

ASME STS-1-2006
(Revision of ASME STS-1-2000)

Steel Stacks

AN AMERICAN NATIONAL STANDARD



**The American Society of
Mechanical Engineers**

ASME STS-1-2006
(Revision of ASME STS-1-2000)

Steel Stacks

AN AMERICAN NATIONAL STANDARD



**The American Society of
Mechanical Engineers**

Three Park Avenue • New York, NY 10016

Date of Issuance: October 13, 2006

The 2006 edition of this Standard is being issued with an automatic addenda subscription service. The use of addenda allows revisions made in response to public review comments or committee actions to be published as necessary. This Standard will be revised when the Society approves the issuance of a new edition.

ASME issues written replies to inquiries concerning interpretations of technical aspects of this Standard. The interpretations will be included with the above addenda service.

ASME is the registered trademark of The American Society of Mechanical Engineers.

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 assure that individuals from competent and concerned interests have had an opportunity to participate. The proposed code or standard was made available for public review and comment that provides an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large.

ASME does not “approve,” “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 assumes 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 representative(s) or person(s) 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.

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
Three Park Avenue, New York, NY 10016-5990

Copyright © 2006 by
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
All Rights Reserved
Printed in U.S.A.

CONTENTS

Foreword	iv
Committee Roster	v
Correspondence with the Steel Stacks Committee	vi
Introduction	vii
1 Mechanical Design	1
2 Materials	4
3 Linings and Coatings	7
4 Structural Design	13
5 Dynamic Wind Loads	20
6 Access and Safety	23
7 Electrical	28
8 Fabrication and Erection	29
9 Inspection and Maintenance	31
10 References	33
Figures	
6.2.6-1 Example of the General Construction of Cages	24
6.2.6-2 Minimum Ladder Clearances	25
6.3.6 Ladder Dimensions, Support Spacing, and Side Clearances	26
6.3.8 Landing Platform Dimensions	27
Tables	
4.4.6 Factors of Safety	16
4.4.7 Minimum Structural Plate Thickness and Maximum Stiffener Spacing	16
4.10.1.3 Cable Selection Criteria	18
5.2.1 Representative Structural Damping Values (β_s)	21
Mandatory Appendix	
I Structural Design	35
Nonmandatory Appendices	
A Mechanical Design	46
B Materials for Ambient and Elevated Temperature Service	59
C Linings and Coatings	75
D Structural Design	79
E Example Calculations	86
F Conversion Factors: U.S. Customary to SI (Metric)	97

FOREWORD

In early 1978, the American Society of Mechanical Engineers was approached by a group interested in formulating a standard for the design, fabrication, and erection of steel stacks and their appurtenances. They felt there was a need for such a code to establish a better level of standardization in the industry and for safeguarding the community. Because of the particular nature of stacks and their susceptibility to failures due to wind and seismic-induced vibrations, along with corrosion and erosion, the design process is a complex one. Additionally, recent regulations by the Environmental Protection Agency concerning emissions have placed a strong emphasis on the mechanical design of stacks. In the last several decades, much research has been done and many papers written on the subject. While investigation and research continued, it was the feeling of these persons that some formal guidelines needed to be established. Therefore, in April of 1979, a group comprised of stack users, researchers, designers, fabricators, and erectors convened at the United Engineering Center in New York City under the auspices of the American Society of Mechanical Engineers to formulate such a code.

With the above in mind, the group subdivided and began gathering information to formulate guidelines for mechanical design, material selection, the use of linings and coatings, structural design, vibration considerations, access and safety, electrical requirements, and fabrication and construction. When these were established, a section on maintenance and inspection was added. The following is a result of their work and investigation. The initial document was approved as an American National Standard in August 1986 and published as ASME/ANSI STS-1-1986 in May 1988.

During the next three years, the committee received comments from the public at large and from its own membership regarding the Standard's content. Several formulas needed correction and some of the symbols needed clarification. Section 6.3.3 regarding Earthquake Response was also reviewed and revised to allow for static rather than dynamic analysis in certain cases, and to correlate it with ASCE STD-7-88 (formerly ANSI A58-1). These changes were then submitted to the general membership and approved.

In 1994, the committee was reorganized to further review and update this steel stack Standard. Emphasis was given to the Structural Design and Vibrations chapters. Chapter 4, "Structural Design," was rewritten to be more compatible with the nomenclature, formulae, and symbols used in the Manual of Steel Construction - Allowable Stress Design (ASD), 9th Edition and Load and Resistance Factor Design (LRFD) 1st Edition. Chapter 5, "Vibrations," was revised to be more "user friendly." These and other chapters were updated to include the latest recognized applicable codes and standards.

