CF3M
ASTM A380	N/A	N/A	Cleaning and surface treatment practices
ASTM A403M	304 ² , 316	Wrought pipe fittings	Pipework
ASTM A480M	304 ² , 316	Plate, sheet, strip	General fabricated components e.g. tundishes
ASTM A484M	316	Bar	Shaft sleeves
ASTM A494M	CW2M, CW6M (Hastelloy C [®])	Castings	Pressure containing components such valve bodies, valve discs and valve balls
	M-35-1 (Monel [®])	Castings	Pressure containing components such valve bodies, valve discs and valve balls
	CY40 (Inconel [®])	Castings	Good corrosion resistance, valve components
ASTM A632	316	Tube	General applications
ASTM A743	CF3M ¹	Castings	General applications e.g. valve components and pump casings
	CF8M ¹	Castings	Corrosion resistant for general application, globe valve seats (e.g. control valves)
	CW12M (Hastelloy C [®])	Castings	Good resistance to corrosion. Pressure containing components such valve bodies
	M-35-1 (Monel [®])	Castings	Weldable with good resistance to corrosion from organic acids, salt water and alkaline solutions.
	CY40 (Inconel [®])	Castings	Good resistance to strongly corrosive media, valve components
ASTM 890M	4A	Castings	Valve components

NOTES:

1. CF8M is equivalent to grade 316 and CF3M is equivalent to grade 316L
2. Grade 304 is not suitable for immersion in water
3. Low carbon stainless steels should be used where welding of components is required e.g. 316L

32.3.4.4 Galling of Stainless Steel

Stainless steel can be particularly susceptible to galling if correct design, installation and operational practices are not followed. Related information is contained in the Clause on 'Galling of Materials' located below.

32.3.4.5 Welding of Stainless Steels

The following items should be considered in the design of welded stainless steel systems:

- (a) For welding standards relating to stainless steel refer to the Welding section of this Standard;
- (b) Austenitic grades of stainless steel exhibit very good weldability and do not suffer from hydrogen embrittlement;
- (c) Ferritic grades of stainless steel exhibit poor weldability limited to thin gauges and may suffer from hydrogen embrittlement;
- (d) Chromium stainless steels (12%) exhibit good weldability and may suffer from hydrogen embrittlement. Low carbon grades of product and welding consumables shall be used e.g. 316L;
- (e) Duplex grades of stainless steel exhibit very good weldability and do not suffer from hydrogen embrittlement.

32.3.4.6 Pickling

Stainless steel that has been subjected to heat during manufacturing shall be pickled in order to mitigate against potential corrosion effects. The Designer should refer to 'Pickling and Passivation of Stainless Steel' in the 'Corrosion' section of this Standard.

32.3.4.7 Passivation

Stainless steel that has been subjected to mechanical manufacturing processes e.g. grinding, machining etc shall be passivated in order to mitigate against potential corrosion effects. The Designer should refer to Pickling and Passivation of Stainless Steel in the Corrosion section of this Standard.

32.3.5 Steel

32.3.5.1 General

Steel products used by the Corporation tend to fall into either structural steel sections or steel bar and hollow sections for manufacture of engineering steel products. Steel pipework and fittings for water supply purposes are separately covered in the Mild Steel Cement Mortar Lined Pipe section of DS 31-01.

32.3.5.2 Structural

Structural steel sections shall comply with the standards contained in the following table:

Table 32.5 – Structural Steel Sections Standards

Steel Section	Standard	Comments
Hollow sections	AS/NZS 1163	
Hot-rolled structural steel plates, floorplates and slabs	AS/NZS 3678	
Hot-rolled structural steel sections	AS/NZS 3679.1.	Comprises equal and unequal angles, tapered flange beams, universal beams and universal columns
Welded universal beams	AS/NZS 3679.2	
Reinforcing material	AS/NZS 4671	Deformed or plain bars, machine-welded mesh

32.3.5.3 Engineering Steel Products

Structural steel sections shall comply with the standards contained in the following table:

Table 32.6 – Engineering Steel Products Standards and Applications

Steel Section	Standard	Application/Comments
Carbon steel and carbon-manganese steel bars	AS 1442, AS 1443	Machine components
Carbon steel and carbon-manganese steel forgings	AS 1448	Machine components
Cold or hot formed carbon and carbon-manganese steel tubes	AS 1450	Circular, square, rectangular and other sections used for machine and fabricated components
Arc-welded steel pipe (butt welded seams)	AS 1579	Water and wastewater pipework and piles
Hot-rolled silicone-aluminium carbon-manganese steel plate	AS 1548	Boilers and pressure vessels
Hot rolled steel flat sheets	AS/NZS 1594	Fabricated components
Cold-rolled un-alloyed sheet and strip	AS/NZS 1595	Fabricated components
Cast steel	AS 2074	Machine components, valve bodies (L-Ni Cr 1563)

32.3.6 Galling of Materials

32.3.6.1 General

Galling can occur when materials (metals) of similar hardness in contact with each other and subject to relative motion ‘pick up’, seize or weld together. It is most prevalent with fasteners which form a protective surface oxide film e.g. stainless steel. Sliding of components can cause the oxides to wipe off exposing interface high points which shear and weld together. Galling can be aggravated by:

- Rubbing components having similar grades of hardness;
- Presence of contaminants between the contact surfaces;
- Excessive load;
- Lack of lubricant;

- (e) Poor surface finish;
- (f) Excessive clearances between mating parts;
- (g) Generation of heat by excessive rotational speed (rev/min) during assembly of fasteners.

32.3.6.2 Galling Mitigation Strategies

As a guide materials should have a significant hardness difference to minimize galling potential. This hardness difference is particularly important for stainless steel fasteners. Stainless steel is particularly susceptible to galling if correct design and installation practices are not followed.

Accordingly to minimize galling of components manufactured from susceptible materials (e.g. stainless steel) designers should employ design practices such as:

- (a) Selection of materials with at least a 50 HBW hardness difference e.g. Grade 431 stainless steel bolts (285 HBW) fitted with Grade 316 stainless steel nuts (217 HBW);
- (b) Ensuring susceptible components are not subjected to contaminants such as grit during fitting or operation;
- (c) Material design loads are of a magnitude below that which would cause galling;
- (d) Use of nickel anti-seize lubricant (grease) when fitting stainless steel fasteners;
- (e) Provision of a suitable surface finish on components e.g. use of rolled threaded stainless steel fasteners in lieu of machined threads (the latter being particularly susceptible to galling);
- (f) Selection of close tolerance bolts and nuts;
- (g) Reduce speed of rotation of fasteners during assembly.

32.3.7 Corrosion Resistant Metal Designation

The following materials are considered to be corrosion resistant for the purpose of this Standard.

Table 32.7 – Corrosion Resistant Metals

Material	Standard	Grade	Comments
Copper alloys (1)	AS 1565 AS/NZS 1567 AS/NZS 1568		Copper alloys shall comply with AS 2345
Stainless steel	-	-	Refer to standards and grades in the Typical Stainless Steel Specifications table later in this section
Duplex (ferritic-austenitic) stainless steels	UNS	S32750 S32304 S31803 S31500	
Phosphor bronze	AS 2738	Alloy 518	
Nickel-copper-iron alloys	AS 2738	Alloy 713	
	ASTM B 127		
	ASTM B 163		
	ASTM B 164 ASTM B 165		
Copper nickel alloy	AS 2738	Alloy 706	
		Alloy 715	

NOTE: Where ASTM standards are being specified the M designation shall be included where relevant e.g. ASTM A480M etc.

32.4 Materials for Sea Water Service

32.4.1 General

Materials for pumps, valves and appurtenances used in seawater applications require careful selection. Materials used for normal waterworks applications may not be suitable in seawater and may suffer severe degradation and reduced performance. The following information should be considered when selecting materials for seawater service or where high chlorides are present in the water.

32.4.2 Resistance to Pitting and General Corrosion in Seawater

For performance of different metals in seawater under different conditions refer to the Resistance to Pitting and General Corrosion table below. The rate of corrosion of metals increases with increase in temperatures.

