

Australian Standard™

Cranes, hoists and winches

Part 4: Tower cranes



This Australian Standard was prepared by Committee ME-005, Cranes. It was approved on behalf of the Council of Standards Australia on 13 February 2004 and published on 30 March 2004.

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Australian Elevator Association
Australian Industry Group
Australian Institute for Non-Destructive Testing
Bureau of Steel Manufacturers of Australia
Construction and Mining Equipment Association of Australia
Crane Industry Council of Australia
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Part 4: Tower cranes

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PREFACE

This Standard was prepared by the Standards Australia Committee ME-005, Cranes.

The objective of this Standard is to provide nationally uniform requirements for the design of tower cranes for reference by importers, designers, users, and regulators.

Cognizance has been taken of the development of Standards for tower cranes as undertaken by the International Standards Technical Committee ISO/TC 96/SC7, Tower Cranes, at the time of developing this Standard.

Considerations for loads and load factors are based on ISO 8686-3, *Cranes, Design principles and load combinations*, Part 3: *Tower cranes*.

The term ‘informative’ has been used in this Standard to define the appendix to which it applies. An ‘informative’ appendix is for information and guidance only.

This Standard differs from the previous edition as follows:

- (a) Requirements for limiting and indicating devices have been revised.
- (b) Crane Standards have traditionally been based on the permissible stress method and problems arose when the various parts of AS 1170, *Structural design actions*, were revised based on the limit states design method. These problems have been addressed.
- (c) Requirements for inspection and testing have been updated.

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STANDARDS AUSTRALIA

Australian Standard
Cranes, hoists and winches

Part 4: Tower cranes

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard sets out requirements for tower cranes—

- (a) that are dismantled when they have served their purpose; and
- (b) of the permanently erected type,

as defined in AS 2549.

Horizontal jib and luffing jib and boom cranes which may be of the travelling, fixed, or climbing type, are also included.

Power-driven mobile cranes fitted with tower crane configurations are excluded except for the stability and foundation considerations when used in the capacity of a tower crane.

The Standard covers requirements from and including the hook to the anchorages of the tower crane as well as requirements for rail-mounted types.

NOTES:

- 1 Guidance on information to be supplied with an enquiry or order is given in Appendix A.
- 2 Guidance on information to be supplied by the manufacturer is given in Appendix B.
- 3 Guidance on selection and operation of tower cranes is given in AS 2550.4.

1.2 NEW DESIGNS AND INNOVATIONS

This Standard does not preclude the use of materials, designs, methods of assembly, procedures, and the like, that do not comply with a specific requirement of this Standard, or are not mentioned in it, but which can be shown to give equivalent or superior results to those specified.

1.3 APPLICATION

This Standard covers specific requirements for tower cranes and is intended for use in conjunction with AS 1418.1; however, requirements given herein take precedence over corresponding requirements of that Standard.

1.4 TYPES

The types of tower cranes within the scope of this Standard are power-driven cranes that have a vertical tower designed to be freestanding up to a specified height.

The general types of tower cranes are designated by specific features as follows:

- (a) Ram luffing crane.
- (b) Rope luffing crane.
- (c) Trolley jib (horizontal jib) crane.

- (d) Articulated trolley jib crane.
- (e) Self-erecting crane.

NOTE: Typical illustrations of these types of tower crane are given in Appendix C.

1.5 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

- 1000 The international system of units (SI) and its application
- 1359 Rotating electrical machines—General requirements
- 1359.101 Part 101: Rating and performance
- 1418 Cranes, hoists and winches
- 1418.1 Part 1: General requirements
- 1666 Wire-rope slings
- 1666.2 Part 2: Care and use
- 2549 Cranes (including hoists and winches)—Glossary of terms
- 2550 Cranes—Safe use
- 2550.4 Part 4: Tower cranes

AS/NZS

- 1170 Structural design actions
- 1170.2 Part 2: Wind actions

1.6 DEFINITIONS

For the purposes of this Standard, the definitions given in AS 2549 and those below apply.

