HVAC/R

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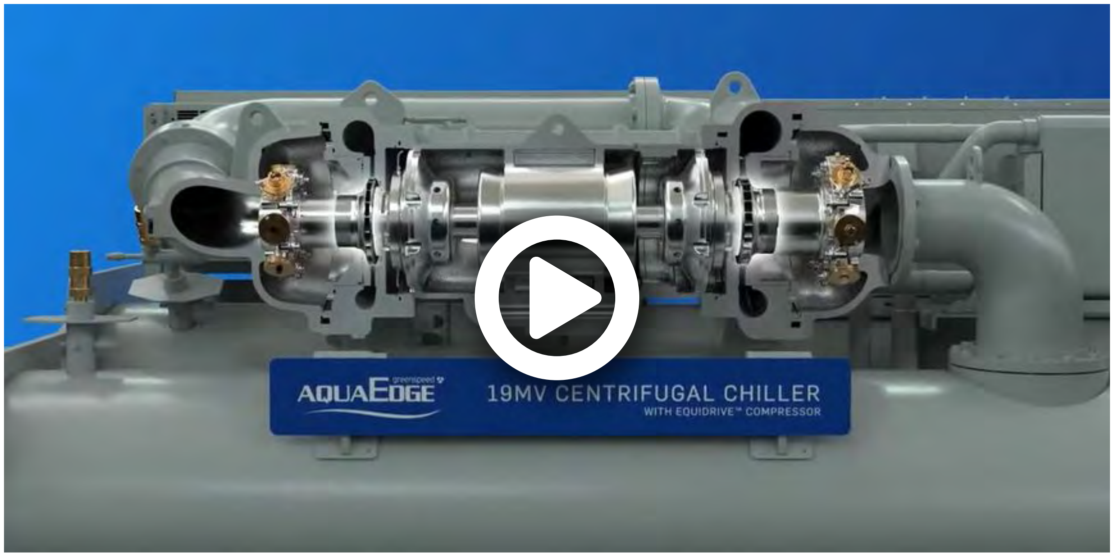
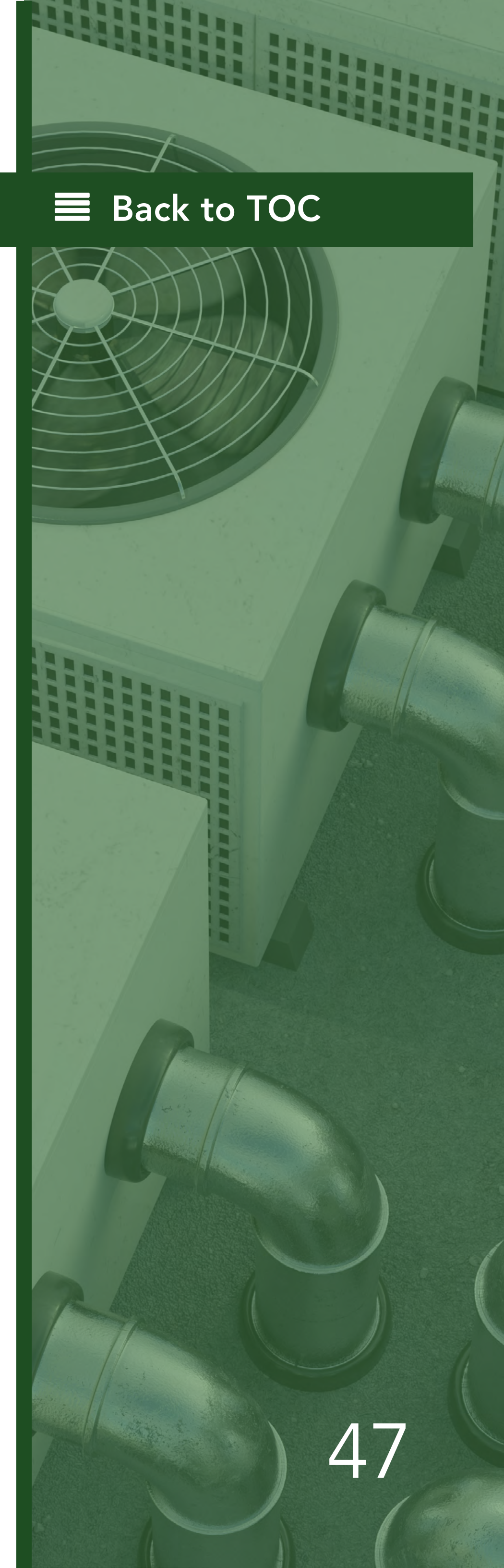


AquaEdge® 19MV Magnetic Bearing Centrifugal Chiller - EquiDrive™ Compressor

Unconditional performance starts with an unbeatable compressor. The AquaEdge 19MV leverages proven EquiDrive two-stage back-to-back compressor technology – with magnetic bearings -- for consistent operation across a wider operating envelope even at severe conditions and heavy cooling loads. Designed to achieve best-in-segment performance while staying quiet and cool under pressure.



EXPERIENCE
UNCONDITIONAL PERFORMANCE.

Introducing the latest Carrier AquaEdge® 19MV centrifugal chiller, designed to deliver high performance and reliability across a wide operating range for all seasons.

For product details, visit **carrier.com/19MV** or contact your local Carrier expert today.

EquiDrive™ two-stage back-to-back compressor with magnetic bearings
Achieves <0.52 kW/Ton and <0.31 kW/Ton (IPLV) at AHRI conditions with sound below 80 dBA.*Available with ultra-low GWP PUREtec™(R-1234ze(E)) or low GWP R-513A or R-515B refrigerant.