Table 32.8 – Resistance to Pitting and General Corrosion

Material	Pitting Resistance	Pit Penetration Rate - microns/yr	General Corrosion versus Velocity – approx microns/yr	
			<0.6 m/s	0.6 to 5 m/s
Cast iron, ductile iron	Good	100 - 300	100 - 150	800
Carbon steel	Fair	380 - 760	100 - 150	800
Austenitic cast iron	Good	Refer Note	50 - 75	<200
Gunmetal	Good	130 - 250	25 - 50	125
Nickel aluminium bronze	Good	50 - 230	25 - 50	125
Cupro nickel (70/30)	Good	25 - 230	<25	<25
Cupro nickel (90/10)	Good	25 - 230	<25	<125
Alloy 20	Good	180	Refer Note	Refer Note
Brass (Muntz metal)	Refer Note	Refer Note	10 - 50	10 - 50
Admiralty brass	Good	150 - 300	Dezincification prone - avoid	
Aluminium brass	Good	180	Dezincification prone - avoid	
Naval brass	Good	180	Dezincification prone - avoid	
Monel [®] alloy 400	Fair	180 - 380	<25	<25
Stainless steel 304	Poor	1780	<25	<25
Stainless steel 316	Fair	1780	<25	<25

NOTE: Information unknown

32.4.3 Stainless Steel

Stainless steels are particularly susceptible to pitting corrosion in static seawater due to oxygen concentration cells whereby corrosion occurs at anodic oxygen-depleted areas. For velocities up to 0.6 m/s stainless steels suffer little general corrosion but are subject to pitting and crevice corrosion due to breakdown of passive films e.g. under barnacles etc. For velocities >1.5 m/s stainless steels are corrosion resistant in seawater and acceptable with corrosion rate <25 microns/year.

Stainless steels and copper nickel materials form protective oxide films in aerated waters, which increase protection e.g. higher water velocities are beneficial as more oxygen is available.

32.4.4 Carbon Steel

Plain carbon steel suffers significant general corrosion in seawater and shall not be used unless an effective and durable barrier coating is provided to exclude all contact between the substrate metal and seawater.

32.4.5 Cast Iron and Cast Steel

Cast iron and cast steel suffer significant general corrosion in seawater up to a velocity of 4 m/s with little increase in corrosion rate for higher velocities. Unlike stainless steel they do not form a passive film on their surface (however chemical and biological slimes may attach to surfaces subject to water quality). Accordingly they shall not be used in this service unless an effective and durable barrier coating is provided to exclude all contact between the substrate metal and seawater.

Cast iron and cast steel are oxygen dependent and accordingly will suffer increasing corrosion with reduced oxygen concentrations.

32.4.6 Copper Alloys

For copper alloys increased oxygen concentrations that occur with increased water velocity are beneficial in terms of corrosion however there is a critical velocity at which impingement attack removes the protective film. However this would generally be well in excess of normal valve flow velocities of 5 m/s.

Increased oxygen concentrations are beneficial in providing corrosion resistance for copper alloy materials.

32.4.7 Galvanic Effects

32.4.7.1 General

Ideally the use of similar materials throughout a pump or valve would provide optimal corrosion resistance from galvanic effects although it may not necessarily be acceptable for other reasons e.g. lack of bearing properties, galling potential and cost by way of example.

32.4.7.2 Anodic or Cathodic Selection

Pump wear rings, and valve trim should be more cathodic (more noble) on the galvanic series than their adjacent casings or bodies respectively in order to provide for selective wear ring or trim protection. Accordingly a pump or valve body should not stimulate corrosion of the wear rings or trim.

Anticipating increased corrosion of the more anodic (less noble) material, a relatively large area/heavy walled pump casing or valve body should be constructed of the more anodic material than the wear ring or trim.

Allow for the possibility that very high velocity and turbulent seawater is capable of removing otherwise protective films thus producing anodic corrosion-prone wear rings or trim.

32.4.7.3 Body and Trim Combinations

Cast iron and ductile iron casings or bodies provide protection for all forms of anodic trim.

Bronze pump casings or valve bodies can be safely used with Monel® or 316 stainless steel trim.

Monel®-bodied valves are satisfactory with Monel® trim however bronze and 316 stainless steel trim are not satisfactory, as they are more anodic.

Alloy 20 bodied-valves are satisfactory with Alloy 20 trim however Monel® and 316 stainless steel trim are not satisfactory, as they are more anodic.

32.4.8 Material Combinations in Seawater

The performance of various material combinations for seawater immersion is shown in the following table.

Table 32.9 – Material Combination Performance in Seawater

Component	Material	Standard/Grade	Comments
Valve Body ¹	Cast iron (CI)	AS 1830-T250	Poor corrosion resistance (uncoated) particularly in contact with copper based alloys – subject to graphitic corrosion and cracking
	Ductile iron	AS 1831	Corrosion resistance is as for CI (uncoated) however is better structurally with improved strength and shock resistance
	Carbon steel		Corrosion resistance is as for CI (uncoated) however is better structurally with improved strength and shock resistance
	Austenitic cast iron	AS 1833-L-NiCuCr 15,6,3	Requires stress relief after which provides high corrosion resistance. However copper based alloyed components in contact should be avoided in favour of 316 stainless steel trim
	Gunmetal	AS 1565	High corrosion resistance and the standard non-ferrous material used for seawater systems
	Nickel aluminium bronze	AS 1565 C95810 (AB2)	Good resistance to corrosion and impingement (velocity effect) attack. AB1 is subject to de-aluminification and not recommended
	Cupro nickel	70/30 (Cu/Zn)	High resistance to corrosion and impingement but de-nickelification is possible
	Alloy 20		Very good corrosion resistance overall but must have Alloy 20 trim and be insulated from Cu-alloy components including pipework. Better corrosion resistance to pitting/crevice corrosion than 316 stainless steel
Valve trim ¹	Brass (Muntz metal)	60/40 (Cu/Zn)	Poor corrosion resistance and liable to dezincification
	Naval brass	60/39/0.75 CuZnSn	Better corrosion resistance than Munz and is anodic to gunmetal (body) corrosion/dezincification of the trim
	Nickel-aluminium bronze		Good corrosion resistance
	Monel [®] Alloy 400		High resistance to corrosion and impingement
	Stainless steel	316	Good resistance to flowing seawater. Stagnant conditions will cause pitting
	Stainless steel	410	Poor pitting and crevice corrosion performance and should be avoided

NOTE: Equally applies to pump casings and seal rings where appropriate.

32.4.9 Galvanic Series of Metals and Alloys in Seawater

Designers shall select materials so as to minimize the effect of galvanic corrosion in seawater. The following lists materials with respect to their anodic and cathodic characteristics to each other in descending order:

Table 32.10 – Galvanic Series of Metals and Alloys in Seawater

ANODIC¹ OR ‘LEAST NOBLE’
Galvanized steel
Mild steel
Cast iron and ductile iron
304 Stainless steel (active ²)
316 Stainless steel (active ²)
Austenitic cast iron (Ni-resist)
60/40 Brass
Naval brass
Phosphor bronze
Gunmetal
Cupro-nickel alloy 90/10
Cupro-nickel alloy 70/30
Nickel-aluminium bronze
304 Stainless steel (passive ²)
316 Stainless steel (passive ²)
Monel [®] alloys 400
Titanium
Graphite
CATHODIC OR ‘MOST NOBLE’

NOTES:

1. The materials higher (anodic) in this list will be corroded by those lower in the list.
2. The expressions active and passive refer to stainless steels without and with its protective oxide film respectively.

ACKNOWLEDGEMENT

The information in this section represents a summary of a paper titled “Corrosion of Valves in Seawater” by RW Saville dated 29/3/78.

32.4.10 Valves and Pumps in Seawater

The following should be considered when considering large butterfly valves, large ductile iron gate valves and pumps for use in seawater or brine:

32.4.10.1 Butterfly Valves

Where possible, seal on body butterfly valves should be the preferred type of isolating valve used in seawater. There may be reasons where this is not practicable such as line pigging requirements.

The butterfly valve construction should be 316 stainless steel shaft (or preferably Monel[®]) and aluminium bronze disc (AS 15765 C95810) for flow velocities >1.0 m/s. Below 0.5 m/s severe pitting of the 316 stainless steel shaft may occur if it is wetted (however the shaft is normally isolated from water contact by sealing of the liner). Accordingly for valves in stagnant or normally closed condition a more appropriate shaft and disc fastener material should be selected if there is a risk it is likely to be exposed to the water e.g. Monel[®].

Seal on body butterfly valves are preferred because of their use of corrosion resistant materials in the wetted area in lieu of coated corrosion prone materials which are used in ductile iron gate valves, and seal in body and seal on disc butterfly valves.

32.4.10.2 Ductile Iron versus Austenitic Iron Gate Valves

Large (and small) ductile iron metal-seated gate valves with the standard bronze trim are not ideal for use in seawater. A preferred alternative would be an austenitic cast iron body and gate fitted with 316 stainless steel seat rings and a Monel® stem. This may however not be practicable in terms of capital cost and availability with respect to the austenitic cast iron components.

