Product Data and Application Guide

Integrated Microturbine Chiller/Heater Power System

240M: Nominal 240 kW Power, 124 Tons Cooling, 1100 MBh Heating
240M: Nominal 240 kW Power, 436 kW Cooling, 324 kW Heating

300M: Nominal 300 kW Power, 149 Tons Cooling, 1381 MBh Heating
300M: Nominal 300 kW Power, 524 kW Cooling, 405 kW Heating

360M: Nominal 360 kW Power, 173 Tons Cooling, 1660 MBh Heating
360M: Nominal 360 kW Power, 608 kW Cooling, 487 kW Heating

PureComfort™ Solution

COOLING, HEATING & POWER

MODEL 360M (PICTURED)
MODEL 300M
MODEL 240M

UTC Power
A United Technologies Company

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PURECOMFORT™ 240M, 300M, 360M SYSTEM REFERENCE DOCUMENTS

- **Product Data & Application Guide (PRMAN61672)**
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- Commissioning Instructions (PRMAN59423)
- Operation and Maintenance Instructions (PRMAN59424)
- Installation Drawing Set
- Remote Monitoring System Software User's Guide (PRMAN59513)
- Remote Monitoring System Software User's Maintenance Guide (PRMAN61008)

The microturbines, chiller/heater and diverter valve have been issued the following applicable certifications.

CE   SA   c UL us

1.0 OVERVIEW

UTC Power, a business unit of United Technologies Corporation (UTX), is focused on the growing market for distributed generation to provide clean, efficient and reliable power. In partnership with United Technologies/Carrier, UTC Power has developed on-site Combined Heat and Power (CHP) systems that are designed and pre-engineered to operate as self-contained cogeneration/trigeneration systems, producing both electric power and chilled or hot water (in cogeneration), or electric power and both chilled and hot water (in trigeneration), for space conditioning purposes. The result is higher efficiency and lower operating costs compared to the more traditional approach of separate power generation, heating, ventilating and air-conditioning (HVAC) systems.

The PureComfort™ Solution is an integrated microturbine and chiller/heater power system that provides an innovative solution to the power and HVAC needs of many commercial buildings. Consisting of a chiller/heater powered by waste heat from the exhaust of multiple microturbines, the PureComfort™ Solution provides on-site cooling, heating and power, and can be configured to operate in four separate modes: Power, Power/Cooling, Power/Heating, and Power/Cooling & Heating. In Power mode, the microturbines provide clean electrical power with ultra-low emissions of less than 9 ppm_v NOx; in Power/Cooling mode, the system provides electrical power and chilled water; in Power/Heating mode, the system delivers electrical power and hot water; and, in Power/Cooling & Heating mode, the system delivers electrical power and both chilled and hot water.

Optional equipment further enhances the operability of the PureComfort™ solution. A trigeneration option allows simultaneous generation of power, chilled water, and hot water. A glycol heat exchanger can also be added to increase efficiency at full thermal load. The microturbines have a dual mode option, whereby power generation independent of the grid is possible.

As a result, building energy efficiency and electrical power reliability can be greatly improved. As an added benefit, the chiller/heater utilizes water as the refrigerant, further qualifying the system as a green technology.

The PureComfort™ Solution can deliver overall energy utilization efficiencies of over 70%, providing substantial energy cost savings in many geographic areas, especially during hot weather conditions when power rates typically peak. This low-maintenance, cost-effective and pre-engineered solution—only available from UTC Power—is offered in several configurations and is sure to fit into a commercial building cost and energy reduction strategy.

2.0 FEATURES AND BENEFITS

Clean reliable power

The heart of the PureComfort™ Solution from UTC Power is the set of microturbines that generate electricity through the combustion of natural gas. The power quality generated from these mini power plants is clean by virtue of advanced digital power electronics, allowing minimal harmonic distortion and compliance with the Institute of Electrical and Electronics Engineers Standard IEEE-519. The microturbines use natural gas as their energy source and generate electrical power that is designed to be always available and not subject to downtime, disturbances or outages as may occur on the grid from time to time. Mechanical reliability is also an inherent feature in the design of the microturbines, given their single shaft and air bearing design.

Operational cost savings

The ability of microturbines to generate electrical power, using natural gas as the energy source, provides the opportunity to reduce high-energy costs by eliminating or reducing grid electrical power consumption. The result is a potential for significant savings in energy costs, especially in service areas with high grid electric costs. Self-generation of power reduces or eliminates demand or ratchet charges that may apply, further increasing energy cost savings compared to that of grid-supplied electrical power. The design of the chiller/heater contributes toward the overall energy cost savings because a non-electric energy source is used to operate the machine. Specifically, waste heat from the microturbines is the source of power required for the chiller/heater to produce cooling or heating. The only electrical power necessary for the chiller/heater is that required to operate the controls and the small self-contained circulation pumps.

Operational flexibility

The PureComfort™ system can be configured for grid-connect, stand-alone or dual-mode operation, depending on location requirements. In grid-connect mode, the microturbines automatically run parallel to the grid and operate at a set power output, displacing the amount of electricity purchased from the grid. In grid-connect mode, the microturbines can be configured to reduce output if the facility peak load drops below the microturbine output, preventing export of electricity to the utility grid. In stand-alone mode, the microturbines provide power to an isolated portion of the facility load. Dual-mode operation permits the microturbines to run in grid-connect mode or, in the event of a grid outage, to transition to stand-alone mode following a brief shutdown period.

Cooling and heating capability

The PureComfort™ system's chiller/heater is capable of operation in either cooling or heating mode, allowing the system to generate either chilled or hot water, depending on the specific building load requirements. Operation in cooling mode produces chilled water that can be piped to other HVAC system components for space cooling. In this configuration, the PureComfort™ system is capable of simultaneous electrical power generation and space cooling. In heating mode, both electrical power and hot water are output from the system, allowing building space to be heated with hot water available from the chiller/heater, potentially reducing or eliminating the size of an existing or supplemental boiler that would otherwise be necessary. With the optional simultaneous cooling and heating, chiller, trigeneration is possible in a combined Power/Cooling/Heating mode. In Power/Heating mode, additional hot water can be generated. The dual capability of the system increases its flexibility year-round in a wide range of commercial buildings, including hospitals, hotels, office buildings and schools. Seasonal changeover from cooling to heating mode is a simple process that can be completed in a short period of time.

Financial incentives

Because of the system's high-operating efficiency, ultra-low emissions and great flexibility, financial incentives, such as government rebates and tax credits, may be available in certain areas. Your local sales representative can provide assistance in identifying these programs.

Remote monitoring service

A remote monitoring service is available from the Carrier Solution Center that allows around-the-clock monitoring and prognostic and customer alerts (and/or repair) services, decreasing response time in the event of a system malfunction.

Pre-engineered / single low installation cost

The PureComfort™ system is enhanced by UTC Power's overall pre-engineered system design, eliminating this task at the installation location. The power generation and cooling/heating components are pre-selected and rated at the design conditions specific to the installation location. The microturbines, gas compressors, chiller/heater and interconnecting ductwork are also pre-engineered and sized to the exact requirements of the job, reducing engineering and installation cost and resulting in a faster and more cost-effective installation. Several standard configurations are available, including a skid-mounted option that minimizes site installation work and enhances customer value; however, help is only a phone call away for special applications that may be necessary in certain situations. Engineering the system up front instead of at the job site not only reduces the cost involved, but also ensures reliable and proven system performance.

Few moving parts / high reliability

Both of the system's two major components, the microturbine and the chiller/heater, have relatively few moving parts, promoting high system reliability and low maintenance. All of the microturbine's rotating components, including the turbine, compressor and generator, are mounted on a common shaft supported by patented air bearings. This single shaft is the only moving part of the microturbine engine. Furthermore, it uses no oil, lubricants, coolants or other liquids, and has no pumps, gearboxes or other mechanical subsystems. With only one moving part, the design of the microturbine is inherently highly reliable. The chiller/heater maintains similar built-in reliability, since its only two moving parts are the hermetically sealed refrigerant and solution pumps integral to the design. There are no large rotating mechanical mechanisms in either component, which greatly simplifies system maintenance and improves overall reliability. Furthermore, the microturbine and chiller/heater are factory tested to ensure proper operation prior to shipment.

Low noise and vibration

Given the few moving parts and the small physical size of the rotating components, the PureComfort™ integrated microturbine chiller/heater power system is naturally quiet; making it an attractive solution in commercial building applications that might otherwise require costly sound attenuation or vibration considerations. The standard full-load sound rating for a single microturbine is 70 dBA @ 10m while the chiller/heater is 65 dBA @ 1m. The unobtrusive sound and vibration characteristics of the system make it ideal in installations which need to be located near occupied space or in areas with strict sound requirements.

Factory-trained service organization

Carrier Commercial Service (CCS) maintains an extensive network of factory-trained and experienced service technicians in every major city. CCS has the largest network of trained professionals in the industry, with over 80 service offices nationwide to quickly and efficiently serve the needs of customers. In addition to routine maintenance and repair services, Carrier offers a wide array of preventative maintenance, full maintenance and/or extended service contracts that can be custom tailored to any level of service for the entire PureComfort^{TM} system.

Environmentally advanced solution

The PureComfort^{TM} system of integrated microturbine chiller/heater power systems is an environmentally friendly solution, providing electrical power and HVAC to many commercial buildings. Electrical power generation through microturbines is inherently clean with very low emissions. The microturbines achieve this ultra-low NO_x performance without post-combustion catalysts or other exhaust cleanup devices because of their lean combustion design, with emissions of less than 9 ppm_v NO_x at full power. Similarly, the chiller/heater utilizes water as the refrigerant, avoiding the use of substances that lead to ozone layer depletion. By driving the chiller/heater with exhaust heat from the microturbines, the PureComfort^{TM} system achieves a high overall energy efficiency. The ultra-low emissions and high efficiency of the system contribute to compliance per the Leadership in Energy and Environmental Design (LEED) certification program as part of the U.S. Green Building Council Rating System.

Sustainability Aspect

UTC Power provides the best solutions possible to suit our customers' needs for increased energy reliability and operational savings, with the common business objective to minimize environmental impact. UTC Power can help its customers to generate its own energy in an efficient, environmentally responsible manner, thereby reducing energy bills and positively affecting environmental impact. The benefits of a single 240 kW CHP system, for example, are equal to taking 250 cars off the road and planting 150 acres of trees, when compared with a traditional central power plant utility.

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3.0 PURECOMFORT SYSTEM DESCRIPTION

The PureComfort™ system consists of an absorption chiller/heater powered by the waste heat from the exhaust of the microturbines and provides on-site cooling, heating and power (CHP) in a packaged and pre-engineered system. Several other components and assemblies also form part of the standard system, including fuel gas boosters that increase natural gas pressure to the microturbines, high pressure fuel kits, and a diverter valve to control the flow of exhaust gas to the chiller/heater in response to cooling or heating demand.

Other hardware required to operate the system includes a cooling tower and water treatment system, chilled water pump, cooling water pump, interconnecting exhaust gas ductwork between the microturbines and the chiller, and electrical power, control and communication interface between the system components and the facility being served. The control and communication interface is provided using a Remote Monitoring System (RMS).

Microturbine

Compact, reliable design

Each 60 kW microturbine system consists of a turbine engine, solid-state power electronics, a fuel system and an indoor/outdoor-rated enclosure.

The 60 kW microturbine engine includes a compressor, a recuperator (exhaust gas heat exchanger), a combustor, a turbine and a permanent magnet generator. The microturbine engine is air-cooled and supported on air bearings.

The compressor impeller, turbine rotor and generator rotor are mounted on a single shaft, which comprises the only moving part of the engine. The engine rotates at up to 96,000 rpm at full load.

Power electronics are solid-state, double conversion type, producing three-phase alternating current output power from the high-frequency alternating current engine output, nominally 60 kW @ 480 vac, 60 Hz.

60 kW Microturbine

Single shaft and air bearings

The rotating components of the patented microturbine are mounted on a single shaft, supported by a unique air bearing design. Use of air bearings eliminates the need for lubricating oil and its associated lubrication system. Also eliminated are environmental hazards such as emissions associated with the use of lubricating oil. The use of air bearings significantly reduces the amount of time required for maintenance operations. Because the generator is direct drive, a gearbox is not required, which eliminates potential noise and an additional maintenance source. Normal preventative maintenance activities on the microturbine require only minutes to perform.

No liquid coolants or lubricants

The power electronics and generator are cooled by separate intake air streams, eliminating the need for liquid cooling. This simplifies the system, reducing emissions and lowering maintenance costs.

High quality, self-synchronized power

The digital power controller (DPC) converts variable frequency AC from the high-speed permanent magnet generator to DC, and then converts the DC to grid-referenced AC @ 480 v.c. 3 phase, 60 Hz. The rotating machinery is isolated from the utility, eliminating the need for additional equipment or operator intervention for synchronization. In grid-connect mode, the current waveform total harmonic distortion is compliant with IEEE-519. In Stand-alone mode, voltage is 480 v.c. on each phase. The microturbine is also Underwriters' Laboratories (UL) certified with UL-1741 and UL-2200.

Packaged for outdoor installation

The microturbines are designed for either indoor or outdoor operation and are compact and lightweight, simplifying rigging and installation.

Low noise and vibration

The microturbine has standard inlet filtering and exhaust ducting that contributes to high overall sound attenuation. Each microturbine has inherently low vibration levels, avoiding the need for additional equipment and simplifying installation. An enhanced noise reduction package is also available for applications where low noise operation is required.

Fuel system certification

High-pressure and low-pressure gas fuel systems have achieved UL certification to meet the new Generator Standard 2200 in both stand-alone and grid-connect modes.

High efficiency

The microturbine design provides good electrical efficiency and high overall efficiency with exhaust heat recovery. The microturbine engine recuperator reclaims exhaust heat to preheat intake combustion air. This greatly improves the electrical efficiency, nominally 28%, based on lower heating value (LHV) over a non-recuperated microturbine. Additionally, the microturbine exhaust temperature, nominally 608°F (320.4°C), provides enough sensible heat for efficient use in a double-effect absorption chiller/heater system, such as the PureComfort™ system.

Low maintenance

The microturbine is designed to have very low maintenance requirements. The air bearings operate free of contact with the shaft, eliminating the need for lubrication and resulting in greater reliability and lower maintenance. An air filter change is recommended after every 8,000 hours of operation, with routine maintenance typically following every 20,000 hours. Factory engine servicing is recommended after 40,000 hours of intermittent or continuous use.

Low NO_x means simplified permitting

Emissions of nitrogen oxides (NO_x) for a natural gas fueled microturbine are less than 9 ppm_v @ 15% O_2. Emissions of carbon monoxide and hydrocarbons are 15 ppm_v and 9 ppm_v, respectively. The California Air Resource Board (CARB) certified the PureComfort™ system for distributed generation in 2003. This performance is achieved by patented lean premix combustion technology and enabled by the continuous-combustion characteristics of the gas turbine. After-combustion emissions controls are not required to achieve these numbers, which are comparable to Best Available Control Technology (BACT) for much larger gas turbines using post-combustion controls, such as selective catalytic reduction. Part-load emissions are also minimized through the use of multiple fuel injectors.

4.0 CHILLER/HEATER

Cost-effective cooling and heating

The 16DNP chiller/heater operates off the waste heat from the four to six 60 kW microturbines' exhaust, providing cooling or heating from an essentially "free" energy source. Electrical power required for operation is minimal and used only for the controls and for the refrigerant and solution pumps. The chiller/heater employs a double-effect design, which is more efficient than a single effect type, providing more capacity for the same heat input. Operation in the cooling mode produces chilled water that can be used for air-conditioning or sub-cooling refrigeration loops, while heating mode operation produces hot water up to 140°F (60°C), with optional temperature generation of 175F° (79.4°C) that can be utilized for space heating or other purposes. Utilizing waste heat from the microturbines, full load cooling operation results in a chiller coefficient of performance (COP) greater than 1.2 at standard Air Conditioning and Refrigeration Institute (ARI) operating conditions.

Water is the refrigerant

The 16DNP absorption chiller/heater uses a lithium bromide (LiBr) and water absorption refrigeration cycle to produce either chilled water or hot water as part of a building's HVAC system. Using water as the refrigerant, avoids the use of substances believed to deplete the ozone layer or that could otherwise damage the environment.

Designed for long life and reliability

Mechanical integrity of the unit is protected because the only rotating parts within the 16DNP chiller/heater are the refrigerant and solution pumps. These pumps are hermetic by design and proven to perform in this process.

The absorption chiller/heater incorporates a highly effective corrosion inhibitor to provide an extra margin of protection against internal corrosion. The superior corrosion protection of the inhibitor allows the use of standard copper tube material throughout the machine (except for the high-temperature generator fire tubes that are made of carbon steel and the high temperature solution heat exchanger tubes made of cupro-nickel). To further aid in ensuring longevity, each unit is factory tested, which forms a protective coating on internal machine surfaces. These measures result in long machine life, reliable performance and maximum beneficial use for cooling or heating year-round.

Figure 1 -16DNP Chiller/Heater

Double-effect, absorption cooling cycle

The double-effect, exhaust-fired absorption chiller/heater consists of an evaporator, absorber, condenser, high-temperature and low-temperature generators, and solution heat exchangers. It also contains refrigerant, solution and purge pumps, and panel and auxiliary controls. Water is used as the refrigerant in vessels maintained under low absolute pressure (vacuum). In cooling mode, the chiller operates on the principle that under vacuum, water boils at a low temperature. Under typical operating conditions, this occurs at approximately 40°F (4.4°C), thereby cooling the chilled water that circulates through the evaporator tubes. A refrigerant pump is used to spray the refrigerant water over the evaporator tubes to improve heat transfer.

To make the cooling process continuous, the refrigerant (water) vapor must be removed as it is produced (refer to Figure 2 on the next page). To accomplish this, a lithium bromide solution, which has a high affinity for water, is used to absorb the water vapor. As this process continues, the lithium bromide becomes diluted, reducing its absorption capacity. A solution pump then transfers this weak (diluted) solution to the generators where it is re-concentrated in two stages (double-effect) to boil off the previously absorbed water. A variable frequency drive on the solution pump automatically maintains optimum solution flow to the generators at all operating conditions for maximum efficiency. The diluted solution is pumped to the high-temperature generator where it is heated and re-concentrated to a medium concentration solution by the heat from the microturbine exhaust. The medium concentration solution from the high-temperature generator flows to the low-temperature generator where it is heated and re-concentrated to a strong solution by the high temperature water vapor released from the solution in the high-temperature generator. Since the low-stage generator acts as the condenser for the high-stage generator, the heat energy first applied in the high-stage generator is used again in the low-stage generator, reducing the heat input by approximately 45% as compared to an absorption chiller with a single-stage of re-concentration. The water vapor released in the shell side of the low-stage generator, in addition to the now condensed water vapor from the tube side of the low-stage generator, enters the condenser to be cooled and returned to a liquid state. The refrigerant water then returns to the evaporator to begin a new cycle.

To remove heat from the machine, relatively cool water from a cooling tower or other source is first circulated through the tubes of the absorber to remove the heat of vaporization. The water is then circulated through the tubes of the condenser. The strong (re-concentrated) solution from the low-stage generator flows back to the absorber to begin a new cycle.