This edition includes changes and improvements to the Environmental Protection Agency regulation concerning emissions that have created a strong emphasis on the mechanical design of steel stacks, makes necessary changes found through practical experience with the previous edition, expands formulas as necessary, and provides both revised and new sections for steel stack design, fabrication, and erection. It revises sections on appurtenances to meet today's requirements for these items. A new section provides the fundamental concepts for guyed stacks. Revisions to the section on the physical properties of steel at elevated temperatures have been made to match information available through a comprehensive review of current technical literature. Sections on vibration include minor changes but will yield a more workable standard. Also, a detailed example is included to provide a method for determining the magnitude of across wind loads. One method is included to address fatigue due to vibration. Fatigue can be a significant issue in steel stack design and needs to be considered in the design. Methods to determine across wind load and seismic loads are provided in the nonmandatory appendices. If fatigue requires close examination, the engineer is cautioned to review this issue with other design standards if necessary. There are several standards among them: AISC, CICIND, or ASME that can be helpful.

This revised standard was approved as an American National Standard on March 21, 2006 and reissued as STS-1-2006.

ASME STS COMMITTEE

Steel Stacks

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

OFFICERS

J. C. Sowizal, *Chair*
M. J. Gault, *Vice Chair*
A. L. Guzman, *Secretary*

COMMITTEE PERSONNEL

A. K. Bhowmik, Hamon Custodis
K. Scott, *Alternate*, Hamon Custodis
J. J. Carty, R and P Industrial Chimney Co.
V. Z. Gandelsman, Consultant
M. J. Gault, Braden Manufacturing
A. L. Guzman, The American Society of Mechanical Engineers
W. L. Mathay, Nickel Development Institute
D. C. Mattes, Hoffmann, Inc.
T. Oswald, Jr., Sauereisen Co.
S. L. Reid, Industrial Environment Systems, Inc.
C. Reid, *Alternate*, Industrial Environment Systems, Inc.
W. C. Rosencutter, Meca Enterprises, Inc.
R. K. Simonetti, Parsons E&C
R. L. Schneider, *Alternate*, Parsons E&C
R. S. Slay, Warren Environment, Inc.
J. C. Sowizal, Industrial Chimney Engineering Co.
B. J. Vickery, University of Western Ontario
L. A. Yadav, Foster Wheeler Energy Corp.
W. J. Van Dyke, *Alternate*, Foster Wheeler Energy Corp.
N. Zarrabi, Assoc. Engineering Resources, Inc.

CORRESPONDENCE WITH THE STEEL STACKS COMMITTEE

General. ASME Standards are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Standard may interact with the Committee by requesting interpretations, proposing revisions, and attending Committee meetings. Correspondence should be addressed to:

Secretary, Steel Stacks Standards Committee
The American Society of Mechanical Engineers
Three Park Avenue
New York, NY 10016

Proposing Revisions. Revisions are made periodically to the Steel Stacks Standard 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 periodically.

The Committee welcomes proposals for revisions to this Standard. 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 proposals, including any pertinent documentation.

Interpretations. Upon request, the Committee will render an interpretation of any requirement of the Standard. Interpretations can only be rendered in response to a written request sent to the Secretary of the Steel Stacks Standards Committee.

The request for interpretation should be clear and unambiguous. It is further recommended that the inquirer submit his request in the following format:

Subject: Cite the applicable paragraph number(s) and concise description.
Edition: Cite the applicable edition of the Standard for which the interpretation is being requested.
Question: Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. The inquirer may also include any plans or drawings, which are necessary to explain the question; however, they should not contain proprietary names or information.

Requests that are not in this format will be rewritten in this format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

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.

Attending Committee Meetings. The Steel Stacks Standards Committee regularly holds meetings, which are open to the public. Persons wishing to attend any meeting should contact the Secretary of the Steel Stacks Standards Committee.

INTRODUCTION

The following Standard applies to steel stacks; that is, those stacks where the primary supporting shell is made of steel. It applies to both single- and multiple-walled steel stacks, either of which can be lined or unlined. It also applies to steel stacks that are guyed, or to certain aspects of tower stacks. The stack may be supported on a foundation or from another structure.

This Standard covers many facets of the design of steel stacks. It outlines the consideration which must be made for both the mechanical and structural design. It emphasizes what consideration must be taken for wind- and seismic-induced vibrations. It gives guidelines for the selection of material, linings, and coatings. It gives the requirements for lighting and lightning protection based upon existing building and federal codes. It gives the requirements for climbing and access based upon current Occupational Safety and Health Administration (OSHA) standards. It emphasizes the important areas regarding fabrication and construction. It outlines areas requiring maintenance and inspection following initial operation.

