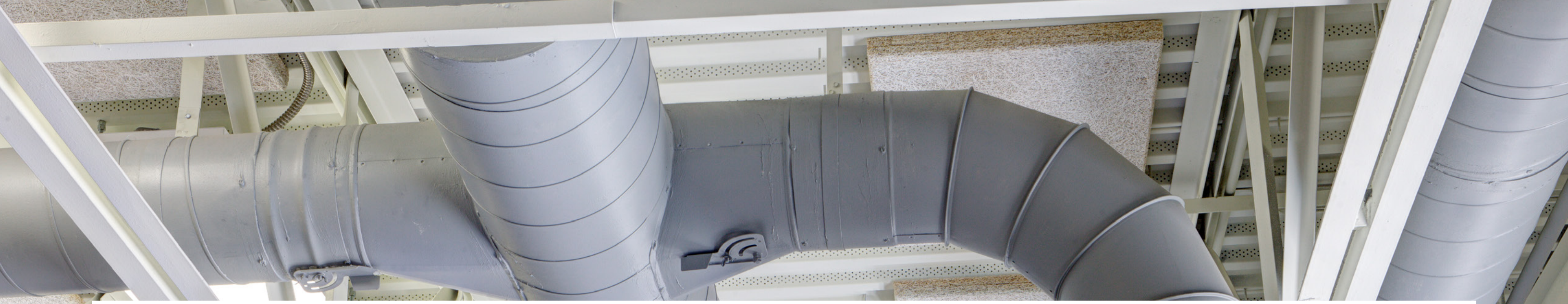
THE TOP 5 MOST

OVER-ENGINEERED BUILDING COMPONENTS

NEWYORK ENGINEERS



INTRODUCTION

When specifying the mechanical and electrical equipment for a building, it is easy to assume that extra capacity is a good thing, but it actually can be just as counterproductive as having undersized installations. In the first place, extra capacity comes at a higher upfront cost, which makes the building owner assume unnecessary expenses. There are also many types of equipment that experience performance issues when over-engineered, which can range from low energy efficiency to a diminished service life. In a few words, oversized systems come with both a higher price tag and an increased operating cost.

This ebook will provide an overview of the building systems that are most commonly over-engineered, pointing out the pitfalls that must be avoided and the negative consequences that can come from excessive capacity.

1 AIR DUCTS

Air ducts play a very important role in HVAC systems that use packaged rooftop units or chillers with air-handling units, and designing duct systems properly is critical in order to guarantee high performance.

For NYC buildings, duct systems must meet the requirements set forth in:

- The NYC Building Code
- The NYC Mechanical Code, which dedicates its entire Chapter 6 to duct systems
- The ASHRAE Handbook of Fundamentals
- The HVAC Duct Construction Standards by SMACNA (Sheet Metal & Air Conditioning Contractors' National Association)

Proper duct design is based on controlling two key variables: airspeed and pressure drop.

When these variables exceed their optimal design range, the duct system becomes both noisy and inefficient. Ideally, a duct system should be designed for a pressure drop of 0.08 inches of water per every 100 feet of length, and air velocity should be kept under 1200 feet per minute.

Learn which HVAC system is the right system for your building.

Both pressure drop and velocity decrease as the cross-sectional area of a duct becomes larger, but there is an upper limit to how much duct size can be increased.

- The system becomes more expensive for the simple reason that material and labor costs are higher.
- The design process of other building systems may be complicated by the fact that ducts take up so much space. It may even be necessary to reduce ceiling height, disrupting the architectural design.
- Oversized ducts increase fan power because a larger air volume has to be moved through the system.

An ideal duct design keeps pressure drop and air speed under design values, while optimizing the cross-sectional area of ductwork.

2 BOILERS

Even in buildings where high-efficiency boilers are used, heating is normally one of the highest energy expenses; this is especially true for New York and other cities to the northeast of the country, which have cold winters. There are boiler systems for practically any type of energy input, including fossil fuels such as oil or natural gas, electricity, or alternative sources such as sunlight and biodiesel.