For efficiency reasons, the medium concentration solution from the high-stage generator is passed through the high-temperature solution heat exchanger to pre-heat the weak solution, while pre-cooling the medium concentration solution. The strong solution from the low-stage generator is passed through the low-temperature solution heat exchanger to preheat/precool the solution before being returned to the absorber.

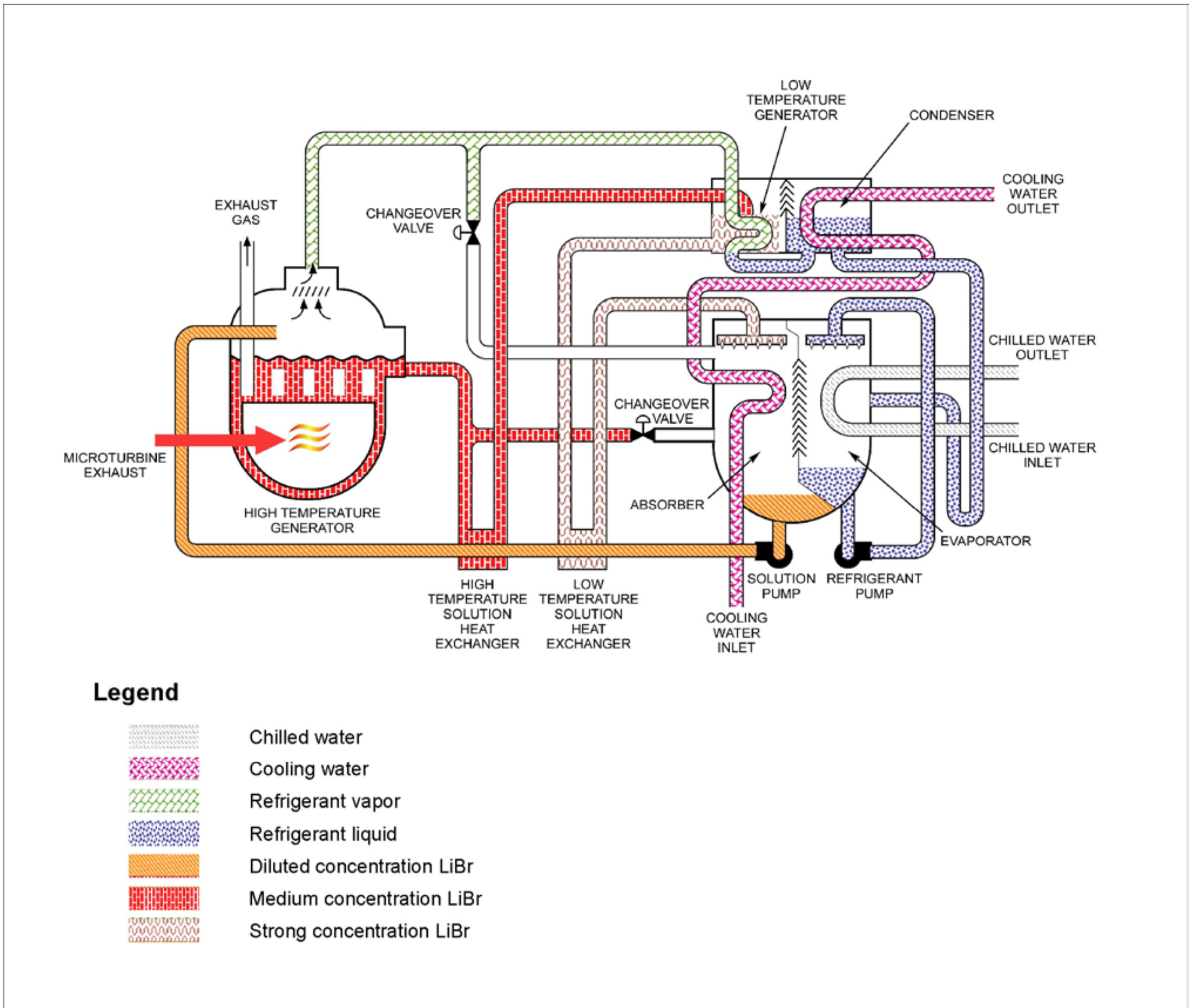

Figure 2 - Absorption Cooling Cycle

Absorption heating cycle

In the heating mode, the absorption chiller/heater delivers hot water for space heating or other applications to reduce or eliminate dependency on existing or supplemental boilers. When operated as a heater, hot water temperatures of 140°F (60°C) are standard (see Figure 3) and do not require additional components. Hot water at 175°F (79.4°C) is available with an additional heat exchanger (see Figure 4, next page).

In this mode, the cycle follows a different vapor flow path than undertaken for cooling and does not use the absorption process. In addition, the absorber-condenser cooling water circuit is drained and not used, since all heat rejection from the machine is designed to take place through the evaporator (now the heating bundle) in a classic two-pipe system that utilizes only the evaporator nozzles.

High temperature water vapor produced in the high-temperature generator section is passed directly to the evaporator through the absorber where it condenses and transfers its heat to the water circulating through the evaporator tubes. This condensed water then flows to the absorber section where it mixes with the concentrated solution returning from the high-temperature generator. The diluted solution is then pumped back to the high-temperature generator to repeat the vapor generation phase for the heating function. Quick changeover from cooling to heating is accomplished by switching the positions of two hand valves, draining the absorber-condenser water circuit and place the machine in heating mode by changing the position of a switch in the control panel.

Hot water at 175° F is available with an additional heat exchanger on top of the high-stage generator. The refrigerant vapor generated from the high-stage generator is condensed in the auxiliary heat exchanger. Three changeover valves isolate the high-stage generator from the rest of the machine. Heating in the 175° F cycle uses only the high-stage generator and the auxiliary heat exchanger.

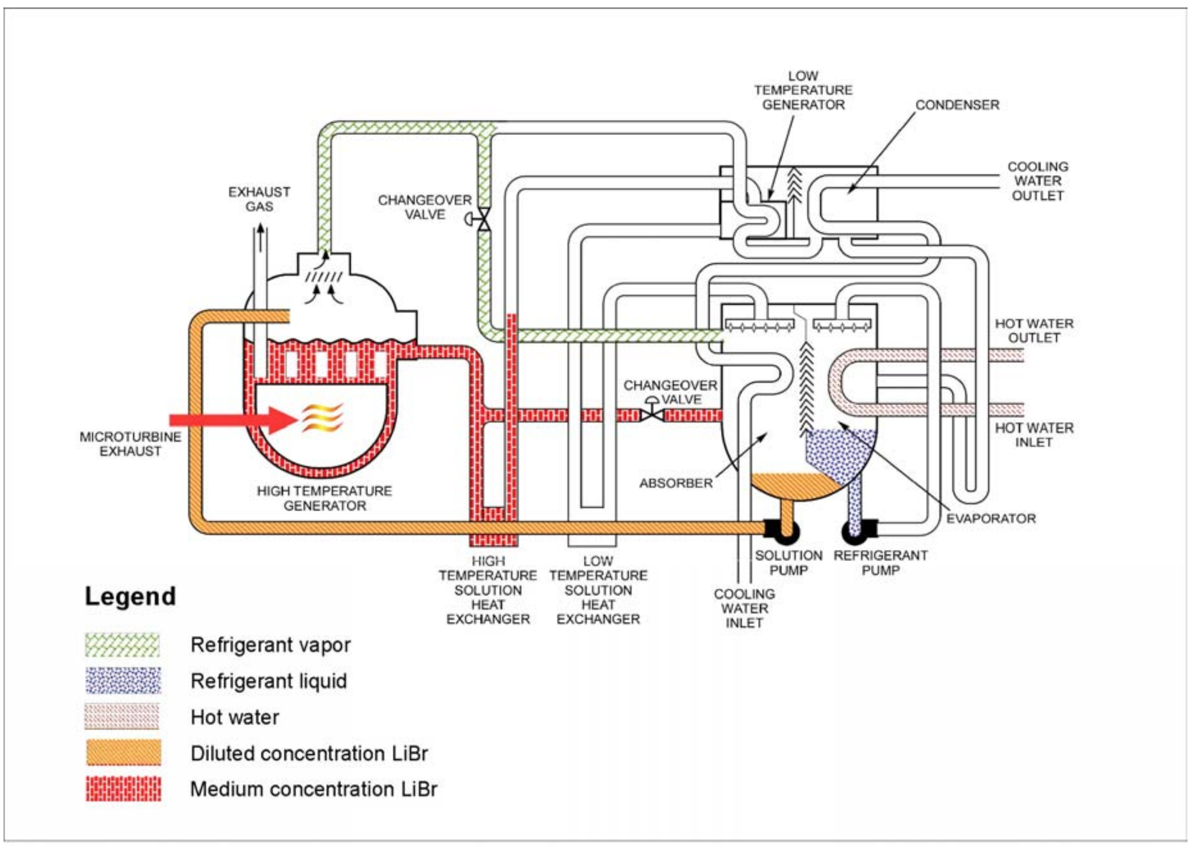

Figure 3 - Absorption Heating Cycle
140° F (60° C)

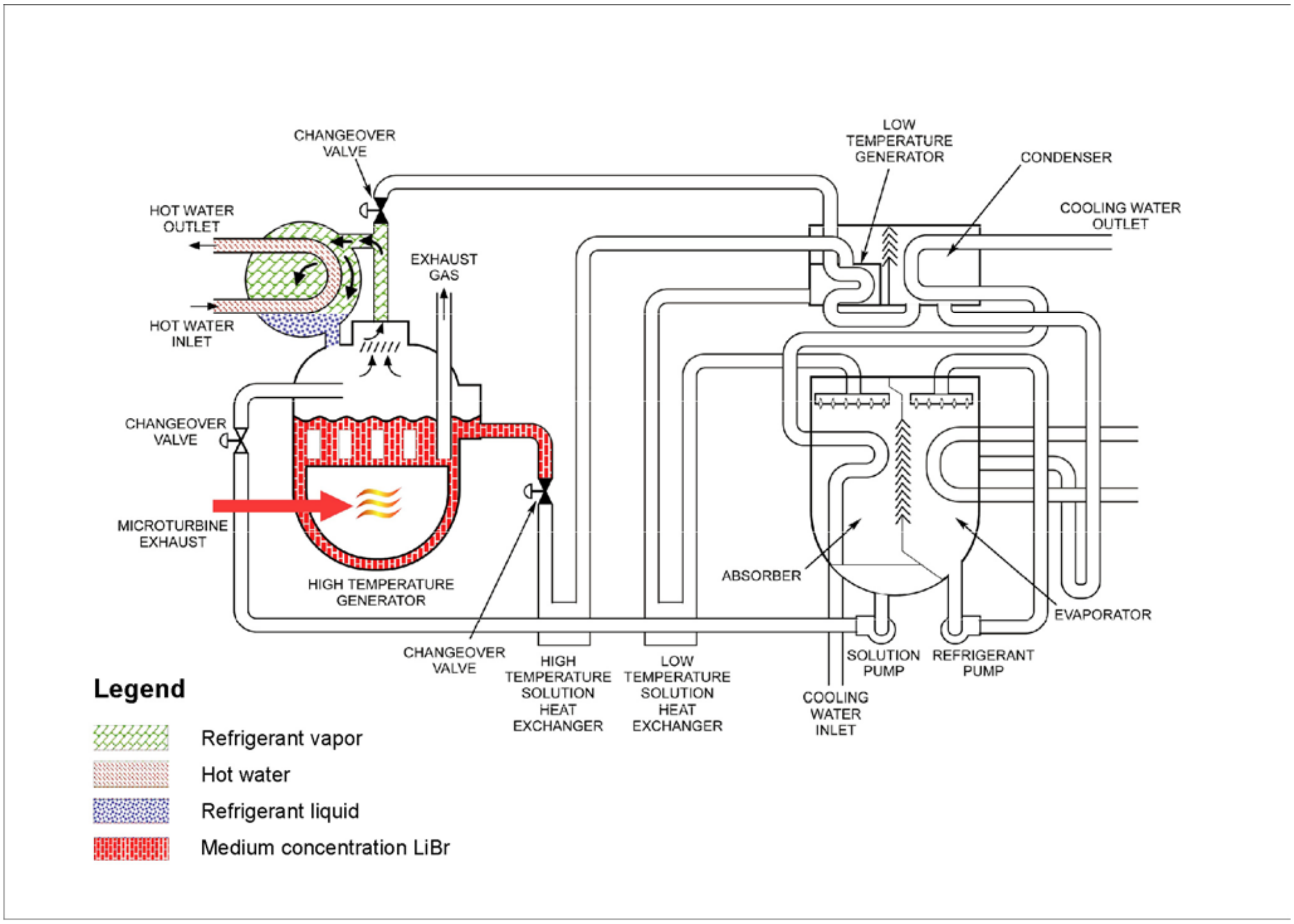

Figure 4 - Absorption Heating Cycle
175° F (79.4° C)

Superior part-load performance

The chiller/heater control system allows stable, continuous part-load operation down to 25% of full electrical load at cooling water temperatures as low as 64.4°F (18°C) without the need for a cooling tower bypass. For maximum efficiency, a variable speed pump automatically maintains optimum solution flow to the high-temperature and low-temperature generators at all operating conditions. This results in improved part-load efficiency and eliminates the need for manual setup adjustments of the solution flow.

Low noise and vibration

Low sound and vibration levels are characteristic of absorption chillers, primarily because the only rotating parts are the refrigerant and solution pumps. The overall sound level of the machine is 65 dBA @ 1m. This allows installation near occupied spaces or in areas with strict sound requirements.

Microprocessor controls allow precise control and operation

Each chiller/heater includes a factory-mounted and wired microprocessor control center that continuously and automatically monitors and controls machine operation. A display on the front of the control center identifies operational status and fault indication. All control center components and the entire machine meet local and national code requirements including Underwriters Laboratories (UL) where appropriate. Major components include a microprocessor central processing unit (CPU) board, molded case circuit breaker, pump contactors, ambient compensated 3-phase pump overload protection, multi-tap control power transformer and all other necessary safeties and controls.

As part of the start-up sequence, the microprocessor control center initiates a self-diagnostic system check to verify that all sensors are in range. Other standard features include a remote start/stop switch and a key-locked control center door that protects against unauthorized access. The chiller/heater's controls are also Carrier Comfort Network (CCN) compatible making it possible to connect the chiller/heater with other HVAC or peripheral equipment into a common energy management system.

Anti-crystallization controls maintain proper solution concentration

Solution concentration is limited in several ways to avoid crystallization and over-dilution, providing dependable, trouble-free operation. Crystallization of the lithium bromide solution depends on a combination of temperature and concentration. The concentration control system automatically monitors the refrigerant water level in the evaporator and the solution temperature returning to the absorber. Because concentration varies with the amount of water in the lithium bromide solution, a rising evaporator level indicates less water in the solution and thus a higher solution concentration. When the refrigerant in the evaporator rises to a pre-determined level, water is transferred from the evaporator to the absorber, preventing over-concentration and ensuring continuous, reliable operation even at cooling water temperature as low as 64.4°F (18C°). Transferring an additional amount of refrigerant from the condenser to the evaporator controls over-dilution (and possible refrigerant pump cavitation).

The chiller/heater also incorporates a simple, passive method of control to correct any crystallization that would typically start to occur on the shell side of the low temperature solution heat exchanger under abnormal conditions. As the hot solution begins to back up in the generator (as a result of any shell side blockage) it rises above the overflow pipe and returns directly to the absorber. It is subsequently pumped through the tube side (heating the shell side) to restore proper operation.

In addition, an automatic dilution cycle ensures proper concentration after unit shutdown so that the solution will not crystallize when the machine cools to ambient or room temperature. The dilution cycle controls operation of the pumps for a set period of time after shutdown to dilute the solution and prevent an over-concentration condition.

Chiller Control System Description

The Microprocessor control on each chiller is factory mounted, wired and tested to ensure chiller protection and efficient capacity control. In addition, the program logic ensures proper starting, stopping, and recycling of the chiller and provides a communication link to the Carrier Comfort Network (CCN).

Features

Control System:

- Component Test and Diagnostic Check
- Menu-Driven Keypad Interface for Status Display, Set point Control, and System Configuration
- CCN Compatibilities
- Primary and Secondary Status Messages
- Individual Start/Stop Schedules for Local and CCN Operation Modes
- Recall of Up to 25 Alarm and 25 Alert Messages with Diagnostic Help
- Extensive Diagnostic and Service Capabilities
- Advanced Crystallization Protection
- Improved Solution Flow Control with Variable Frequency Drive

Safety Cutouts:

- Solution Pump Motor Overload/High Temperature
- Refrigerant Pump Motor Overload/High Temperature
- Low Chilled Water Temperature Cutout
- Low Chilled Water Flow Cutout
- Generator High Temperature Cutout
- Generator High Pressure Cutout
- Flue Gas High Temperature Cutout

Protective Limits:

- Strong Solution Leaving High Temperature Generator Alarm
- High Temperature Generator Solution Low Level Alarm
- Refrigerant Pump Overload/High Temperature Alarm
- Solution Pump Motor Overload/High Temperature Alarm
- Low Refrigerant Temperature Alarm
- Low Chilled Water Temperature Alarm
- Control Valve Leak Alarm
- Weak Solution Leaving Absorber Alert

Overrides:

- Refrigerant Low Temperature
- Generator Condensate High Saturation Temperature
- Generator High Solution Temperature
- High Concentration
- Temperature Sensor Faults
- Entering and Leaving Chilled Water Temperature
- Cooling Water Temperature Entering and Leaving Absorber
- Cooling Water Temperature Leaving Condenser
- Weak Solution Temperature Leaving Absorber
- Strong Solution Leaving Low Temperature Solution Heat Exchanger
- Condensate Temperature Leaving Low Temperature Generator
- Refrigerant Temperature
- Strong Solution Leaving Low Temperature Generator
- Strong Solution Leaving High Temperature Generator
- Flue Gas Temperature
- High Temperature Generator Entering Heat Source Temperature

Capacity Control:

- Leaving Chilled Water Control
- Entering Chilled Water Control
- Ramp Loading
- Running Travel Limit (Control Valve Opening Limit)
- Recycle Control
- Water Temperature Reset
- Solution Flow Control with Variable Frequency Drive

Indications:

- Chiller Operating Status Message
- Absorption Cycle State Points
- Dilution Cycle
- Power-On
- Pre-Alarm Alert
- Alarm
- Safety Shutdown Message
- Run Hours

5.0 DIVERTER VALVE

The diverter valve, as a component of the PureComfort™ system, provides the means to control the cooling or heating capacity of the absorption chiller/heater. It does this by regulating the microturbine exhaust gas flow, which is the heat energy input or driving force behind the operation of the chiller/heater.

The basic design of the diverter valve is that of an automatic, modulating 3-way butterfly valve that obtains its control signal from the chiller control panel. Incorporated within the diverter valve is a pair of butterfly dampers that operate in tandem via an external linkage that connects them together. The design is such, that when one damper is completely open, the other is completely closed, and vice versa. The movement of these dampers allow microturbine exhaust to flow to (through) the chiller and then into the atmosphere, to bypass the chiller and exhaust directly to atmosphere, or to provide partial gas flow to the chiller with the remainder directed to atmosphere, depending on the cooling or heating load requirements. Positioning of the dampers is done through the actuator in response to a control signal from the chiller/heater.