Although many of the topics within these guidelines may be used for all stacks, this Standard is intended to provide design guidelines for stacks containing nonflammable gases such as combustion exhaust gases at low internal pressures. For stacks containing combustible gases under pressure such as flare stacks and flammable vents, additional design considerations must be addressed, including design for internal pressure, design for internal deflagration pressure, and compatibility with adjoining piping design that is in accordance with piping and/or vessel design codes such as ASME B31.3 and Section VIII of the ASME Boiler and Pressure Vessel Code (BPVC). In addition, the materials of construction referenced in this Standard may not be allowed for use with flammable gases under pressure per ASME B31.3 and Section VIII of the ASME BPVC; materials suitable for pressure containment of flammable gases are listed in these codes. No attempt is made within this Standard to define the need or the methods to be used to consider these additional design considerations.

The information presented has been prepared in accordance with established engineering principles utilizing state-of-the-art information. It is intended for general information. While every effort has been made to ensure its accuracy, the information should not be relied upon for any specific application without the consultation of a competent, licensed professional engineer to determine its suitability. It is therefore recommended that Engineering/Design drawings of the stack bear the Professional Engineer Seal, signature, and date.

Nothing in the Standard shall be construed to alter or subvert the requirements of any existing code or authority having jurisdiction over the facility. Furthermore, alternate methods and materials to those herein indicated may be used, provided that the engineer can demonstrate their suitability to all affected agencies and authorities.

STEEL STACKS

1 MECHANICAL DESIGN

1.1 Scope

Mechanical design includes sizing of the gas passage, both in diameter and height; and the drop in gas temperature as heat is transferred through the stack wall. Methods for calculating draft, draft losses, and heat losses are given. Differential expansion of stack components is discussed. Design considerations for stack appurtenances are established.

1.2 General

The purpose of a stack is to vent process exhaust gases to the atmosphere. The mechanical design of stacks is now controlled in part by air pollution rules and regulations. Heights and diameters are set by a balance between structural stability and function, while at the same time meeting the requirements for air pollution control dispersion of the gases to the atmosphere. The heights of steel stacks have increased to satisfy ambient air quality, and stack inlet gas temperatures have decreased as more heat energy is recovered. The importance of attention to stack heat losses has therefore increased. Stack minimum metal temperature should be held above the acid dew point of the vented gases, if possible. Stacks are being designed with many appurtenances to monitor the gases and make stack inspections.

1.3 Size Selection (Height, Diameter, and Shape)

1.3.1 Height. Stack height may be set by one or more factors.

(a) Environmental Protection Agency (EPA) regulations may set the required stack height for downwash due to local terrain or adjacent structures, or to disperse pollutants at a minimum height above the site. Refer proposed stack location and purposes to the proper EPA authorities for the minimum height requirement under controlling air pollution control regulations. See Federal register part II EPA 40CFR, part 51, Stack Height Regulation (July 8, 1985).

(b) The National Fire Protection Association (NFPA) sets minimum height of high-temperature stacks above building roofs and structures for fire protection and human safety. Local codes are often more stringent and must be followed. A minimum of 8 ft of height above a roof surface or roof mounted structure within 25 ft of a stack emitting gases above 200°F (93°C) should be maintained.

(c) The draft requirement of the process to be vented may establish stack height. Formulas to calculate available draft are presented in subsequent paragraphs.

(d) The effective height of a stack considering plume rise may be increased by installing a nozzle or truncated cone at the top to increase the exit velocity of the gases. Several plume rise formulas are available but in actual practice, plume rise can be essentially negated by high wind velocities, low temperatures, and site conditions.

1.3.2 Diameters. The stack diameter may be set by one or more factors.

(a) Gas passage diameter is usually established by the volume of process gas flowing and available draft (natural draft minus draft losses). Velocities in a round stack between 2400 and 3600 ft/min are most common. Stacks venting saturated gases sometimes limit maximum stack velocities between 1800 and 2400 ft/min to reduce entrained or condensed moisture from leaving the stack exit. Tests by EPRI give different ranges for each type of inner surface (see EPRI Wet Stack Design Guide TR-107099-1996).

(b) Stack shell diameters may be controlled by transportation shipping limitations. Caution should be taken to ensure that mechanical performance and structural stability are maintained.

(c) Structural stability may control a stack shell diameter selection and therefore, any size selection based on mechanical criteria must be maintained as tentative until a structural analysis can confirm its acceptability.

(d) Future increases in stack gas volume should be considered as well as future changes in process gas temperatures and gas quality in the diameter selection.

(e) EPA regulations may set stack exit diameter because of plume rise considerations. EPA requirements have sometimes set stack diameters in the test zone to provide optimum velocities for testing.

1.3.3 Shape. The shape of the stack varies with designers' preferences.

(a) Stacks generally are cylindrical in shape for efficiency in structural stability and economy in fabrication. Cylindrical shapes may vary in diameter throughout the height of the stack; however, diameter changes shall occur at an angle not exceeding 30 deg from the vertical.

(b) Other geometrical shapes such as octagonal, triangular, etc. must be considered special and particular attention given to dynamic stability as well as mechanical design. Unusual shapes for aesthetic appearance should be treated both structurally and mechanically as