WITHDRAWN FROM SALE 30.5.85
(Ross Johnson) TYPOGRAPHICAL ERRORS

SUPERSEDED BY AS 1403-1985

AS 1403—1984
UDC 621.82/.83

Australian Standard®
1403—1984

DESIGN OF ROTATING STEEL SHAFTS

STANDARDS ASSOCIATION OF AUSTRALIA

Incorporated by Royal Charter

G

This Australian standard was prepared by Committee ME/5, Cranes. It was approved on behalf of the Council of the Standards Association of Australia on 5 April 1984 and published on 9 November 1984. — Publishing Delayed — Received 15th May 1985

The following interests are represented on Committee ME/5:

Aluminium Development Council

Association of Consulting Engineers Australia

Australian Institute of Building

Bureau of Steel Manufacturers of Australia

Confederation of Australian Industry

Construction Equipment Importers and Manufacturers of Australia

Crane Industry Council of Australia

Department of Defence

Department of Defence Support

Department of Employment and Labour Relations, Qld

Department of Housing and Construction

Department of Industrial Relations, N.S.W.

Department of Labour, S.A.

Department of Labour and Industry, Tas.

Department of Labour and Industry, Vic.

Department of Labour and Industry, W.A.

Department of Mines and Energy, N.T.

Department of Public Works, N.S.W.

Department of Territories and Local Government

Electricity Supply Association of Australia

Maritime Services Board of New South Wales

Metal Trades Industry Association of Australia

Metropolitan Water Sewerage and Drainage Board, N.S.W.

Port of Melbourne Authority

Railways of Australia Committee

Telecom Australia

__Review of Australian Standards.__ To keep abreast of progress in industry, Australian standards are subject to periodic review and are kept up-to-date by the issue of amendments or new editions as necessary. It is important therefore that standards users ensure that they are in possession of the latest edition, and any amendments thereto.

Full details of all SAA publications will be found in the Catalogue of Australian Standards; this information is supplemented each month by SAA's journal 'The Australian Standard', which subscribing members receive, and which gives details of new publications, new editions and amendments, and of withdrawn standards.

Suggestions for improvements to Australian standards, addressed to the head office of the Association, are welcomed. Notification of any inaccuracy or ambiguity found in an Australian standard should be made without delay in order that the matter may be investigated and appropriate action taken.

This standard was issued in draft form for comment as DR 83029.

AUSTRALIAN STANDARD

DESIGN OF ROTATING STEEL SHAFTS

AS 1403—1984

First published (as AS B249) 1969
AS 1403 first published 1979
Second edition 1984

PUBLISHED BY THE STANDARDS ASSOCIATION OF AUSTRALIA
STANDARDS HOUSE, 80 ARTHUR ST, NORTH SYDNEY, N.S.W.

ISBN 0 7262 3407 9

PREFACE

This edition of this standard was prepared by the Association's Committee on Cranes, to supersede AS 1403—1979, Design of Steel Shafts for Transmission of Power.

A number of the changes have been initiated by teaching institutions with a view to simplifying the standard and enable its use in their curricula.

The major changes in this edition are as follows:

(a) A number of definitions have been revised, added or detailed, while some definitions have been omitted. In conjunction, notations have been changed to align with the accepted conventions.

(b) Table 1 is presented in a completely different form. Instead of providing two general formulas and a note explaining their specific uses, Table 1 now provides specific formulas for shaft torques in the first four shafts of a mechanism. It also separates them into driving systems and braking systems and whether the inertia is or is not significant. The establishment of a pattern of formulas was thought to be superior to that of a general formula.

(c) Data for high tensile steel has been included in Appendix A.

(d) Appendix B, Iterative Method, has been added; this addition reflects the wide use of programmable calculators.

(e) The existing worked example has been expanded and two additional worked examples are included. Thus most possible cases, i.e. driving and braking, moments of inertia of components with rotating and linear motions, and their combinations, are covered by examples.

(f) The appendix covering the corrosion fatigue strength of nickel-containing materials has been deleted. However, the deleterious effect of certain conditions has been brought to the attention of the user of this standard in Clause 7.2.

CONTENTS

STANDARDS ASSOCIATION OF AUSTRALIA

Australian Standard for DESIGN OF ROTATING STEEL SHAFTS

FOREWORD

The method of design in this standard is the same as that contained in the 1979 issue and is based on calculations for infinite life of the shaft.

It is noted that, as the result of extensive laboratory and/or field tests, shafts of diameters smaller than those resulting from calculations in this standard may be used.

Although the method is not theoretically precise, it gives results which are of sufficient accuracy for practical purposes. The method makes no allowance for corrosive or other abnormal conditions, such as the presence of buckling, 'whipping', cyclic vibrations and similar effects (see Clause 7.2).

In some cases, deflection may be the factor which determines the minimum value of the shaft diameter (see Clause 7.6).

Typical worked examples employing this method of shaft design are given in Appendices D, E and F.

A 'trial' diameter may be necessary in the application of the design method. The value may be assumed on the basis of the designer's previous experience, or a simplified version of the method may be used to determine the order of magnitude of the shaft diameter, and the full method then applied to check the assumed trial diameter. A convenient quick method of estimating the 'trial' diameter is given in Appendix A, and an iterative method using programmable calculators is provided in Appendix B.

