ASME BTH-1–2023
(Revision of ASME BTH-1–2020)

Design of Below-the-Hook Lifting Devices

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

ASME BTH-1–2023
(Revision of ASME BTH-1–2020)

Design of Below-the-Hook Lifting Devices

AN AMERICAN NATIONAL STANDARD



The American Society of Mechanical Engineers

Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: October 16, 2023

The next edition of this Standard is scheduled for publication in 2026. This Standard will become effective 1 year after the Date of Issuance.

This code or standard was developed under procedures accredited as meeting the criteria for American National Standards. The standards committee that approved the code or standard was balanced to ensure that individuals from competent and concerned interests had an opportunity to participate. The proposed code or standard was made available for public review and comment, which provided an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large.

ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity. ASME does not take any position with respect to the validity of any patent rights asserted in connection with any items mentioned in this document, and does not undertake to insure anyone utilizing a standard against liability for infringement of any applicable letters patent, nor does ASME assume any such liability. Users of a code or standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Participation by federal agency representatives or persons affiliated with industry is not to be interpreted as government or industry endorsement of this code or standard.

ASME accepts responsibility for only those interpretations of this document issued in accordance with the established ASME procedures and policies, which precludes the issuance of interpretations by individuals.

The endnotes and preamble in this document (if any) are part of this American National Standard.



ASME Collective Membership Mark

"ASME" and the above ASME symbol are registered trademarks of The American Society of Mechanical Engineers.

No part of this document may be reproduced in any form,
in an electronic retrieval system or otherwise,
without the prior written permission of the publisher.

The American Society of Mechanical Engineers
Two Park Avenue, New York, NY 10016-5990

Copyright © 2023 by
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
All rights reserved
Printed in U.S.A.

CONTENTS

Foreword v

Committee Roster vi

Correspondence With the BTH Committee vii

Summary of Changes viii

Chapter 1 **Scope, Definitions, and References** 1

1-1 Purpose 1

1-2 Scope 1

1-3 New and Existing Lifting Devices 1

1-4 General Requirements 1

1-5 Definitions 2

1-6 Symbols 6

1-7 References 9

Chapter 2 **Lifting Device Classifications** 10

2-1 General 10

2-2 Design Category 10

2-3 Service Class 10

Chapter 3 **Structural Design** 11

3-1 General 11

3-2 Member Design 12

3-3 Connection Design 16

3-4 Fatigue Design 20

3-5 Other Design Considerations 22

Chapter 4 **Mechanical Design** 38

4-1 General 38

4-2 Sheaves 38

4-3 Rope 38

4-4 Drive Systems 39

4-5 Gearing 39

4-6 Bearings 40

4-7 Shafting 41

4-8 Fasteners 43

4-9 Grip Support Force 43

4-10 Vacuum Lifting Device Design 44

4-11 Fluid Power Systems 46

Chapter 5 **Electrical Design** 47

5-1 General 47

5-2 Electric Motors and Brakes 47

5-3 Operator Interface 47

5-4 Controllers and Auxiliary Equipment . . . 48
5-5 Grounding . . . 49
5-6 Power Disconnects . . . 49
5-7 Batteries . . . 49
Chapter 6 Lifting Magnet Design . . . 50
6-1 Purpose . . . 50
6-2 Design Requirements . . . 50
6-3 Selection and Design . . . 50

Nonmandatory Appendices

A Commentary for Chapter 1: Scope, Definitions, and References . . . 54
B Commentary for Chapter 2: Lifting Device Classifications . . . 58
C Commentary for Chapter 3: Structural Design . . . 60
D Commentary for Chapter 4: Mechanical Design . . . 69
E Commentary for Chapter 5: Electrical Design . . . 73
F Commentary for Chapter 6: Lifting Magnet Design . . . 75