Flexible operation
Operates with extraordinary efficiency and confidence, thanks to a wide operating range of 40°F to 95°F (4.4°C to 35°C) entering condenser water down to 10% load.*

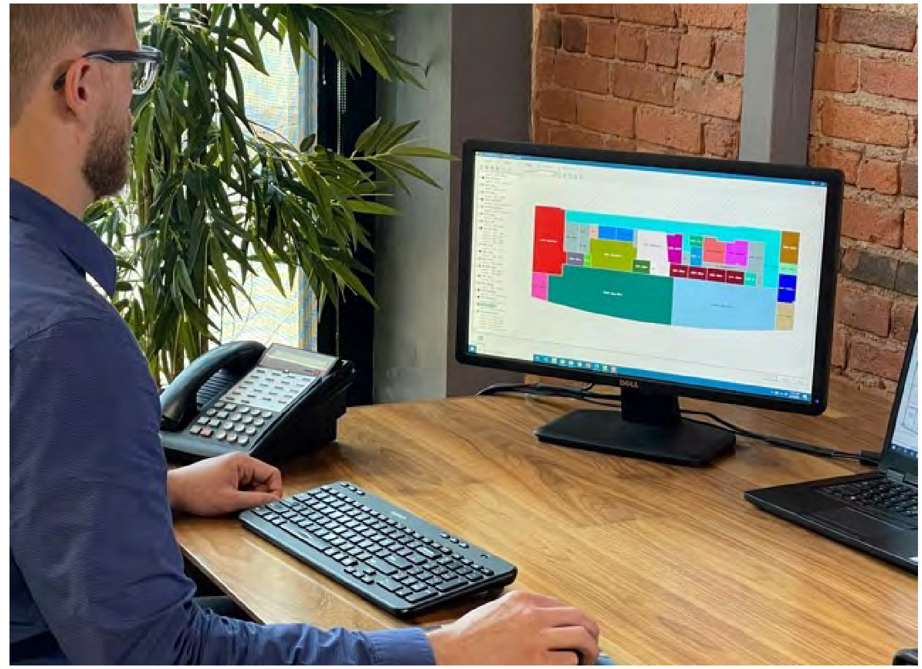
Compact footprint
Fits through double doors (72" x 80") fully assembled for easy installation.*

The 19MV is just the latest winner from the back-to-back chiller champions at Carrier. Explore other innovative water-cooled chiller solutions at carrier.com/chillerchamps.

*Select Models

Carrier

Easing the Pressure of Selecting the Right Chiller Compressor



A Carrier engineer demonstrates the use of Hourly Analysis Program (HAP) software to design an effective HVAC system and compare various alternatives for a corporate office building.

Building environments are undergoing profound transformations. Regardless of type—commercial, data center, healthcare, industrial, educational, government, hospitality, or retail—each has unique HVAC system efficiency, sustainability, and reliability demands. As disparate as these structures are, many have one component in common... chillers.

While chillers are considered the heart of any building's applied HVAC system, the heart of any chiller... is its

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compressor. It’s responsible for driving the refrigeration cycle, ensuring precise temperature to meet the demands of modern spaces.

For over a century, compressors have had their own trajectory of technological evolution. Understanding compression technology, the categories of compressors, and their unique operational attributes will help contribute to making the right recommendations for any chiller’s application.

The Compression Process

Compressors drive the refrigeration cycle by pressurizing refrigerants and enabling heat exchange. Common types include **centrifugal, screw, reciprocating, scroll, and rotary**, each suited for different applications, capacities, and efficiency requirements. Refrigerant in chillers absorbs heat, which changes the refrigerant from a cold liquid to a low-pressure, warm gas. This gas then enters the compressor, which does as its name conveys… it compresses the gas.

Compressors use two different methods for compressing gas. Centrifugal compressors accelerate the gas, increasing its kinetic energy. The gas velocity is then decelerated, converting that kinetic energy into pressure (potential) energy. This conversion of velocity to pressure is a fundamental tenet of Bernoulli’s principle.

Screw, reciprocating, scroll, and rotary compressors compress refrigerant using the principles of Boyle’s Law, which states that the pressure exerted by a given mass of an ideal gas is inversely proportional to the volume it occupies (if the temperature and amount of gas remain unchanged within that enclosed space).

For all of these compressor types, once the compressor creates the high-pressure gas, the refrigerant enters the condenser. There, its energy is removed, and the refrigerant is condensed into its liquid form once again. Then, the expansion valve lowers the pressure and temperature of the liquid, turning it into a low-pressure liquid, which is sent back to the evaporator to repeat the heat transfer process.

The following five compressor types represent the latest technology found in today's commercial chillers, each performing distinct compression functions for consideration when specifying chillers.

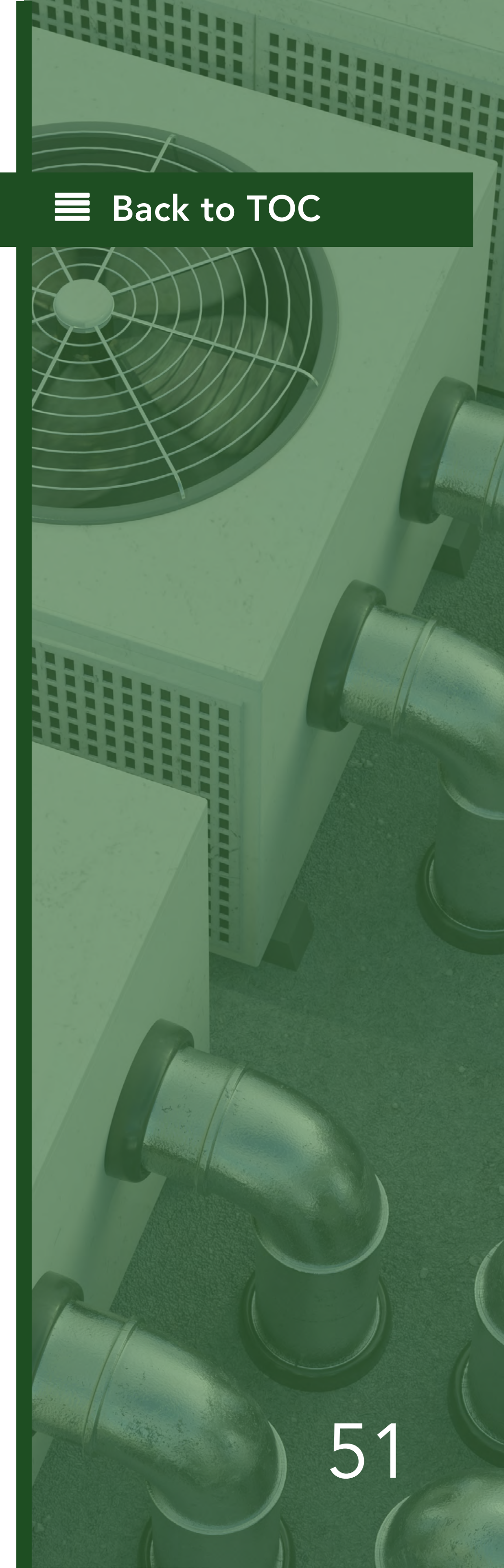
Compressor Types, Refrigerant Cycles, and Applications

1. Centrifugal

Centrifugal compressors are the preferred choice for large-scale chiller systems in high-capacity environments. They utilize a high-speed impeller(s) to accelerate refrigerant and convert kinetic energy into pressure. Their design allows for rapid cooling, smooth operation, the ability to handle large cooling loads efficiently, and exceptional energy performance.

