SPECIAL PUBLICATIONS

Cold Air Distribution System Design Guide

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COLD AIR DISTRIBUTION
SYSTEM DESIGN GUIDE

Allan T. Kirkpatrick
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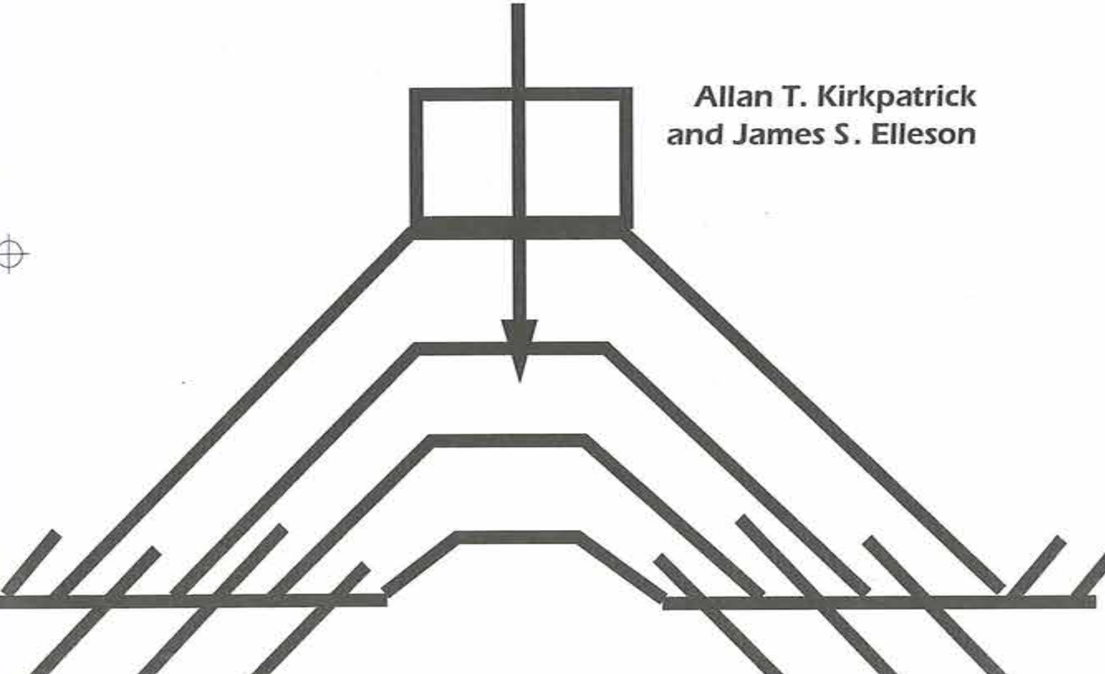

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Cold-air distribution systems supply air for space conditioning at reduced temperatures compared to current typical air distribution designs. These systems, sometimes referred to as low-temperature air distribution systems, typically supply air between 40°F and 50°F (4°C and 10°C). This is in contrast to most "conventional" air distribution designs, which utilize supply air at nominal temperatures between 50°F (10°C) and 59°F (15°C).

The use of cold-air distribution technology can result in lower mechanical system costs, reduced energy consumption, and improved comfort. This design guide provides designers and building owners with the basic information needed to design, install, and operate successful cold-air distribution systems. The design guide is intended to be a practical how-to manual for design practitioners. It provides comprehensive coverage of cold-air distribution design considerations, including evaluation techniques, detailed design information, construction requirements, and design examples. It can also function as an entry point into the literature for those seeking more detailed information on specific aspects of cold-air distribution design. The guide does not cover standard heating, ventilating, and air-conditioning (HVAC) design procedures in depth, but it does provide appropriate references for those readers who desire more information on these topics.

Cold-air distribution is not a new technique, even though its implementation involves some changes from today's "standard" design practice. Supply air temperatures of 40°F (4°C) and less have long been used in industrial applications for humidity control. Many residential and small commercial buildings were retrofitted for air conditioning in the 1950s with 48°F (9°C) supply air, 3.5-in. (89-mm) ducts to fit inside stud walls, and high-velocity jet diffusers to mix the cold air with room air within a short distance of entering the space. Many hospitals were designed in the 1960s with 36°F to 39°F (2°C to 4°C) primary air supplied to constant-volume room induction units.

The current "conventional" standard of 55°F (13°C) supply air evolved from the desire to maintain a space relative humidity (RH) of 50% to 60% while maximizing chilled-water supply temperature and chiller efficiency. For a typical office space with a sensible heat ratio of 0.8 to 0.9, a supply air temperature of 55°F (13°C) provides a space relative humidity of 55% to 60% at 75°F (24°C). This supply temperature also allows flexibility in the selection of cooling coils, as there are many options available for a chilled-water supply temperature of 42°F to 44°F (6°C to 7°C). However, these "standard" design parameters do not necessarily maximize comfort or minimize either first cost or operating costs. They evolved largely out of convenience and have become deeply ingrained in today's HVAC industry.

With the renewed interest in ice storage cooling systems in the 1980s, the advantages of reducing supply air temperatures became evident. With the 34°F to 39°F (1°C to 4°C) chilled fluid temperatures available from ice storage, supply air temperatures of 40°F to 49°F (4°C to 9°C) could now be easily achieved, allowing significant savings in air distribution system costs and energy consumption. Improvements in occupant comfort at reduced relative humidity levels were also recognized.