A more practicable solution could be the use of a ductile iron gate valve fitted with 316 stainless steel seats (providing the seats were not exposed to prolonged stagnant conditions and therefore subject to pitting). For stagnant conditions existing in the bonnet a shaft constructed from a corrosion resistant material e.g. Monel® should be selected. Stem nut and seal components in contact with water should also be appropriately selected e.g. nickel aluminium bronze.

The ductile iron components shall be coated with a fusion bonded polymeric coating which shall be fully effective and with no holidays in the wetted area. Any ductile iron areas and interfaces that cannot be fully and effectively coated shall be constructed from corrosion resistant materials. If pigging through the valve was intended the coating thickness should be of sufficient thickness to withstand erosion due to sand and pigging for the life of the project. Periodic inspections and where required repairs effected to the coating should be undertaken.

32.4.10.3 Seawater Pump Components

For seawater service vertical submersible electric centrifugal pump casings should be manufactured from nickel aluminium bronze. Impellers should be nickel aluminium bronze and the shaft should be Monel®.

End suction and axially split pumps casings should be austenitic cast iron with nickel aluminium bronze impellers with a Monel® shaft for seawater duty.

33 NOISE

33.1 General

The facility shall be designed so that equipment noise complies with the requirements of the Regulations under the Occupational Health, Safety and Welfare Act.

Designs shall comply with all relevant Australian Standards related to noise level procedures and testing requirements for, and the environmental location of the station, in particular, the following:

- (a) Occupational Safety and Health Regulations 1996
- (b) Environmental Protection (Noise) Regulations (1997)

As far as possible, noise levels should be less than those permitted under the Regulations and the need for the use of personal hearing protection should be minimised. Designers and contractors shall take into account the close proximity of residences and the potential impact of noise and frequency of noise generated in continuous operation, and shall ensure that the noise emissions from the facility and during the works do not in any way cause inconvenience to residents.

33.2 Daily Noise Dose for Personnel

The overall maximum sound pressure level within a general plant shall be 85 dB(A) for equipment in areas where virtually continuous presence of plant personnel is required when equipment is operating.

A daily noise dose (DND) of 1.0 shall not be exceeded for any operations personnel within the plant area based on an equivalent to 85 dB(A) for 8 hours.

For emergency short-term conditions, unless otherwise specified, the absolute noise limit (sound pressure level) of 115 dB (A) shall not be exceeded.

The Corporation's policy is that where practicable noise levels shall be less than those permitted under the Regulations and that the need to use personal hearing protection should be minimised.

Where it is not practicable to achieve a DND of 1.0 the area shall be designated a noise hazard area and appropriate signage shall be provided requiring personnel to wear hearing protection at all times. This situation will generally apply in pump stations or other large machinery installations. Sound attenuation of large pumpsets either by the manufacturers during design or by retrofitting sound attenuation is generally not practicable.

33.3 Neighbourhood Noise Levels

Noise attributable to the operation of Corporation facilities and assets shall be within the requirements of the Environmental Protection (Noise) Regulations 1997.

33.4 Acoustic Enclosures

The use of separate acoustic enclosures to reduce the sound levels to those stated will be accepted only after all other practicable means of achieving those noise levels have been investigated. The performance of plant and equipment shall not be prejudiced by the installation of noise attenuation treatment.

33.5 Sound Level Measurements

Sound level measurements, evaluation of results and corrections for background noise shall be carried out in accordance with the procedures in AS 1055, AS 1081 and AS/NZS 1269 at the operating conditions at which the highest level of sound occurs.

33.6 Noise Reduction Strategies

The following noise reduction strategies should be considered in noise sensitive areas:

- (a) Locate the facility to an area which is less sensitive to noise (where practicable);

- (b) Minimise the machinery noise and vibration levels with appropriate design and selection;
- (c) Incorporate sound attenuation of the facility as an integral part of the design;

NOTE: The use of sound enclosures fitted over large items of machinery that require them to be removed for maintenance purposes are not preferred.

33.7 Sound Pressure versus Sound Power Levels (Informative)

33.7.1 Sound Pressure

Determination of sound pressure is dependent on the surrounding environment, background noise levels and the distance the sound pressure is being measured from the noise source. Sound pressure is measured in μPa or Pa.

33.7.2 Sound Pressure Analogy

Measurement of sound from a noise source is analogous to measurement of heat being radiated into a room from an electric heater. By way of example, temperature of a room with respect to the electric heater is analogous to the sound pressure generated from a vacuum cleaner operating in the room. The temperature reading of the room is dependent on the location of the thermometer in the room, which is influenced by proximity to the radiator and the characteristics of the room e.g. size, external ambient temperature, insulation and whether doors and windows are open or closed etc.

This similarly applies to measurement of sound pressure generated from the vacuum cleaner, which is influenced by distance, the characteristics of the environment (e.g. materials and shape of the surrounds) and background noise levels. Accordingly because of the influence of environmental factors, measurement and determination of sound pressure is not necessarily straightforward.

33.7.3 Sound Power

The Corporation generally specifies noise level limits of equipment, particularly for pumpsets, in terms of sound power levels rather than sound pressure levels. This is because sound power can be readily determined and is essentially independent of the surrounding environment and background noise levels. Sound power is measured in Watts.

33.7.4 Sound Power Analogy

Using the electric heater analogy referred to above, power from the electric radiator can be readily measured with a wattmeter and its value is independent of the environment. Similarly sound power, which can also be readily measured, is independent of distance, the environment and background noise levels.

33.7.5 Sound Pressure and Sound Power Relationship

Sound pressure levels may be determined from sound power measurements however the reverse is generally not practicable e.g. sound power cannot readily be determined from sound pressure measurements.

Further information regarding sound power and sound pressure is contained in the 'Glossary' in DS 30-01.

34 OCCUPATIONAL SAFETY AND HEALTH

34.1 General

Legislation compels employers and employees to follow safe practices regarding safety and health in the workplace. Accordingly mechanical assets shall be designed to facilitate safe operational and maintenance practices.

All equipment shall comply with the requirements of the Commission for Occupational Safety and Health and Work safe Western Australia in obtaining all necessary approvals, certificates, permits and the like.

All proprietary equipment shall be designed to afford maximum protection and safety for operating personnel. Safety equipment shall include signage, guards, access covers, inspection covers, emergency stop equipment, safety interlocks, and other devices as specified or implied by any statutory authority having jurisdiction.

34.2 Safety Standards

The following general safety standards shall apply to the design:

- (a) The Dangerous Goods Regulations,
- (b) AS 1318 SAA Industrial safety colour code,
- (c) AS 1319 Safety signs for the occupational environment,
- (d) AS 1470 Health and safety at work – principles and practices,
- (e) Work safe Occupational Safety and Health Act 1984,
- (f) Work safe Occupational Safety and Health Regulations 1996,
- (g) Work safe Commission Code of Practice.
- (h) S151 - Prevention of Falls Standard,
- (i) WC OSH 108 – Safe Working in Confined Spaces Procedure;
- (j) Corporation’s WC-OSH 109 Tagging and Isolation Procedure;
- (k) “Safety in Design” Storybook (Corporation publication).

34.3 Duty of Care

The Corporation has a duty of care with regard to its employees and other members of the community and accordingly Designers shall provide designs taking into account but not limited to the following:

- (a) Safe working environment in terms of air quality, engulfment, access, noise, vibration, tripping hazards etc.
- (b) Safe access to equipment during operation and maintenance by way of appropriate platforms, ladders and walkways.
- (c) Safe access clearances around equipment.
- (d) Safe operating torque for manual actuation e.g. a maximum of 100 Nm maximum torque.
- (e) Safe operating positions for hand wheels and controls e.g. hand wheel operating height of 900±150 mm.
- (f) Safe guarding of moving or high temperature equipment.
- (g) Safe control and interlocking of automated equipment.
- (h) Appropriate signage for various hazards.
- (i) Appropriate signage for facilities, machinery and associated electrical switchboards.

- (j) Appropriate backflow prevention devices to protect the potable water supply.
- (k) Proper lighting.
- (l) Adequate ventilation.
- (m) Safe manual handling facilities.
- (n) Compliance with Dangerous Goods Regulations.
- (o) Provision of fire extinguishers or fire control systems.
- (p) Operator facilities such as desk, toilet and hand basin as required.
- (q) Recommended training of personnel on new technology or specialized and unfamiliar equipment.
- (r) Provision of operations and maintenance manuals for new facilities and all relevant equipment.
- (s) Safe working conditions with respect to prevention of falls,
- (t) Safe working conditions with respect to confined space.

35 PIPEWORK

For information relating to mechanical pipework design criteria the Designer should refer to DS 31-01 and for information related to valves refer to DS 31-02.

36 PITS AND CHAMBERS

36.1 General

The first and most important consideration should be to avoid the use of a below ground pit or chamber if it is at all feasible in favour of provision of an above-ground facility.