The Refrigerant Cycle Process:
A centrifugal chiller's compressor changes the velocity of the refrigerant gas from a low velocity to a high velocity, then slows it back down again, minimizing turbulence and friction.

In a centrifugal compressor, the refrigerant cycle process begins when low-pressure, low-temperature refrigerant vapor (usually after absorbing heat from the chilled water



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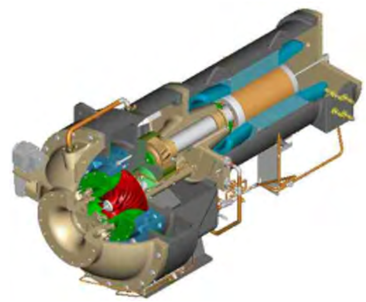
circuit) enters the centrifugal compressor at the center or inlet of its impeller. Once inside the compressor, the impeller rotates at an extremely high speed. This high velocity rotation applies centrifugal force to the refrigerant vapor, accelerating it radially outward from the impeller's center to its edges.

As the refrigerant is pushed outward, its velocity increases, converting kinetic energy into pressure energy. The high-speed refrigerant vapor is then passed through a diffuser, which further 'slows down' the refrigerant. As its velocity decreases, the refrigerant's kinetic energy is converted into higher pressure by a relationship of changing dynamic pressure to static pressure. This high-pressure refrigerant is essential for the subsequent stages of the refrigeration cycle because it can now release heat in the condenser.

The high-pressure refrigerant flows to the condenser, where it releases heat to the surroundings (either using water or air as a cooling medium). As the refrigerant cools, it condenses into a high-pressure liquid, ready for the next steps in the cycle.



Economizer Cycle: After the condenser, the high-pressure liquid is routed to an economizer, where the pressure is reduced to an intermediate level slightly higher than the first stage discharge. This creates flash gas, which is routed back to the compressor and mixed with the first stage discharge gas before entering the second stage. The gas is then compressed back to condensing pressure. The economizer cools the remaining liquid refrigerant, increasing system capacity and reducing the total work of the refrigeration cycle. Increased capacity and reduced work enhance overall cycle efficiency.

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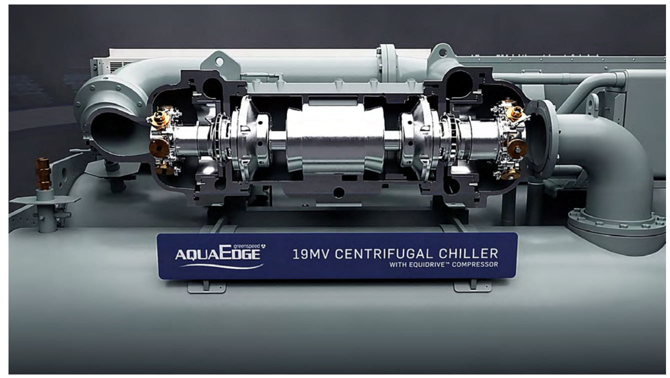
After the refrigerant leaves the economizer, it is throttled down to a low-pressure liquid by an expansion valve, then evaporates in the evaporator, absorbing heat from the chilled water. The refrigerant vapor then re-enters the centrifugal compressor to repeat the cycle.



Two-Stage Centrifugal Compressors:
A two-stage centrifugal compressor is designed to compress refrigerant in two stages, improving efficiency and performance. A two-stage centrifugal compressor compresses refrigerant in two steps, using impellers and economizing to achieve a high pressure at the exit, which improves cooling capacity and energy efficiency in large-scale chillers.

Here's a detailed breakdown of its structure and function:

Inlet Guide Vanes (IGVs): The refrigerant enters the compressor through inlet guide vanes, which help control the refrigerant flow and direct it optimally into the impellers. Adjusting these vanes can modulate compressor capacity.

First Stage Impeller: The first stage consists of an impeller, which rotates at high speed. As refrigerant enters the impeller, it is accelerated outward due to centrifugal force, increasing its pressure and velocity.

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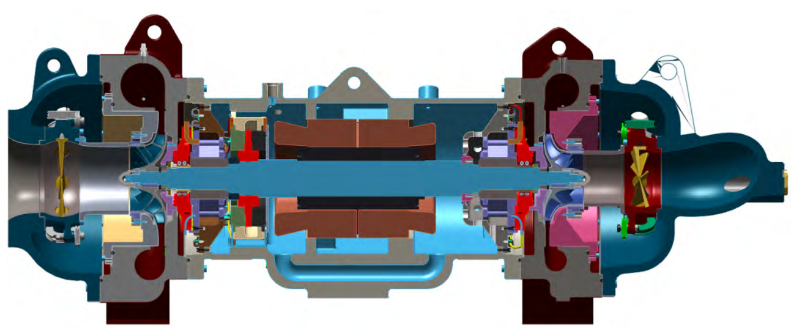
First Stage Diffuser and Volute: The compressed refrigerant exits the first stage impeller and enters a diffuser, which converts the kinetic energy of the high-velocity refrigerant flow into higher pressure. The refrigerant then passes into the volute, a casing that directs it toward a pipe that feeds the second stage of compression. In this intermediate connection between stages, the flash gas from the economizer is mixed in, cooling the refrigerant before it enters the second stage.

Second Stage Impeller: The refrigerant enters the second stage impeller, where it undergoes further compression. This second stage increases the refrigerant's pressure to the desired level required for effective cooling in the chiller.