1.6.1 Crane structure

All components of the crane excluding the crane support structure.

1.6.2 Crane support structure

The portion of the crane from the top of the tower to the foundation, including the transition piece (if used), grillages, ties and attachment to the building, and the foundation of the crane (whether it be rail-mounted or stationary).

1.6.3 Boom

The use of the term boom herein may also be applicable to jib.

1.6.4 Design installation life

The time that a loading action acts on a particular tower crane structural support system, e.g., foundation, building ties or combinations thereof.

1.6.5 Weathervane

A feature of a crane where the wind is able to slew the crane when out of service so that the boom provides the least resistance to the wind.

SECTION 2 GENERAL REQUIREMENTS FOR DESIGN

2.1 CLASSIFICATION AND LOAD RATING

2.1.1 Classification of tower crane

2.1.1.1 *General*

The basis of the classification of tower cranes is given in AS 1418.1, which establishes a classification of lifting appliances based on the number of operating cycles to be carried out during the expected life of appliance and a load spectrum factor that represents a nominal state of loading.

The classification of tower cranes is defined according to their category.

2.1.1.2 *Categories of tower cranes*

Tower cranes shall be divided into three general categories based on the service the tower crane is intended to endure, as follows:

- (a) *Light* Tower cranes in irregular use or having a light state of loading.
- (b) *Moderate* Tower cranes for general building construction.
- (c) *Heavy* Tower cranes in regular use or having a heavy state of loading.

2.1.1.3 *Classification of the tower crane as a whole*

The classification of the tower crane as a whole shall be as given in Table 2.1.1.3 and shall be interpreted in accordance with AS 1418.1.

NOTE: Guidance on typical group classifications of the tower crane as a whole is given in Appendix D.

TABLE 2.1.1.3
CLASSIFICATION OF TOWER CRANES

Crane category	Crane classification		
	Class of utilization	State of loading	Group classification
Light	U ₁ to U ₄	Q1 and Q2	C1 to C4
Moderate	U ₃ and U ₄	Q2	C3 and C4
Heavy	U ₄ and U ₅	Q2 and Q3	C4 to C6

2.1.2 Crane rating

The tower crane shall be rated in terms of—

- (a) the rated capacity of each hoisting motion; and
- (b) the classification of the application of the tower crane or the use for which it is intended.

NOTE: The use of a tower crane may vary during its life.

2.2 CRANE LOADS

2.2.1 General

The proof of competence of components shall be determined by either the limit state method or the permissible stress method, as set out in AS 1418.1.

2.2.2 Loads and applicable factors

Table 2.2.2(A) specifies factors Φ_n for dynamic effects, which are used for load combinations listed in Tables 2.2.2(B1) and (B2).

The line numbers listed in the first column of Table 2.2.2(A) are those shown in column 3 of Tables 2.2.2(B1) and (B2).

Reduced partial load factors shall be applied to the masses of parts of the crane that act to reduce load effects and are therefore 'favourable' loads.

Where the masses and their centres of gravity are determined by experiment (weighing), the factors in accordance with favourable effects 1.2.1 of Table 2.2.2(B2), line 1, shall be used.

Where the masses and their centres of gravity are calculated based on final piece lists, the factors in accordance with favourable effects 1.2.2 of Table 2.2.2(B2), line 1, shall be used.

NOTE: Tables 2.2.2(B1) and 2.2.2(B2) categorize load combinations as follows:

A—frequently occurring load combinations.

B—infrequently occurring load combinations.

C—rarely occurring load combinations.