NOTES:

1. An above ground installation removes confined space; personnel access; stairways, walkways ladders, landings and handrails; equipment accessibility, drainage, prevention of falls and other issues (e.g. reduced cost) associated with below-ground facilities.
2. The following requirements are not intended to apply to below ground chambers associated with dry well, submersible or vacuum sewage pump stations.
3. For valve pits this section of the Standard should be read in conjunction with the additional requirements contained in 'Valve Pits and Chambers' section contained in DS 31-02.

36.2 Pit (Chamber) Requirements

36.2.1 Access

The pit or chamber shall comply with S151 and in particular to the 'Valve/Pump/Instrument Equipment Pits' section. Large pits should be designed for access via stairways rather than ladders. Use of handrails, stairways and ladders shall take preference over fitting metal grating over the top of a pit (Note 1). Suspended flooring and covers shall comply with DS 100.

The pit (chamber) shall be sized to provide adequate clearance around equipment for operation and maintenance and for removal of components.

Handrails, stairways, walkways and ladders shall comply with S151. They shall not interfere with the location of equipment, access to it and removal of components for maintenance purposes.

Well liners shall not be used as pits or chambers for installation of equipment that has ongoing access and servicing requirements (Note 2).

NOTES:

1. Overhead metal grating introduces problems with respect to its removal during maintenance of equipment. There is then an issue of safety with respect to the open pit once the grating is removed with respect to prevention of falls necessitating temporary barrier fencing etc. Grating also tends to support the proliferation of spiders and their webs within the chamber.
2. Small well liners do not provide acceptable access during installation of components and later for access by maintenance personnel. Also an earthen floor allows weeds to proliferate and fill the liner requiring their removal prior to valve adjustments or maintenance.

36.2.2 Flooring

The floor of the chamber shall be concrete, graded to provide drainage into the sump. The floor shall be provided with an anti-skid surface if slippery conditions are likely to occur (e.g. formation of algae), or where specified by the client be fitted with a floor grating. Floor grating shall be installed 25 mm above the concrete floor and comply with the requirements of DS 100. A hose tap shall be provided to allow the concrete floor to be cleaned to reduce potential slipping hazards.

36.2.3 Drainage

- (a) The top of the pit (chamber) shall be raised a minimum of 300 mm above the finished level of the adjacent ground to prevent ingress of surface water runoff.
- (b) Pilot control valve drain pipes which discharge water after every operation shall have the drain water piped directly into a sump.
- (c) Where a drainage sump is provided (larger facilities) it shall be generously sized so that flip balls do not foul the pump e.g. 500 mm minimum size unless alternative control sensors such as electrodes are used.

- (d) Small valve pits shall be provided with two 300 mm x 300 mm open drainage sumps filled with crushed rock and fitted with 'Webforge' grating covers.

36.2.4 Lighting, Ventilation and Sunlight

The pit shall be well ventilated and where required fitted with a sunshade to screen sensitive equipment from direct sunlight e.g. magnetic flow meters.

Permanent fluorescent lighting shall be provided where appropriate in order to allow servicing at night or for low light conditions.

NOTE: Lighting would subject to availability of a permanent power supply.

36.2.5 Instrumentation, and Labelling

- (a) Instrumentation, gauges and associated equipment shall be mounted on the wall of the chamber between 700 mm and 1000 mm above the working floor level.
- (b) All equipment shall be labelled in accordance with the Labelling of Equipment and Pipework that is contained in the Signage and Labelling section of this Standard.

36.3 Lifting Requirements

Pits shall be designed so as to allow access via a vehicular crane to reach to all large items of equipment and their components. Where heavy components require lifting from underneath e.g. large radial valves, a lifting arrangement shall be provided as part of the pit design.

37 PUMP STATIONS

For information relating to pump stations the Designer should refer to:

- DS 32 for major pump stations;
- DS 32-01 for borehole pump stations;
- DS 32-02 for small (packaged) booster pump station.

38 PREFERRED EQUIPMENT

For information relating to preferred equipment the Designer should refer to the Strategic Products Register.

39 QUALITY

39.1 Quality Assurance

The processes for design, manufacture, supply, transportation, handling, delivery, storage and installation work associated with Corporation mechanical infrastructure shall form part of one or more documented quality management systems. Each system shall, individually or collectively, provide for identification and traceability, control of production, transportation, handling, delivery, storage, installation, customer verification and control of all associated documents and records and shall be certified by a Certification Body as complying with the requirements of AS/NZS ISO 9001.

Where a Corporation's Strategic Product Specification has been published for a particular product, the Quality Assurance clause contained therein including requirements for the following shall also apply:

- (a) Certification of product
- (b) Quality system
- (c) Product reverification
- (d) Means of demonstrating product compliance
- (e) Product acceptance criteria
- (f) Manufacturing repairs in process
- (g) Product warranty
- (h) Product repair

40 SEALS

40.1 Packed Glands

40.1.1 General

Packed glands or stuffing boxes have been the traditional method used for sealing fluid leakage from valves and pumps. However the water industry in Australia has moved away from the concept of constantly leaking valve packed glands in favour of drip-tight elastomeric sealing e.g. O-rings seals for large gate valves and screw down fire hydrants. Further the Corporation has increasingly used mechanical seals into its pumps in lieu of packed glands.

40.1.2 Advantages of Pump Packed Glands

The few virtues of a packed gland would be that they don't fail catastrophically compared with a mechanical seal and that they can be serviced in-situ without major disassembly of the pump. This may be a consideration for remote locations where expertise and spares may be an issue. However the advent of the split mechanical seal dilutes this argument.

40.1.3 Disadvantages Pump Packed Glands

Disadvantages in using packed glands in pumps are as follow:

40.1.3.1 Maintenance

- (a) Pump packed glands have an ongoing maintenance requirement. For them to operate properly it is necessary to provide a continuous controlled leakage through the gland. This is to avoid overheating of the packing and consequent damage to the shaft sleeve.
- (b) Ongoing maintenance is not restricted to regular gland adjustment but also involves ancillary items particularly relating to sewage (but not restricted to) such as blocked drainage holes, drainage pipes and tundishes, cleaning of sumps, servicing of sump pumps, vermin control and corrosion treatment of spray affected housings. There is also the issue of contamination and odour in sewage pump stations due to gland leakage or spray (for severe leakage).

40.1.3.2 Wear

Packing wears shaft sleeves which require replacement when leakage rates exceed acceptable rates. This is costly exercise often necessitating premature replacement of other components as a matter of course whilst the pump is down e.g. bearings and wear rings.

40.1.3.3 Power Consumption

Pump packed gland have a six times higher power requirement than mechanical seals.

40.1.3.4 Product Leakage

- (a) Leakage occurs in glands for both vacuum and pressure and can be wasteful of the product and efficiency.
- (b) Leakage requires the product to be piped away and dealt with and in the case of sewage creates an unnecessarily messy and smelly installation with an additional equipment requirement such as sump pumps, valves and control equipment. Sumps are also a source of vermin such as cockroaches.
- (c) Gland leakage can directly cause bearing failure if excessive leakage is directed at the bearing housing.

40.1.4 Packed Gland Requirements

Pump packed gland should embody the following features:

- (a) Corrosion resistant gland follower, lantern ring, studs, nuts and shaft sleeve components.

- (b) Internal or external flushing (as dictated by the manufacturer) from the pump discharge directed through the lantern ring. Flushing pressure should be a minimum of 1 bar above the stuffing box internal pressure.
- (c) An external clean water flushing source should be specified for dirty water; a suction lift exceeding 3 m or a discharge head less than 7 m.
- (d) Packing ring material which in accordance with manufacturer's recommendations, appropriate for the sealing application. Die cut packing rings are preferred for optimal performance due to their dimensional accuracy.
- (e) A minimum of 5 rings of packing with the lantern ring located between the 2nd and 3rd packing rings for clean water applications. Dirty water applications would benefit from the lantern ring being located between the 1st and 2nd packing rings. Packing rings should be staggered by 90° to prevent a leakage path forming.

NOTE: The first two packing rings adjacent to the gland receive the highest compressive stress and this translates in them producing the highest rate of wear on the shaft sleeve e.g. approximately 70% of the total packing ring wear. The additional packing rings are required as backup in case of failure of one of these rings.

40.2 Mechanical Seals

40.2.1 General

Mechanical seals shall be the preferred method of shaft sealing for rotodynamic machinery such as pumps (in lieu of packed glands). The following information mainly relates to requirements for the use of mechanical seals in centrifugal pumps. For other seals such as seals relating to anti-friction bearings refer to the 'Bearings' section of this Standard.