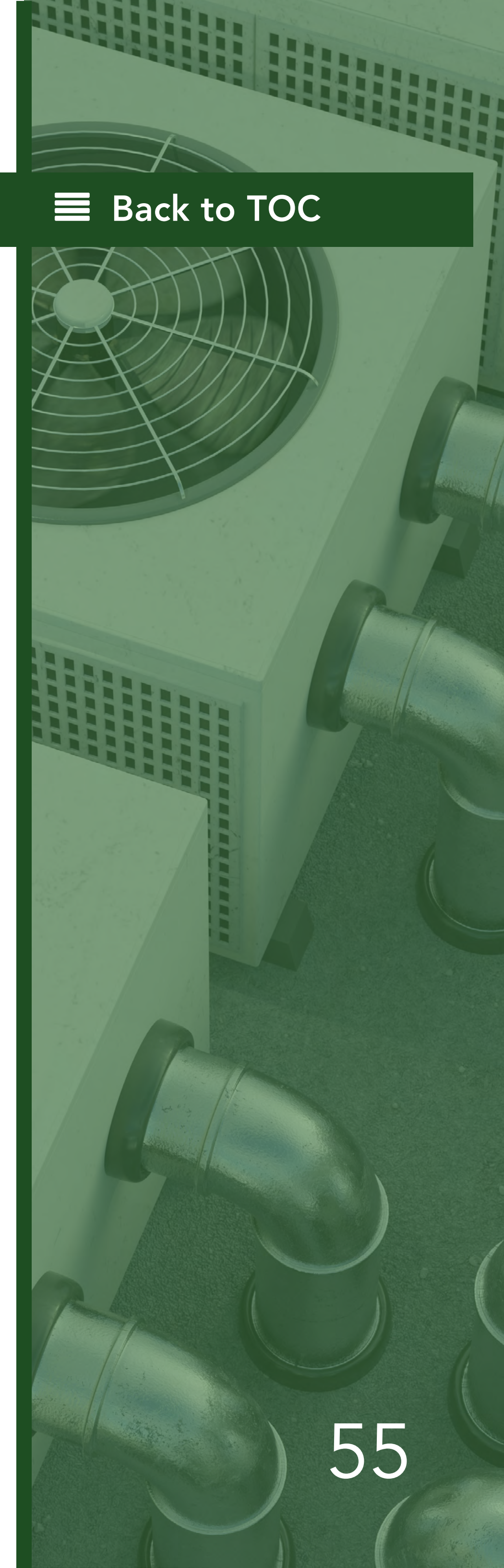


Second Stage Diffuser and Volute: The compressed refrigerant exits the second stage impeller and enters a diffuser, converting high-velocity flow into higher pressure. It then passes into a volute. The diffusers and volutes of both stages are designed to optimize energy conversion.

Centrifugal Applications

Commercial Buildings: Large office buildings, hotels, and shopping malls, where consistent and efficient cooling is needed.

Industrial Facilities: Factories and manufacturing plants, particularly those with significant cooling loads.



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Data Centers: Hyperscale or enterprise where cooling systems must manage immense heat loads and provide dependable and safe cooling under fluctuating server loads.

Medical Facilities: Hospitals or medical complexes that demand precise temperature control and reliability for patient care and sensitive equipment environments.

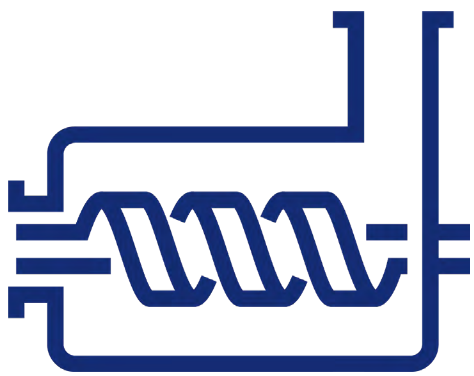
District Cooling Systems: Multiple buildings in a municipal district, campuses, such as universities or business complexes.

On an historical note, in May 1922, Willis Carrier unveiled his single most influential innovation, the centrifugal refrigeration machine (or "chiller"). His invention would give rise to an HVAC company that inspired an entire industry essential to global productivity and personal comfort.

Today, Carrier's AquaEdge® 19MV water-cooled centrifugal chiller with magnetic bearings leverages Equi-Drive™ two-stage back-to-back compressor technology for high performance and reliability across a wide operating range.

2. Screw

Known for efficiency, reliability, and the ability to handle a wide range of cooling capacities, screw compressors help deliver consistent performance, adapt to variable loads, and may support the reduction of operating costs. Utilizing two interlocking, helical rotors (or three for the AquaEdge® 23XRV) that compress refrigerant



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smoothly and continuously, screw compressors are highly durable. Fewer moving parts deliver a robust solution with consistent performance over long periods.

The Screw Compression Process:
Low-pressure refrigerant gas enters the compressor through the suction port. The gas is trapped between the interlocking helical rotors which rotate to compress the refrigerant. As the rotors turn, the gas is progressively compressed in decreasing volume along the length of the screws. This continuous, smooth compression process reduces pulsation and mechanical stress.

At the end of the compression process, the refrigerant exits through the discharge port and check valve. The internal check valve prevents the screw compressor from rotating backwards on shutdown. The high-pressure refrigerant is then directed to the condenser, where it releases heat and condenses before continuing through the refrigeration cycle. The design of the discharge port is critical to optimizing the performance of the compressor and the chiller in which it is installed.

Tri Rotors:
Tri-rotor screw compressors feature three intermeshing rotors—a center screw which engages with a screw on either side. They work together under very tight tolerances to compress the refrigerant. This configuration allows for a more even distribution of the compression radial load on the center rotor's bearings, which tend to experience high loads. As a result, fewe bearings are necessary on the center rotor, enhancing overall efficiency.

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Screw Applications

Commercial Buildings: Large office complexes must maintain consistent cooling for varying occupancy levels. In hotels, screw compressors ensure efficient, quiet operation in systems that must handle fluctuating comfort demands.

Data Centers: Colocation or edge facilities demand reliable, 24/7/365 cooling for mission-critical environments with high heat loads.