TABLE 2.2.2(A)
FACTOR Φ_n FOR DYNAMIC EFFECTS
(APPLICABLE FOR BOTH PERMISSIBLE STRESS AND LIMIT STATE METHODS)

Line No. in Table 2.2.2(B)	Factor Φ_n	Guidance on values of factors Φ_n and load factors
1	Φ_1	$\Phi_1 = 1 \pm a$ $a = 0.1$ $\Phi_1 = 1$ for design against tipping
2	Φ_2	In accordance with AS 1418.1
	Φ_3	
3	Φ_7	$\Phi_7 = 1.1$ is recommended for building site crane. Other values may be used when the rail tracks tolerances (as agreed between user and manufacturer) vary from Standard
4 and 5	Φ_4	When using rigid body kinetic models: $\Phi_4 = 1.2$ if the acceleration or braking forces are changed with stepless control systems without backlash $\Phi_4 = 1.5$ in other control systems where drive forces are acting on the crane practically free of backlash $\Phi_4 = 2$ where considerable backlash exists Other values for Φ_4 may be used when substantiated or in accordance with AS 1418.1
6		Partial load factors shall be considered where appropriate
7		In-service wind load as specified in Clause 2.3.1(c)(i)
8		Snow and ice loads need only be considered in special cases and then in accordance with regional conditions
9		Loads due to temperature variations need only be considered where appropriate, according to regional and local conditions
10		Loads caused by skewing are negligible when using common undercarriages, otherwise requirements for AS 1418.1 apply
11	Φ_2	In accordance with AS 1418.1
12		Out-of-service wind load in accordance with AS/NZS 1170.2
13	Φ_5	In accordance with AS 1418.1
14	Φ_6	In accordance with AS 1418.1 Buffer forces need not be considered where the travelling velocity at contact with the buffer or end stop is less than 0.7 m/s
15		Tilting forces shall not be considered
16	Φ_4	In accordance with AS 1418.1
17		Loads caused by failure of mechanism or components shall be considered where appropriate
18		Excitation effects shall be considered where appropriate

TABLE 2.2.2(B1)
LOADS AND LOAD COMBINATIONS—TOWER CRANES—PERMISSIBLE STRESS METHOD

1	2				3	4				5					6							
Categories of loads	List of the loads f_i				Line No.	Load combinations A				Load combinations B					Load combinations C							
						A1	A2	A3	A4	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5	C6	C7	C8
Regular	Gravitation, acceleration, impacts	1	Weight of the crane	1.1 Unfavourable effects	1.1																	
				1.2.1 Favourable effects	1.2	ϕ_1	ϕ_1	1		ϕ_1	ϕ_1	1			ϕ_1	1	ϕ_1	1		1		1
				1.2.2 Favourable effects	1.3																	
		2.1	Weight of the gross load			2.1	ϕ_2	ϕ_3	1		ϕ_2	ϕ_3	1				1		1		1	
		2.2	η^*			2.2																
	3	Weights of crane and hoist load travelling on uneven surface			3				ϕ_7				ϕ_7	ϕ_7								
	Acceleration from drives	4	Weights of crane and gross load	4.1 Hoist drives excluded	4	ϕ_4	ϕ_4			ϕ_4	ϕ_4						ϕ_4					
				4.2 Hoist drives included	5			ϕ_4	ϕ_4			ϕ_4	ϕ_4									
Loads due to displacement	5	e.g., pre-stressing, uneven settlement of supports			6	1	1	1	1	1	1	1	1	1	1	1	1		1		1	
Occasional	Effects of climate	1	In-operation wind loads			7					$1^\dagger$	$1^\dagger$	$1^\dagger$	$1^\dagger$	$1^\dagger$							
		2	Snow and ice loads			8					1	1	1	1	1		1					
		3	Temperature variations			9					1	1	1	1	1		1					
	Loads due to skewing	4	Acceleration acting on asymmetrical mass distribution			10									1							
Exceptional	1 Hoisting a grounded load				11										ϕ_2							
	2 Out-of-operation wind loads				12											$0.67^\ddagger$						
	3 Test loads				13												ϕ_5					
	4 Buffer forces				14													ϕ_6				
	5 Tilting forces				15																	
	6 Emergency cut-out				16															ϕ_4		
	7 Failure of mechanism				17																	
	8 Vibration of the crane's foundation				18																1	
	Load combination factor γ_n				19	1.0				0.9					0.8							

* η is the weight of that part of the hoist load remaining suspended from the appliance (e.g., magnetic or other grabs attached).