40.2.2 Inside-Mounted Single Rotating Mechanical Seals

40.2.2.1 Arrangement

Inside-mounted single rotating mechanical seals have only one set of sealing faces in conjunction with a spring or springs that rotate with the shaft and with the sealing components immersed in the pumped fluid (in most Corporation applications). Apart from submersible sewage pumps (which generally use tandem seals immersed in an oil chamber) this would be the most commonly used seal type in the Corporation's water and wastewater pumping applications.

40.2.2.2 Features

Features of this seal type are that it is relatively cheap, centrifugal force tends to throw solids away from critical components and the O-ring seals are able to move on a clean shaft surface in order to accommodate axial wear of the seal faces. Since the critical components are immersed in water they are required to be corrosion resistant.

40.2.2.3 Disadvantages

Disadvantages would include the requirement for closely-controlled manufacturing tolerances on mating pump components, time required by having to dismantle the pump and expertise required to carry out the fitting work.

40.2.3 Multiple Seals

40.2.3.1 Arrangement

Multiple seals have more than one set of sealing faces e.g. seals arranged in tandem as used in submersible sewage pumpsets for Corporation pump stations. Tandem seals comprise two separate sets of seals arranged one behind the other with a low pressure chamber between them.

40.2.3.2 Features

Tandem seals are used in critical situations e.g. a secondary seal provides backup protection for a pumpset electric motor in the event of the primary seal failure. Condition monitoring sensors within the chamber can detect failure of the primary seal allowing repair when convenient.

40.2.3.3 Back-to-Back and Face-to-Face Seals

Back-to-back and face –to-face sealing are not preferred as failure of common critical component may not provide the required redundancy.

40.2.4 Cartridge Seals

40.2.4.1 Arrangement

Cartridge seals are designed for use in a conventional centrifugal pump stuffing box. They are pre-assembled (self-contained) inside-mounted single rotating seals with an integral sleeve that is secured to the pump shaft externally to the seal chamber and with preloaded seal faces. Cartridge seals are commonly used in Corporation pumps.

40.2.4.2 Features

Cartridge seals are easy to install compared with the more complex conventional mechanical seal. The cartridge seal, being self-contained, do not rely to the same degree on accurate machining and precise alignment and concentricity of the pump components as for the conventional seal.

40.2.4.3 Cost Comparison

Cartridge seals are however initially more expensive than conventional single seals. On a life cycle cost basis however they could be much cheaper.

40.2.5 Split seals

40.2.5.1 Arrangement

Split seals are designed to be diametrically split in order to facilitate fast installation and removal from the pump without disassembling any of the pump components.

Split seal elastomeric components such as O-rings shall not use gluing or high tolerance fitting as the method of assembly but shall have a mechanical connection such as a ball and socket push fit.

40.2.5.2 Features

Split seals shall be able to handle the dynamic cycle of vacuum to pressure. The Corporation uses split seals on large sewage pumps to obviate disassembly of pump components which is time consuming, expensive and could pose an operational risk in terms of pump redundancy.

40.2.5.3 Life Cycle Cost

As with the cartridge seal split seals are initially more expensive, however properly applied they can be life cycle cost effective and operationally efficient.

40.2.6 Unbalanced Seals

40.2.6.1 Arrangement

A rotating mechanical seal is subject to internal hydraulic forces in the stuffing box. An opening force tends to separate the seal mating faces and a closing force (acting on the back of the rotating face) tends to force them closed. An unbalanced mechanical seal is one where the back of the rotating face has its full area exposed to the closing pressure thus producing a closing force of approximately twice the opening force.

40.2.6.2 Limitations

The relatively high closing force of an unbalanced seal can cause excessive heat generation and wear between the seal mating faces and this requires operating limits to be set for the unbalanced seal. Factors involved are shaft speed, fluid viscosity, temperature, shaft size, stuffing box pressure and face material.

40.2.6.3 Disadvantages

There are no advantages in using an unbalanced seal compared to a balanced seal in fact there are only disadvantages e.g. they can open under vacuum and have operating limits as mentioned. In most

Corporation applications stuffing box pressure would be the major limiting factor and unbalanced seals should generally not be used in excess of 30m.

40.2.7 Balanced Seals

A balanced seal is one where the back of the rotating face has a reduced area exposed to the closing pressure thus producing a smaller closing force, which reduces the load on the seal mating faces. Balanced seals generally have approximately 70% of the face area exposed to the closing pressure. A balanced seal requires a stepped sleeve and is of similar cost to an unbalanced seal (apart from the sleeve). Balanced seals are more versatile and can operate from vacuum through to pressure.

40.2.8 Seal Materials

40.2.8.1 Metallic Components

Metal components in contact with water shall be of grade 316 stainless steel material minimum.

40.2.8.2 Springs

Springs in contact with water shall be of a material that will not be subject to corrosion e.g. Hastelloy C®. Stainless steel shall not be used for springs because it is susceptible to chloride stress corrosion.

40.2.8.3 Seal Faces

Seal faces for most applications should be low friction face combinations (soft face on hard) and specifically unfilled carbon graphite (rotary) and ceramic or silicon carbide (stationary). For abrasive fluids it is necessary however to use high friction face combinations (two hard faces) and specifically silicon carbide on silicon carbide (which is preferred to tungsten carbide on tungsten carbide).

40.2.8.4 Elastomers

Elastomers for water and wastewater applications should be Ethylene propylene rubber (EPDM) or Nitrile-butadiene rubber (NBR) or Fluorocarbon rubber (FPM).

40.2.9 Seal Flushing

The term flushing related to mechanical seals is often used (perhaps erroneously) to cover a number of different methods of providing fluid to a centrifugal pump stuffing box for cooling and removing solids etc from the seal area. The methods include suction recirculation, discharge recirculation, flushing, barrier fluid, jacketing fluid and finally quenching or vent and drain. Barrier fluid, jacketing fluid and quenching or vent and drain will not be addressed here as they have limited or no use in the Corporations applications.

40.2.9.1 Suction Recirculation

Suction recirculation involves a hard piped connection from the bottom of the stuffing box (or mechanical seal gland connection) to the suction of the pump. The higher discharge pressure in the gland (fed from the discharge volute) will circulate fluid from the stuffing box to the pump suction. The fluid is relatively clean having been in-effect centrifuged by the pump impeller. Suction recirculation would be the preferred method for removing solids from the seal area and to provide cooling (providing the fluid is not hot water which would not normally be the case for Corporation applications).

For balanced O-ring mechanical seals the removal of accumulated solids would be the only requirement as they generally don't have to be cooled. Unbalanced seals could have the dual requirements of removing solids and cooling. The configuration comprises a close clearance neck bush and pipework to the suction connection, incorporating an orifice and venting for vertical pumps to eliminate air or gas accumulation.

This arrangement shall comply with API Plan 13.

40.2.9.2 Discharge Recirculation

Discharge recirculation involves a hard-piped connection from the discharge of the pump to the stuffing box or mechanical seal gland connection in conjunction with throttling neck bush at the impeller side of

the seal. The pump discharge pressure causes re-circulation of fluid through the stuffing box then through to the back of the pump impeller.

This arrangement shall comply with API Plan 11.

Whilst this is a common flushing method used in the industry it has the potential of transporting any suspended solids (which have been centrifuged to the discharge by the impeller) into the stuffing box. This can cause damage to the components due to high velocity impingement of particles onto the seal, wearing of close clearances and clogging of seal components. A cyclone separator upstream of the stuffing box should be the preferred method seal flushing for fluids containing suspended solids such as source waters or water containing sand from degraded cement mortar lining e.g. Goldfields pipeline.

This arrangement shall comply with API Plan 31 (basically Plan 11 including a cyclone separator).

40.2.9.3 External Flushing

External Flushing involves injecting cool clean fluid from an external source at 1 bar higher than the stuffing box pressure in the area of the mating faces in order to lower the temperature or to remove suspended solids or both. Balanced O-ring mechanical seals have a solids removal requirement only as they generally don't have to be cooled. Unbalanced seals could have the dual requirements of solids removal and cooling. For Corporation applications external flushing would normally be limited to sewage and sewage treatment pumping applications possibly using reclaimed effluent. If the drinking water supply was the external source it would have to be fitted with appropriate backflow prevention devices.

This arrangement shall comply with API Plan 32.

40.2.10 Seal Venting

Venting shall be provided for vertically oriented pump upper mechanical seals in order to remove air or gas that could otherwise accumulate with the potential to cause overheating of mating faces and the premature seal failure.

40.2.11 Cyclone Separators for Seals

As mentioned earlier cyclone separators are fitted upstream of a pump stuffing box for discharge recirculation systems in order to remove solid particles in suspension that otherwise could be detrimental to the mechanical seal.