Manufacturing Plants: High production facilities which must maintain precise temperature control and continuous cooling in production processes.

Hospitals: Complexes which require precise robust, reliable and efficient cooling for medical equipment, patient rooms, and operating suites.

Universities: Large campuses which need scalable and efficient cooling solutions for classrooms, labs, and dormitories.

Shopping Malls: Large retail spaces which must meet the cooling demands of varying occupancy levels.

Theaters and Arenas: Venues must have low-noise, high-efficiency performance, especially during peak usage periods.

Carrier's AquaEdge® 23XRV chiller is a versatile, water-cooled screw chiller with variable-speed technology. Designed to enhance reliability and efficiency across various operating conditions, it features a tri-rotor screw compressor known for its efficiency. The

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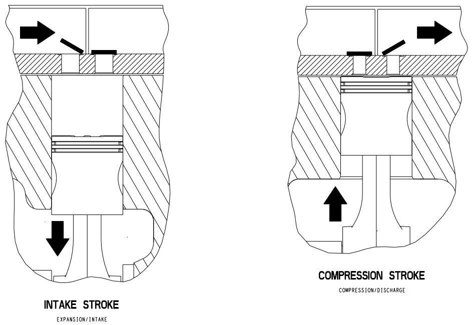
23XRV benefits from this advanced, brilliantly simple compression technology, with only the screw rotors and a variable speed electric motor as moving parts.

3. Reciprocating

Reciprocating compressors are positive-displacement compressors that use pistons housed within cylinders which move back and forth (reciprocate) to compress the refrigerant. Used in small to medium-capacity chillers (typically up to 200 tons), their robust design and ability to reach a range of capacities for variable-load applications, make them versatile solution.



Each cylinder has an intake (suction) and exhaust (discharge) valve. These valves are spring-loaded and automatically open and close based on pressure differences, allowing refrigerant in and out of the compression chamber.

Suction Stroke: As the piston moves downward in the cylinder, the pressure inside the cylinder becomes lower than that in the suction plenum. This pressure difference causes the intake valves to open, allowing refrigerant vapor to flow into the cylinder from the evaporator side.

Compression Stroke: When the piston reaches the bottom dead center and starts moving upward, the intake valve closes. This action reduces the cylinder's volume, compressing the refrigerant and increasing its pressure and temperature.

Discharge Process: As the piston nears the top of the compression stroke, the cylinder pressure exceeds the pressure in the cylinder head, causing the discharge valve to open. The high-pressure refrigerant then flows out of the cylinder and into the condenser.

The Refrigerant Cycle:
In the evaporation phase, the refrigerant absorbs heat and evaporates at low pressure in the evaporator. Next, the reciprocating compressor raises the refrigerant pressure and temperature to prepare it for condensation. During condensation, the high-pressure refrigerant releases heat and condenses back into a liquid. During expansion, the refrigerant's pressure and temperature are reduced, enabling it to absorb heat again in the evaporator.

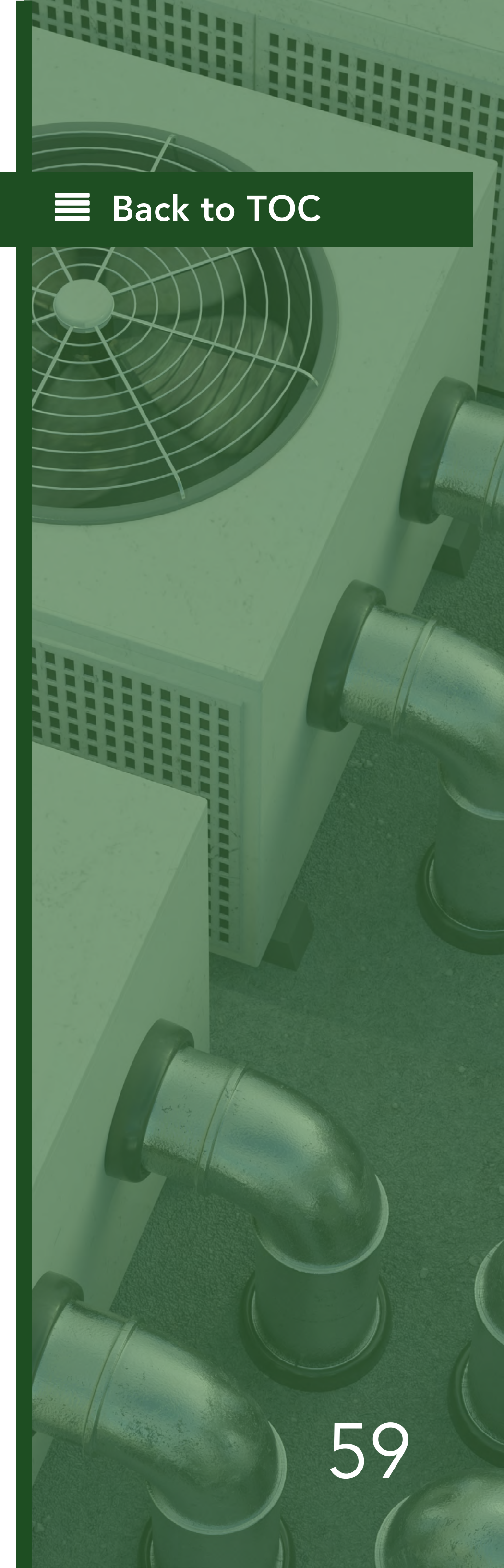
This cycle repeats continuously, with the reciprocating compressor driving the flow and pressure changes. The suction and discharge valves of reciprocating compressors make them highly adaptable to changing operating conditions.

Reciprocating Applications

Small- to Mid-Sized Office Buildings: Buildings with variable occupancy and cooling demands benefit from load flexibility. Relatively compact, they are suitable for smaller buildings.

Data Centers: Smaller data centers or server rooms, the staging capability of reciprocating compressors helps meet varying cooling loads in these environments.

Hospitality: Public areas, restaurants, and conference rooms often experience fluctuating cooling loads due to varying occupancy rates. Well-suited to handling



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The 06E reciprocating compressor from Carlyle, a Carrier company, features a high-flow, automatically reversible oil pump and an oversized sump, to support reliable lubrication and enhanced efficiency even under challenging conditions.