† This factor applies to the forces obtained using the working wind speed specified in Clause 2.3.1(c)(i).

‡ This factor converts the limit state wind forces 'F' obtained directly from AS/NZS 1170.2 into a working stress wind force.

TABLE 2.2.2(B2)
LOADS AND LOAD COMBINATIONS — TOWER CRANES—LIMIT STATE METHOD

1	2			3	4				5					6											
Categories of loads	List of the loads f_i			Line No.	Load combinations A				Load combinations B					Load combinations C											
					Partial load factors	A1	A2	A3	A4	Partial load factors	B1	B2	B3	B4	B5	Partial load factors	C1	C2	C3	C4	C5	C6	C7	C8	
Regular	Gravitation, acceleration, impacts	1	Weight of the crane	1.1 Unfavourable effects	1.1	1.22					1.16						1.1								
			1.2.1 Favourable effects	1.2	1.16	ϕ_1	ϕ_1	1		1.1	ϕ_1	ϕ_1	1			1.05	ϕ_1	1	ϕ_1	1		1		1	
			1.2.2 Favourable effects	1.3	1.1					1.05						1.0									
		2.1	Weight of the gross load		2.1	1.34	ϕ_2	ϕ_3	1		1.22	ϕ_2	ϕ_3	1			1.1		1.0		1		1		1
		2.2	η^*		2.2																				
	3	Weights of crane and hoist load travelling on uneven surface		3	1.22				ϕ_7	1.16				ϕ_7	ϕ_7										
	Acceleration from drives	4	Weights of crane and gross load	4.1 Hoist drives excluded	4	1.34	ϕ_4	ϕ_4			1.22	ϕ_4	ϕ_4				1.1			ϕ_4					
4.2 Hoist drives included				5				ϕ_4	ϕ_4																
Loads due to displacement	5	e.g., pre-stressing, uneven settlement of supports		6	1.16	1	1	1	1	1.1	1	1	1	1	1	1.05	1	1	1	1		1		1	
Occasional	Effects of climate	1	In-operation wind loads		7					1.16 [†]	1	1	1	1	1										
		2	Snow and ice loads		8					1.22	1	1	1	1	1	1.1		1							
		3	Temperature variations		9					1.16	1	1	1	1	1	1.05		1							
	Loads due to skewing	4	Acceleration acting on asymmetrical mass distribution		10					1.16					1										
Exceptional	1 Hoisting a grounded load			11												1.1	ϕ_2								
	2 Out-of-operation wind loads			12												0.733 [‡]		1							
	3 Test loads			13												1.1			ϕ_5						
	4 Buffer forces			14												1.1				ϕ_6					
	5 Tilting forces			15												1.1									
	6 Emergency cut-out			16												1.1						ϕ_4			
	7 Failure of mechanism			17												1.1									
	8 Vibration of the crane's foundation			18												1.0								1	
	Resistance coefficient			19	1.1					1.1					1.1										

[†] is the weight of that part of the hoist load remaining suspended from the appliance (e.g., magnetic or other grabs attached).

[‡] This factor applies to the forces obtained using the working wind speed specified in Clause 2.3.1(c)(i).

[§] This factor applies directly to the limit state wind forces obtained from AS/NZS 1170.2.