The process of carrying out an accurate and complete analysis of loadings applied to a shaft (see Clause 5) may involve much time and effort, and is warranted where it is desired to keep shaft diameters as small as possible. Where larger diameter shafts can be tolerated, it may be more appropriate to use approximations or to ignore inertia or other effects, but it is important to ensure that, where such inaccuracies are introduced, they result in increased rather than decreased margin of safety and stress-raising characteristics are avoided.

The effect of electric motors with high breakdown torque (also known as pull-out torque) or high locked-rotor torque (also known as starting torque) and the characteristics of motor controllers and torque-limiting devices are outlined in Appendix C.

SPECIFICATION

1 SCOPE. This standard applies to the design of rotating steel shafts which are subjected to torsional, bending and axial-tensile loads either singly or in combination, on the basis of infinite life.

The standard does not apply to shafts specially developed, e.g. those involving extensive laboratory and field testing, heat treatment and like developments, or to shafts for specific applications such as automotive and construction equipment transmissions.

NOTES:

1. Particular consideration has to be given to deflections of long shafts where the effects of out-of-balance forces tend to induce 'whipping', and to long shafts which are subject to buckling due to compressive loading (see Foreword).
2. The use of this method of shaft design enables justification of the use of shafts of minimal diameter. Where the designer conservatively sizes a shaft, then only those calculations necessary to ensure that the shaft complies with this standard (see Clause 5) are required.

2 REFERENCED DOCUMENTS. The following standards are referred to in this standard:

AS 1204	Structural Steels—Ordinary Weldable Grades
AS 1391	Methods for Tensile Testing of Metals
AS 1654	Limits and Fits for Engineering
AS B212	Straight Sided Splines
AS B213	Involute Splines
AS B265	Involute Serrations
ISO 14	Straight-sided Splines for Cylindrical Shafts with Internal Centering—Dimensions, Tolerances and Verification
ISO 4156	Straight Cylindrical Involute Splines—Metric Module, Side Fit—Generalities, Dimensions and Inspection
BS 2059	Straight-sided Splines and Serrations
BS 4235	Metric Keys and Keyways Part 1—Parallel and Taper Keys Part 2—Woodruff Keys and Keyways

3 DEFINITIONS. For the purpose of this standard, the following definitions apply:

3.1 Applied loading—

3.1.1 *Axial loading*—force applied to a shaft in the direction of the shaft axis.

3.1.2 *Bending loading*—bending moment applied to a shaft.

3.1.3 *Torsional loading*—torque applied to a shaft.

3.2 Equivalent rotational mass moment of inertia of a shaft and its associated components—the linear mass moment of inertia and the rotational mass moment of inertia of the component, related to the rotational full-load speed of the braking or driving medium of the mechanism.

3.3 Stress-raising characteristic—a detail, of a shaft, which induces increased stress in the shaft, e.g. step in diameter, keyway, spline, interference fit with a component on the shaft, transverse hole, annular groove.

NOTE: Stress-raising effects are intensified by machining marks, notching and the like.

4 NOTATION. For the purpose of this standard, the following notation applies:

D = minimum calculated diameter of shaft at cross-section under consideration, in millimetres (see also Clause 6.2)

D_a = estimated diameter in iterative method (see Appendix B)

D_{a-1} = previous estimated diameter in iterative method (see Appendix B)

D_I = internal diameter of hollow shaft, in millimetres

D_O = minimum calculated outside diameter of hollow shaft at cross-section under consideration, in millimetres

e = allowable deviation between successive iterations, expressed as a percentage (see Appendix B, Fig. B1)

F_R = endurance limit of shaft material in reversed bending during rotation, based on tests of polished steel specimens of diameter between 8 mm and 10 mm, in megapascals
= $0.45\ F_U$, where actual value is not known

F_s = safety factor

F_U = tensile strength of shaft material, in megapascals

F_Y = yield strength of shaft material, in megapascals

I_{Ei} = equivalent rotational mass moment of inertia of a shaft and its associated rotating and linear components, in kilogram metres squared
= $I_{Ri} + I_{Lj}$

I_{Ri} = equivalent rotational mass moment of inertia of a shaft and its associated rotating components, in kilogram metres squared

$$= I_i \left(\frac{N_i}{N}\right)^2$$

I_{Lj} = equivalent rotational mass moment of inertia of components with linear motion, associated with the shaft under consideration, in kilogram metres squared

$$= m_j \left(\frac{V_j}{2\pi N}\right)^2$$

$I_1, I_2\ I_3 \dots I_n$ = rotational mass moment of inertia at first, second, third ... nth shafts and its components rotating at N_1, N_2, N_3 ... N_n revolutions per second, in kilogram metres squared

i = number defining the rotational motion component under consideration (1, 2, 3, ... n)

j = number defining the linear motion component under consideration (1, 2, 3 ... k)

k = total number of components with linear motion

K = stress-raising factor (see Clause 8.2):
for a stepped shaft, see Fig. 4
for a shaft fitted with rolling-element bearing, see Fig. 5