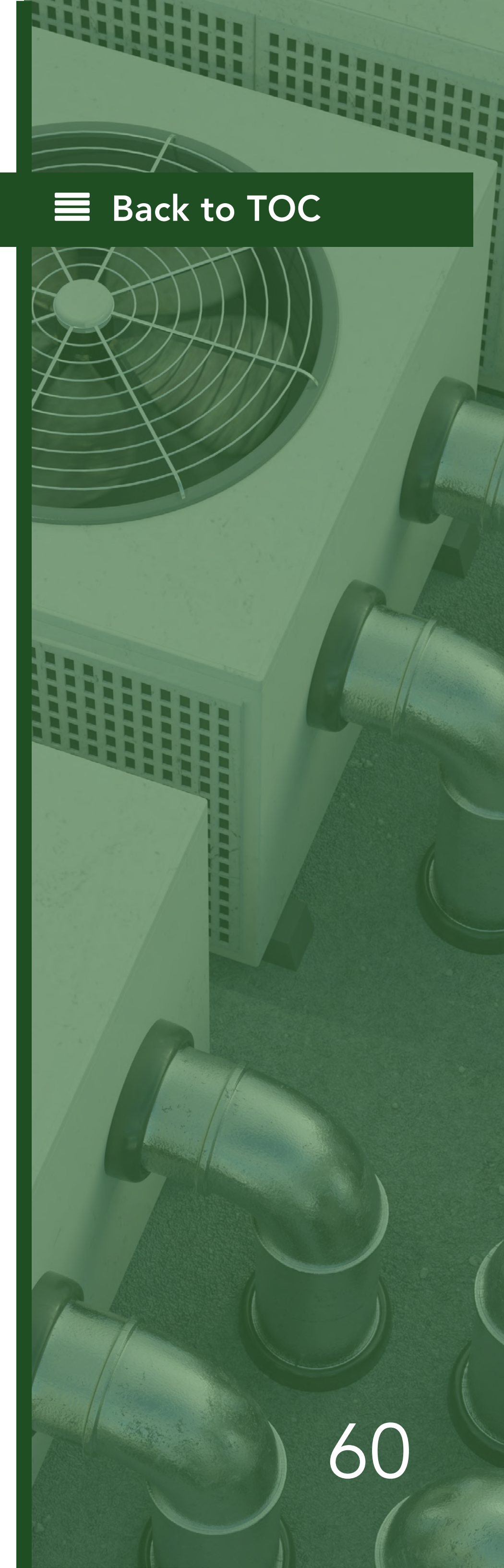
these variable loads and can be staged on and off as needed.

Marine: Effective for marine HVAC systems, providing reliable cooling performance in compact spaces with the ability to adapt to varying load demands.

4. Scroll

Scroll compressors are positive displacement compressors commonly used in commercial HVAC chillers due to their efficiency, reliability, and quiet operation.

Its working principle revolves around the interaction of two spiral-shaped components—one stationary (fixed scroll) and one that moves in an orbiting motion (orbiting scroll). The orbiting scroll rotates around the fixed scroll, which compresses the refrigerant and draws it toward the center. This compresses the refrigerant by progressively reducing the volume of gas between the scrolls.



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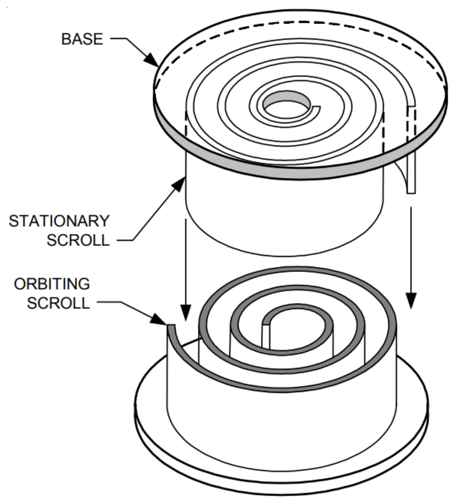
The Refrigerant Cycle

Suction Process: The refrigerant vapor enters the compressor through a suction port and fills the outermost sections between the fixed and orbiting scrolls. At this stage, the vapor is at low pressure and temperature.

Compression Process: As the orbiting scroll moves in a circular path, it traps the refrigerant between the scrolls, pushing it towards the center. This reduces the volume of the refrigerant vapor, causing its pressure to rise. The continuous movement of the orbiting scroll allows for a smooth and quiet compression process, a key advantage of scroll compressors.

Discharge Process: Once the refrigerant reaches the center of the scroll set, it is fully compressed and at a higher pressure and temperature. The compressed refrigerant is then released through a discharge port and sent to the next stage of the refrigeration cycle, the condenser. An internal check valve prevents the scroll compressor from rotating backwards on shutdown.

The scroll compressor is responsible for circulating refrigerant through the system, enabling the chiller to absorb heat from the building and reject it outside. Scroll compressors are known for their energy efficiency, especially in partial-load conditions, making them ideal for applications that demand consistent performance and lower operational costs.



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Scroll Applications

Scroll compressors are ideal for light- to medium-duty applications due to their compact design and low noise levels. They offer both cost-effectiveness and longevity, maintaining high efficiency across a wide range of operating conditions. With fewer moving parts, scroll compressors may offer an extended lifespan and help reduce maintenance costs.

Office Buildings: Provides efficient cooling for workspace environments, where consistent temperatures are needed for employee comfort.

Hospitality: Hotels which require quiet operation— essential for guest comfort—and energy efficiency.

Retail: Shopping malls, department stores, and smaller retail spaces which require climate control for customers.

Healthcare: Small to mid-sized hospitals, clinics, and medical offices to maintain strict temperature requirements.

Educational: Schools, universities, and training centers to maintain consistent temperatures for classrooms, libraries, and administrative spaces.

Data Centers: Smaller data centers and telecommunications facilities to maintain the cooling needed for IT equipment.

Restaurants and Commercial Kitchens: Food service establishments for efficient cooling in dining areas and kitchen environments.

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These compressors are found on both Carrier's small air- and water-cooled chillers, including the AquaSnap® 30MP water-cooled chiller. Designed for faster, more cost-effective installation, the AquaSnap® 30MP chiller is trim enough to fit through a standard size door or elevator and can also be easily connected in a series to provide greater capacity.