When in the full load cooling (or heating) mode, the gas flow from the microturbines enters the diverter valve and is directed to the chiller. In this mode, the pair of dampers within the valve is positioned so that the bypass is completely closed off; with all exhaust gas flow going to the chiller. When the chiller is offline, the dampers are in the opposite position, with all gas bypassing the chiller and diverted to atmosphere. To ensure against leakage across the dampers and possible damage to the chiller when not in operation, an air seal blower is activated. This prohibits the hot microturbine exhaust gases from entering the chiller high-stage generator and protects against crystallization of the lithium bromide solution on the shell side of the chiller. It is important to note that the air seal blower only operates when the chiller is offline, i.e. when there is no call for either cooling or heating. The air seal blower operates off a 120-1-60 power supply provided from the chiller control panel.

Control of the diverter valve is governed by the chiller/heater and is dependent on the load required from the chiller. As the load fluctuates and the chiller is able to satisfy the load at less than 100% available capacity, the signal to the actuator is modified and the dampers change position accordingly. The control signal to the actuator from the chiller control panel is 24 VAC.

The body of the diverter valve is fabricated of carbon steel while the damper blades and the shafts that the blades rotate on are stainless steel.

6.0 EXHAUST DUCTING AND FLUE STACK REQUIREMENTS

Each PureComfort™ system requires interconnecting ductwork and 2 sets of suitable insulated exhaust flue stacks. The ductwork directs the microturbine exhausts to the chiller through the diverting valve. Each system includes the standard configuration of pre-insulated ductwork as part of the base offering. The customer may delete this ductwork from the base offering if they so choose, although ductwork is required for PureComfort™ system operation.

The primary (chiller) and secondary (diverter valve bypass) exhaust flue stacks are required to divert the hot exhaust safely to the environment. The exhaust flue stacks are normally customer-supplied.

Several factors must be considered when designing the exhaust flue stacks:

- Backpressure: Exhaust ducting must be pressure rated, and properly sealed to avoid buildup of toxic fumes. However, the exhaust system must limit backpressure to no more than eight inches of water column under all operating conditions. The exhaust outlet of the chiller and the diverter valve bypass are 20” diameter.
- Temperature Rating: At full power, the exhaust temperature of the microturbines can reach 700°F, during transients and high ambient temperature. Both the primary and secondary exhaust ducting must be rated to at least 700°F (371° C). In addition, sufficient thermal insulation should be provided to avoid hazards to personnel or building due to contact with high temperature ducting. As a reference, double wall stainless steel ducting with two to four-inch ceramic fiber insulation is a general-purpose solution.
- Design and construction of the flue stack should comply with all municipal, state, and federal codes and regulations, as applicable. Typical exhaust gas temperature from the 16DNP chiller is approximately 340° F (171° C). However, the stack design temperature should be no less than 1000°F. It is recommended that insulated, double-wall, round ducting be used in all applications.
- Flat-sided ducting is not recommended since it has a tendency to flex. Flexing causes pulsations in the flue stack, and possibly erratic chiller/heater operation. Proper stack design should allow continuous flow by avoiding sharp bends. A vent cap with bird screen, lightning arrestor, and provisions for a condensate drain are also required.
- Cross-sectional area of the stack is determined by calculating the volumetric flow rate of the exhaust gases and then selecting a diameter that results in an exhaust gas velocity of no greater that 12 to 15 ft/sec (3.6 to 4.6 m/sec).
- Height of the stack is determined by the length of the horizontal run and the number of 90-degree bends. As a general rule, provide 7 in. (180 mm) of stack height for every 1 ft (300 mm) of horizontal length and 4 ft (1.20 m) for every 90-degree bend. The location, height, and positioning of the stack outside the building should consider roof patterns, projections, ancillary equipment, aesthetics, and wind flow.
- Every PureComfort™ system includes backflow dampers that must be installed on each microturbine to prevent hot exhaust gases from entering an idle machine. These dampers must be installed properly according to the manufacturer’s written instructions.
- Connection of the flue stack to the 16DNP exhaust gas outlet is made using a rectangular-to-round transition piece, which is provided as part of the standard offering.

7.0 FUEL GAS BOOSTER

If high pressure natural gas (> 80 psig) is not available at the installation site, then a Fuel Gas Booster (FGB) is required. In the standard configuration each FGB serves a pair of microturbines. See the accompanying chart for specific FGB to microturbine pairing, based upon inlet site gas pressure.

The FGB is powered directly from the microturbine and boosts inlet gas pressure from as little as 4 inches WC to100 psig in a single stage of compression. The FGB is an industrial grade stand-alone package that features electronic control to provide smooth, accurate pressure control, yielding the highest efficiencies available today. The FGB is both UL and CE approved.

INLET PRESSURE TO FGB	NUMBER OF FGBs	GRID CONNECT MT	STAND ALONE MT
Note 1 0.25 to 2.5 psig	1	1	1
2.6 to 4.9 psig	1	2- with a staggered start.	2- with a staggered start.
5 to 7.9 psig	1	2 - both can be started at the same time.	2- with a staggered start.
8 to 10 psig	1	2 - both can be started at the same time.	2 - both can be started at the same time.

Fuel Gas Booster startup requirements

Fuel Gas Booster

8.0 REMOTE MONITORING SYSTEM

The Remote Monitoring System (RMS) provides for the local and remote monitoring and/or control of all UTC PureComfort™ products at a customer site from either the UTC Intranet or the Internet. Connection to remote sites is established through an Internet web portal, through which users can access reports of power plant performance (when requested). Product alarms are instantaneously forwarded to a 24x7 Remote Monitoring Center and are stored along with product data in a central database. The RMS design leverages UTC Power's experience in remote monitoring and provides low cost installation and operation. For more information on using the Remote Monitoring System, see UTC Power document # PRMAN59513 (RMS Software User's Guide).

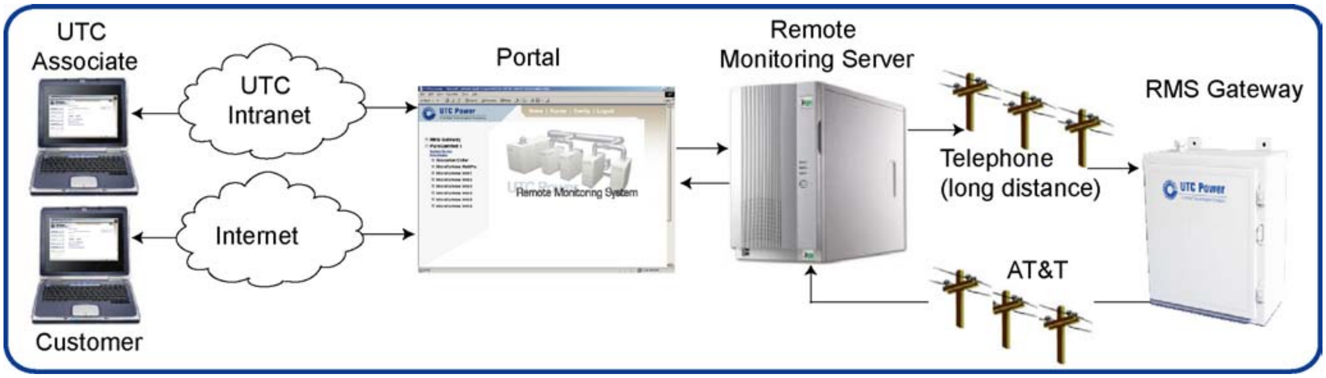

Figure 5 - Remote Monitoring Communications Flow

RMS Capabilities/Features

The RMS Gateway collects data and forwards it to a central database. Alarms are forwarded to the Remote Monitoring Server in Charlotte, NC, which maintains an alarm history, and provide a web server interface that supports local and remote monitoring/control through a standard browser interface. Communication to the Remote Monitoring Server is usually established through a standard analog telephone line and public internet. All products interface through a single RMS Gateway at a given site. Data encryption techniques are used to provide secure communication. RMS offers the following features:

1. **Communications and remote monitoring server –**The RMS Gateway communicates with the Remote Monitoring Server using the internet. When the RMS Gateway at the site needs to establish contact with the Remote Monitoring Server for data collection and alarm dial out, it places a local call through the AT&T Business Internet Service (BIS), eliminating long distance charges. In so doing, the RMS Gateway will establish an Internet connection through which it communicates with the Remote Monitoring Server. When the Remote Monitoring Server needs to communicate with the RMS Gateway it places a long distance call to the customer site requesting that the RMS Gateway call back through the AT&T BIS. Since connection with the server is done via internet, many customers can connect to the same site at the same time. The Remote Monitoring Server is the bridge between the customer site and the UTC Intranet. Customers can connect to their site using the public internet. They log on to www.utcpower.com and are then given a log on ID and password. The customer can monitor the site remotely.
2. **Alarms –**
   - **24x7 remote monitoring center** – all alarms are automatically routed to a monitored computer workstation screen at the Remote Monitoring Center. The following services are provided by the Remote Monitoring Center:
   - **Alarm Logging –** The Remote Monitoring Center logs all alarms received from a site.
   - **1st Level Remote Response –** Remote Monitoring Center technicians are responsible for assessing the product state after an alarm is received and must take appropriate remote action to return the product to an operational state if it has shutdown. The Remote Monitoring Center trains all support personnel to provide the correct response. An electronic record of remote is kept in a site-specific file.
   - **2nd Level Service Dispatch –** When a product is no longer operating in its intended state, and when efforts have been exhausted to remotely return the product to this state, the Remote Monitoring Center dispatches trained

service personnel to the site. An electronic record of the service call and case resolution is kept in a site-specific file.

- **24x7 Call Support –** A Call Center is available 24x7 to provide first level customer service and facilitate problem resolution.

3. **Web Portal for Remote Monitoring & Database Queries –** A web portal, accessible from the main UTC Power Internet Site (www.utcpower.com) allows customers and UTC associates with proper credentials, to remotely monitor sites through an Internet connection. Individuals logging on to the portal site are provided with a list of sites that they are authorized to monitor. By selecting a web link, the customer is connected to the Remote Monitoring Server, which then "shoulder taps" the selected RMS Gateway.

The Web Portal also serves as an interface to a database, which stores historical performance data, product configuration and business related data. A graphical user interface facilitates database queries and the generation of reports.

4. **Data Center –** A central database stores all relevant product data and alarm/maintenance history.

   Periodically, data from the RMS Gateway will be uploaded to the Remote Monitoring Server, typically once a week. Upon receipt of this data the Remote Monitoring Server advises the Web Portal Application that data has been received. The Web Portal Application then launches an application that validates the data and populates the database.

Standard reports are available and are generated monthly. Customized reports can be available upon requester's approval. For example, the user can request a standard monthly report be generated, or select a query to identify the number of alarms that occurred on each product.

9.0 COOLING TOWER REQUIREMENTS

Every PureComfort^{TM} system requires the heat rejection of the chiller to be dissipated to atmosphere or some other heat sink to allow the system to operate as intended. Typically, a cooling tower is utilized to perform this function but other equipment or processes are occasionally used depending on the design of the specific system involved. This discussion will focus exclusively on the use of cooling towers since they are the most common type of equipment used for this purpose in commercial installations.

Cooling towers transfer heat from the water circulated in the absorption chiller's absorber-condenser loop to the atmosphere by pumping or spraying the water over the cooling tower "fill", which has a relatively large surface area to improve heat transfer. Air is drawn over or through the fill section (typically by one or more fans) causing evaporation of a portion of the water, thereby cooling the remaining water to within a few degrees of the ambient wet-bulb temperature. The actual water temperature is dependent on the sizing of the tower but most towers are selected at approach temperatures (the difference between the wet-bulb temperature and the leaving water temperature) of between 7° F to 10° F. As an example, a tower selected for an 8° F approach could achieve a return water temperature to the chiller of 85° F given a design wet-bulb temperature of 77° F.

Sizing and selection of a cooling tower is dependent on knowing the chiller heat rejection, the design ambient wet-bulb temperature, the cooling water flow and the supply and return water temperatures (the approach temperature is automatically determined if both the design cooling water return temperature and the design wet-bulb temperature are known). Chiller heat rejection for a PureComfort^{TM} system can be approximated by the following equation where capacity and heat rejection are expressed in like units:

Chiller Heat Rejection = Chiller Capacity x $\left(1 + \frac{1}{COP}\right)$

As a result of the evaporation of some of the water as explained above, it is necessary to replenish whatever amount of water is lost. Generally, evaporation loss accounts for approximately 1% of the amount of water in circulation. In addition, about .2% is also lost due to droplets being entrained into the air (drift) as well as by regularly draining off a portion of the water in the cooling tower sump (blow-down) to maintain the water's physical and chemical properties within acceptable guidelines. Blow-down typically equates to about a .3% loss. The total loss attributed to all of these conditions determines the amount of make-up water that has to be added, which is usually done by automatically maintaining a pre-determined level in the cooling tower sump or basin via a float valve.

To aid in properly maintaining water quality and cleanliness, a water treatment system should be provided on each installation. These can be either manual or automatic type systems, which control the chemical and biological properties of the water to prevent corrosion, algae and fouling. The tower manufacturer can recommend additional equipment or maintenance procedures accordingly.

Temperature control of the water is a critical element in the design and selection of a cooling tower for a PureComfort^{TM} system, since it influences the operation of the absorption chiller. Providing colder water than design is beneficial as it allows the chiller to achieve an increase in cooling capacity as well as more efficient operation. However, the return cooling water temperature to the chiller must be maintained above its minimum limit of 64° F to guard against an upset in the absorption cooling cycle, which could impact chiller operation and performance. Water temperature is typically controlled by either cycling the fan(s), utilizing variable-speed or two-speed fan motors or by incorporating a tower bypass valve into the system design.

Location of the cooling tower will vary according to local site design and other considerations. In general, the location of the cooling tower should allow for unrestricted airflow and to prevent recirculation, consideration for fogging or drift and what other equipment or objects might be wetted in the event of strong winds, consideration of the increase in sound level to the surrounding area, and the weight of the tower if installed on a roof. Close proximity to the chiller should also be considered to avoid long pipe runs and increased pumping costs. If installed in areas where the ambient temperature can go below 32° F, attention should be paid to providing an auxiliary sump located inside a heated space to preclude freezing of the water. Alternatively, a heated sump could also be provided. Insulation of the cooling water piping should also be considered in cold climates.

The manufacturer of the cooling tower can provide more details on the design and installation of the tower relative to the specific jobsite requirements.

10.0 SYSTEM MODES OF OPERATION

The PureComfort™ system can be used in four different modes of operation: 1-Power operation, 2-Power and cooling operation, 3-Power and heating operation, and 4- Power, cooling and heating operation. Detailed performance data are listed in the system performance and operation section of this document.

Power Mode (Microturbines Only)

In power operation mode, the PureComfort™ system is used to produce power in grid connect mode, or stand-alone mode when equipped with an optional Dual Mode Controller (DMC). In this power only mode, only the microturbines are running and the exhaust is diverted out through the bypass and not used by chiller.

Power and Cooling Mode

During combined power and cooling operation, the microturbines are used to produce electric power and the exhaust is used as the heat source to drive the absorption chiller for cooling.

The diverter valve operates automatically, adjusting the exhaust flow into the chiller to maintain chilled water at a set temperature.

The fuel capacity of the chiller is reached when all microturbines are running at 100% electrical output. Only two 60 kW microturbines are required to be running in order to start the chiller at reduced capacity. Once the chiller is started, it can operate at reduced capacity with only one microturbine running.

The figure showing the absorption cooling cycle (in the beginning of this document) illustrates how chilled water is generated in power and cooling mode. Note that the seasonal “changeover” valves need to be closed for the cooling operation.

Power and Heating Mode

In the power and heating operation, the microturbine is used to produce power and the exhaust is used as the heat source for the absorption chiller for heating. In heating mode, the unit is capable of delivering 140°F hot water through the absorption chiller evaporator bundle. The diverter valve operates automatically, redirecting the microturbine exhaust into the chiller in order to assure that the hot water leaves the machine at the set temperature.

The figure showing the absorption heating cycle at 140° F (see page 11) illustrates how the 140° F hot water is generated. The absorption chiller uses the same evaporator tube bundles that are used for cooling to generate hot water. Transition to heating mode from cooling mode requires manually positioning the “changeover” valves to the open position and draining the cooling water circuit. When equipped with the 175°F (80°C) hot water option, the chiller is configured with an auxiliary heat exchanger. The figure showing the absorption heating cycle at 175° F (see page 12) illustrates how hot water is generated. During this operation, the cooling water must be drained and “changeover” valves re-positioned as shown.

Microturbine Modes of Operation

Grid Connect Mode

In grid connect mode, the microturbines are connected in parallel to the grid-connected loads. Electricity generated by the Microturbines is supplied to these loads only when the utility is present.

During grid supply interruptions, the PureComfort™ system senses the loss and immediately disconnects from the grid and performs a shutdown. When the utility returns, the system restarts automatically and resumes supplying electricity to the connected loads.

In grid connect mode, the PureComfort™ system provides a current source only. The existing grid is used for both voltage and frequency reference.

Dual Mode

The microturbines, when equipped with the optional dual mode controller, may be configured to transition to stand-alone from grid connect mode during a grid supply interruption. They can also be configured to automatically return to grid connect mode when the grid returns. A battery system in each microturbine provides energy for transient energy demands.

Stand Alone (Grid Independent) Mode

The microturbines may be operated in stand-alone mode. In this mode, the connected loads can be powered directly, enabling the unit to become both a voltage source and a current source. A battery system in each microturbine provides energy for starting and for transient energy demands.

Using the stand-alone mode permits the PureComfort™ system to be run in grid connect mode, but it must be manually changed over unless the dual mode controller option is installed. The chiller may be operated under dual mode/stand-alone operation. Contact your UTC Power sales representative for details of your application.

NOTE
The chiller control panel must be energized when operating in Stand Alone Mode to allow operation of the air seal blower and prevent hot exhaust gases from leaking into the chiller.

Grid Connect Power Loading Scenarios

Base Loading (Recommended to maximize system efficiency)

In normal loading, the microturbine utilizes electric grid power in excess of constant microturbine base power to meet the customer power demand, referred to as **Base Loading**. In this situation, the microturbines provide maximum electrical output and the absorption chiller optimizes exhaust recovery for customer chilling or heating needs. In this case, the electric and thermal outputs are optimized and recommended to preserve overall system efficiency.

In Figure 6 below, the microturbine is supplying 240 kW base power and electric utility grid is supplying the balance of the load demand.