Figures

1-5.5-1 Lifting Magnets . . . 5
4-2.6-1 Sheave Dimensions . . . 39
4-2.8-1 Sheave Gap . . . 39
4-9.2-1 Illustration of Holding and Support Forces . . . 44
C-2.6-1 Selected Examples of Table 3-2.2-1 Requirements . . . 64
C-3.2-1 Block Shear . . . 65
C-3.3.1-1 Pin-Connected Plate Notation . . . 66
C-3.3.2-1 Stiffened Plate Lifting Beam . . . 66

Tables

2-3-1 Service Class . . . 10
3-2.2-1 Limiting Width-Thickness Ratios for Compression Elements . . . 13
3-3.4.2-1 Minimum Effective Throat Thickness of Partial-Penetration Groove Welds . . . 20
3-3.4.3-1 Minimum Sizes of Fillet Welds . . . 20
3-4.3-1 Allowable Stress Ranges, ksi (MPa) . . . 21
3-4.4-1 Fatigue Design Parameters . . . 23
4-5.3-1 Strength Factors for Calculating Load Capacity (American Standard Tooth Forms) . . . 40
4-6.2-1 L_{10} Bearing Life . . . 41
4-7.5-1 Key Size Versus Shaft Diameter (ASME B17.1) . . . 42
4-7.5-2 Key Size Versus Shaft Diameter (DIN 6885-1) . . . 42
4-7.6.1-1 Fatigue Stress Amplification Factors . . . 42
4-10.2-1 Intended Use Type Summary . . . 45
B-3-1 Service Class Life . . . 59
C-1.3-1 Design Category A Static Load Spectrum . . . 61
C-1.3-2 Design Category A Dynamic Load Spectrum . . . 61
C-1.3-3 Design Category B Static Load Spectrum . . . 61
C-1.3-4 Design Category B Dynamic Load Spectrum . . . 62

FOREWORD

There have been many formal requests for interpretation of the limited structural design criteria stated within ASME B30.20, Below-the-Hook Lifting Devices, a safety standard. As a consequence, industry has for quite some time expressed a need for a comprehensive design standard for below-the-hook lifting devices that would complement the safety requirements of ASME B30.20. All editions of ASME B30.20 have included structural design criteria oriented toward the industrial manufacturing community requiring a minimum design factor of 3, based on the yield strength of the material; recent editions have also included design criteria for the fatigue failure mode. However, members of the construction community expressed the need for design criteria more suitable to their operating conditions, including a lower design factor, and the necessity to address other failure modes such as fracture, shear, and buckling, and design topics such as impact and fasteners.

A Design Task Group was created in 1997 to begin work on a design standard as a companion document to ASME B30.20. The ASME BTH Standards Committee on the Design of Below-the-Hook Lifting Devices was formed out of the Design Task Group and held its organizational meeting on December 5, 1999.

ASME BTH-1-2005, Design of Below-the-Hook Lifting Devices, contained five chapters: Scope and Definitions, Lifter Classifications, Structural Design, Mechanical Design, and Electrical Components. This Standard, intended for general industry and construction, set forth two design categories for lifting devices based on the magnitude and variation of loading, and operating and environmental conditions. The two design categories provided different design factors for determining allowable static stress limits. Five Service Classes based on load cycles were provided. The Service Class establishes allowable stress range values for lifting device structural members and design parameters for mechanical components. ASME BTH-1–2005 was approved by the American National Standards Institute (ANSI) on October 18, 2005.

ASME BTH-1–2008 incorporated editorial revisions and two new mechanical design sections for grip ratio and vacuum lifting device design. ASME BTH-1–2008 was approved by ANSI on September 17, 2008.

ASME BTH-1–2011 incorporated revisions throughout the Standard and the addition of a new mechanical design section for fluid power systems. ASME BTH-1–2011 was approved by ANSI on September 23, 2011.

ASME BTH-1–2014 incorporated into Chapter 4 a section on lifting magnets. Other technical revisions included new requirements for fluid pressure control and electrical system guarding. Along with these technical changes, the nonmandatory Commentary for each chapter was moved to its own respective Nonmandatory Appendix. ASME BTH-1–2014 was approved by ANSI on June 24, 2014.

