# Wind Loads for Petrochemical and Other Industrial Facilities

Task Committee on Wind-Induced Forces

ASCE

# WIND LOADS FOR PETROCHEMICAL AND OTHER INDUSTRIAL FACILITIES

PREPARED BY
Task Committee on Wind-Induced Forces of the
Petrochemical Committee of the
Energy Division of the
American Society of Civil Engineers

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# ASCE Petrochemical Energy Committee

This publication is one of five state-of-the-practice engineering reports produced, to date, by the ASCE Petrochemical Energy Committee. These engineering reports are intended to be a summary of current engineering knowledge and design practice, and present guidelines for the design of petrochemical facilities. They represent a consensus opinion of task committee members active in their development. These five ASCE engineering reports are:

1) *Design of Anchor Bolts in Petrochemical Facilities*
2) *Design of Blast Resistant Buildings in Petrochemical Facilities*
3) *Design of Secondary Containment in Petrochemical Facilities*
4) *Guidelines for Seismic Evaluation and Design of Petrochemical Facilities*
5) *Wind Loads for Petrochemical and Other Industrial Facilities*

The ASCE Petrochemical Energy Committee was organized by A. K. Gupta in 1991 and initially chaired by Curley Turner. Under their leadership the five task committees were formed. More recently, the Committee has been chaired by Joseph A. Bohinsky and Frank J. Hsiu. The five reports were initially published in 1997.

Buildings codes and standards have changed significantly since the publication of these five reports, specifically in the calculation of wind and seismic loads and analysis procedures for anchorage design. Additionally, new research in these areas and in blast resistant design has provided opportunities for improvement of the recommended guidelines. The ASCE has determined the need to update four of the original reports and publish new editions, based on the latest research and for consistency with current building codes and standards.

The ASCE Petrochemical Energy Committee was reorganized by Magdy H. Hanna in 2005 and the following four task committees were formed to update their respective reports:

- Task Committee on Anchor Bolt Design for Petrochemical Facilities
- Task Committee on Blast Design for Petrochemical Facilities
- Task Committee on Seismic Evaluation and Design for Petrochemical Facilities
- Task Committee for Wind Load Design for Petrochemical Facilities

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# The ASCE Task Committee on Wind-Induced Forces

This report is intended to be a state-of-the-practice set of guidelines. It is based on reviews of current practice, internal company standards, published documents, and the work of related organizations. The report includes a list of references that provides additional information. The reference list emphasizes readily available commercial publications and government reports.

This report was prepared to provide guidance for determination of wind induced forces on structures found in petrochemical and other industrial facilities. It should be of interest to engineers familiar with design of industrial type structures and the application of ASCE 7, "Minimum Design Loads for Buildings and other Structures," to these types of structures.

In helping create a consensus set of guidelines, a number of individuals provided valuable assistance and review. Reviewers included John Geigel (ExxonMobil), Drew Troyer (ConocoPhillips), and Eric Wey (Fluor Corporation). The committee is appreciative of the efforts of these reviewers.

The task committee would also like to acknowledge the numerous contributions made to this task committee and other technical committees over the years by both Michael Bergeron (SNC Lavalin – GDS Engineers) and Mike Chen (Fluor Corporation). Both Michael and Mike passed away during the preparation of this report update and will be sorely missed by the committee and the broader engineering community.

Finally, the committee would also like to thank Judy Falcon (Exponent, Inc.) who patiently and diligently edited the manuscript and put up with all of our changes.

## The ASCE Task Committee on Wind-Induced Forces

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# CHAPTER 1
# INTRODUCTION

The focus of this report is on the procedures for determining the design wind loads for non-building structures in petrochemical and other industrial facilities. The report is structured around the following generic types of structures usually found in these facilities. Examples are also provided for some of these structures:

a. Pipe support structures (pipe racks, pipe bridges)
b. Open and partially clad frame structures
c. Vessels (vertical, horizontal and spherical)
d. Cooling towers
e. Air coolers (air cooled heat exchangers, also known as fin fans)
f. Tanks
g. Steel stacks

## 1.1 Background

The basis and procedures for determining design wind loads for enclosed structures and other conventional structures are well documented in the engineering literature. These design basis and procedures have been adopted by ASCE and prescribed in ASCE/SEI 7-05[1] (herein referred to as *ASCE 7*) and its predecessor documents. Other organizations have incorporated the major provisions of *ASCE 7* into building codes. The International Building Code (IBC) states that wind loads should be calculated in accordance with *ASCE 7*, and the IBC has been adopted throughout the United States. *ASCE 7* provides three methods for calculating design wind loads on the main wind force resisting system (MWFRS) and on components and cladding:

1. Simplified procedure
2. Analytical procedure
3. Wind tunnel procedure

The simplified procedure (Method 1 in *ASCE 7*) was introduced to simplify the analysis of typical regular-shaped building structures. Its use is restricted to relatively rigid, low-rise, enclosed structures. The analytical procedure (Method 2 in *ASCE 7*) is permitted for structures of any height that do not have unusual geometric irregularities or unusual response characteristics. The wind tunnel procedure is required for complex structures that cannot be evaluated using Method 1 or 2.

The Scope statement for *ASCE 7* indicates that the standard provides minimum load requirements for the design of buildings and other structures that are subject to building codes. ASCE 7 also addresses enclosed structures, trussed towers, and simple cylinders commonly found in petrochemical facilities. However, to address important non-building structures in petrochemical and other industrial facilities, this report enhances ASCE 7 provisions for open frame structures, structures with

[1] At the time of publication of this report, ASCE/SEI 7-10 had been released.

interconnecting piping, partially clad structures, vessels with attached piping and platforms, cooling towers, and air coolers. Design wind loads on non-building structures are typically calculated using the force equation from *ASCE 7*:

$$F = q_z G C_f A_f \qquad (\textit{ASCE 7} \text{ Eq. 6-28})$$

In this equation $q_z$ is the velocity pressure component, G is the gust effect factor, $C_f$ is the force/shape/drag/shielding component, and $A_f$ is the area for which the force is calculated that is usually the projected area normal to the wind. The velocity pressure, $q_z$, is calculated using *ASCE 7* based on several factors, such as the importance of the structure, the surrounding terrain (exposure category), and the basic wind speed, among others.

The selection of basic wind speed, importance factor, exposure category, gust effect factor, and other factors is described in *ASCE 7* and, therefore, is not discussed in detail herein. This report also expands upon ASCE 7 coverage of force coefficients, tributary areas, and shielding for industrial type structures and equipment, which must be carefully defined to assure behavior under wind forces are accounted for. These wind load components are discussed in this report and recommendations for selecting values are made. Since this report is intended to supplement *ASCE 7*, the designer is referred to that document when it provides the appropriate information. The nomenclature used in the recommendations of this report mirrors those found in *ASCE 7*.

### 1.2 State of the Practice

This report reflects various company practices, available research and committee consensus for the wind load design of petrochemical and other industrial facilities. The committee performed a survey (see Section 3.2) and the results indicate that more than half of the companies surveyed have design practices that reference the first edition of this report released in 1997. These survey results are evidence that there has been increased uniformity from a decade ago in determining wind loads on petrochemical structures.

### 1.3 Purpose of Report

It is the intent of this committee that the publication of this report will continue to progress a more uniform application of practices for the computation of design wind loads for petrochemical and industrial facilities. In order to facilitate this goal, a set of recommended guidelines is presented as part of this report.