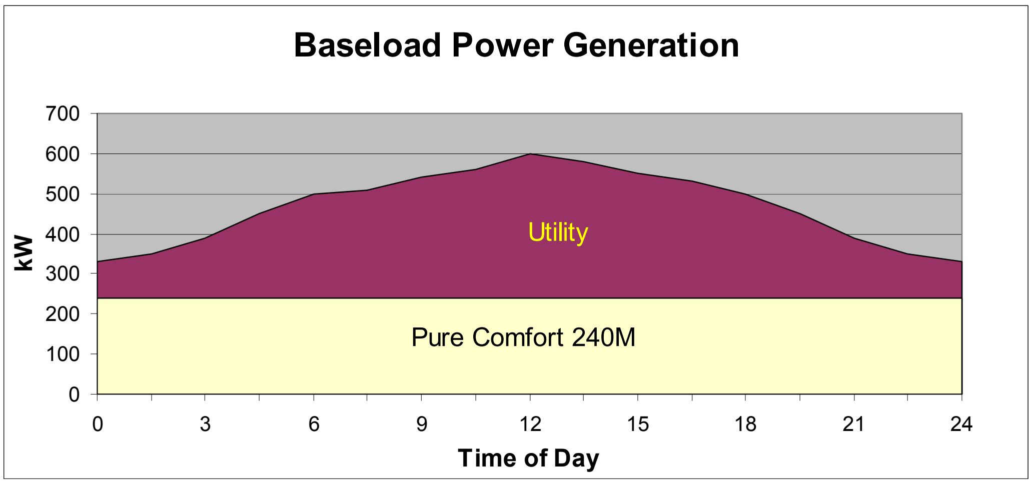

Figure 6 - Base Loading

Peak Loading (Time of Use)

In Time of Use mode, the microturbine may be used for peak shaving during periods of the day when electricity from the utility is at a premium. Time of Use mode allows the user to selectively determine start/stop commands and/or power output levels up to 20 times, referred to as events. Events are programmed by day of week, time of day, and power demand in any order, and are sorted by time to determine event order. Under these conditions, due to changing loads, the chiller may not be able to operate to full-rated capacity (see Figure 7).

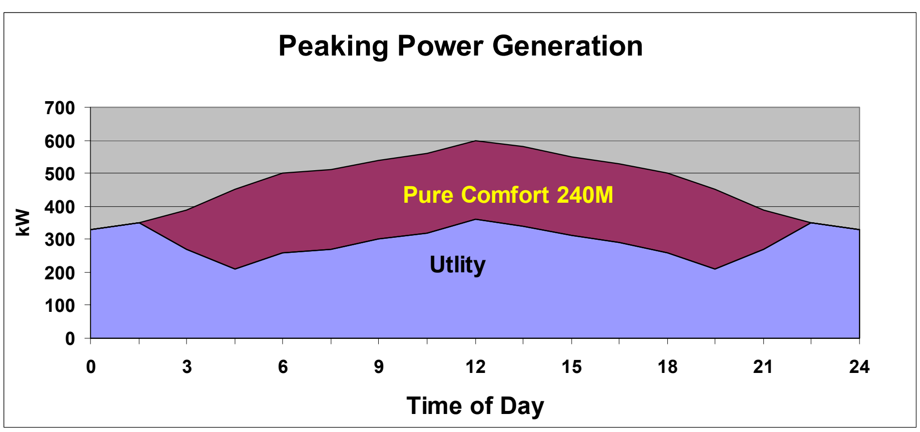

Figure 7 - Time of Use Mode

Peak Loading (Load Following)

Load Following mode utilizes microturbine power in excess of the base power supplied by the utility grid (when required by external loads), allowing the microturbine to track local electrical loads, and supply only as much power as required. The microturbine regulates the utility power flow to an adjustable maximum: the utility power set point. If the local demand rises above this level by an adjustable amount for a selected time period, the microturbine is directed to supply the difference (up to its capacity). This requires an external power meter (see Figure 8).

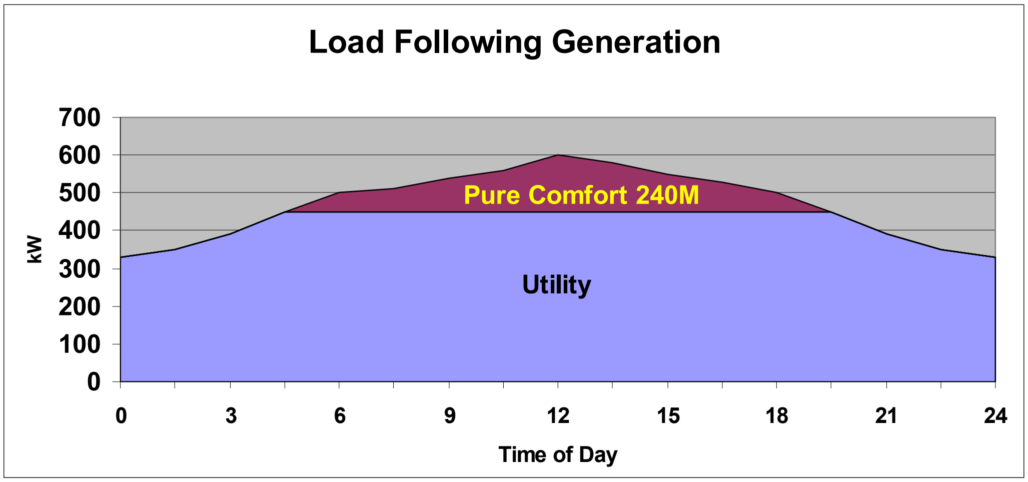

Figure 8 - Load Following

11.0 EQUIPMENT LIST

	STANDARD	OPTION (Factory Installed)	ACCESSORY (Field Installed)
PureComfort™ SYSTEM			
Remote Monitoring System[1]	X		
Exhaust Ducting[2]	X		
Diverter Valve	X		
Chiller/Heater Inlet/Outlet Duct	X		
MICROTURBINE			
Grid Connect Microturbines	X		
Backflow Dampers	X		
Fuel Gas Boosters + External Fuel Kits[2]	X		
Surge Suppressor	X		
Acoustic Inlet Hoods		X	
Stand-Alone Operation[3]		X	
Dual-Mode Operation[3]		X	
Skid Mounting[3]		X	
Supervisory Control		X	
CHILLER/HEATER			
Chiller/Heater	X		
Outdoor Enclosure[4]			X
140°F (60°C) Hot Water, flanged connections	X		
175°F (79.4°C) Hot Water, flanged connections[3]		X	
Victaulic Nozzle Connections		X	
High-Pressure Waterboxes		X	
Special Tubing		X	
Evaporator Pass Quantity		X	
Evaporator Inlet Nozzle Location		X	
Vibration Isolation Package			X
Flow Switch for Absorber-Condenser Circuit		X	

1. Remote monitoring service is included for the first 12 months. It is also available as part of all UTC Power service contracts.
2. Included as standard but can be omitted from UTC Power scope of supply if desired.
3. Contact your local sales representative.
4. Can be configured for low ambient temperature protection.

12.0 MICROTURBINE

A. Range of Application

There are four to six microturbines in the PureComfort™ system. Each of the microturbines are rated for 60 kW, 480 VAC, 3-phase.

B. Applicable Certifications

C. UL listing

Microturbines are UL listed to UL 2200 for both United States and Canada. In addition, the following certifications are applicable:

- NFPA (various)
- NEC (installation must meet NFPA 70)
- NEMA 250-1997 (enclosure)
- IEEE 519
- UL1741

D. Fuel Systems

The standard PureComfort™ Model 300M system comes with 3 fuel gas boosters and 5 high pressure fuel kits. The standard PureComfort™ Model 360M comes with 3 fuel gas boosters and 6 high pressure fuel kits.

E. Fuel Input Requirements

Natural gas B is used as the primary fuel for the Microturbine, as noted in Table 6 below. The fact that a fuel may meet all of the requirements detailed in Tables 6 and 7 does not necessarily mean that fuels within the range of limits tabulated can be interchanged for one given system. To change from fuel originally specified for a given system, contact UTC Power to see whether the change is permissible, and what hardware and/or software changes may be required or what consequences may ensue.

Natural Gas pressure and temperature requirements are listed in Table 7. For Natural Gas pressure less than 75 psig, a fuel gas booster is required. Fuel pressure must be regulated down to requirements in Table 7 for the fuel gas booster application.

FUEL	CALORIFIC VALUE (HHV) BTU/FT^3 (MJ/M^3) (NOTE 1)	SPECIFIC GRAVITY RELATIVE TO AIR (NOTE 1)	COMPOSITION
Natural Gas B range (Note 2)	970 to 1130 (36.14 to 42.10)	0.55 to 0.70	Mixture containing over 90% methane (CH4). The rest consists of ethane (C2H6), propane (C3H8), butanes (C4H10), carbon dioxide (CO2), Nitrogen (N2) and H2S @ < 5 ppm V.

Table 6: Heating Value Requirements

NOTES:

1. Calorific Values/Specific Gravity/Wobbe Index values taken considering 59° F and 14.696 psia (15°C and 101.33 kPa).
2. Higher heating Value (HHV) range is per Table 2-1 of the Gas Research Institute report (entitled Variability of Natural Gas Composition in Select Major Metropolitan Areas of the United States), dated March 1992.

NATURAL GAS SOURCE	MAX SUPPLY PRESSURE psig (KPA GAUGE)	MIN SUPPLY PRESSURE psig (KPA GAUGE)	SUPPLY TEMP MAX F (C)	SUPPLY TEMP MIN C (F)	FUEL FLOW CONTROL DEVICE
Site with High Pressure Source (NOTE 1) (Fuel Gas Booster NOT Required)	80 (552)	75 (517)	122 (50)	Note 2	SPV 25
Site with Requiring Fuel Gas Boosters	15 (103)	0.25 (1.72)	122 (50)	Note 2	SPV 25

Table 7: Natural Gas Pressure and Temperature Requirements

NOTES:

1. Fuel gas compressors may be deleted from standard offering if site natural gas supply meets the minimum requirements. Fuel gas regulation system is available as an option for sites with high-pressure source.
2. This value must be the highest 0 – 20° C (-4° F), or 10° C (18° F) above the fuel dew point temperature at the Fuel Supply Pressure maximum noted above.

F. High Pressure Fuel Kit

One high pressure fuel kit is required per microturbine. The gas train and oil supply systems are supplied pre-assembled and with pre-installed interconnection fittings. Specific fuel system components and instrumentation will vary depending on local regulations, codes, and ordinances.

G. Local Microturbine Controls

The 60kW microturbines have an individual controller that controls the operation of its respective unit. The PureComfort™ system is equipped with the MultiPac Interconnection Kit that allows one of the turbines to be designated as the master.

The master directs signal and command information to all other turbines. However, any individual turbine in the group may be designated as the master. MultiPac operation features synchronous voltage and frequency for all microturbines. Individual turbines share power and load on both a dynamic and steady state basis.

The MultiPac is designed to maximize the combined output power of multiple microturbines.

13.0 CHILLER

A. MATERIAL SPECIFICATIONS

ITEM	MATERIAL	SPECIFICATION
Shell		
Evaporator	Carbon Steel	ASTM A285
Absorber	Carbon Steel	ASTM A285
Condenser	Carbon Steel	ASTM A285
Generator	Carbon Steel	ASTM A285
Tubesheet		
Evaporator	Carbon Steel	ASTM A285
Absorber	Carbon Steel	ASTM A285
Condenser	Carbon Steel	ASTM A285
Generator	Carbon Steel	ASTM A285
Water box		
Evaporator	Carbon Steel	ASTM A285
Absorber	Carbon Steel	ASTM A285
Condenser	Carbon Steel	ASTM A285
Generator	Carbon Steel	ASTM A285
Tubes		
Evaporator	Carbon Steel	ASTM A285
Absorber	Copper	ASME SB75
Condenser	Copper	ASME SB75
Low Temperature Generator	90-10 CuNi	ASME SB111 Alloy 706
High Temperature Generator	90-10 CuNi	ASME SB111 Alloy 706
Piping	Carbon Steel	ASTM A53

Table 8 – Material Specifications

LEGEND

ASME – American Society of Mechanical Engineers
ASTM – American Society of Testing and Materials

B. Waterboxes

The standard waterbox pass arrangement for each heat exchanger is shown in Table 9. The evaporator provides either chilled water or 140° F hot water to the building. Cooling water is piped first to the Absorber section and then to the Condenser section in a series arrangement.

STANDARD PASS QUALITY					
EVAPORATOR		ABSORBER		CONDENSER	
4-Pass		3-Pass		1-Pass	
NOZZLE LOCATION					
IN	OUT	IN	OUT	IN	OUT
RH	RH	RH	LH	LH	RH

Table 9: Heat Exchanger Standard Pass Quantity and Nozzle Location

Facing the High-Temperature Generator, the standard location of the Evaporator nozzles are on the Right Hand (RH) end of the chiller. Left Hand (LH) configuration is also possible in addition to 1-, 2- or 3-pass configurations for the Evaporator (refer to Table 10). Nozzle locations and pass quantity for the Absorber-Condenser are fixed. Contact your UTC Power sales representative for more details.

EVAPORATOR PASS OPTIONS					
1-Pass		2-Pass		3-Pass	
NOZZLE LOCATION					
IN	OUT	IN	OUT	IN	OUT
LH	RH	LH	LH	LH	RH
RH	LH	RH	RH	RH	LH

Table 10: Evaporator Pass Options and Nozzle Locations Vent and Drain Connection

Vents and drain connections are provided on each water box. Connection size is 3/4-in. FPT.

Provide vents on the high points of the machine and drains on the low points. If shutoff valves are provided in the main water piping near the unit, a minimum amount of the system water will be lost when the heat exchangers are drained.

It is recommended that pressure gages be provided at each nozzle to measure pressure drop through the heat exchanger. Pressure gages installed in the waterboxes do not include nozzle pressure losses.

Use a reliable differential pressure gauge to measure pressure drop when determining water flow. Pressure gages of a commercial nature are insensitive and do not provide accurate measurement of flow conditions.

C. Fusible Plug

The 16DNP is equipped with a ¾ in fusible plug on the high-temperature generator. It is recommended that piping from this device be routed to appropriate areas away from the machine in accordance with Carrier's written installation instructions, the current version of ANSI/ASHRAE 15 (American Society of Heating, Refrigeration, and Air-conditioning Engineers), and any local jurisdictional requirements that may apply. Piping should be adequately supported and the proper fittings should be provided to allow periodic inspection. Refer to chiller outline drawings for exact location of the fusible plug on the chiller.

14.0 PHYSICAL DATA

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	SI	ENGLISH	SI	ENGLISH	SI
PureComfort™ SYSTEM						
Operating Weight	28,550 lb	12,945 kg	30,833 lb	13,980 kg	32,566 lb	14,765 kg
MICROTURBINE (per unit)						
Rigging Weight: Grid Connect Dual Mode and Stand Alone	 1,700 lb 2,470 lb	 770 kg 1,120 kg	 1,700 lb 2,470 lb	 770 kg 1,120 kg	 1,700 lb 2,470 lb	 770 kg 1,120 kg
Gas Inlet Pipe Connection Size	1 / 2 in. female flare	1 / 2 in. female flare	1 / 2 in. female flare	1 / 2 in. female flare	1 / 2 in. female flare	1 / 2 in. female flare
Exhaust Duct Size	8 in.	8 in.	8 in.	8 in.	8 in.	8 in.
FUEL GAS BOOSTER (per unit)						
Rigging Weight	550 lb	250 kg	550 lb	250 kg	550 lb	250 kg
Gas Inlet Pipe Connection Size	1 in. NPT	1 in. NPT	1 in. NPT	1 in. NPT	1 in. NPT	1 in. NPT
Gas Outlet Pipe Connection Size	3 / 4 in. NPT	3 / 4 in. NPT	3 / 4 in. NPT	3 / 4 in. NPT	3 / 4 in. NPT	3 / 4 in. NPT
CHILLER/HEATER						
Rigging Weight Chiller/Heater Diverter Valve Inlet duct	 18,544 lb 720 lb 300 lb	 8,410 kg 327 kg 136 kg	 18,544 lb 720 lb 300 lb	 8,410 kg 327 kg 136 kg	 18,544 lb 720 lb 300 lb	 8,410 kg 327 kg 136 kg
Operating Weight	19,735 lb	8,950kg	19,735 lb	8,950 kg	19,735 lb	8,950 kg
Lithium Bromide Solution Charge	113 gal	428 L	113 gal	428 L	113 gal	428 L
Refrigerant (Water) Charge	37 gal	140 L	37 gal	140 L	37 gal	140 L
Chilled/Hot Water (Evaporator) Pipe Connection Size No. Passes	 4 in. 4	 4 in. 4	 4 in. 4	 4 in. 4	 4 in. 4	 4 in. 4
Cooling Water Pipe Connection Size No. Passes Absorber Condenser	 5 in. 3 1	 5 in. 3 1	 5 in. 3 1	 5 in. 3 1	 5 in. 3 1	 5 in. 3 1
Exhaust Ducting Interface Chiller Outlet Diverter Valve Bypass	 20 in. dia 20 in. dia	 20 in. dia 20 in. dia	 20 in. dia 20 in. dia	 20 in. dia 20 in. dia	 20 in. dia 20 in. dia	 20 in. dia 20 in. dia

UTC Power
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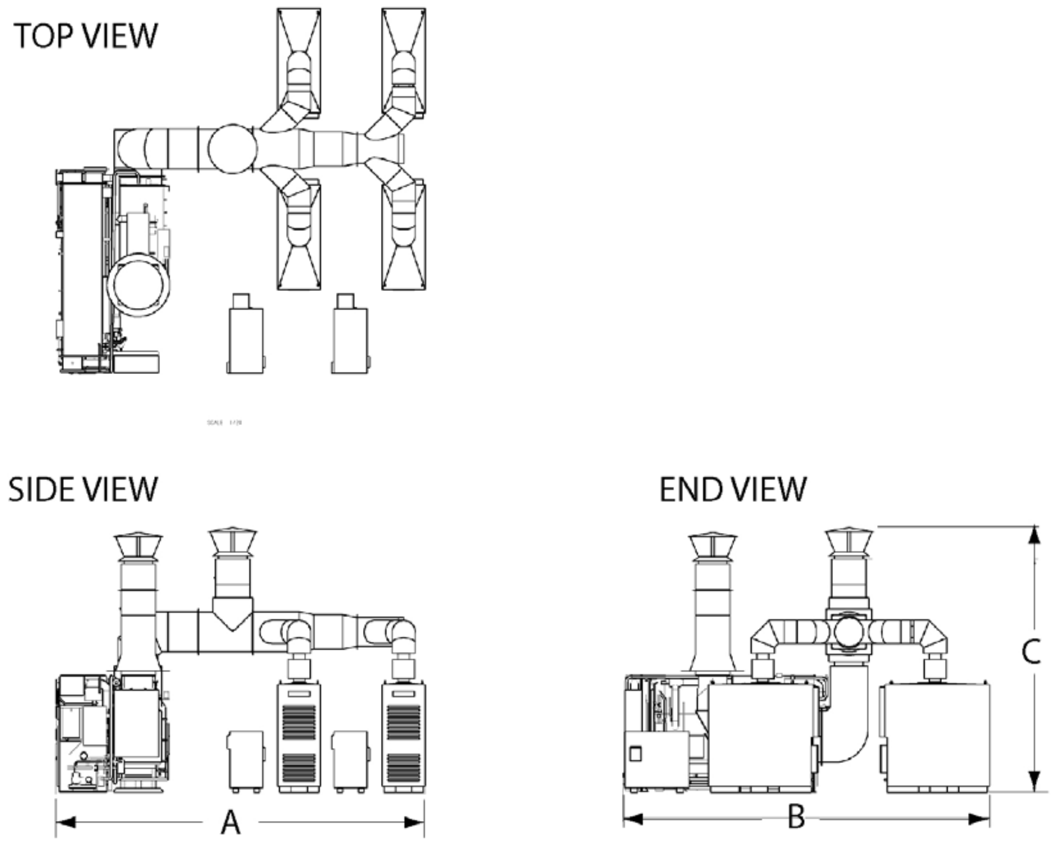
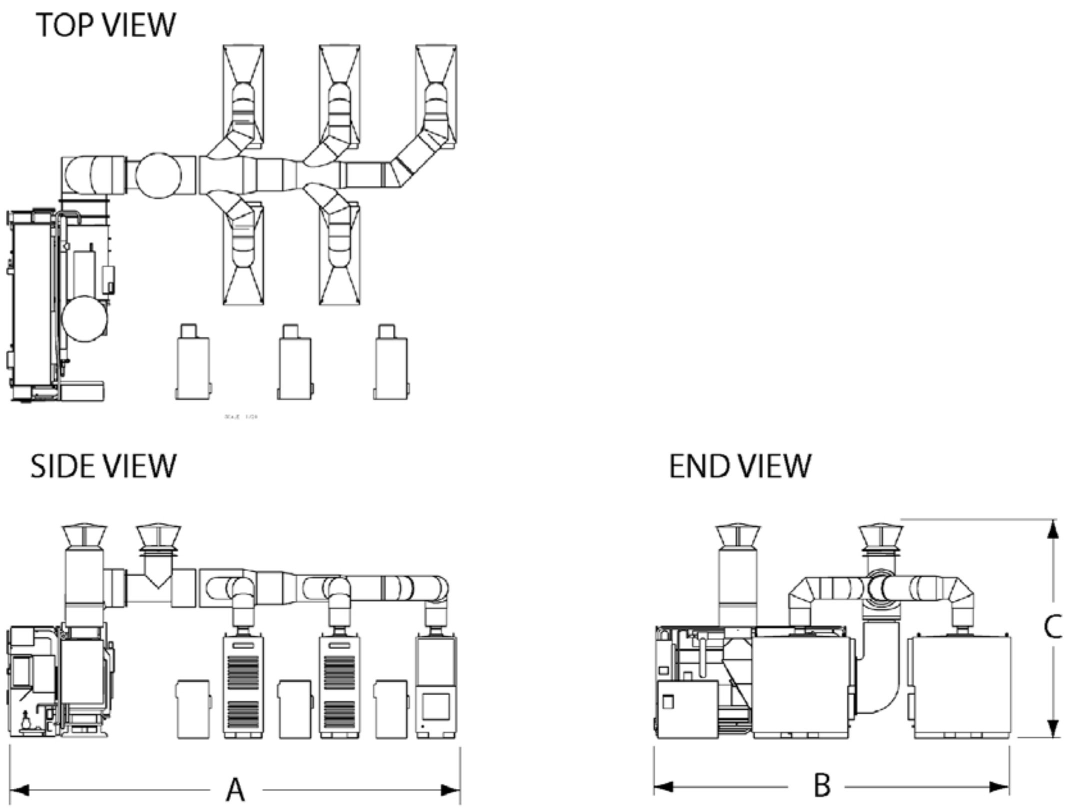
15.0 DIMENSIONS