ASME BTH-1–2017 included the addition of Chapter 6: Lifting Magnet Design, an accompanying Nonmandatory Appendix with commentary for the new chapter, and other revisions. Following the approval by the ASME BTH Standards Committee, ANSI approved ASME BTH-1–2017 on January 6, 2017.

ASME BTH-1–2020 included clarification of the requirement to establish the rated load of a lifting device by calculation, incorporation of ASME B30.30-2019 into the rope requirements in Chapter 4, improvements based on user input, revision of Chapter 5 title to Electrical Design, and consideration for load blocks and lifting attachments. Following the approval by the ASME BTH Standards Committee, ANSI approved this edition as an American National Standard, with the new designation ASME BTH-1–2020, on December 9, 2020.

This edition of ASME BTH-1 includes revision of the terms “lifter” to “lifting device” and “magnet lifter” to “lifting magnet,” updating of the fatigue design provisions, clarification of the effective shear area for tubular members, addition of an equation for the calculation of the tensile stress area of a threaded fastener, addition of a reference to ASME B30.1 for fluid power cylinders used in lifting devices, and expansion of the provisions for vacuum lifting devices. Following the approval by the ASME BTH Standards Committee, ANSI approved this edition as an American National Standard, with the new designation ASME BTH-1–2023, on June 16, 2023.

ASME BTH STANDARDS COMMITTEE
Design of Below-the-Hook Lifting Devices

(The following is the roster of the committee at the time of approval of this Standard.)

STANDARDS COMMITTEE OFFICERS

J. D. Edmundson, *Chair*
D. R. Verenski, *Vice Chair*
E. Dominguez, *Secretary*

STANDARDS COMMITTEE PERSONNEL

J. Alberson, Means and Methods Engineering
B. B. Bacon, Tennessee Valley Authority
G. A. Bond, Wood's Powr-Grip Co., Inc.
D. R. Carroll, Citgo Petroleum Corp.
P. B. Debuigne, Blue Origin
E. Dominguez, The American Society of Mechanical Engineers
D. Duerr, 2DM Associates, Inc.
J. D. Edmundson, Konecranes Nuclear and Services, LLC
C. Fox, Ruby and Associates
M. T. Gaunce, SCHUNK
K. M. Jankowski, Industrial Magnetics, Inc./Walker Magnetics
T. C. Mackey, HiLine Engineering and Fabrication, Inc.
M. P. McShane, Washington River Protection Solutions
B. A. Pickett, Systems Engineering and Forensic Services
T. Raines, Jr., CMCO
D. T. Rebbin, Bradley Lifting Corp.
J. W. Rowland III, Consultant
P. D. Sweeney, Riverside Engineering, LLC
D. R. Verenski, Hunter Lift Ltd.
M. P. Zerba, Lampson International, LLC
T. J. Brookbank, *Alternate,* Hunter Lift Ltd.
D. Meuchel, *Alternate,* Wood's Powr-Grip Co., Inc.
J. Rea, *Alternate,* Bradley Lifting Corp.
R. S. Stemp, *Alternate,* Lampson International, LLC
S. Barton, *Contributing Member,* Consultant
P. W. Boyd, *Contributing Member,* Consultant
A. Faris, *Contributing Member,* Rice Engineering
M. Hughes, *Contributing Member,* Simpson Gumpertz and Heger
R. A. Dahlin, *Honorary Member,* Walker Magnetics
J. W. Downs, Jr., *Honorary Member,* Downs Crane and Hoist Co., Inc.

CORRESPONDENCE WITH THE BTH COMMITTEE

General. ASME codes and standards are developed and maintained by committees with the intent to represent the consensus of concerned interests. Users of ASME codes and standards may correspond with the committees to propose revisions or cases, report errata, or request interpretations. Correspondence for this Standard should be sent to the staff secretary noted on the committee's web page, accessible at https://go.asme.org/BTHcommittee.

Revisions and Errata. The committee processes revisions to this Standard on a continuous basis to incorporate changes that appear necessary or desirable as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published in the next edition of the Standard.