40.2.12 Summary of Mechanical Seals Requirements

The following table summarises the requirements for mechanical seals used in Corporation water and Wastewater applications.

Table 40.1 – Mechanical Seals for Water and Wastewater Applications

Item	Water	Wastewater
1. Temperature	<100°C	<50°C
2. Seal type	Single seal	Single seal, or in tandem
	Cartridge seal	Cartridge seal
	Split seal ³	Split seal
3. Arrangement	Unbalanced or preferably balanced	
	O-ring secondary seals	
	Rotating spring in contact with fluid or internal springs and seal faces	
4. Flushing	No flush connections but with internal circulation; or suction or discharge ¹ recirculation.	No flush connections but with internal circulation; or suction recirculation ² ; or external flushing
5. Venting of upper seal	Vertical pumps	
6. Materials:		
• Stationary face	Ceramic ⁵ , silicon carbide ^{5,6} , tungsten carbide ⁵	
• Rotating face	Carbon graphite ⁵	Silicon carbide ^{5,6} , tungsten carbide ⁵
• Secondary seals (O-rings)	EPDM, FPM	EPDM, NBR ⁴ , FPM
• Spring/springs	Hastelloy C [®]	
• Other components	316 Stainless steel	
7. Applications:		
• End suction centrifugal pump (radially split)	Single seal, Cartridge seal	Single seal, Cartridge seal
• Axially split centrifugal pump	Single seal, Cartridge seal Split seal ³	Single seal, Cartridge seal, Split seal
• Helical rotor pumps	Single seal	Single seal

NOTES:

- Not preferred but if used the discharge recirculation pipe should be fitted with a cyclone separator to remove grit particles in suspension.
- Discharge recirculation should not be used on sewage applications.
- Split seals are not normally used for Corporation water applications due to the relatively low maintenance frequency but they can equally be used as for the other types if there are advantages in doing so.
- Where hydrocarbons are present.
- Solid materials shall be used in the seal manufacture e.g. not coated
- Silicon carbide should be supplied in preference to tungsten carbide

ACKNOWLEDGEMENT:

“The McNally Technical Series was used as reference material for the Sealing section”

41 SECURITY

Corporation facilities shall be assessed by the Designer in accordance with the Water Corporation’s DS 62 Security Treatments Standard and Guidance Notes for Security Treatments. In the interests of maintaining proper security protocol all requirements of this standard should, in the first instance be directed to the Corporation’s Security Program Manager, Steve McCarthy, on 9420 3879, mobile 0427 195 536, fax 9420 2656 or at steve.mccarthy@watercorporation.com.au.

42 SIGNAGE AND LABELS

42.1 General

Corporation facilities shall be provided with adequate and proper signage and all machinery and plant therein identified with labels prior to commissioning, and in accordance with the following requirements.

42.2 Safety Signs

Safety signs shall be installed for the following:

42.2.1 Hazchem Signs

Where necessary and/or as required by the relevant statutory regulations hazchem signs shall be supplied and installed. Hazchem identification signs shall be provided at facilities as required for each relevant hazardous chemical. Relevant signs shall be mounted at the front gate and also at the location of the hazardous chemical.

42.2.2 Statutory Requirements

Where necessary and/or as required by Worksafe Western Australia safety signs shall be supplied and installed e.g.:

- (a) HEARING PROTECTION MUST BE WORN
- (b) HAND PROTECTION MUST BE WORN
- (c) PROTECTIVE BODY CLOTHING MUST BE WORN
- (d) SAFETY FOOT PROTECTION MUST BE WORN
- (e) SAFETY GOGGLES PROTECTION MUST BE WORN etc

42.2.3 Hazard Identification

Safety signs shall comply with AS 1319.

Signs shall warn of potential hazards, assist in preventing accidents and give operational and emergency procedures for potentially hazardous situations. Signs shall provide warnings where equipment may start automatically, where equipment may move without warning and where other potential hazards such as high temperature may occur.

Noise hazard signs where required shall be placed at entry points into the building or area where the noise hazard exists.

42.2.4 Electric Interlocks

Where electrical interlocks are required labels shall be provided which shall describe the operation of the interlock. The labels shall be permanently fixed with 316 stainless steel fasteners and shall be clearly visible from the operating position or walkway.

42.2.5 Automatic Equipment

Automatic equipment shall be provided with a metal sign painted white, of minimum dimension 1000 mm x 500 mm with 50 mm red lettering stating:

"THIS <EQUIPMENT> STARTS AUTOMATICALLY"

e.g. "THIS PUMP STARTS AUTOMATICALLY"

42.3 Labelling of Equipment and Pipework

- (a) All major items of equipment or critical equipment shall be clearly labelled with their respective identification in accordance with the P&ID's;
- (b) Labels shall be secured either with 316 stainless steel self-tapping screws, or with Scotch Mount 4031 durable coated foam tape;
- (c) All valves shall be numbered in accordance with the P&ID's with 316 stainless steel tags and wire;
- (d) Pipework identification shall comply with the pipework identification 'line number' designation in accordance with DS 80.
- (e) Process pipework colour marking shall be in accordance with section 5 'Standard Colour Coding for Pipework' contained in DS 80 (Drawing EG71-1-1). Pipework identification shall be via colour banding and not fully painted. Exposed PVC pipework shall be painted to prevent ultraviolet degradation;
- (f) All cranes and monorails shall be labelled with the Working Load Limit (WLL)
- (g) All machinery shall be functionally identified with a plaque mounted at the mid-to-lower level of the machine either on the baseplate or immediately alongside e.g. PUMP 1, COMPRESSOR 1, ALUM DOSE PUMP 1 etc. (Refer Note below)
- (h) The identification plaque shall use identical terminology to that provided on the electric motor switchboard in order to avoid confusion during lockout and subsequent maintenance.
- (i) Lettering shall be black on a white background and a minimum of 75 mm high.
- (j) Operational information e.g. OPEN/CLOSE (valve direction of closure) etc shall be provided.

NOTE: Identification labels or plaques should not be attached to a machine, or fitted to removable covers, or to a removable component as subsequent changes could lead to incorrect labelling and identification e.g. due to maintenance.

43 SITE CONDITIONS AND SELECTION

43.1 General

The following ambient operating conditions and factors should be determined for the site (where applicable):

- (a) Ambient temperature range;
- (b) Altitude;
- (c) Maximum humidity – The maximum monthly average index of mean relative humidity should be quoted where relevant;
- (d) Operating environment in terms of presence of dusty, cyclonic or coastal (salt laden air) conditions, buried service, immersion etc;
- (e) Operating fluid temperature and total dissolved solids (TDS);
- (f) Thunder and lightning – the thunder day rating in terms of days per year should be specified where relevant;
- (g) Average annual rainfall and month when maximum monthly average occurs should be specified where relevant;
- (h) Vandalism risk;
- (i) Neighbourhood noise considerations;
- (j) Presence of hazards e.g. chemicals etc.

43.2 Temperature

All mechanical equipment shall be rated for operation in working and ambient temperatures of 60 °C.

43.3 Operating Periods

Unless otherwise specified all equipment shall be designed to satisfy the following operating and maintenance criteria:

- (a) Equipment shall be rated to operate continuously 24 hours per day, for no less than 350 days per year, at full rated load, for up to 20 years, at the site.
- (b) Equipment shall be capable of performing the specified duty with minimal maintenance during 350 days operating period in any one year.

43.4 Site Selection and Design

43.4.1 Selection

The following should be considered when selecting and designing a Corporation plant or equipment site layout e.g. pump station or valve complex etc:

- (a) The site location shall be as far as practicable from residential properties and where possible surrounded by public open space to minimise noise or odour nuisance. This is particularly important when doors and covers may be open during maintenance.
- (b) The site shall size to accommodate all the amenities e.g. pumping station, transformers, switchboards, water treatment equipment, surge vessels, valve and pipework pits, access roadways and if required a vehicle turning area, any embankments where filling is involved etc. There shall be a minimum of 1 m clearance between major equipment and site fencing.

43.4.2 Design

43.4.2.1 Surface Treatment

- (a) The site shall be compacted, levelled, bitumen sealed, kerbed and drained unless local circumstances require the use of other materials, in which case the matter shall be discussed with the Corporation. Surfaces shall be uniformly graded for storm water runoff and shall be free of local depressions. The kerbing shall be continuous mountable kerbing 135mm high by 250mm wide.

NOTE: The bitumen sealing is required to eliminate bare sand which produces weeds requiring regular pulling or environmentally unfriendly weedicide control.