PureComfort™ *Model 240M System*



MODEL	ENGLISH		SI
Overall Length A	21'-6"	258"	6553 mm
Overall Width B	22'-6"	270"	6858 mm
Overall Height C	15'-6"	186"	4724 mm

PureComfort™ Model 300M System



MODEL	ENGLISH		SI
Overall Length A	27'-7"	331"	8407 mm
Overall Width B	22'-6"	270"	6858 mm
Overall Height C	15'-6"	186"	4724 mm

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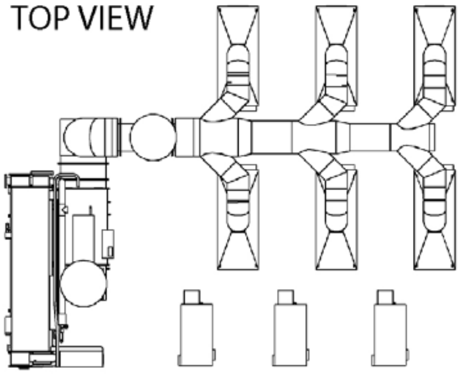
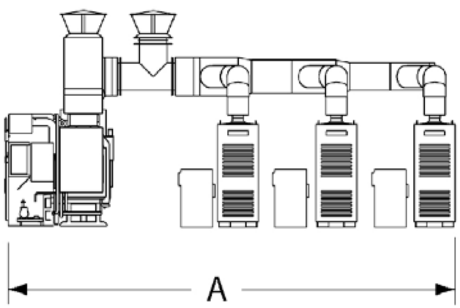
PureComfort™ Model 360M System

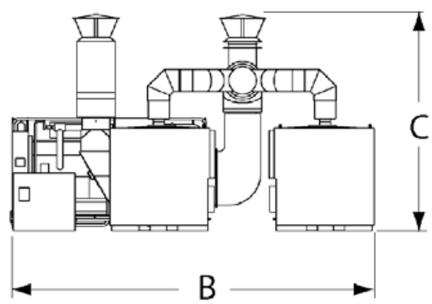
TOP VIEW



SIDE VIEW



END VIEW



MODEL	ENGLISH		SI
Overall Length A	27'-7"	331"	8407 mm
Overall Width B	22'-6"	270"	6858 mm
Overall Height C	15'-6"	186"	4724 mm

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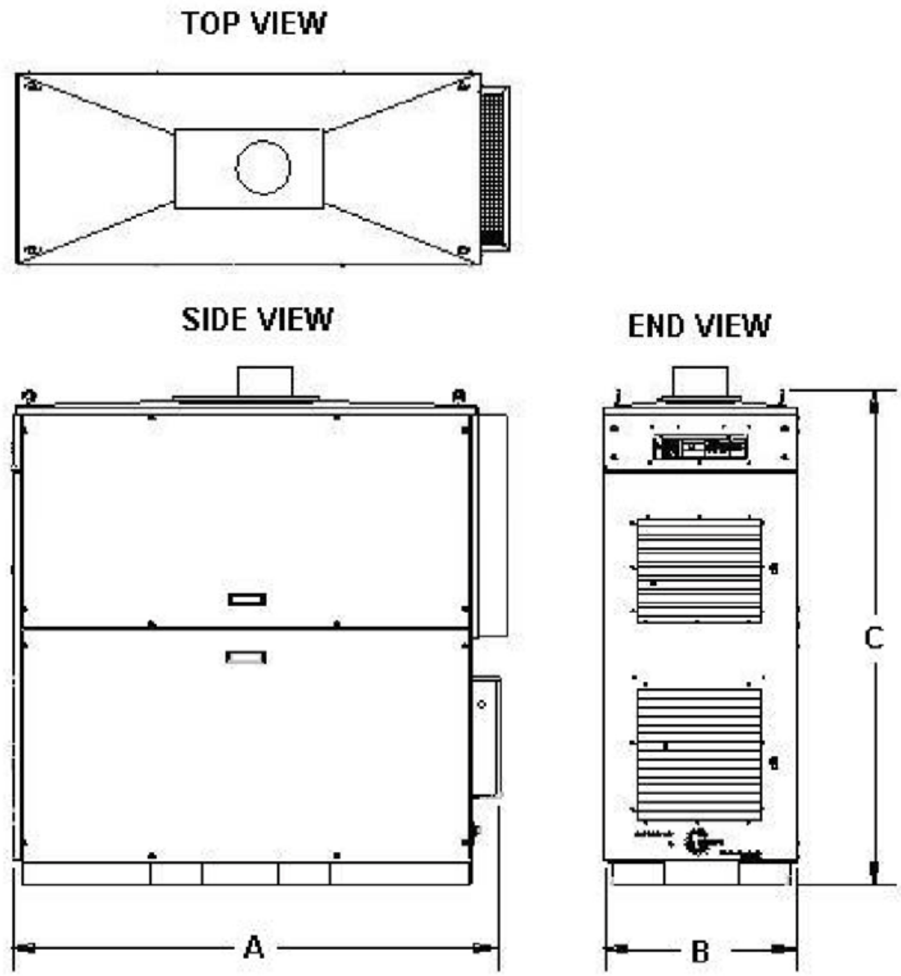
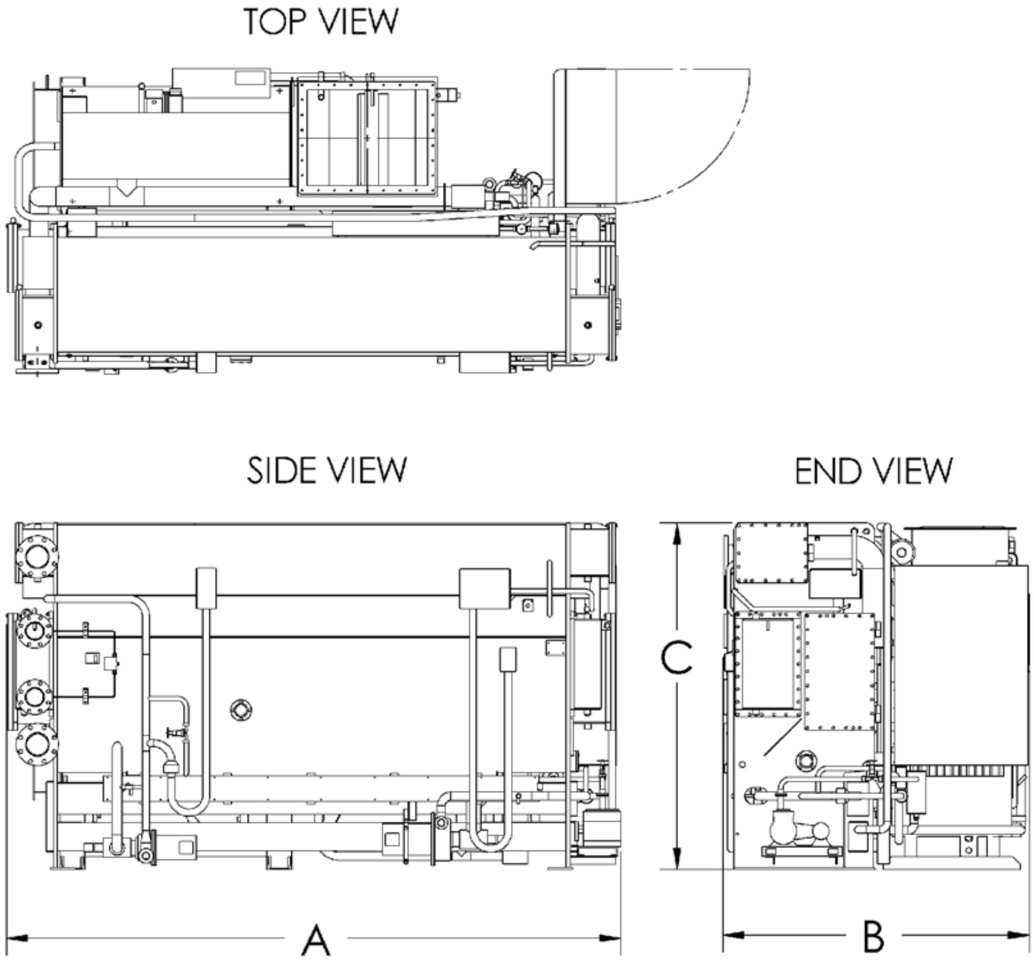
Microturbine



C60	ENGLISH		SI
Overall Length A	6' – 1"	73 in.	1854 mm
Overall Width B	2' – 6"	30.0 in.	762 mm
Overall Height C	6' –11"	83.0 in.	2108 mm

NOTES: For routine maintenance, allow 42 in. (1070 mm) clearance on all sides.
Shown without optional inlet silencer.

Chiller/Heater (140 F Hot Water Version)



16DNP	ENGLISH		SI
Overall Length A	12' – 1"	145 in.	3683 mm
Overall Width B	6' – 7"	79 in.	2007 mm
Overall Height C	6' – 10"	82 in.	2083 mm

NOTES:

1. For routine maintenance, allow 42 in. (1070 mm) clearance on all sides and 6 in. (150 mm) above chiller.
2. For tube removal, allow space equal to "A" dimension (length) at either end of the chiller.

16.0 SYSTEM PERFORMANCE AND OPERATION

Full Load Performance as a Function of System Operation

PureComfort™ system performance data for power, power and chilling, and power and heating operations are shown in the following tables.

Performance Data

The performance tables in this section provide comparison data for the following grid connect conditions:

Standard 59° F ISO day[1]

- Power only mode, page 31.
- Power and heating mode, page 33.
- Power and cooling mode, page 32.
- Dual Mode – Power Only, page 34.

Hot 95° F day[2]

- Power only mode, page 35.
- Power and cooling mode, page 36.
- Dual Mode – Power Only, page 37.

Cold 32° F day[3]

- Power only mode, page 38.
- Power and heating mode, page 39.
- Dual Mode – Power Only, page 40.

PERFORMANCE - 59° (Standard ISO) DAY[1]

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	SI	ENGLISH	SI	ENGLISH	SI
ISO – Power Only (Microturbines only)						
Gross Power Output 90 psig (620 kPa) Natural Gas Supply to Microturbine	240 kW	240 kW	300 kW	300 kW	360 kW	360 kW
Gross Electrical Efficiency (LHV) ± 2%	28	28	28	28	28	28
Net Power Output [4] 10 psig (69 kPa) Natural Gas Supply to Fuel Gas Booster	230 kW	230 kW	287 kW	287 kW	345 kW	345 kW
Net Electrical Efficiency (LHV) [4] ± 2%	27	27	27	27	27	27
Output Voltage	480 vac	480 vac	480 vac	480 vac	480 vac	480 vac
Frequency	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz
Output Power Connection	4-wire, L_1, L_2, L_3, N	4-wire, L_1, L_2, L_3, N	4-wire, L_1, L_2, L_3, N	4-wire, L_1, L_2, L_3, N	4-wire, L_1, L_2, L_3, N	4-wire, L_1, L_2, L_3, N
Output Current (Maximum Steady State)	400 A	400 A	500A	500 A	600 A	600 A
Output Current Total Harmonic Distortion (IEEE 519 Compliant) [5]	< 5% THD	< 5% THD	< 5% THD	< 5% THD	< 5% THD	< 5% THD
Fuel Consumption (LHV)	2,900 MBh	3,100,000 kJ/hr	3,700 MBh	3,900,000 kJ/hr	4,400 MBh	4,700,000 kJ/hr
Microturbine Exhaust Gas Temperature	604° F	318° C	605° F	318° C	608° F	320° C
NOx Emissions [6]	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2
Microturbines Sound Level [7,8]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m
System Sound Level [7,8]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m

1. Rating based on 59° F (15° C) ambient temperature at sea level, 60% RH, at ≤ 7 iwc microturbine backpressure.
2. Rating based on 95° F (35° C) ambient temperature at sea level, 46% RH, at ≤ 7 iwc microturbine backpressure.
3. Rating base on 32° F (0° C) ambient temperature at sea level, 60% RH, at ≤ 7 iwc microturbine backpressure.
4. Inclusive of parasitic power for fuel gas booster and air seal blower, fuel gas booster inlet pressure = 10 psig.
5. Grid connect only.
6. Meets California Air Resources Board (CARB) 2003 requirements.
7. Subtract 7 ± 2 dB if using optional silencers.
8. No PureComfort™ system model will exceed the 85 decibel, 8 hour time weighted average, OSHA hearing protection threshold under normal operation.

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PERFORMANCE - 59° (Standard ISO) DAY[1], continued

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	SI	ENGLISH	SI	ENGLISH	SI
ISO – Power/Cooling (Microturbines + Chilled Water)						
Gross Power Output 90 psig (620 kPa) Natural Gas Supply to Microturbine	240 kW	240 kW	300 kW	300 kW	360 kW	360 kW
Gross Electrical Efficiency (LHV) ± 2%	28	28	28	28	27	27
Net Power Output [2] 10 psig (69 kPa) Natural Gas Supply to Fuel Gas Booster	227 kW	227 kW	284 kW	284 kW	341 kW	341 kW
Net Electrical Efficiency (LHV) [2] ± 2%	26	26	26	26	26	26
Gross System Efficiency ± 5%	85	85	83	83	80	80
Net System Efficiency (LHV) [2] ± 5%	84	84	81	81	79	79
Nominal Cooling Capacity [3] ± 5%	142 RT	500 kW	171 RT	602 kW	198 RT	696 kW
Chiller Coefficient of Performance (COP)	1.30	1.30	1.29	1.29	1.26	1.26
Chilled Water Flow Rate Pressure Drop	297 gpm 26 ft	19 l/s 77 kPa	358 gpm 38 ft	23 l/s 114 kPa	415 gpm 50 ft	26 l/s 149 kPa
Cooling Water Flow Rate Pressure Drop	494 gpm 24 ft	31 l/s 71 kPa	597 gpm 34 ft	38 l/s 102 kPa	691 gpm 45 ft	44 l/s 134 kPa
Fuel Consumption (LHV)	3,000 MBh	3,100,000 kJ/hr	3,700 MBh	3,900,000 kJ/hr	4,500 MBh	4,700,000 kJ/hr
Microturbine Exhaust Gas Temperature	604° F	318° C	606° F	319° C	609° F	321° C
Chiller Exhaust Gas Temperature	236° F	113° C	249° F	121° C	262° F	128° C
Microturbines Sound Level [4,5]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m
Chiller/Heater Sound Level[5]	65 dBA @ 33 ft	65 dBA @ 10 m	65 dBA @ 33 ft	65 dBA @ 10 m	65 dBA @ 33 ft	65 dBA @ 10 m
System Sound Level [4,5]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m

1. Rating based on 59° F (15° C) ambient temperature at sea level, 60% RH, at ≤ 7 iwc microturbine backpressure.
2. Inclusive of parasitic power for fuel gas booster and chiller; fuel gas booster inlet pressure = 10 psig.
3. Rating based on ARI 560, latest edition, 44° F out (2.4 gpm/ton) chilled water; 67° F (4.0 gpm/ton) cooling water; fouling factor 0.00025 ft^2 hr F/Btu for absorber and condenser, 0.0001 ft^2 hr F/Btu for evaporator.
   Rating based on ARI 560, latest edition, 6.7° C out (0.043 L/s per kW)) chilled water; 29.4° C (0.072 L/s per kW)) cooling water; fouling factor 0.000044 m^2 • °C/W for absorber and condenser, 0.0000176 m^2 • °C/W for evaporator.
4. Subtract 7 ± 2 dB if using optional silencers.
5. No PureComfort™ system model will exceed the 85 decibel, 8 hour time weighted average, OSHA hearing protection threshold under normal operation.
6. Rating based on ARI 560, latest edition, 140° F hot water out; 0.0001 ft^2 hr F/Btu evaporator fouling factor.
   Rating based on ARI 560, latest edition, 54.4° C in, 60° C hot water out; 0.0000176 m^2 • °C/W for evaporator.