Given the critical role they play in buildings, as well as the potential negative consequences that can come from system malfunctioning, the NYC Department of Buildings has a dedicated Boiler Unit. This unit oversees the installation and operation of boilers, and runs a yearly inspection cycle for all systems currently in operation. Boilers are addressed in the NYC Building Code, Mechanical Code, and Plumbing Code, and the Fuel Gas Code also applies if the boiler is combustion-based.

Redundancy is desirable in boiler systems, but installing two boilers sized for the full building load each can result in plenty of unused capacity and a high upfront cost. The best design recommendation is to size each boiler for 60% of the total building load, which provides a favorable degree of redundancy, as well as an extra 20% capacity that can be used during initial building warmup.

Avoiding "rules of thumb" is strongly recommended, since they can result in boiler systems that are two to three times larger than required.

Boilers could eventually be displaced by variable refrigerant flow (VRF) systems, which offer a much higher energy efficiency, as well as greater flexibility to meet varying heating loads. As implied by their name, VRF systems use refrigerant to deliver or remove heat, and speed is controlled according to the current building load.

THE ADVANTAGES OF VRF SYSTEMS ARE SIGNIFICANT:

- They can use heat pumps, which operate in both heating and cooling modes, displacing both boilers and traditional AC condensers. The latest heat pump models offer a comparable efficiency to a chiller in cooling mode, and in heating mode they can provide savings of over 70% compared to a resistance heater.
- Heat is transported in refrigerant lines, which are much more compact than water pipes and air ducts.
- VRF systems are modular, which allows them to be expanded incrementally according to building needs – boilers, chillers, and packaged rooftop units are limited in this aspect by their fixed capacities.

VRF systems are very popular in Japan, where they were developed, as well as in Europe. They are relatively new in the US market, but their installed cost is comparable to that of a traditional chiller-based system.

3 AIR CONDITIONERS

The performance of air conditioning equipment improves in direct proportion to how well the unit matches the application. There is a common but erroneous belief that oversizing the unit is preferable, so that it can cool indoor spaces faster while reducing the compressor runtime. However, this comes with many performance issues. Also, even though the compressor runs less time, it also draws more power than a properly sized unit, so energy savings are minimal or zero.

Air conditioning systems are addressed in the NYC Building Code and Mechanical Code. The ASHRAE Handbook of Fundamentals is also a solid reference when designing any HVAC system.

POOR HUMIDITY CONTROL

An effective air conditioning system doesn't only remove indoor heat; it also keeps humidity within a range that is comfortable for human beings. When an AC system is oversized, it can reach the required indoor temperature within a shorter amount of time, and then the compressor is turned off – or slowed down in modern units with variable speed capabilities. The problem when AC units operate like this is that there is not enough time for them to bring indoor humidity to acceptable levels, and this results in an indoor environment that is cold but humid, similar to a refrigerator. Other than causing discomfort, this is a situation that can result in respiratory health issues among occupants.

EXCESSIVE COMPRESSOR CYCLING

An oversized AC unit has spare cooling power, so it can bring indoor temperature in less time than a properly sized system. This means that the unit will tend to operate in a series of short bursts, which can wear down electrical and mechanical components, reducing their service life. On the other hand, a properly sized compressor runs for longer periods but without frequent starts and stops, which is the intended mode of operation.

When AC installations are compared based on their total ownership cost, considering both energy and maintenance expenses as well as their service life, a system of optimal capacity is superior to both undersized and oversized systems.

DISCOMFORT FOR OCCUPANTS

Since an oversized AC unit has excessive cooling power for the application, sitting right under an air duct opening or in front of an evaporator can be very uncomfortable. The fans of evaporators are normally sized in proportion to the AC unit, so the air is both cold and fast-moving, causing a chilling effect.

4 ELECTRICAL POWER

Plenty of devices and systems used in buildings run on electric power, and that includes many types of mechanical equipment. When specifying electrical installations, the same principle used in mechanical systems applies: components should have just the right capacity for the application, not less and not more.

