Wind Loads and Anchor Bolt Design for Petrochemical Facilities

Prepared by the
TASK COMMITTEE ON WIND INDUCED FORCES
and the
TASK COMMITTEE ON ANCHOR BOLT DESIGN of the
PETROCHEMICAL COMMITTEE of the
ENERGY DIVISION of the
AMERICAN SOCIETY OF CIVIL ENGINEERS

Published by
ASCE American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia 20191-4400

Abstract:
Current codes and standards do not address many of the structures found in the petrochemical industry. Therefore, many engineers and companies involved in the industry have independently developed procedures and techniques for handling different engineering issues. This lack of standardization in the industry has led to inconsistent structural reliability. These reports, *Wind Loads on Petrochemical Facilities and Design of Anchor Bolts in Petrochemical Facilities*, are intended as state-of-the-practice set of guidelines in the determination of wind induced forces and the design of anchor bolts for petrochemical facilities, respectively. These reports are aimed at structural design engineers familiar with design of industrial-type structures.

Library of Congress Cataloging-in-Publication Data

Wind loads and anchor bolt design for petrochemical facilities / prepared by the Task Committee on Wind Induced Forces and the Task Committee on Anchor Bolt Design of the Petrochemical Committee of the Energy Division of the American Society of Civil Engineers.
p. cm.
ISBN 0-7844-0262-0
1. Petroleum refineries--Design and construction. 2. Wind-pressure. I. American Society of Civil Engineers. Task Committee on Wind Induced Forces. II. American Society of Civil Engineers. Task Committee on Anchor Bolt Design
TH4571.W55 1997 97-20890
693.8'5--dc21 CIP

Library of Congress Catalog Card No: 97-20890
ISBN 0-7844-0262-0
Manufactured in the United States of America.

Wind Loads on Petrochemical Facilities

Prepared by the

Task Committee on Wind Induced Forces

The 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 the current 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 on Petrochemical Facilities*

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

Frank Hsiu	J. Marcell Hunt
Chevron Research and Technology Company	Hudson Engineering Corporation
chairman	secretary

Joseph A. Bohinsky	Brown & Root, Inc.
William Bounds	Fluor Daniel, Inc.
Clay Flint	Bechtel, Inc.
John Geigel	Exxon Chemical Company
Ajaya K. Gupta	North Carolina State University
Magdy H. Hanna	Jacobs Engineering Group
Steven R. Hemler	Eastman Chemical Co.
Gayle S. Johnson	EQE International, Inc.
James A. Maple	J. A. Maple & Associates
Douglas J. Nyman	D. J. Nyman & Associates
Norman C. Rennalls	BASF Corporation
Curley Turner	Fluor Daniel, Inc.

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 provide additional information.

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

The committee would like to thank Ahmad Nadeem who was assisted greatly with our research on open frame structures.

Norman C. Rennalls
BASF
chairman

Jon Ferguson
Brown & Root, Inc.
secretary

Nguyen Ai	Jacobs Engineering Group
John Geigel	Exxon Chemical Company
Udaykumar Hate	M. W. Kellogg Company
Manuel Heredia	John Brown Engineers
Marc Levitan	Louisiana State University
Marvin Lisnitzer	Stone & Webster
James Maple	J. A. Maple & Associates
Pravin Patel	E.I. Du Pont De Nemours and Company
Ted Puteepotjanart	Raytheon Engineers and Constructors
Ashvin Shah	Fluor Daniel, Inc.
Jerry Suderman	Bechtel, Inc.
John Tushek	Dow Chemical

Reviewers

Al Wussler	El Paso Natural Gas / Gas Processors Association
David Kernion	RPM Engineering Inc.
Jon Peterka	Cermak Peterka Petersen, Inc.

CONTENTS

CONTENTS (Cont'd)

CHAPTER 1
INTRODUCTION

This report is structured around generic types of facilities usually found in the process industries:

a) Pipe support structures (pipe racks).
b) Open and partially clad frame structures.
c) Vessels (vertical, horizontal and spherical).

1.1 BACKGROUND

The basis and procedures for determining wind induced forces 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 codified in *ASCE 7* and its predecessor documents. Other organizations have incorporated the major provisions of *ASCE 7* into building codes, including the Uniform Building Code, Standard Building Code and BOCA/National Building Code. These building codes have been adopted in ordinances and laws written by various local and regional jurisdictions.

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* does not adequately address open frame structures, structures with interconnecting piping, partially clad structures, and vessels with attached piping and platforms. However, it does address enclosed structures, trussed towers and simple cylinders.

Wind induced forces are typically calculated using the force equation from *ASCE 7*:

$$F=q_z G C_f A \tag{1.1}$$

In this equation q_z is the velocity pressure component, G is for the gust component, C_f is the force/shape/drag/shielding component, and A is the area for which the force is calculated. The velocity pressure component of this force (q_z) has three factors; the importance of the structure, the surrounding terrain (exposure category), and design wind speed.

The selection of basic wind speed, importance factor, exposure category and gust response factor are defined in *ASCE 7* and therefore are not discussed in detail. Force coefficients, tributary areas, and shielding are not clearly defined in *ASCE 7* for industrial - type structures and equipment. These 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 will be referred to that document when it provides the appropriate information. The nomenclature and glossary used in the recommendations of this document mirror those found in *ASCE 7*.

1.2 STATE OF THE PRACTICE

This study is based on current industry practices in the design of petrochemical facilities. The practices are generally based on a company's experience and the desire to provide an economical facility that provides a margin of safety that is consistent with the perceived risk. These practices, as interpreted by the committee, are quite varied. For a given type of structure, the practices currently in use can result in design wind induced forces that vary by factors as large as 5, when using the same basic wind speed and exposure category.

1.3 PURPOSE OF REPORT

It is intent of this committee that the publication of this report will result in a more uniform application of practices across the petrochemical energy industry. In order to facilitate this goal a set of recommended guidelines is presented as part of this report.