PERFORMANCE - 59° (Standard ISO) DAY[1], continued

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	SI	ENGLISH	SI	ENGLISH	SI
ISO – Power/140° F Heating (Microturbines + Heated Water)						
Gross Power Output 90 psig (620 kPa) Natural Gas Supply to Microturbine	240 kW	240 kW	300 kW	300 kW	360 kW	360 kW
Gross Electrical Efficiency (LHV) ± 2%	28	28	28	28	27	27
Net Power Output [2] 10 psig (69 kPa) Natural Gas Supply to Fuel Gas Booster	230 kW	230 kW	287 kW	287 kW	344 kW	344 kW
Net Electrical Efficiency (LHV) [2] ± 2%	27	27	26	26	26	26
Gross System Efficiency ± 5%	71	71	71	71	70	70
Net System Efficiency (LHV) [2] ± 5%	70	70	70	70	69	69
Nominal Heating Capacity [6] ± 5%	1,282 MBh	376 kW	1,601 MBh	469 kW	1,928 MBh	565 kW
Hot Water Flow Rate Pressure Drop	297 gpm 26 ft	19 l/s 77 kPa	358 gpm 38 ft	23 l/s 114 kPa	415 gpm 50 ft	26 l/s 149 kPa
Fuel Consumption (LHV)	3,000 MBh	3,100,000 kJ/hr	3,700 MBh	3,900,000 kJ/hr	4,500 MBh	4,700,000 kJ/hr
Microturbine Exhaust Gas Temperature	604° F	318° C	606°F	319°C	609° F	321° C
Chiller Exhaust Gas Temperature	245° F	118° C	248°F	120°C	253° F	123° C
Microturbines Sound Level [4,5]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m
Chiller/Heater Sound Level[5]	65 dBA @ 33 ft	65 dBA @ 10 m	65 dBA @ 33 ft	65 dBA @ 10 m	65 dBA @ 33 ft	65 dBA @ 10 m
System Sound Level [4,5]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m

1. Rating based on 59° F (15° C) ambient temperature at sea level, 60% RH, at ≤ 7 iwc microturbine backpressure.
2. Inclusive of parasitic power for fuel gas booster and chiller; fuel gas booster inlet pressure = 10 psig.
3. Rating based on ARI 560, latest edition, 44° F out (2.4 gpm/ton) chilled water; 67° F (4.0 gpm/ton) cooling water; fouling factor 0.00025 ft^2 hr F/Btu for absorber and condenser, 0.0001 ft^2 hr F/Btu for evaporator.
   Rating based on ARI 560, latest edition, 6.7° C out (0.043 L/s per kW)) chilled water; 29.4° C (0.072 L/s per kW)) cooling water; fouling factor 0.000044 m^2 • °C/W for absorber and condenser, 0.0000176 m^2 • °C/W for evaporator.
4. Subtract 7 ± 2 dB if using optional silencers.
5. No PureComfort™ system model will exceed the 85 decibel, 8 hour time weighted average, OSHA hearing protection threshold under normal operation.
6. Rating based on ARI 560, latest edition, 140° F hot water out; 0.0001 ft^2 hr F/Btu evaporator fouling factor.
   Rating based on ARI 560, latest edition, 54.4° C in, 60° C hot water out; 0.0000176 m^2 • °C/W for evaporator.

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PERFORMANCE - 59° (Standard ISO) DAY[1], continued

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	**SI**	**ENGLISH**	**SI**	**ENGLISH**	**SI**
ISO – Dual Mode – Power Only (Microturbines only – Stand Alone)						
Gross Power Output[4] 90 psig (620 kPa) Natural Gas Supply to Microturbine	228 kW	228 kW	285 kW	285 kW	342 kW	342 kW
Gross Electrical Efficiency (LHV) ± 2%	26	26	26	26	26	26
Net Power Output [5] 10 psig (69 kPa) Natural Gas Supply to Fuel Gas Booster	218 kW	218 kW	272 kW	272 kW	327 kW	327 kW
Net Electrical Efficiency (LHV) [5] ± 2%	25	25	25	25	25	25
Output Voltage	480 vac	480 vac	480 vac	480 vac	480 vac	480 vac
Frequency	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz
Output Power Connection	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N
Output Current (Maximum Steady State) [6]	360 A_{RMS}	360 A_{RMS}	450 A_{RMS}	450 A_{RMS}	540 A_{RMS}	540 A_{RMS}
Output Current (Maximum Instantaneous) [7]	648 A_{PEAK}	648 A_{PEAK}	810 A_{PEAK}	810 A_{PEAK}	972 A_{PEAK}	972 A_{PEAK}
Output Current Total Harmonic Distortion	< 5% THD	< 5% THD	< 5% THD	< 5% THD	< 5% THD	< 5% THD
Fuel Consumption (LHV)	2,900 MBh	3,100,000 kJ/hr	3,700 MBh	3,900,000 kJ/hr	4,400 MBh	4,700,000 kJ/hr
Microturbine Exhaust Gas Temperature	604° F	318° C	605° F	318° C	608° F	320° C
NOx Emissions[8]	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2
Microturbines Sound Level [9,10]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m
System Sound Level [9,10]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m

1. Rating based on 59 °F (15 °C) ambient temperature at sea level, 60% RH, at ≤ 7 iwc microturbine backpressure.
2. Rating based on 95 °F (35 °C) ambient temperature at sea level, 46% RH, at ≤ 7 iwc microturbine backpressure.
3. Rating based on 32 °F (0 °C) ambient temperature at sea level, 60% RH, at ≤ 7 iwc microturbine backpressure.
4. Full load grid connect performance prediction with 5% power output reduction.
5. Inclusive of parasitic power for fuel gas booster and air seal blower, fuel gas booster inlet pressure = 10 psig.
6. 100 Amps RMS per microturbine * Number of microturbines * 10% reduction per multiple microturbine configuration
7. 180 Amps Peak per microturbine * Number of microturbines * 10% reduction per multiple microturbine configuration
8. Meets California Air Resources Board (CARB) 2003 requirements.
9. Subtract 7 ± 2 dB if using optional silencers.
10. No PureComfort™ system model will exceed the 85 decibel, 8 hour time weighted average, OSHA hearing protection threshold under normal operation.

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PERFORMANCE – 95° DAY[1]

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	SI	ENGLISH	SI	ENGLISH	SI
ARI – Power Only (Microturbines only)						
Gross Power Output 90 psig (620 kPa) Natural Gas Supply to Microturbine	208 kW	208 kW	260 kW	260 kW	311 kW	311 kW
Gross Electrical Efficiency (LHV)	25	25	25	25	25	25
Net Power Output[2] 10 psig (69 kPa) Natural Gas Supply to Fuel Gas Booster	198 kW	198 kW	246 kW	246 kW	295 kW	295 kW
Net Electrical Efficiency (LHV)[2] ± 2%	24	24	24	24	24	24
Output Voltage	480 VAC	480 VAC	480 VAC	480 VAC	480 VAC	480 VAC
Frequency	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz
Output Power Connection	4-wire, L_1, L_2, L_3, N	4-wire, L_1, L_2, L_3, N	4-wire, L_1, L_2, L_3, N	4-wire, L_1, L_2, L_3, N	4-wire, L_1, L_2, L_3, N	4-wire, L_1, L_2, L_3, N
Output Current (Maximum Steady State)	400 A	400 A	500 A	500 A	600 A	600 A
Output Current Total Harmonic Distortion (IEEE 519 Compliant)[3]	< 5 % THD	< 5 % THD	< 5 % THD	< 5 % THD	< 5 % THD	< 5 % THD
Fuel Consumption (LHV)	2,800 MBh	3,000,000 kJ/hr	3,500 MBh	3,700,000 kJ/hr	4,200 MBh	4,500,000 kJ/hr
Microturbine Exhaust Gas Temperature	631° F	333° C	632° F	333° C	634° F	334° C
NOx Emissions[4]	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2
Microturbines Sound Level[5,6]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m
System Sound Level[5,6]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m

1. Rating based on 95° F (35° C) ambient temperature at sea level, 46% RH, at ≤ 7 iwc microturbine backpressure.
2. Inclusive of parasitic power for fuel gas booster and air seal blower; fuel gas booster inlet pressure = 10 psig.
3. Grid connect only.
4. Meets California Air Resources Board (CARB) 2003 requirements.
5. Subtract 7 ± 2 dB if using optional silencers.
6. No PureComfort™ system model will exceed the 85 decibel, 8 hour time weighted average, OSHA hearing protection threshold under normal operation.
7. Inclusive of parasitic power for fuel gas booster and chiller.
8. Rating based on ARI 560, latest edition, 44 °F out (2.4 gpm/ton) chilled water; 85° F (4.0 gpm/ton) cooling water; fouling factor 0.00025 ft^2 hr F/Btu for absorber and condenser, 0.0001 ft^2 hr F/Btu for evaporator.
   Rating based on ARI 560, latest edition, 6.7° C out (0.043 L/s per kW) chilled water; 29.4° C (0.072 L/s per kW) cooling water; fouling factor 0.000044 m^2 • °C/W for absorber and condenser, 0.0000176 m^2 • °C/W for evaporator.

PERFORMANCE – 95° DAY[1] - continued

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	SI	ENGLISH	SI	ENGLISH	SI
ARI – Power/Cooling (Microtubines + Chilled Water)						
Gross Power Output 90 psig (620 kPa) Natural Gas Supply to Microturbine	206 kW	206 kW	256 kW	256 kW	304 kW	304 kW
Gross Electrical Efficiency (LHV) ± 2%	25	25	25	25	25	25
Net Power Output [7] 10 psig (69 kPa) Natural Gas Supply to Fuel Gas Booster	193 kW	193 kW	239 kW	239 kW	285 kW	285 kW
Net Electrical Efficiency (LHV) [7] ± 2%	23	23	23	23	23	23
Gross System Efficiency ± 5%	77	77	76	76	74	74
Net System Efficiency (LHV) [7] ± 5%	76	76	74	74	72	72
Nominal Cooling Capacity [8] ± 5%	124 RT	436 kW	149 RT	524 kW	173 RT	608 kW
Chiller Coefficient of Performance (COP)	1.20	1.20	1.19	1.19	1.18	1.18
Chilled Water Flow Rate Pressure Drop	297 gpm 26 ft	19 l/s 77 kPa	358 gpm 38 ft	23 l/s 114 kPa	415 gpm 50 ft	26 l/s 149 kPa
Cooling Water Flow Rate Pressure Drop	494 gpm 24 ft	31 l/s 71 kPa	597 gpm 34 ft	38 l/s 102 kPa	691 gpm 45 ft	44 l/s 134 kPa
Fuel Consumption (LHV)	2,800 MBh	3,000,000 kJ/hr	3,500 MBh	3,700,000 kJ/hr	4,200 MBh	4,500,000 kJ/hr
Microturbine Exhaust Gas Temperature	630° F	332° C	630° F	332° C	632° F	334° C
Chiller Exhaust Gas Temperature	287° F	141° C	298° F	148° C	309° F	154° C
Microturbines Sound Level [5,6]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m
Chiller/Heater Sound Level[6]	65 dBA @ 33 ft	65 dBA @ 10 m	65 dBA @ 33 ft	65 dBA @ 10 m	65 dBA @ 33 ft	65 dBA @ 10 m
System Sound Level [5,6]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m

1. Rating based on 95° F (35° C) ambient temperature at sea level, 46% RH, at ≤ 7 iwc microturbine backpressure.
2. Inclusive of parasitic power for fuel gas booster and air seal blower; fuel gas booster inlet pressure = 10 psig.
3. Grid connect only.
4. Meets California Air Resources Board (CARB) 2003 requirements.
5. Subtract 7 ± 2 dB if using optional silencers.
6. No PureComfort™ system model will exceed the 85 decibel, 8 hour time weighted average, OSHA hearing protection threshold under normal operation.
7. Inclusive of parasitic power for fuel gas booster and chiller.
8. Rating based on ARI 560, latest edition, 44 °F out (2.4 gpm/ton) chilled water; 85° F (4.0 gpm/ton) cooling water; fouling factor 0.00025 ft^2 hr F/Btu for absorber and condenser, 0.0001 ft^2 hr F/Btu for evaporator.
   Rating based on ARI 560, latest edition, 6.7° C out (0.043 L/s per kW) chilled water; 29.4° C (0.072 L/s per kW) cooling water; fouling factor 0.000044 m^2 • °C/W for absorber and condenser, 0.0000176 m^2 • °C/W for evaporator.

PERFORMANCE – 95° DAY[1] - continued

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	SI	ENGLISH	SI	ENGLISH	SI
ARI – Dual Mode – Power Only (Microturbines only – Stand Alone)						
Gross Power Output[2] 90 psig (620 kPa) Natural Gas Supply to Microturbine	198 kW	198 kW	247 kW	247 kW	295 kW	295 kW
Gross Electrical Efficiency (LHV)	24	24	24	24	24	24
Net Power Output [3] 10 psig (69 kPa) Natural Gas Supply to Fuel Gas Booster	188 kW	188 kW	233 kW	233 kW	279 kW	279 kW
Net Electrical Efficiency (LHV) [3] ± 2%	23	23	23	23	22	22
Output Voltage	480 vac	480 vac	480 vac	480 vac	480 vac	480 vac
Frequency	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz
Output Power Connection	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N
Output Current (Maximun Steady State) [4]	360 A_{RMS}	360 A_{RMS}	450 A_{RMS}	450 A_{RMS}	540 A_{RMS}	540 A_{RMS}
Output Current (Maximum Instantaneous) [5]	648 A_{PEAK}	648 A_{PEAK}	810 A_{PEAK}	810 A_{PEAK}	972 A_{PEAK}	972 A_{PEAK}
Output Current Total Harmonic Distortion	< 5% THD	< 5% THD	< 5% THD	< 5% THD	< 5% THD	< 5% THD
Fuel Consumption (LHV)	2,800 MBh	3,000,000 kJ/hr	3,500 MBh	3,700,000 kJ/hr	4,200 MBh	4,500,000 kJ/hr
Microturbine Exhaust Gas Temperature	631° F	333° C	632° F	333° C	634° F	334° C
NOx Emissions[6]	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2
Microturbines Sound Level [7,8]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m
System Sound Level [7,8]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m

1. Rating based on 95 °F (35 °C) ambient temperature at sea level, 46% RH, at . 7 iwc microturbine backpressure.
2. Full load grid connect performance prediction with 5% power output reduction
3. Inclusive of parasitic power for fuel gas booster and air seal blower, fuel gas booster inlet pressure = 10 psig.
4. 100 Amps RMS per microturbine * Number of microturbines * 10% reduction per multiple microturbine configuration
5. 180 Amps Peak per microturbine * Number of microturbines * 10% reduction per multiple microturbine configuration
6. Meets California Air Resources Board (CARB) 2003 requirements.
7. Subtract 7 ± 2 dB if using optional silencers.
8. No PureComfort™ system Model will exceed the 85 decibel, 8 hour time weighted average, OSHA hearing protection threshold under normal operation.

PERFORMANCE – 32° DAY[1] - continued

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	SI	ENGLISH	SI	ENGLISH	SI
32° F Day – Power Only (Microturbines Only)						
Gross Power Output 90 psig (620 kPa) Natural Gas Supply to Microturbine	240 kW	240 kW	300 kW	300 kW	360 kW	360 kW
Gross Electrical Efficiency (LHV)	29	29	29	29	29	29
Net Power Output[2] 10 psig (69 kPa) Natural Gas Supply to Fuel Gas Booster	231 kW	231 kW	288 kW	288 kW	346 kW	346 kW
Net Electrical Efficiency (LHV) [2] ± 2%	28	28	28	28	28	28
Output Voltage	480 VAC	480 VAC	480 VAC	480 VAC	480 VAC	480 VAC
Frequency	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz
Output Power Connection	4-wire L_1, L_2, L_3, N	4-wire L_1, L_2, L_3, N	4-wire L_1, L_2, L_3, N	4-wire L_1, L_2, L_3, N	4-wire L_1, L_2, L_3, N	4-wire L_1, L_2, L_3, N
Output Current (Maximum Steady State)	400 A	400 A	500 A	500 A	600 A	600 A
Output Current Total Harmonic Distortion (IEEE 519 Compliant) [3]	< 5 % THD	< 5 % THD	< 5 % THD	< 5 % THD	< 5 % THD	< 5 % THD
Fuel Consumption (LHV)	2,800 MBh	2,900,000 kJ/hr	3,500 MBh	3,700,000 kJ/hr	4,200 MBh	4,400,000 kJ/hr
Microturbine Exhaust Gas Temperature	574° F	301° C	575° F	302° C	577° F	303° C
NOx Emissions [4]	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2
Microturbines Sound Level [5,6]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m
System Sound Level [5,6]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m

1. Rating based on 32° F (0° C) ambient temperature at sea level, 60% RH, at ≤ 7 iwc microturbine backpressure.
2. Inclusive of parasitic power for fuel gas booster and air seal blower; fuel gas booster inlet pressure = 10 psig.
3. Grid connect only.
4. Meets California Air Resources Board (CARB) 2003 requirements.
5. Subtract 7 ± 2 dB if using optional silencers.
6. No PureComfort™ system model will exceed the 85 decibel, 8 hour weighted average, OSHA hearing protection threshold under normal operation.
7. Inclusive of parasitic power for fuel gas booster and chiller, fuel gas booster inlet pressure = 10 psig.
8. Rating based on ARI 560, latest edition, 140° F hot water out; 0.0001 ft^2 hr F/Btu evaporator fouling factor. Rating based on ARI 560, latest edition, 54.4° C in, 60° C hot water out; 0.0000176 m^2 • °C/W for evaporator.

PERFORMANCE – 32° DAY[1] - continued

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	SI	ENGLISH	SI	ENGLISH	SI
32° F Day – Power/140° F Heating (Microturbines + Heated Water)						
Gross Power Output 90 psig (620 kPa) Natural Gas Supply to Microturbine	240 kW	240 kW	300 kW	300 kW	360 kW	360 kW
Gross Electrical Efficiency (LHV) ± 2%	29	29	29	29	29	29
Net Power Output[7] 10 psig (69 kPa) Natural Gas Supply to Fuel Gas Booster	231 kW	231 kW	288 kW	288 kW	346 kW	346 kW
Net Electrical Efficiency (LHV) [7] ± 2%	28	28	28	28	28	28
Gross System Efficiency ± 5%	69	69	69	69	68	68
Net System Efficiency (LHV)[7] ± 5%	68	68	67	67	67	67
Nominal Heating Capacity [8] ± 5%	1,100 MBh	324 kW	1,381 MBh	405 kW	1,660 MBh	487 kW
Hot Water Flow Rate Pressure Drop	297 gpm 26 ft	19 L/s 77 kPa	358 gpm 38 ft	23 L/s 114 kPa	415 gpm 50 ft	26 L/s 149 kPa
Fuel Consumption (LHV)	2,800 MBh	2,900,000 kJ/hr	3,500 MBh	3,700,00 kJ/hr	4,200 MBh	4,500,000 kJ/hr
Microturbine Exhaust Gas Temperature	573° F	301° C	575° F	301° C	577° F	303° C
Chiller Exhaust Gas Temperature	238° F	115° C	242° F	117° C	245° F	119° C
Microturbines Sound Level [5,6]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m
Chiller/Heater Sound Level[6]	65 dBA @ 33 ft	65 dBA @ 10 m	65 dBA @ 33 ft	65 dBA @ 10 m	65 dBA @ 33 ft	65 dBA @ 10 m
System Sound Level [5,6]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m

1. Rating based on 32° F (0° C) ambient temperature at sea level, 60% RH, at ≤ 7 iwc microturbine backpressure.
2. Inclusive of parasitic power for fuel gas booster and air seal blower; fuel gas booster inlet pressure = 10 psig.
3. Grid connect only.
4. Meets California Air Resources Board (CARB) 2003 requirements.
5. Subtract 7 ± 2 dB if using optional silencers.
6. No PureComfort™ system model will exceed the 85 decibel, 8 hour weighted average, OSHA hearing protection threshold under normal operation.
7. Inclusive of parasitic power for fuel gas booster and chiller, fuel gas booster inlet pressure = 10 psig.
8. Rating based on ARI 560, latest edition, 140° F hot water out; 0.0001 ft^2 hr F/Btu evaporator fouling factor.
   Rating based on ARI 560, latest edition, 54.4° C in, 60° C hot water out; 0.0000176 m^2 • °C/W for evaporator.