Apartment Complexes and Multi-Family Housing: Residential buildings to provide cooling to common areas and, in some cases, individual apartments.

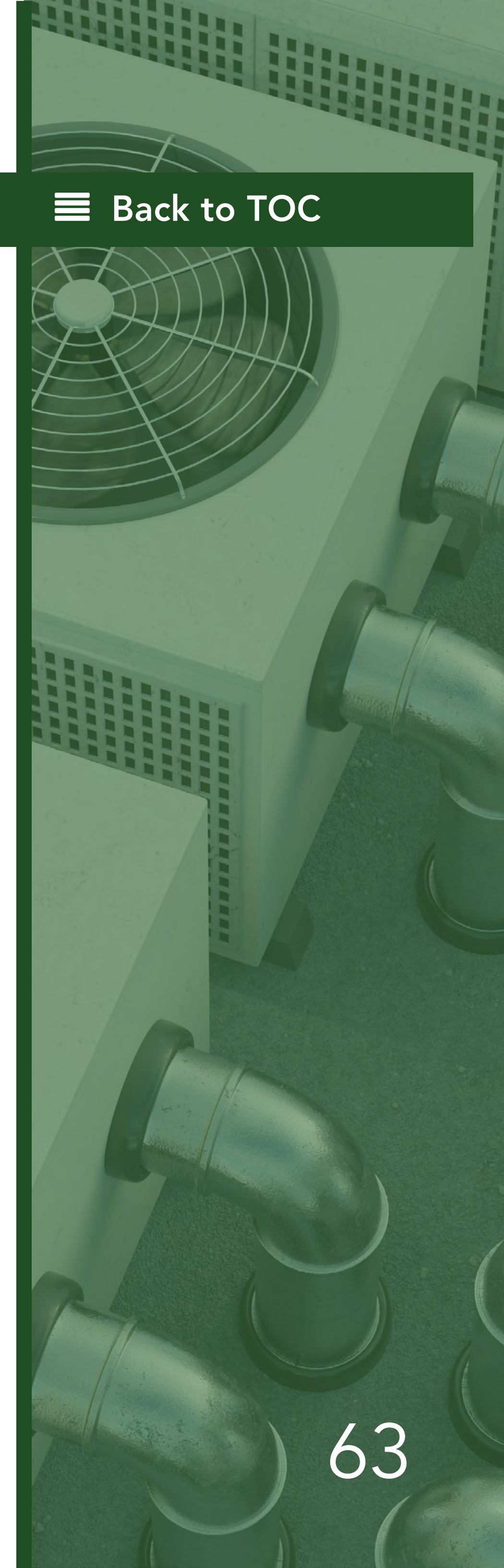
Scroll compressor chillers are especially popular in applications where energy efficiency, low maintenance, and reliable performance are key considerations.

5. Rotary

Rotary compressors are an economical choice for smaller light commercial and residential applications where moderate to low cooling loads are required. Typically found in smaller specialty chillers, rotary compressors are known for their durability and smooth operation and deliver a balance of efficiency, quiet operation, reliability, and compact design.

They use an eccentric rotor that traps the gas against a vane to compress the refrigerant. They layout may have a stationary vane that slides within the housing or rotating vanes that slide within the eccentric rotor.

Intake Phase: The compressor's rotor begins to rotate within a cylindrical chamber. As it rotates, it creates a small gap where refrigerant gas enters through an intake



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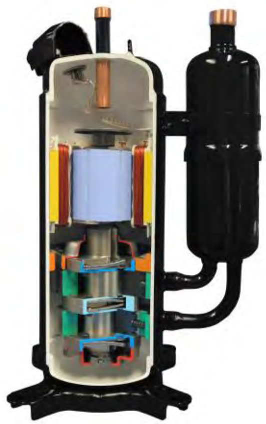
port and creates a trapped volume between the cylinder walls, eccentric rotor and sliding vane.

Compression Phase: Inside the chamber, the rotor continues rotating, pushing the refrigerant gas toward a smaller space. This decreases the volume of the chamber, compressing the refrigerant gas and increasing its pressure and temperature.

Discharge Phase: As the rotor continues to rotate, it pushes the compressed refrigerant toward the discharge port. Once the pressure within the space increases above discharge pressure, the high-pressure refrigerant exits the compressor through a discharge valve to flow through the rest of the cooling system, typically to a condenser, where it dissipates heat.

Rotary Applications

Residential: Popular in dehumidifiers, window air conditioners, and duct-free split systems. Multi-family residential buildings which require decentralized cooling between units.



Light Commercial Buildings: Smaller settings that require a lighter cooling capacity, often a small space that requires cooling within a larger unconditioned space.

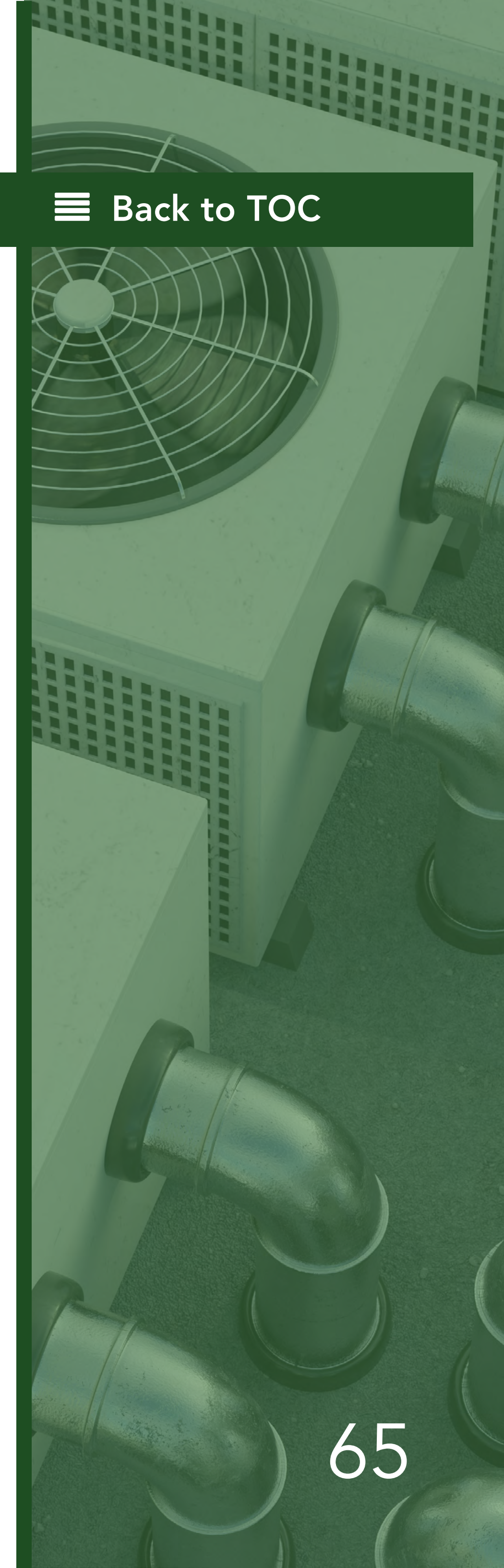
Data Centers: Smaller data centers and IT rooms where reliability and temperature control is critical but cooling needs are small.