In addition, the committee may post errata on the committee web page. Errata become effective on the date posted. Users can register on the committee web page to receive e-mail notifications of posted errata.

This Standard is always open for comment, and the committee welcomes proposals for revisions. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent background information and supporting documentation.

Cases. The committee does not issue cases for this Standard.

Interpretations. Upon request, the committee will issue an interpretation of any requirement of this Standard. An interpretation can be issued only in response to a request submitted through the online Interpretation Submittal Form at https://go.asme.org/InterpretationRequest. Upon submitting the form, the inquirer will receive an automatic e-mail confirming receipt.

ASME does not act as a consultant for specific engineering problems or for the general application or understanding of the Standard requirements. If, based on the information submitted, it is the opinion of the committee that the inquirer should seek assistance, the request will be returned with the recommendation that such assistance be obtained. Inquirers can track the status of their requests at https://go.asme.org/Interpretations.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME committee or subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

Interpretations are published in the ASME Interpretations Database at https://go.asme.org/Interpretations as they are issued.

Committee Meetings. The BTH Standards Committee regularly holds meetings that are open to the public. Persons wishing to attend any meeting should contact the secretary of the committee. Information on future committee meetings can be found on the committee web page at https://go.asme.org/BTHcommittee.

ASME BTH-1–2023
SUMMARY OF CHANGES

Following approval by the ASME BTH Committee and ASME, and after public review, ASME BTH-1–2023 was approved by the American National Standards Institute on June 16, 2023.

ASME BTH-1–2023 includes the following changes identified by a margin note, **(23)**.

Page	*Location*	*Change*
1	Chapter 1	Terms *lifter* and *device* revised to *lifting device* throughout
2	1-5.1	(1) Definition of *below-the-hook lifting device (lifting device, lifter)* revised
		(2) Definition of *nonmandatory appendix* added
3	1-5.3	Definitions of *bystander*, *fall zone*, *manual vacuum lifting device*, *mechanical vacuum lifting device*, *powered vacuum lifting device*, *precharged vacuum lifting device*, *safety-trained person*, and *self-priming vacuum lifting device* added
4	1-5.5	(1) Definitions of *air gap*, *magnet duty cycle*, and *maximum energy product* revised
		(2) The following terms revised: *electrically controlled permanent magnet* to *electrically controlled permanent lifting magnet* and *manually controlled permanent magnet* to *manually controlled permanent lifting magnet*
5	Figure 1-5.5-1	Title revised
6	1-6.1	Definitions of d_b, n, and p added
8	1-6.3	Note revised
9	1-7	Updated
10	Chapter 2	Terms *lifter* and *device* revised to *lifting device* throughout
11	Chapter 3	Terms *lifter* and *device* revised to *lifting device* throughout
15	3-2.3.7	Added
17	3-3.2	(1) Equations (3-45) and (3-46) added, and subsequent equations redesignated
		(2) Definition of A_s revised
		(3) Definitions of d_b, m, n, and p added
23	Table 3-4.4-1	Revised in its entirety
38	Chapter 4	Terms *lifter* and *device* revised to *lifting device* throughout
38	4-2.2	Revised
38	4-2.3	Revised
38	4-2.6	Title revised
38	4-2.7	(1) Added, and subsequent paragraph redesignated
		(2) Former Figure 4-2.7-1 redesignated as Figure 4-2.8-1
39	4-3.2	Revised
44	4-10.2	Revised in its entirety
45	Table 4-10.2-1	Added

