1

Introduction

1.1 OVERVIEW OF THIS BOOK

Today's datacom (data and communications) facility managers and operators understand the importance of protecting their business' critical data and information technology (IT) equipment (or *datacom equipment*), which includes servers as well as storage, communications, and networking equipment. Data center operators must therefore implement standards and practices for ensuring the integrity and functionality of the equipment within the datacom environment.

High-performance data center facilities accommodate a variety of complex and sensitive datacom equipment that is vulnerable to internal and external sources of shock and vibration. Shock and vibration sources are unwanted forces found at some level in most datacom facilities that over time can degrade both facilities and equipment. The datacom equipment and infrastructure equipment can themselves be vibration sources within the data center. Datacom equipment manufacturers can control these vibration sources by reducing the internal vibrations that are transmitted to the surroundings. External sources such as airports, trains, nearby mining operations (quarry blasting), construction activities, and earthquake and weather events are other sources of operational shock and vibration. These shock and vibration sources are transferred through the building structure to the data center and finally to any operating server and supporting infrastructure equipment. The effect of these disturbances on the function of the IT and telecommunications equipment depends on the design or the robustness of the equipment itself. The best practice to reduce and circumvent the potential disruptive effects of these shock and vibration sources is to eliminate, minimize, and control the input shock and vibration levels. The best place to manage shock and vibration is at the originating source, which may not always be possible.

For users, manufacturers, and installers of servers and storage, telecommunication, and networking equipment, this publication provides design information and criteria to allow for continuous data center equipment operation during vibration or seismic events.

Datacom equipment centers require a focus on the structural and vibration performance of the facility, the building infrastructure, and the contents (e.g., data-

com equipment). As the datacom equipment density continues to increase (compaction), the requirements of the datacom facility continue to evolve because:

- the power and cooling infrastructure becomes larger, heavier, and inherently more structurally challenging
- the datacom equipment itself becomes heavier
- the facility is able to house more datacom equipment and therefore becomes increasingly important to the owner, which may result in the need for increased structural resistance against potential threats of high wind, snow, and seismic and physical assault

In order to maintain high levels of resilience and availability, it is critical to view these topic in a holistic way. The obvious areas to focus on would be the fundamental building envelope and the datacom equipment itself. However, compaction is causing the scope for a typical data center construction project to be dominated by the mechanical and electrical portions of the project. Further, keeping the cooling system in operation without interruption has become just as critical as keeping the power systems operating without interruption. As a result, datacom equipment centers must consider the structural and vibration performance of:

- the building structure,
- the building infrastructure (power, cooling, flooring, and ceiling systems), and
- the datacom equipment (servers, storage, tape drives, network equipment, etc.).

Fundamentally, the current building codes focus on life safety issues. Therefore, although they address issues such as weather events, these events are specifically within the context of reasonably expected conditions and life safety. A datacom facility must include all the typical life safety issues but also must consider what is required to keep the facility in operation during and after more extreme natural or man-made conditions such as a major weather event (e.g., a hurricane or tornado) or an explosion.

The structural and vibration provisions (design features for withstanding external vibration without inducing any failure) are very important but are designed and integrated into the facility and equipment as an enabler for the successful operation and performance of the IT equipment, the power systems, and the cooling systems. For example, some people within the industry are starting to describe the data center as "the computer" since the IT equipment is so integrated and tightly coupled to the power and cooling systems.

The typical refresh rate of datacom equipment is often three to five years. This increases the challenge to provide power, cooling, and structural systems with the right capacities to support the datacom equipment since these systems typically have a life span of at least five times that of datacom equipment. The ASHRAE book *Datacom Equipment Power Trends and Cooling Applications* (ASHRAE 2005a) provides a means of predicting power and cooling capacities in the future. A similar resource does not exist from a structural perspective.

Since structural systems now need to be far more integrated and specialized to accomplish the needs of today's data center facilities, it is important for not only

designers but also owners and operators to have a general understanding of the structural and vibration basics. For example, unintentionally the structural or vibration system could be seriously compromised by an operator's not understanding the importance of the structural and vibration systems' interactions within the building system.

The intent of this book is to provide some basics for addressing these highly integrated topics of building structure, infrastructure, and datacom equipment. In order to effectively address this holistic topic, the contributors to this book include datacom equipment manufacturers, mechanical/electrical engineers, building architects, and building structural engineers.

1.2 OVERVIEW OF THE DATACOM INDUSTRY

The data center and telecommunications industry relies on a physical infrastructure, including datacom equipment centers, for which there is a widely varying range of size, capacity, level of resilience, configuration, use, staffing strategy, etc. As a result, it is very important not to overgeneralize or use a cookbook/recipe approach. Table 1.1 shows typical ranges of applications for various topics but is not intended to show the absolute extremes.