Performance – 32° F Day[1]- continued

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	SI	ENGLISH	SI	ENGLISH	SI
32° F Day – Dual Mode – Power Only (Microturbines only – Stand Alone)						
Gross Power Output[2] 90 psig (620 kPa) Natural Gas Supply to Microturbine	228 kW	228 kW	285 kW	285 kW	342 kW	342 kW
Gross Electrical Efficiency (LHV)	28	28	28	28	28	28
Net Power Output [3] 10 psig (69 kPa) Natural Gas Supply to Fuel Gas Booster	219 kW	219 kW	273 kW	273 kW	328 kW	328 kW
Net Electrical Efficiency (LHV) [3] ± 2%	27	27	27	27	27	27
Output Voltage	480 vac	480 vac	480 vac	480 vac	480 vac	480 vac
Frequency	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz	60 Hz
Output Power Connection	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N	4-wire L_1,L_2,L_3,N
Output Current (Maximum Steady State) [4]	360 A_{RMS}	360 A_{RMS}	450 A_{RMS}	450 A_{RMS}	540 A_{RMS}	540 A_{RMS}
Output Current (Maximum Instantaneous) [5]	648 A_{PEAK}	648 A_{PEAK}	810 A_{PEAK}	810 A_{PEAK}	972 A_{PEAK}	972 A_{PEAK}
Output Current Total Harmonic Distortion	< 5% THD	< 5% THD	< 5% THD	< 5% THD	< 5% THD	< 5% THD
Fuel Consumption (LHV)	2,800 MBh	2,900,000 kJ/hr	3,500 MBh	3,700,000 kJ/hr	4,200 MBh	4,400,000 kJ/hr
Microturbine Exhaust Gas Temperature	574° F	301° C	575° F	302° C	577° F	303° C
NOx Emissions[6]	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2	9 ppmv @ 15% O_2
Microturbines Sound Level [7,8]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m
System Sound Level [7,8]	76 dBA @ 33 ft	76 dBA @ 10 m	77 dBA @ 33 ft	77 dBA @ 10 m	78 dBA @ 33 ft	78 dBA @ 10 m

1. Rating based on 32 °F (0 °C) ambient temperature at sea level, 60% RH, at ≤ 7 iwc microturbine backpressure.
2. Full load grid connect performance prediction with 5% power output reduction
3. Inclusive of parasitic power for fuel gas booster and air seal blower, fuel gas booster inlet pressure = 10 psig.
4. 100 Amps RMS per microturbine * Number of microturbines * 10% reduction per multiple microturbine configuration
5. 180 Amps Peak per microturbine * Number of microturbines * 10% reduction per multiple microturbine configuration
6. Meets California Air Resources Board (CARB) 2003 requirements.
7. Subtract 7 ± 2 dB if using optional silencers.
8. No PureComfort™ system model will exceed the 85 decibel, 8 hour time weighted average, OSHA hearing protection threshold under normal operation.

17.0 OPERATIONAL EFFECTS ON PERFORMANCE

Full Load Performance as Function of System Operation

PureComfort™ system Performance data for power, power and chilling, and power and heating operations are shown in the following tables. Note the data are for ISO Standard and ARI Standard day.

Operation and Performance Variability

The chiller is designed to operate at 25% to 100% of full rated performance as long as the microturbines provide the required heat input. Part load performance are affected by the following:

- Microturbine Backpressure
- Ambient temperature
- Natural Gas Pressure
- Fuel Gas Booster Performance
- Microturbine Exhaust Flow Characteristics
- Cooling or chilled water inlet temperature
- Installation Altitude

In general, the chiller/heater output is linearly proportional to the microturbine electrical output. For example, at 100% microturbine electrical output allow full capacity of the chiller. Actual chiller performance will depend on the performance variables above.

The microturbine controller is designed to load share as the electrical demand is reduced. For example, when the microturbine output power is reduced from 240 kW to 160 kW, the loads will be evenly distributed among the 4 running turbines to approximately 40 kW each.

Operational Effects of Changes in Backpressure on performance

Please note that increasing the backpressure will decrease the performance of the microturbines and chiller. Figure 9 below illustrates the impact of increased backpressure to microturbine output power and efficiency. The Efficiency curve does not include Fuel Gas Booster and air seal blower; therefore, the overall efficiency must be calculated. Please contact your UTC Power sales representative to receive estimates for your application.

The PureComfort™ system is designed to create less than 7.5 inches H_2O backpressure at the microturbine exhaust. Backpressure for Model 240M is 5 inches H_2O, and backpressure for Model 300M is 6 inches H_2O. Model 240M and Model 300M backpressure can be increased to 7.5 inches H_2O if additional ducting or valves are required to adapt the PureComfort™ system to a facility. Please contact UTC Power if additional ducting or valves causing increased backpressure are needed on Model 360M.

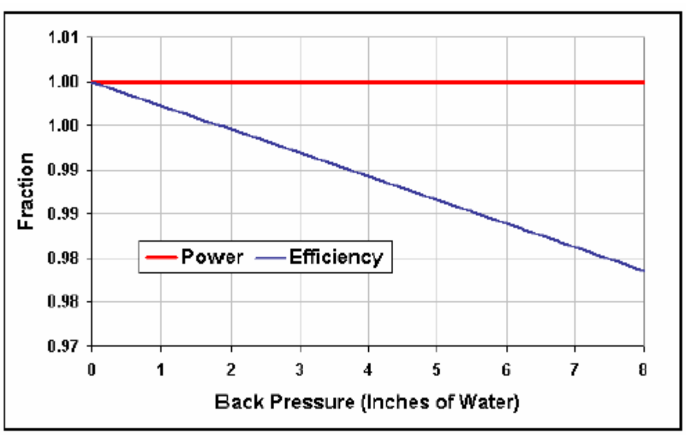

Figure 9 - Effect of Exhaust Backpressure to Electrical Output and Efficiency

Operational Effects of Ambient Temperature on Performance

The figure below illustrates the effect of ambient temperature to gross and net power output at sea level during Power Mode. The typical expected power output can be calculated by measuring the ambient temperature and using the graph in Figure 10 below.

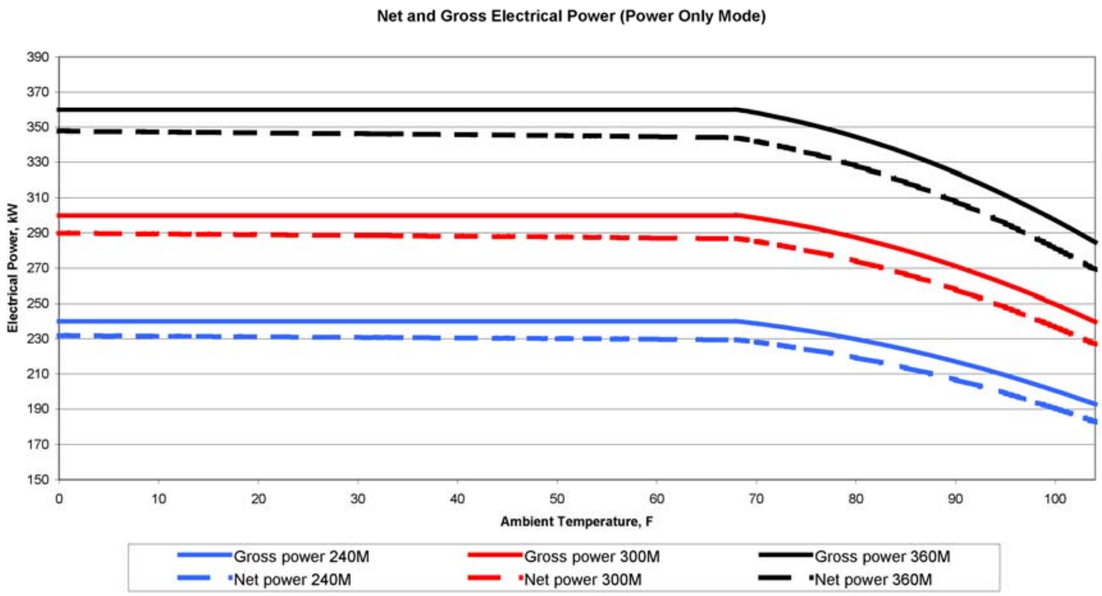

Figure 10 - Power Operation

Figure 11 below illustrates the effect of ambient temperature to gross and net power output and cooling capacity at sea level during Power and Cooling Mode. Measuring the ambient temperature and using the graph below one can calculate the typical expected power output and cooling capacity.

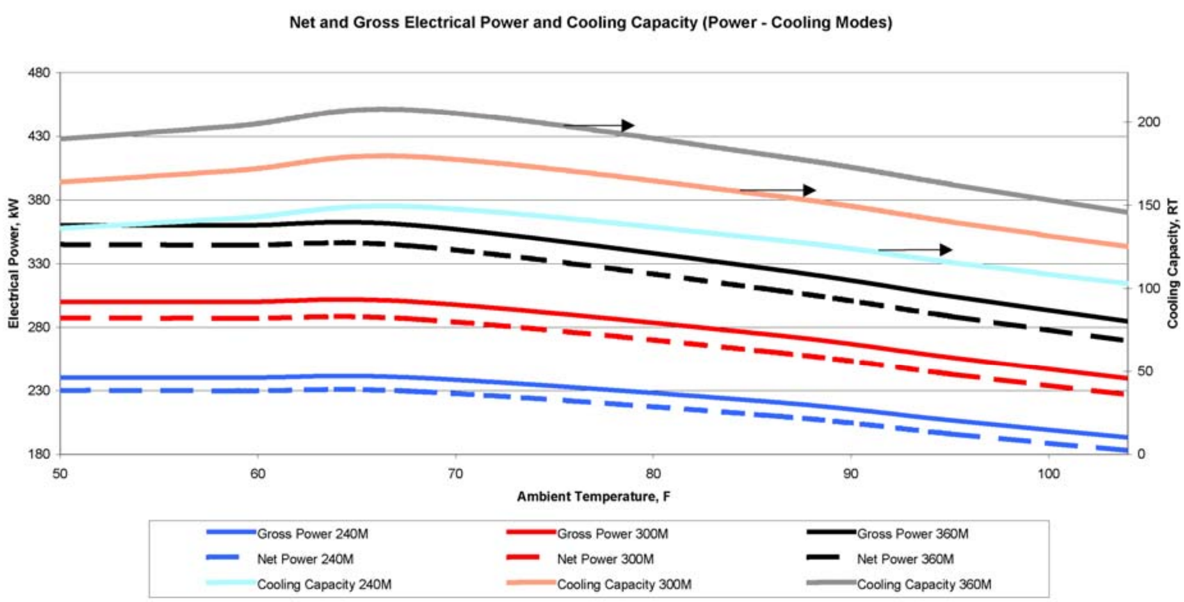

Figure 11 - Power/Cooling Operation

Figure 12 below illustrates the effect of ambient temperature to gross and net power output and heating capacity at sea level during Power/Heating mode. By measuring the ambient temperature and using the graph below one can calculate the typical expected power output and heating capacity.

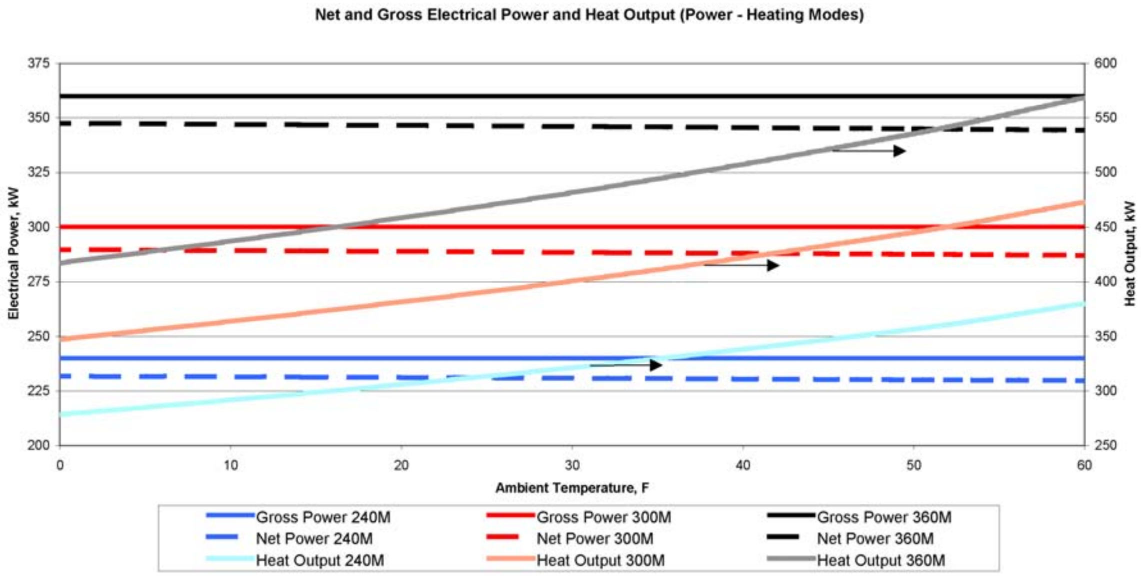

Figure 12 - Power/Heating Operation

Operational Effects of Natural Gas Pressure

The recommended inlet operating pressure for the 60kW Microturbines is between 75 and 80 psig (517 and 552 kPa gauge). Higher supply pressures will require regulation down to within the noted range. Applications in which the inlet-supply pressures range from 0.25 to 15.0 psig (1.7 to 103 kPa gauge) require the use of fuel gas boosters.

Depending on inlet pressure the system startup requirements may vary.

NOTE
Please contact your UTC Power sales representative to receive estimates for your application.

Fuel Gas Booster Performance

Inlet pressure affects the performance of the Fuel Gas Booster. Consideration must be made to minimize parasitic load from the Fuel Gas Booster. The power needed to operate the compressors depends on the pressure available.

A single compressor running with 15-psig natural gas requires approximately 3.3 kW and with 2.5-psig natural gas it requires approximately 6.5 kW @ 100% microturbine output.

NOTE
Please contact your UTC Power sales representative to receive estimates for your application.

Operational Effects of Changes in Exhaust Gas Flow Characteristics

The microturbine exhaust mass flow rate and temperature change with ambient temperature. Figure 13 below shows how microturbine exhaust temperature increases with increasing ambient temperature. Figure 14 below shows how microturbine exhaust mass flow rate varies with ambient temperature. These variations have an impact on cooling and heating capacity.

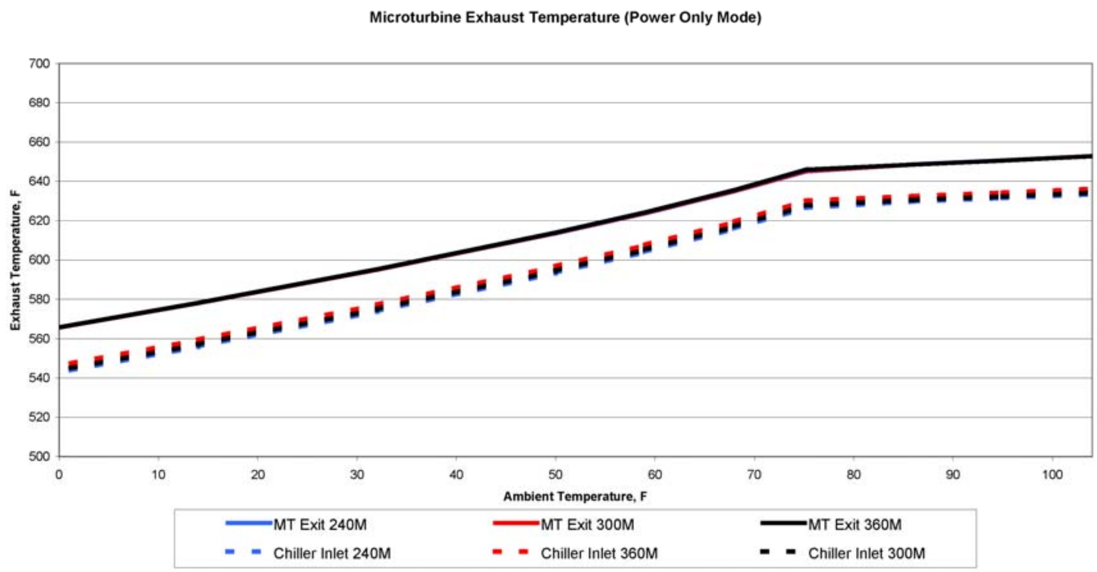

Figure 13 - Microturbine exhaust temperature as a function of ambient temperature

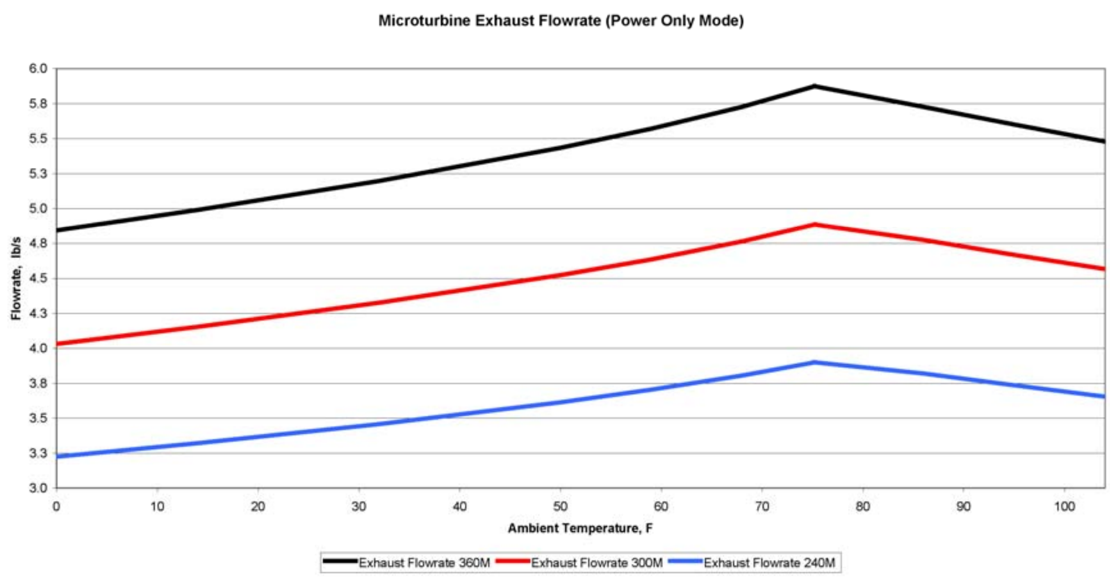

Figure 14 - Microturbine exhaust flow rate vs. Ambient Temperature

Operational Effects of Changes to Cooling Water or Chilled Water Temperature

Cooling water temperature entering the chiller affects the performance of chiller. As the cooling water temperature increases, the performance of the chiller decreases, as shown in Figure 15 below. Changes in chilled water return temperature also affect chiller performance. As shown in Figure 16 below, as chilled water return temperature increases, chiller cooling capacity increases.