Page	*Location*	*Change*
46	4-11.2	Revised in its entirety
47	Chapter 5	Terms *lifter* and *device* revised to *lifting device* throughout
49	5-6.3	Terms *magnet* and *electromagnet* revised to *lifting magnet* and *lifting electromagnet*, respectively
50	Chapter 6	(1) Terms *magnet* and *material handling magnet* revised to *lifting magnet* throughout
		(2) Terms *lifter* and *device* revised to *lifting device* throughout
54	Nonmandatory Appendix A	Terms *lifter* and *device* revised to *lifting device* throughout
56	A-5.3	Added
56	A-7	Updated
58	Nonmandatory Appendix B	Terms *lifter* and *device* revised to *lifting device* throughout
60	Nonmandatory Appendix C	Terms *lifter* and *device* revised to *lifting device* throughout
62	C-2.2	In third paragraph, last AISC reference updated
64	C-2.6	AISC reference updated
65	C-3.1	In second paragraph, last two AISC references updated
67	C-4.1	AISC reference updated
68	C-4.4	AISC reference updated
68	C-4.5	AISC reference updated
68	C-4.6	AISC reference updated
69	Nonmandatory Appendix D	Terms *lifter* and *device* revised to *lifting device* throughout
71	D-10.2	Revised in its entirety
72	D-11.2	(1) First paragraph added
		(2) Second paragraph revised
73	Nonmandatory Appendix E	Terms *lifter* and *device* revised to *lifting device* throughout
75	Nonmandatory Appendix F	Term *magnet* revised to *lifting magnet* throughout

INTENTIONALLY LEFT BLANK

Chapter 1
Scope, Definitions, and References

(23)

1-1 PURPOSE

This Standard sets forth design criteria for ASME B30.20, Below-the-Hook Lifting Devices. This Standard serves as a guide to designers, manufacturers, purchasers, and users of below-the-hook lifting devices.

1-2 SCOPE

This Standard provides minimum structural, mechanical, and electrical design criteria for ASME B30.20, Below-the-Hook Lifting Devices.

The provisions in this Standard apply to the design or modification of below-the-hook lifting devices. Compliance with requirements and criteria that may be unique to specialized industries and environments is outside the scope of this Standard.

Lifting devices designed to this Standard shall comply with ASME B30.20, Below-the-Hook Lifting Devices. ASME B30.20 includes provisions that apply to the marking, construction, installation, inspection, testing, maintenance, and operation of below-the-hook lifting devices.

The provisions defined in this Standard address the most common and broadly applicable aspects of the design of below-the-hook lifting devices. A qualified person shall determine the appropriate methods to be used to address design issues that are not explicitly covered in the Standard so as to provide design factors and/or performance consistent with the intent of this Standard.

1-3 NEW AND EXISTING LIFTING DEVICES

The effective date of this Standard shall be one year after its date of issuance. Lifting devices manufactured after the effective date shall conform to the requirements of this Standard.

When a lifting device is being modified, its design shall be reviewed relative to this Standard, and the need to meet this Standard shall be evaluated by the manufacturer or a qualified person.

1-4 GENERAL REQUIREMENTS

1-4.1 Design Responsibility

Lifting devices shall be designed by, or under the direct supervision of, a qualified person.

1-4.2 Units of Measure

A dual unit format is used. Values are given in U.S. Customary units as the primary units followed by the International System of Units (SI) in parentheses as the secondary units. The values stated in U.S. Customary units are to be regarded as the standard. The SI units in the text have been directly (softly) converted from U.S. Customary units.

1-4.3 Design Criteria

All below-the-hook lifting devices shall be designed for specified rated loads, load geometry, Design Category (see section 2-2), and Service Class (see section 2-3). Resolution of loads into forces and stress values affecting structural members, mechanical components, and connections shall be performed by an accepted analysis method. The rated load shall not be determined by a load test only.

1-4.4 Analysis Methods

The allowable stresses and stress ranges defined in this Standard are based on the assumption of analysis by classical strength of material methods (models), although other analysis methods may be used. The analysis techniques and models used by the qualified person shall accurately represent the loads, material properties, and lifting device geometry; stress values resulting from the analysis shall be of suitable form to permit correlation with the allowable stresses defined in this Standard.

1-4.5 Material

The design provisions of this Standard are based on the use of carbon, high-strength low-alloy, or heat-treated constructional alloy steel for structural members and many mechanical components. Other materials may be used, provided the design factors and fatigue life are equal to or greater than those required by this Standard.

All ferrous and nonferrous metal used in the fabrication of lifting device structural members and mechanical components shall be identified by an industry-wide or written proprietary specification.