- (b) Trafficable areas shall be paved to take the loads imposed by maintenance vehicles. Design axle loads shall be A14 as defined in the National Association of Australian State Road Authorities (NAA SRA) Bridge Design Specification.
- (c) Earthworks on sites shall be stabilised to prevent wind or water erosion. The sites shall be suitably landscaped to conform to the immediate surroundings.

43.4.2.2 Access

- (a) Access and parking for a maintenance truck shall be provided for installation and removal of equipment within buildings. Truck mounted crane access shall be provided for installation and removal of equipment within external pits or chambers. The access to each site shall be designed to minimise traffic hazards on public roads caused by vehicles entering or leaving the site.
- (b) The parking space provided shall take into account the location of the site relative to the public road. Pedestrian traffic shall be able to pass the site at all times without encroaching onto the roadway.
- (c) Crossovers from the road to the site shall be located and constructed to the requirements of the local authority controlling the road. The site access roadway shall finish at the same level as the crossover that it abuts.
- (d) To assist with the removal of equipment, the maximum distance from the roadway to the centre line of the most remote item of plant shall be 3.0 m. Where it is necessary to provide a vehicle turning area within the site, the minimum outside turning radius shall be 12.8 m.

43.4.2.3 Security and Protection

- (a) Where a site needs to be enclosed with a fence it shall be appropriate with the level of security required of the facility as assessed in accordance with DS 62. If a fence is required in a residential area it should match the type of fencing used on adjoining properties subject to security requirements. Where pine-post and rail barrier fencing is required, removable bollards shall be provided across the access roadway. The gate shall be recessed if there exists the likelihood of the tray of the maintenance truck will overhang the public roadway whilst it is parked prior to opening the gate.
- (b) Buried service valves and other appurtenances shall be protected from vehicular traffic movement around the site by use of bollards and other means. Where there is likely to be a proliferation of bollards other means should be considered e.g. barriers.

44 STAIRWAYS, WALKWAYS AND LADDERS

44.1 General

Access stairways, landings, walkways and ladders shall be provided as required for access to and operation of equipment and shall be designed and installed in accordance with the following:

- (a) AS 1657;
- (b) The Commission for Occupational Safety and Health's 'Code of Practice' relating to 'The Prevention of Falls at Workplaces';
- (c) The Corporation's 'Prevention of Falls Standard S151',
- (d) DS 100 for suspended grid mesh and chequer plate flooring for pedestrian, equipment and vehicular loads as well as ladders and stair treads; and
- (e) With the following specific requirements.
 - (i) The surface finish of handrails and ladder styles shall be smooth and free from projections likely to cause injury.
 - (ii) Automatic closing safety gates shall be provided on hand railing at stairway and vertical ladder openings. Automatic closing safety gates used for machinery transport access (not personnel access) through the hand railing at openings shall incorporate a bolted latch to secure it when not being used e.g. at the top of drywells
 - (iii) Step-through ladders shall be provided in preference to side access ladders.
 - (iv) Ladder cages and fall injury protection systems shall comply with S151.
 - (iv) Location of handrails, stairways, walkways and ladders shall not interfere with the access to, or removal of equipment or components for operation and maintenance.

44.2 Materials

44.2.1 Steel

Steel access stairways, landings, walkways and ladders shall be hot-dip galvanized after fabrication in accordance with the 'Coatings' section of this Standard.

44.2.2 FRP

- (b) Where these structures may be exposed to chemicals corrosive to steel, such as in chemical bund areas, appropriately selected FRP structures shall be used. This is particularly important in areas where corrosive gases can accumulate, such as wastewater pump station wet wells. Table A2-1 of DS 100 lists suitable walkway material for use in various environments. This table makes the assumption that only intermittent contact is made with these chemicals in the case of spillage, after which it is washed; the material may not necessarily be suitable for immersion.
- (c) The basic Webforge FRP system is a glass fibre-reinforced polyester resin. For greater corrosion resistance to acidic, caustic or solvent environments a glass-reinforced vinyl ester resin can be used.

44.2.3 Stainless Steel

(Stainless steel will generally be a suitable replacement, at a higher cost, for applications where mild steel is shown as suitable but better environmental corrosion resistance is required.

44.2.4 Aluminium

Aluminium is not generally suitable for the majority of our applications due to its high reactivity and tendency to preferentially corrode when in contact with other steel structures when externally exposed.

NOTES:

1. Large spills of ferric and aluminium salts tend to form loose scales when dried, which can be slippery. These are generally too thick for non-slip coatings to be of benefit.
2. FSA attacks glass, so FRP should be inspected following a spill and replaced if the resin encapsulating the glass does not appear sound.
3. Particular attention to non-slip surfaces is required on walkways that may encounter spills of this chemical.

44.3 Ladders versus Stairways

44.3.1 Ladders versus Stairways

In accordance with S151 the use of ladders should be avoided. Preference should be given to ramps or stairways due to the following non-desirable properties of ladders:

- (a) They inhibit the ready movement of personnel particularly where emergency evacuation is required.
- (b) They have an increased slipping and falling hazard over stairways e.g. if personnel are carrying tools, documents etc.
- (c) They require higher physical exertion by personnel than stairways.

44.3.2 Step Iron Ladders

A step-iron ladder should only be used where the vertical rise does not exceed 1 m and it is not reasonably practicable to use any other type of ladder.

45 STATUTORY AUTHORITIES

Design and construction of all Works shall comply with the requirements of relevant statutory authorities, which may include but not be restricted to the following:

AlintaGas

Austel

Commission for Occupational Safety and Health

Department of Agriculture

Department of Environment and Regulation

Department of Parks and Wildlife

Department of Health

Department of Industrial Affairs

Department of Industry and Resources (DOIR)

Department of Land Information

Department for Planning and Infrastructure

Environmental Protection Authority (EPA)

Fire and Emergency Services Authority of W.A. (FESA)

Heritage Council of WA

Land Information System, Western Australia (WALIS)

Local government councils or shires

Office of Energy, Western Australia

Office of Road Safety

Main Roads Western Australia

Police WA

Swan River Trust

Water Corporation

Waters and Rivers Commission

Western Power Corporation

Work Safe Western Australia, etc.

46 SURGE VESSELS

For information relating to:

- Air cushions and surge tanks refer to DS 35;
- Surge vessels refer to DS 35-01.

47 TESTING

47.1 General

Mechanical equipment shall have been subject to type testing of its design to an appropriate standard (where they exist). Equipment production tests shall be conducted at the manufacturer's works to validate performance prior to dispatch.

47.2 Engines

Diesel engine testing shall comply with 'Testing' clause in the 'Diesel Engines' section of DS 35.

47.3 Pumps

Acceptance testing of production and engineered pumps shall comply with the relevant pump strategic product specification contained in Section 7.1.10 of DS31-01.

47.4 Valves

Acceptance testing of production and engineered valves shall comply with the relevant valve strategic product specification contained in Section 7.1.10 of DS31-01.

48 TRANSMISSION DRIVES

48.1 General

Transmission drives for major equipment should be via direct coupling using a proprietary type flexible coupling. Alternative types of transmission e.g. line shaft or vee belt shall be referred to the Corporation for approval and would only be approved for special circumstances.

Safety guards shall be fitted to all hazardous components of transmission drives in accordance with the 'Guards' section of this Standard.

48.2 Flexible Couplings

- (a) All flexible couplings shall be radially, angularly and longitudinally flexible. Coupling halves shall be able to be disconnected without removing the hubs from the driver or driven shafts e.g. to run the motor independent of the driven machine e.g. pump.
- (b) Pin and bush type couplings shall be preferred for general applications.
- (c) Transmission couplings shall be designed using the appropriate service factors. They shall be based on a minimum service factor of 1.5 based on the rated motor power, or if greater, the braking torque.
- (d) Where a space is required between the two shafts, in order to allow removal for maintenance purposes (e.g. back pull out centrifugal pumps), the equipment should be fitted with a spacer type flexible coupling.
- (e) High-speed couplings on direct-coupled motor drives with flanged motors may be to manufacturer's standard but shall provide adequate resilience and flexibility.
- (f) Couplings and half keys shall be balanced in accordance with the 'Balancing' section of this Standard.

48.3 Line shaft Drives

- (a) Lineshaft drives should be provided in the event that motors are required to be located above the equipment facility flood level (i.e. where submersible motors are inappropriate or not available) and;
- (b) Shall be subject to a torsional vibration analysis;
- (c) Ideally should have tube diameters sufficiently large to eliminate intermediate bearings;
- (d) As a guide the drive shaft length should not exceed 30 times the driveshaft diameter
- (e) Extremely long shafting should be divided into sections of approximately equal length to ensure similar natural frequencies for each section.
- (f) Lineshaft drives shall incorporate an intermediate bearing arrangement if the above requirement (c) cannot be satisfied;
- (g) The intermediate bearing should be located on a rigid support structure, which for guideline purposes has a fundamental natural frequency of at least four times the drive shaft rotational speed.
- (h) Bearings shall be accessible for lubrication and maintenance;
- (i) Lineshaft drives including couplings shall be dynamically balanced in accordance with the 'Balancing' section of this Standard;
- (j) Lineshafts and associated couplings shall be designed using the appropriate service factors.