Table 1.1 Datacom Industry Wide Range of Applications

Topic	Range
Space size	Small room to the entire building
Building size	500 to over 500,000 ft^2 (46.45 to over 46,451.52 m^2)
Building configuration	Single building to an entire campus
Power and cooling density	5 to 500 W/ft^2 (54 to 5382 W/m^2)
Equipment weight	30 to 3600 lb (13.6 to 1634.4 kg)
Infrastructure performance/availability	Tier 1 to Tier 4
Scope	Minor renovation to a new building or campus
Operations staffing	Lights out (unmanned) to full 7 × 24 staffing
Use	Mixed use to dedicated use
Main function	Telecommunications, call center, data center
Backup site	No backup site to automatic failover backup site
Lifetime changes	Minimal to extreme
Occupancy	Owner occupied to tenant occupied
Code	Barely meets code to significantly exceeds code
Stories	Single story to high-rise
Climate	Below 0°F (–18°C), above 100°F (38°C), dry/wet, hurricane, tornado prone
Soil type	Sand, clay, organic, high water table

1.3 OVERVIEW OF ASHRAE TECHNICAL COMMITTEE 9.9

Key technical experts of the major IT manufacturers recognized in the late 1980s that power and cooling capacities were going to become increasingly more challenging for the industry. Further, they saw no vendor-neutral professional society holistically addressing the technical aspects of the data center industry. Additionally, they were seeing increasing need for the collaboration and coordination of the IT industry and the facilities industry.

Due to ASHRAE's major international presence and leadership, long history (it was started in 1894), and major publishing infrastructure (including model codes, standards, guidelines, courses, etc.), the IT manufacturers saw ASHRAE as the source to publish unbiased information. As a result, Roger Schmidt (IBM) and Don Beaty (DLB Associates) started the formal process of providing ASHRAE the justification for creating a dedicated technical committee for data center facilities.

Since no other vendor-neutral, nonprofit organization existed for data center facilities, an ASHRAE technical committee (TC) was organized and its members carefully selected to address the broadest possible scope. For example, even the committee title, "Data Center Facilities, Technology Spaces, and Electronic Equipment," reflects a broad perspective (the facility down to the electronics).

TC 9.9 members include experts from IT manufacturers as well as the facility design, construction, and operation areas. The committee also includes members from numerous countries around the world to help provide an even broader perspective. A number of these committee members are neither members of ASHRAE nor thermal engineers.

The focus of the committee is to identify informational and technical needs of the data center industry and to meet those needs. Where the committee does not have a full range of resources or expertise, resources are sought and added to the team. These needs in some cases are not HVAC based, so the committee and ASHRAE's publishing capabilities are employed as a means of meeting the industry's needs.

TC 9.9 has the following major objectives:

- to produce unbiased technical material on data center HVAC
- to provide unbiased training on data center HVAC
- to provide a forum for publishing unbiased technical material on subjects other than HVAC for the data center industry

1.4 OVERVIEW OF THE ASHRAE DATACOM SERIES

The ASHRAE Datacom Series is ASHRAE TC 9.9's primary means to meet the informational needs of the data center industry. The content is intended to provide value to both technical and nontechnical readers.

The books vary in that sometimes they are totally independent of previous books in the series while occasionally they may build on previous books in the series.

At the time of this publication, the following four books have been published, with another three books having substantial work already completed:

1. *Thermal Guidelines for Data Processing Environments* (2004)
2. *Datacom Equipment Power Trends and Cooling Applications* (2005)

3. *Design Considerations for Datacom Equipment Centers* (2006)
4. *Liquid Cooling Guidelines for Datacom Equipment Centers* (2006)

1.5 DOCUMENT FLOW

This book is organized into the following main sections:

Part I—Introduction and Best Practices. Part 1 provides an overview of this book and ASHRAE TC 9.9. It includes the following chapters:

Chapter 1—Introduction
Chapter 2—Best Practices

Part II—Building Structure. Part 2 focuses on the basic building structure, such as the building envelope, building beams, building columns, floor slabs, and roof slabs. It includes the following chapters:

Chapter 3—Building Structures Overview
Chapter 4—New Structures
Chapter 5—Existing Structures and Additions
Chapter 6—Types of Building Structures

Part III—Building Infrastructure. Part 3 focuses on power, cooling, flooring, and ceiling systems. Infrastructure includes exterior equipment yards, such as those for power and cooling. Part 3 includes the following chapters:

Chapter 7—Building Infrastructure Overview
Chapter 8—Structural Considerations for Infrastructure
Chapter 9—Raised-Access Floor Systems
Chapter 10—Vibration Sources and Control

Part IV—Datacom Equipment. Part 4 focuses on the IT or electronic packaging, including items within a rack, the rack, and a row of racks. Part 4 includes the following chapters:

Chapter 11—Shock and Vibration Testing on Datacom Equipment
Chapter 12—Seismic Anchorage of Datacom Equipment
Chapter 13—Analysis of Datacom Equipment and Seismic Anchorage Systems

Appendices and Back Matter. These include background material, a bibliography, and a glossary of terms.

1.6 PRIMARY USERS FOR THIS DOCUMENT

The intended audience for this publication includes both technical and nontechnical readers. Those involved in the design, construction, commissioning, operating, implementation, and maintenance of datacom equipment centers can all benefit from this book. In addition, those who develop and/or design electronic, cooling, and

other infrastructure equipment will benefit from these guidelines. Specific examples of users of this document include:

- computer equipment manufactures (research and development engineers and marketing and sales organizations)
- infrastructure equipment manufacturers (cooling and power)
- consultants
- general construction and trade contractors
- equipment operators, IT departments, facilities engineers, and chief information officers