2.2.3 Load combinations—Inertia forces

The inertia forces acting on the crane structure during acceleration and deceleration shall be determined from the maximum driving forces arising in regular operations and combined as follows:

- (a) When there is no restriction to operating different movements simultaneously:
 - (i) Hoist movement combined with one of—
 - (A) slewing and crab traversing;
 - (B) slewing and luffing; or
 - (C) slewing and crane travelling.
 - (ii) The inertia forces during slewing and deceleration shall be combined with centrifugal forces. For centrifugal forces, $\Phi_4 = 1$.
- (b) When there are restrictions to operate different movements simultaneously, the inertia forces shall be combined so they can act simultaneously.

2.2.4 Load combinations

The appropriate load combinations as given in Tables 2.2.2(B1) and (B2) shall be used.

2.2.5 Rail-mounted installations

A rail-mounted tower crane shall be designed so that it is stable in operation and out of operation. For movement along rails, an anchorage system shall be provided to prevent the movement of the tower crane under the action of out-of-service wind loads.

2.3 WIND ACTIONS

2.3.1 Wind actions on tower cranes support structures

The wind actions on the support structure shall be determined in accordance with the relevant requirements of AS 1418.1, AS/NZS 1170.2 and with the following:

- (a) The load combinations and coefficients shall be as given in Tables 2.2.2(B1) and (B2).
- (b) *Out-of-operation conditions:*
 - (i) *General* The design Structure Importance Level, and the Reference Probability of Exceedance shall comply with the requirements of Tables 2.3.1(A) and 2.3.1(B). The regions shall be as designated in AS/NZS 1170.2.

The design annual probability of exceedance for a wind event on a tower crane installation for subsequent use in AS/NZS 1170.2 to determine design wind pressures, shall be determined as follows:

$$P = P_{\text{ref}} \times (5/N)$$

where

P = annual probability of exceedance

P_{ref} = reference probability of exceedance (see Table 2.3.1(B))

N = design installation life (years) i.e., the period of time the crane is on site

‘ N ’ shall be not less than 1 year.

A design installation life ‘ N ’ of greater than 5 years is beyond the scope of this Standard.

Due allowance should be made for a possible extension of time that the crane is installed on site.

- (ii) *Weathervaning* The designer shall state in the information provided to the user whether the crane design relies on its ability to weathervane.
- (c) *In-operation conditions:*
 - (i) *General* Tower cranes and their installations shall be designed for minimum permissible stress in-operation wind speed of 20 m/s.
 - (ii) *Special applications* For special applications where a tower crane is operating in higher wind conditions, consideration shall be given to the specific site requirements.
- (d) *Tower crane boom and jib* Calculations for wind drag on lattice type boom and jibs shall be performed in accordance with the requirements for latticed towers, multiple frames, and oblique wind direction specified in AS/NZS 1170.2.

2.3.2 Wind actions on tower crane structure

The annual probability of exceedance for a wind loading event on the tower crane structure shall be determined in accordance with AS/NZS 1170.2 for a structure importance level and reference probability of exceedance relevant to the most severe of its intended uses and shall not be less than 1 in 50 years.

The design life of the crane structure shall be in accordance with AS 1418.1.

TABLE 2.3.1(A)
STRUCTURE IMPORTANCE LEVEL

Structure importance level	Examples of structure classes
1	Potential collapse zone over site only, Rarely applicable to tower cranes
2	Cranes in normal conditions, e.g., lifting over public areas
3	Cranes operating in the vicinity of post disaster function, e.g., servicing hospitals
4	Situations where failure of the crane could trigger a disaster posing extreme danger to large numbers of people or a large area. Such cranes require individual consideration outside the scope of this Standard, e.g., servicing a nuclear power station or cyanide factory

TABLE 2.3.1(B)
REFERENCE PROBABILITY OF EXCEEDANCE

Structure importance level	Reference probability of exceedance (P_{ref})
1	1 in 250
2	1 in 500
3	1 in 1000
4	1 in 2000

2.4 CRANE STRUCTURE DESIGN

2.4.1 Basis of design of the crane structure

The crane structure including the support tower or mast shall comply with the requirements of AS 1418.1.