Electrical installations in New York City are required to comply with the following codes:

- NYC Building Code – in particular, Chapter 27
- NYC Electrical Code
- NFPA 70: National Electric Code
- In the case of emergency and standby power systems, compliance with NFPA 110, NFPA 111, and the NYC Fuel Gas Code is also required.

OVERSIZED FEEDERS AND BRANCH CIRCUITS

Undersized electrical circuits tend to fail quickly, sometimes within hours, but oversized circuits have no negative consequences in terms of operation. In fact, an oversized electrical circuit experiences a lower voltage drop and power loss than a properly sized circuit. However, this benefit is negligible compared with the project cost increase that comes with oversized electrical installations.

ELECTRIC MOTORS

The case of motors is different from that of conductors, and there are several negative consequences when they are oversized:

- Motor efficiency is reduced under part-load conditions. For a given mechanical load, a properly specified motor operating near full load will be more efficient than an oversized motor.
- Power factor is also reduced. The oversized motor draws a high reactive current, which can contribute to power factor charges in the power bill. The extra reactive current also uses up capacity in transformers, distribution boards, and circuits, without contributing to the transmission of useful power.

When motors will be subject to part-load conditions frequently, the best option is to use technologies that allow speed control: Electronically commutated motors (ECMs) can be used for fractional horsepower applications, and variable frequency drives (VFDs) with three-phase motors can be deployed for larger loads.

If the motors in a building will be upgraded, three aspects must be considered to achieve the best possible results:

- Adequate horsepower.
- Upgrading to a higher efficiency tier, for example NEMA Premium.
- Implementing automation and speed control measures.

In chiller-based air conditioning systems, it is possible to achieve exceptional synergy if the chiller plant has variable-speed multi-stage compressors, while the associated water pumps and AHUs use motors with speed control.

5 SPRINKLER SYSTEMS

A complex building layout normally means that the fire sprinkler system will have a piping layout of similar complexity, as well as a high sprinkler headcount. When the teams in charge of architectural design and fire protection design work in isolation, complex sprinkler systems are a common consequence.

These systems come with many drawbacks:

- The upfront cost is increased, both in terms of materials and labor.
- Pumps must be sized larger to provide the adequate water pressure and flow rate for a system with more piping length and a higher sprinkler count.

The following are some design recommendations to optimize sprinkler layouts, reducing their complexity and upfront cost:

- Coordinating fire sprinkler design and architectural design, so that the interference of ceiling features, such as offsets and soffits, is minimized.
- Merging smaller rooms into single areas whenever possible, because each time a small room is added, the sprinkler count is increased by one.

Learn more about our sprinkler engineering services.

When designing sprinkler systems in New York, it is important to observe the requirements set for in the following standards and codes:

- NYC Building Code – in particular, Chapter 7 (Fire and Smoke Protection Features), Chapter 9 (Fire Protection Systems) and Appendix Q (Modifications to National Standards)
- NYC Fire Code
- NFPA 13 – Standard for the Installation of Sprinkler Systems
- NFPA 13D – Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes
- NFPA 13R – Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies

It is important to note that Appendix Q of the Building Code takes precedence over national standards, introducing modifications that are specific for New York.

CONCLUDING REMARKS

There are many reasons not to oversize mechanical and electrical building systems. In most cases, oversized systems are just as problematic as undersized systems, if not more, causing performance issues and extra maintenance expenses. Even when there are no performance issues associated with extra capacity, it represents a higher upfront cost that must be assumed by the building owner.

Hiring professional MEP designers is the best way to ensure all building systems will be specified optimally according to the application at hand. Meeting applicable codes and standards is mandatory for a building to be approved, but these documents often specify just the minimum requirements; with professional design, a project can meet code requirements while maximizing performance.

WANT TO LEARN MORE?

Over-engineering a project drives up construction cost without any benefit. Get your construction project back on budget with a free value engineering service.

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