These benefits encouraged designers to reevaluate the "standard" 55°F (13°C) supply air temperature and to explore the potential of cold-air distribution. Beginning with a small number of pioneers, cold-air distribution technology was developed, refined, and brought into the mainstream. At this time, hundreds of cold-air systems are successfully operating. As facility owners become more aware of the benefits of cold-air distribution, design professionals are faced with an increasing demand to provide cold-air distribution designs. This design guide was commissioned by ASHRAE to disseminate the information that engineers need to design successful cold-air distribution systems.

The remainder of this chapter provides an introduction to the benefits and limitations of cold-air distribution, sources of further information, and a discussion of the organization of this design guide.

1.2 BENEFITS AND LIMITATIONS

The benefits of cold-air distribution include:

- reduced mechanical system costs,
- decreased floor-to-floor height requirements,
- improved comfort with lower space relative humidity,
- reduced fan energy consumption and demand, and
- increased cooling capacity for existing distribution systems.

Reductions in first cost have been an important factor driving the application of cold-air distribution. Lower supply air temperatures reduce the required supply air quantity. In turn, the size of fans and ductwork is reduced, resulting in lower mechanical system costs. In some cases, cost savings resulting from the use of cold-air distribution can offset the incremental cost of adding ice storage. Owners can then realize the operating cost savings of ice storage while paying the same or less initially as for a nonstorage system.

Smaller duct sizes can also lead to reduced floor-to-floor height requirements, with significant savings in structural, envelope, and other building systems costs. In some cases, duct sizes are reduced to the point that they can be run through trusses or beam penetrations rather than under the beams. Cold-air distribution also helps increase a designer's options in applications where space for ductwork is severely limited, such as in the renovation of historic buildings.

The lower space relative humidity maintained by cold-air distribution systems provides improved comfort and indoor air quality. Laboratory research shows that subjects feel cooler and more comfortable at lower humidities, and the air is judged to be fresher with a more acceptable air quality.

Cold-air distribution systems also offer savings in energy costs. Supply fan energy consumption can be reduced by 30% to 40% due to reductions in airflow. This reduction is primarily in expensive, on-peak energy. Where cold-air distribution is used with cool storage, any increases in cooling energy are in the form of less expensive, off-peak energy. Electric demand for supply fans is also reduced up to 40%. This demand savings adds to the reduction in cooling equipment demand when ice storage is used.

Cold-air distribution can be particularly effective in systems where loads exceed the capacity of existing fans and ductwork. By reducing supply air temperatures, owners can avoid the expense of replacing or supplementing existing air distribution equipment.

There are some misconceptions about cold-air distribution that may lead to reluctance on the part of some engineers and building owners to consider it as an option. Some examples of these unfounded misgivings include the following:

Misconception: Reduced supply air volumes will make it difficult to ensure acceptable indoor air quality.

Fact: The volume of outdoor air to be supplied to the space normally remains the same as with a higher supply temperature, although the percentage is higher. The same indoor air quality considerations must be applied to a cold-air distribution design as for a higher temperature design. As with any design, systems serving multiple spaces with varying occupant densities may require special attention to ensure adequate outside air is delivered to each space. Chapter 3 discusses these considerations in detail.

Misconception: Condensation on ducts and diffusers will be a major problem.

Fact: In most buildings, the use of cold-air distribution reduces the humidity throughout the building. At these low-dewpoint conditions, the potential for condensation is no greater than in a space of higher humidity with higher supply air temperatures. See chapter 4 for further discussion.

Misconception: Cold-air distribution can only be applied with ice storage cooling.

Fact: Cold-air distribution has been widely applied to take advantage of the 34°F (1°C) to 39°F (4°C) chilled fluid available from ice storage systems. However, the benefits of cold-air distribution can also be realized if cooling is provided from a nonstorage cooling plant. See chapter 4 for further discussion.

Misconception: Low supply air temperatures will cause uncomfortable drafts.

Fact: With proper selection of terminals and diffusers, the supply air will be almost completely mixed with room air within a short distance of the diffuser. See chapter 5 for further discussion.

There are many applications where cold-air distribution is particularly attractive. Among these are instances where

- decreased floor-to-floor height will significantly reduce the total height of a high-rise building, reducing total construction cost
- space for ducts or air-handling equipment is limited;
- reduced space humidity is desirable; or
- cooling loads have increased beyond the capacity of the existing distribution system.

Of course, there are some applications where cold-air distribution should be used with caution. These include cases where

- generation of chilled fluid at 34°F to 40°F (1°C to 4°C) is not practical,
- space relative humidity must be maintained above 40%,
- high volumes of ventilation air are required, or
- economizer cooling is available with outdoor temperatures of 45°F to 55°F (7°C to 13°C) for many hours of the year.

Such applications should be analyzed on a case-by-case basis using the principles presented in this guide to determine whether cold-air distribution is applicable. The suitability of cold-air distribution for a given project depends on an informed evaluation of all applicable technical and economic factors. The information contained in this guide provides the information and methodology needed to perform such an evaluation.

1.3 SOURCES OF INFORMATION

Additional information on cold-air distribution is available from several sources. A reference list and bibliography are provided following each chapter, and a complete list of references is included at the end of the guide. In addition, information is available from the following sources:

The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)
The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE), publishes technical papers and other publications and sponsors research covering a wide range of subject matter of interest to the HVAC&R industry. Technical papers presented at society meetings are published semi-annually in the *ASHRAE Transactions*. ASHRAE's *Technical Data Bulletins* contain collections of papers pertaining