48.4 Vee-Belt Drives

48.4.1 Drives

Belt drives should not normally be used for transmission design of major equipment, e.g. main pumpsets for major pump stations without Corporation approval. Where unavoidable for small pump stations or ancillary equipment, vee-belt drives shall be:

- (a) Designed for continuous duty in accordance with the manufacturer's recommendations using a minimum service factor of 1.5 times the rated power of the motor or driver;
- (b) Provided with a minimum of two and a maximum of five belts on all belt drives unless otherwise approved by the Corporation;
- (c) Incorporate a means of adjusting the belt tension;
- (d) Slide rails shall incorporate adjusting screws and lock nuts;
- (e) The maximum reduction ratio of the drive shall be 3:1 unless otherwise approved by the Corporation.

48.4.2 Pulleys

Vee-belt pulleys shall comply with the following requirements:

- (a) Pulleys shall be standard vee or wedge belt types with matching pulleys fitted to shafts with taperlock bushes;
- (b) Pulleys shall be fitted to the shafts using British Standard parallel keys;
- (c) Pulleys shall be machined from cast iron or steel and dynamically balanced in accordance with the 'Balancing' section of this Standard.

48.4.3 Belts

Vee-belts shall comply with the following requirements:

- (a) Belts shall be a matched set and designed to transmit the maximum motor or driver starting torque without slip;
- (b) Belts of the high tension wedge type of SPZ, SPA, SPB and SPC sections in accordance with AS 2784 shall be preferred over the classical V-belt types;
- (c) Linked adjustable belts and flat belts are not acceptable

48.5 Reduction Gearboxes

Reduction gearboxes shall have gears designed and manufactured in accordance with requirements of AS 2938. Worm and wheel, helical gears and Cyclo drives are preferred.

48.5.1 Rating and Service Factors

All reducers shall be rated for applicable service factors and the installed motor power. Unless otherwise specified by the manufacturer, the minimum service factor shall be 1.5.

48.5.2 Case Construction

Gearboxes shall be of cast iron/cast steel or fabricated mild steel construction. The internal surfaces of the casing shall be protected against corrosion damage. Gearboxes shall be totally enclosed with an IP rating to AS 60529 that is appropriate to the service conditions with respect to indoor, outdoor or immersed duty.

48.5.3 Bearings and Seals

Reduction box input and output shafts shall be fitted with anti-friction bearings and seals that shall comply with the requirements of the 'Bearings' section contained in this Standard.

48.5.4 Lubrication

- (a) 'Splash' lubrication is preferred to forced lubrication for reducers < 100 kW.
- (b) Where pressurised lubrication is required, a low pressure cut out switch suitable for the operating pressure range and a pressure gauge and snubber with isolation valve shall be provided.
- (c) Where oil filters are fitted, they shall be of the canister type mounted in pairs to facilitate filter replacement.
- (d) Base mounted reducers shall be fitted with:
 - (i) A magnetic sump plug.
 - (ii) A drain connection terminating in a screwed gate valve not less than 20 BSP.
 - (iii) A dust tight dipstick clearly marked with maximum and minimum levels.
 - (iv) A filling plug not less than 40 BSP.
 - (v) A replaceable element filtered breather set on a vertical standpipe 75 mm minimum length.
 - (vi) Breather assemblies shall be delivered loose with a temporary solid plug in place.

48.5.5 Cooling Fans

Fans suitably guarded in accordance with the 'Guards' section of this Standard may be mounted on the high speed shaft of speed reducers to assist with the thermal rating.

49 VALVES

For information relating to valve and appurtenance design criteria the Designer should refer to the relevant parts of DS 31-02. For information relating to the site selection, and design of valve pits and chambers refer to the 'Site Conditions and Selection', and the 'Pits and Chambers' sections of this Standard.

50 VIBRATION

Rotating mechanical equipment shall be designed to operate with minimal torsional and translational vibration. The acceptable limits for particular equipment are detailed below.

50.1 Torsional Vibration

Exciting frequencies are generated by the rotating element's speed; pump impeller vane passage frequency and harmonics; and universal joint frequency which are twice the shaft speed.

In order to minimise torsional vibration Designers shall select machinery rotational speeds whereby the torsional exciting frequencies do not adversely influence the rotating element's torsional natural frequency.

The fundamental exciting frequencies should be less than 50% of the torsional natural frequency.

50.2 Translational Vibration

In order to minimise translational vibration Designers shall select machinery rotational speeds that are not coincident with or excite the natural frequencies of the translational vibration of the rotating element (critical speed).

Imbalance or misalignment in the rotating machinery will contribute to translational vibration and can be magnified severely at the critical speed. Accordingly rotating components shall be correctly balanced and aligned.

50.3 Equipment Vibration Limits

50.3.1 Machinery

Vibration limits of rotodynamic equipment (except pumps which are specified below) shall comply with AS 2625.1 and AS 2625.4. Vibration values determined during factory testing shall not exceed the flexible support classifications for the relevant class of machine.

50.3.2 Pumps

Vibration limits of pumps shall comply with ISO 10816-7. The maximum vibration velocity limit for new pumps (Zone A) shall not exceed the values shown in Table A1 for Category II pumps. Vibration values determined during factory testing shall not exceed the values in the rows for the "Factory acceptance test – Allowable operating range" and "Factory Acceptance Test – Preferred Operating Range" when operating at any flow rate within the respective operating range.

50.3.3 Submersible Sewage Pumps

Submersible sewage pumps are a special case in terms of permissible vibration levels with higher levels being tolerated. Mounting of the pumps is deemed to be flexible and accordingly the maximum severity of up to 7.1 mm/s is considered acceptable.

50.4 Vibration Isolation

Anti-vibration mountings shall be selected to achieve 95% isolation efficiency at the normal operating speed of the equipment. The following strategies should be considered in order to isolate vibration.

50.4.1 Structural Vibration Mitigation Strategies

To minimise the possibility of structural vibration the Designer should seek to:

- (a) Design the building structure so that machinery maximum rotational speeds do not excite structural resonances.
- (b) For susceptible equipment use vibration isolators to isolate them from the building structure.

50.4.2 Pumpsets

Vibration isolators are generally not required for pumpsets because their vibrational energy is low frequency and do not normally impact on the building structure in terms of noticeable noise or vibration. Should the fundamental pump frequency exceed 100 Hz there may be a problem with building structure borne noise and vibration.

50.4.3 Generating Sets, Ventilating Fans and Air Compressors

Generating sets, ventilating fans and air compressors characteristically generate sufficient low and high frequency energy to the building structure to cause noise and vibration problems and accordingly the need to incorporate vibration isolators shall be investigated by the Designer.

50.5 Vibration Monitoring and Protection

Vibration monitoring where applicable shall be in accordance with the 'Vibration and Monitoring' section of DS 32, DS 32-01 and DS 32-02.

51 WATER AND WASTEWATER TREATMENT PLANTS

For information relating to water treatment plant design criteria the Designer should refer to DS 33 and for wastewater treatment plant refer to DS 34.

52 WELDING

52.1 Metal Arc Welding

All metal arc welding shall be performed in accordance with the requirements of the Corporation Technical Specification WS-1

Preparation shall be power tool clean to Australian Standard 1627.2 Class 3. Remove all welding scale, slag and corrosion products.

Repair of Field Welds on HDG in Severe Corrosion Service (semi immersion or severe corrosive zones) shall be performed by the application of 2 coats of 2 pack epoxy zinc to AS 3750.9 to 150 micro m followed by 2 pack epoxy enamel to 150µm.

For moderate Corrosion Service (Atmospheric) repair shall be 2 coats of Galvanite epoxy zinc rich primer to 125-150 µm dry film thickness.

52.2 Brazing

Silver brazing (formerly known as silver soldering) of copper alloy components used in Corporation infrastructure is covered in the 'Materials' section of this Standard.

53 WORKMANSHIP

All mechanical work shall be carried out by qualified mechanical tradesmen under the supervision of suitably qualified supervisors.

All materials used in the installation shall be new and, where applicable, material and workmanship shall be in accordance with the relevant standard of the Standards Association of Australia or, in their absence, recognised International standards.

Workmanship shall comply with the relevant parts of the Corporation's DS 30 series of mechanical standards

END OF DOCUMENT