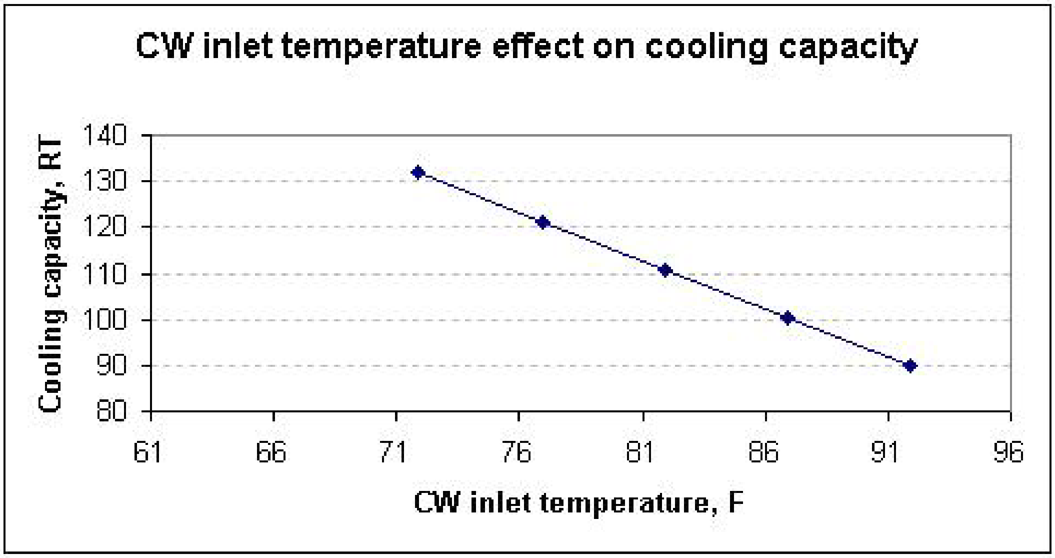

Figure 15 - Cooling Water Inlet Temperature effect on cooling capacity

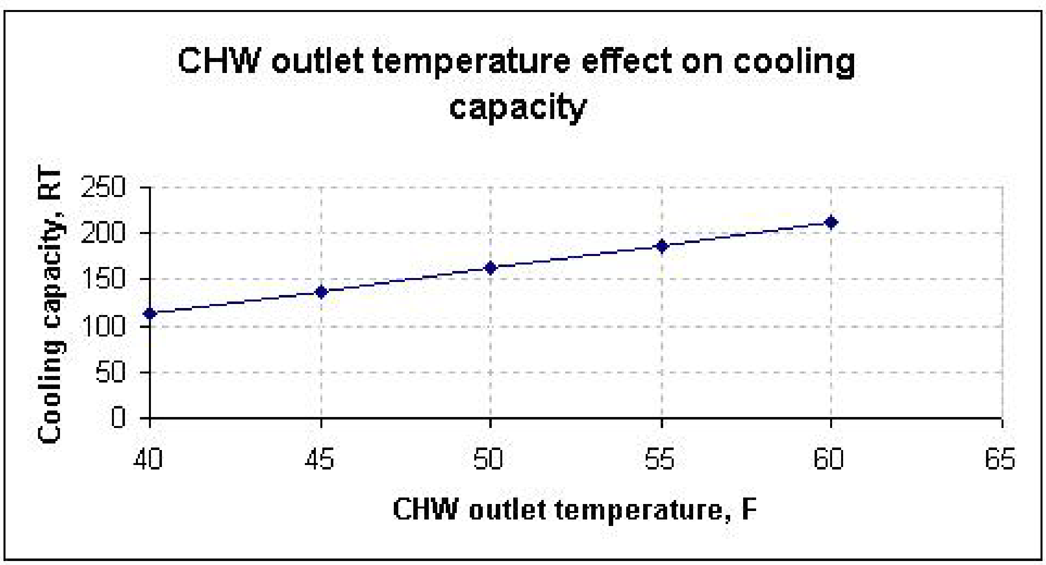

Figure 16 - Chilled Water Return Temperature effect on cooling capacity110

APPENDIX A

Trigeneration Option using Simultaneous Cooling and Heating Chiller

A.1. System Description

Trigeneration option using simultaneous cooling and heating chiller

UTC Power's PureComfort^{TM} trigeneration cooling, heating and power solution enables higher annual efficiencies and improved year-round energy savings. Exhaust gas from a bank of microturbines fires a double-effect absorption chiller, equipped with special features to simultaneously produce both chilled and hot water. This capability allows the system to be extremely flexible, as the chiller has a wide range of stable operation, a combination cooling/heating mode, and an automated changeover between cooling and heating mode. Continuous operation in cooling, heating, or combination mode is possible from full capacity to near zero capacity, exceeding the turndown of typical absorption machines. The range of application of the PureComfort^{TM} cooling, heating and power solution is greatly increased, as customers without a thermal base load can utilize the additional capacity in the machine to produce extra heating or cooling in the combination cooling/heating mode. During the shoulder months, such as April and October, the system can provide cooling during the day and heating at night without a shutdown to manually change over the system. The system can be monitored and operated remotely, and can receive input from building management systems or other site controllers. UTC Power's simultaneous cooling, heating and power solution is truly unique, as its seasonal flexibility with the combination mode and automated changeover between cooling and heating modes yields full utilization throughout the year, increasing annual efficiency and energy savings.

A.2 Modes of Operation

The trigeneration option of the PureComfort^{TM} combined cooling, heating and power solution has two additional modes of operation. Chilled and hot water can be produced simultaneously in either Simultaneous Mode - Cooling Priority or Simultaneous Mode – Heating Priority.

Simultaneous Mode – Cooling Priority

During the simultaneous mode – cooling priority, the exhaust flow of the microturbines is used as the heat source to drive the absorption chiller. The chiller allows two temperature setpoints: one for chilled water (which takes priority) and one for hot water. The chiller will first meet the chilled water demand, and then utilize any excess microturbine exhaust energy to meet the hot water setpoint. The diverter valve operates automatically, adjusting the exhaust flow into the chiller to maintain both setpoints. In this mode, continuous operation is possible from 0% to 100% cooling and 0% to 95% heating. See Section A.5 for a tabulation of the performance.

Simultaneous Mode – Heating Priority

During the simultaneous mode – heating priority, the exhaust flow of the microturbines is used as the heat source to drive the absorption chiller. The chiller allows two temperature setpoints: one for hot water (which takes priority) and one for chilled water. The chiller will first meet the hot water demand, and then utilize any excess microturbine exhaust energy to meet the chilled water setpoint. The diverter valve operates automatically, adjusting the exhaust flow into the chiller to maintain both setpoints. In this mode, continuous operation is possible from 0% to 95% cooling and 0% to 100% heating. See Section A.5 for a tabular representation of the performance.

A.3 Physical Data

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	SI	ENGLISH	SI	ENGLISH	SI
PureComfort™ SYSTEM			Specifications to be published in Revision D			
Operating Weight	29,458 lb	13,362 kg				
MICROTURBINE (per unit)						
Rigging Weight: Grid Connect Dual Mode and Stand Alone	 1,700 lb 2,470 lb	 770 kg 1,120 kg				
Gas Inlet Pipe Connection Size	1 / 2 in. female flare	1 / 2 in. female flare				
Exhaust Duct Size	8 in.	8 in.				
FUEL GAS BOOSTER (per unit)						
Rigging Weight	550 lb	250 kg				
Gas Inlet Pipe Connection Size	1 in. NPT	1 in. NPT				
Gas Outlet Pipe Connection Size	3 / 4 in. NPT	3 / 4 in. NPT				
CHILLER/HEATER						
Rigging Weight Chiller/Heater Diverter Valve Inlet duct	 19,460 lb 720 lb 300 lb	 8,827 kg 327 kg 136 kg				
Operating Weight	20,871 lb	9,467kg				
Lithium Bromide Solution Charge	2,645 lb	1200 kg				
Refrigerant (Water) Charge	573 lb	260 kg				
Chilled/Hot Water (Evaporator) Pipe Connection Size No. Passes	 4 in. 4	 4 in. 4				
Cooling Water Pipe Connection Size No. Passes Absorber Condenser	 6 in. 3 1	 6 in. 3 1				
Hot Water (Auxiliary Heat Exchanger) Pipe Connection Size No. Passes	 3 in. 4	 3 in. 4				
Hot Water (Glycol Heat Exchanger) Pipe Connection Size	 1.25 in.	 1.25 in.				
Exhaust Ducting Interface Chiller Outlet Diverter Valve Bypass	 20 in. dia 20 in. dia	 20 in. dia 20 in. dia				

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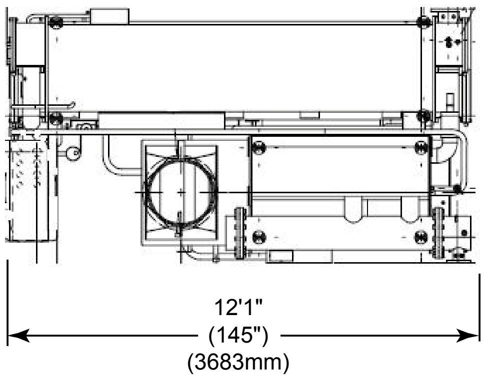
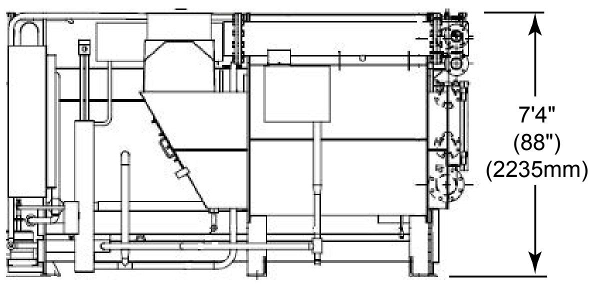
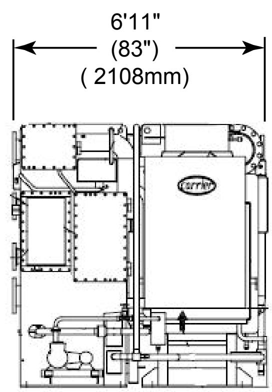
A.4 Chiller Dimensions







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A.5 System Performance and Operation

Performance – 59° F Day

Simultaneous Mode, Cooling Priority

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	SI	ENGLISH	SI	ENGLISH	SI
Power + Cooling/175° F Heating (Microturbines + Chilled Water + Hot Water)						
Gross Power Output 90 psig (620 kPa) Natural Gas Supply to Microturbine	240 kW	240 kW	Specifications to be published in Revision D			
Gross Electrical Efficiency (LHV) ± 2%	28	28				
Net Power Output [2] 10 psig (69 kPa) Natural Gas Supply to Fuel Gas Booster	227 kW	227 kW				
Net Electrical Efficiency (LHV) [2] ± 2%	26	26				
Gross System Efficiency ± 5%	85	85				
Net System Efficiency (LHV)[2] ± 5%	84	84				
Maximum Cooling Capacity[3] ± 5%	142 RT	500 kW				
Chiller Coefficient of Performance (COP)	1.30	1.30				
Chilled Water Flow Rate Pressure Drop	297 gpm 26 ft	19 l/s 77 kPa				
Cooling Water Flow Rate Pressure Drop	494 gpm 24 ft	31 l/s 71 kPa				
Gross System Efficiency 175° F Heating	65	65				
Net System Efficiency 175° F Heating[2]	64	64				
Maximum 175° F Heating Capacity[6] ± 5%	1104 MBh	323 kW				
Hot Water (175° F) Flow Rate Pressure Drop	217 gpm 23 ft H2O	14 l/s 66 kPa				
Gross System Efficiency Glycol HEX Cooling Gross System Efficiency Glycol HEX 175° Heating	93 75	93 75				
Net System Efficiency Glycol HEX Cooling[2] Net System Efficiency Glycol HEX 175° Heating[2]	92 74	92 74				
Glycol HEX Option Heating Capacity[7] 100 % Cooling Load 100 % Heating Load	262 MBh 330 MBh	77 kW 97 kW				
Fuel Consumption (LHV)	3,000 MBh	3,100,000 kJ/hr				
Microturbine Exhaust Gas Temperature	604° F	318° C				
Chiller Exhaust Gas Temperature	236° F	113° C				
Microturbines Sound Level [4,5]	76 dBA @ 33 ft	76 dBA @ 10 m				
Chiller/Heater Sound Level [5]	65 dBA @ 33 ft	65 dBA @ 10 m				
System Sound Level [4,5]	76 dBA @ 33 ft	76 dBA @ 10 m				

1. Rating based on 59° F (15° C) ambient temperature at sea level, 60% RH, at ≤ 7 iwc microturbine backpressure.
2. Inclusive of parasitic power for fuel gas booster and chiller; fuel gas booster inlet pressure = 10 psig.
3. Rating based on ARI 560, latest edition, 44° F out (2.4 gpm/ton) chilled water; 74° F (4.0 gpm/ton) cooling water; fouling factor 0.00025 ft^2 hr F/Btu for absorber and condenser, 0.0001 ft^2 hr F/Btu for evaporator.

Rating based on ARI 560, latest edition, 6.7° C out (0.043 L/s per kW)) chilled water; 29.4° C (0.072 L/s per kW)) cooling water; fouling factor 0.000044 m^2 • °C/W for absorber and condenser, 0.0000176 m^2 • °C/W for evaporator.

4. Subtract 7 ± 2 dB if using optional silencers.
5. No PureComfort™ system model will exceed the 85 decibel, 8 hour time weighted average, OSHA hearing protection threshold under normal operation.
6. Rating based on 175° F hot water out; 217 gpm flow rate.
7. Rating based on 140° F hot water out ; 50 gpm flow rate through glycol heat exchanger.

UTC Power
A United Technologies Company

Performance – 95° F Day

Simultaneous Mode, Cooling Priority

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	SI	ENGLISH	SI	ENGLISH	SI
Power + Cooling/175° F Heating						
Gross Power Output 90 psig (620 kPa) Natural Gas Supply to Microturbine	206 kW	206 kW	Specifications to be published in Revision D			
Gross Electrical Efficiency (LHV) ± 2%	25	25				
Net Power Output [2] 10 psig (69 kPa) Natural Gas Supply to Fuel Gas Booster	193 kW	193 kW				
Net Electrical Efficiency (LHV)[2] ± 2%	23	23				
Gross System Efficiency ± 5%	77	77				
Net System Efficiency (LHV)[2] ± 5%	76	76				
Maximum Cooling Capacity[5] ± 5%	124 RT	436 kW				
Chiller Coefficient of Performance (COP)	1.20	1.20				
Chilled Water Flow Rate Pressure Drop	297 gpm 26 ft.	19 l/s 77 kPa				
Cooling Water Flow Rate Pressure Drop	494 gpm 24 ft.	31 l/s 71 kPa				
Gross System Efficiency w/Glycol HEX	89	89				
Net System Efficiency w/Glycol HEX[2]	88	88				
Glycol HEX Option Heating Capacity[6] 100% Cooling Load	335 MBh	98 kW				
Gross System Efficiency 175° Heating	66	66				
Net System Efficiency 175° Heating	65	65				
175° Heating Capacity[6]	1,195 MBh	350 kW				
Fuel Consumption (LHV)	2,800 MBh	3,000,000 kJ/hr				
Microturbine Exhaust Gas Temperature	630° F	332° C				
Chiller Exhaust Gas Temperature	287° F	141° C				
Microturbines Sound Level[3,4]	76 dBA @ 33 ft	76 dBA @ 10 m				
Chiller/Heater Sound Level[4]	65 dBA @ 33 ft	65 dBA @ 10 m				
System Sound Level[3,4]	76 dBA @ 33 ft	76 dBA @ 10 m				

1. Rating based on 95° F (35° C) ambient temperature at sea level, 46% RH, at ≤ 7 iwc microturbine backpressure.
2. Inclusive of parasitic power for fuel gas booster and air seal blower; fuel gas booster inlet pressure = 10 psig.
3. Subtract 7 ± 2 dB if using optional silencers.
4. No PureComfort™ system model will exceed the 85 decibel, 8 hour time weighted average, OSHA hearing protection threshold under normal operation.
5. Rating based on ARI 560, latest edition, 44 °F out (2.4 gpm/ton) chilled water; 85° F (4.0 gpm/ton) cooling water; fouling factor 0.00025 ft^2 hr F/Btu for absorber and condenser, 0.0001 ft^2 hr F/Btu for evaporator.
   Rating based on ARI 560, latest edition, 6.7° C out (0.043 L/s per kW) chilled water; 29.4° C (0.072 L/s per kW) cooling water; fouling factor 0.000044 m^2 • °C/W for absorber and condenser, 0.0000176 m^2 • °C/W for evaporator.
6. Rating based on 140° F hot out and 50 gpm flow rate through glycol heat exchanger.
7. Rating based on 175° F hot water out and 217 gpm flow rate.

Performance – 32° F Day

Simultaneous Mode, Heating Priority

	MODEL 240M		MODEL 300M		MODEL 360M	
	ENGLISH	SI	ENGLISH	SI	ENGLISH	SI
Power + 175° F/Heating (Microturbines + Hot Water)						
Gross Power Output 90 psig (620 kPa) Natural Gas Supply to Microturbine	240 kW	240 kW	**Specifications to be published in Revision D**			
Gross Electrical Efficiency (LHV) ± 2%	29	29				
Net Power Output [2] 10 psig (69 kPa) Natural Gas Supply to Fuel Gas Booster	231 kW	231 kW				
Net Electrical Efficiency (LHV) [2] ± 2%	28	28				
Gross System Efficiency ± 5% (175° F Heating)	62	62				
Net System Efficiency (LHV)[2] ± 5% (175° F Heating)	61	61				
Maximum 175° F Heating Capacity[5] ± 5%	936 MBh	274 kW				
140° F Hot Water[5] Flow Rate Pressure Drop	297 gpm 19 ft	19 l/s 57 kPa				
Gross System Efficiency w/Glycol HEX	72	72				
Net System Efficiency w/Glycol HEX[2]	71	71				
Glycol HEX Option Heating Capacity[6] 100 % Heating Load 140° F	309 MBh	90 kW				
Fuel Consumption (LHV)	2800 MBh	2,900,000 kJ/hr				
Microturbine Exhaust Gas Temperature	573° F	301° C				
Chiller Exhaust Gas Temperature	231° F	111° C				
Microturbines Sound Level[3,4]	76 dBA @ 33 ft	76 dBA @ 10 m				
Chiller/Heater Sound Level[4]	65 dBA @ 33 ft	65 dBA @ 10 m				
System Sound Level[3,4]	76 dBA @ 33 ft	76 dBA @ 10 m				

1. Rating based on 32° F (0° C) ambient temperature at sea level, 60% RH, at ≤ 7 iwc microturbine backpressure.
2. Inclusive of parasitic power for fuel gas booster and air seal blower; fuel gas booster inlet pressure = 10 psig.
3. Subtract 7 ± 2 dB if using optional silencers.
4. No PureComfort™ system model will exceed the 85 decibel, 8 hour weighted average, OSHA hearing protection threshold under normal operation.
5. Rating based on ARI 560, latest edition, 175° F hot water out; 0.0001 ft^2 hr F/Btu evaporator fouling factor. Rating based on ARI 560, latest edition, 54.4° C in, 60° C hot water out; 0.0000176 m^2 • °C/W for evaporator.
6. Rating based on 140° F hot water out; 50 gpm flow rate through glycol heat exchanger.