Healthcare: Smaller medical clinics with medical imaging equipment and laboratories where compact and precise cooling systems are needed.

Manufacturing: Smaller-scale manufacturing applications which require light-duty process cooling.

Hospitality: Restaurants and kitchens for food storage and kitchen cooling where space is limited.

Selecting the right compressor is crucial for achieving precise, energy-efficient, and reliable cooling. Furthermore, it's not just about meeting current cooling needs—it's about futureproofing for energy efficiency, scalability, and sustainability. Today's compressor choices will impact your client's operational costs, environmental impact, and equipment longevity. Your expertise on this topic will help create environments where comfort, technology, efficiency, and sustainability converge. Refer to the chart on the next page to help you navigate future compressor decisions with confidence.



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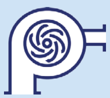
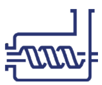
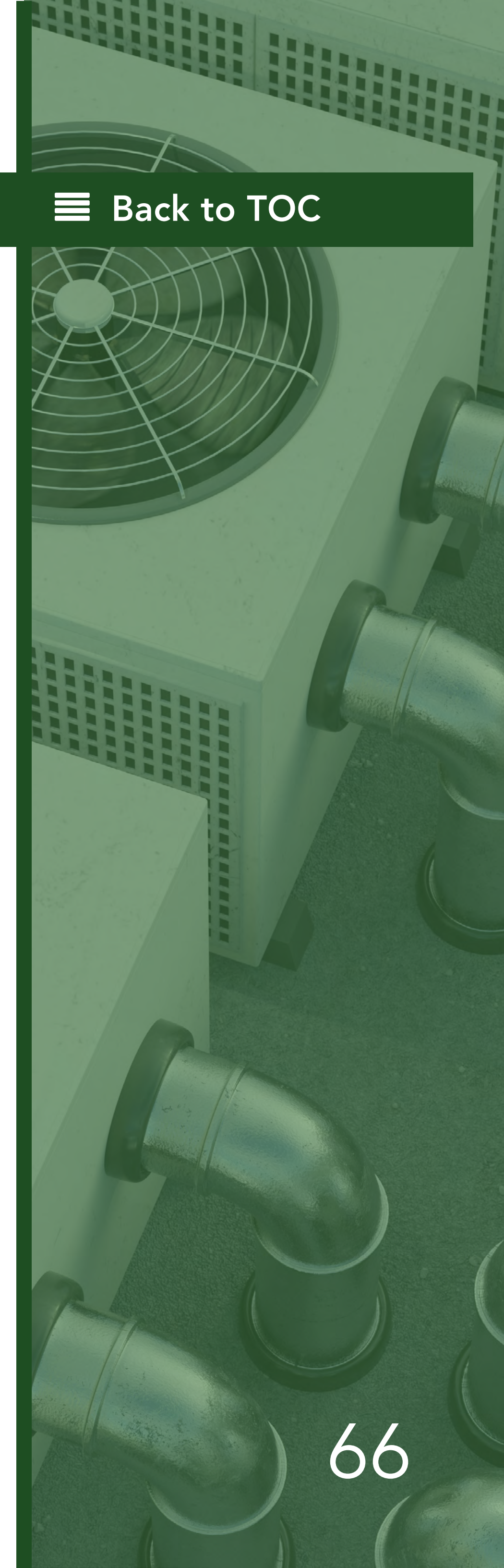
Compressor Technology Comparison

Compressor Type	Characteristics	Applications	Typical* Building Types
Centrifugal 	Rapid cooling, smooth operation, handles large cooling loads efficiently, exceptional energy performance.	Commercial Applied	Large office buildings, hotels, shopping malls, factories and manufacturing plants, hyperscale or enterprise data centers, hospitals/medical complexes, municipal district, campuses, and business complexes.
Screw 	Efficient, reliable, wide range of cooling capacities, consistent performance, adapts to variable loads, helps reduce operating costs.	Commercial Applied	Colocation or edge data centers, manufacturing plants, hospitals, universities, shopping malls, theaters, and arenas.
Reciprocating 	Good at partial load conditions, flexible, scalable, compact design, reliable, can handle higher refrigerant pressures.	Light Commercial and Refrigeration	Small- to mid-sized office buildings, smaller data centers or server rooms, hotels - public areas, restaurants, and conference rooms, and marine.
Scroll 	Compact design, low noise, high efficiency across a wide range of operating conditions, fewer moving parts increase lifespan and help lower maintenance costs.	Light- to Medium-duty	Office buildings, smaller data centers, hotels, shopping malls, department stores, smaller retail spaces, small to mid-sized hospitals, clinics, schools, universities, commercial kitchens, and apartment complexes.
Rotary 	Durable, smooth operation, delivers a balance of efficiency, quiet operation, reliability in a compact design.	Very Light- to Medium-duty	Small office buildings, retail stores, small data centers and IT rooms, small medical clinics, laboratories, small-scale manufacturing, multi-family residential buildings, restaurants and kitchens.

**Represents sample building types. For specific applications, contact your Carrier Representative.*



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