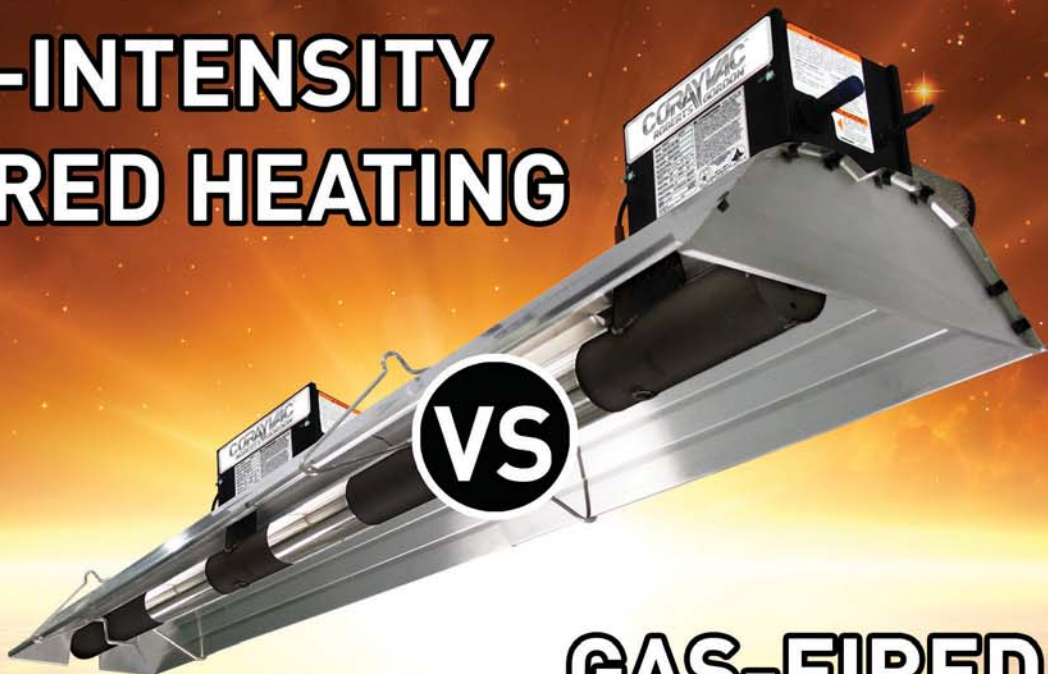
ROBERTS GORDON®
INFRARED HEATING

GAS-FIRED LOW-INTENSITY INFRARED HEATING



GAS-FIRED UNIT HEATERS

Low-intensity, infrared radiant heat is the most fuel efficient and comfortable heating method in the HVAC industry.

Maximize comfort and provide energy efficient heat where it is needed.

ROBERTS GORDON® infrared heating equipment warms a space in the same manner as the sun warms the earth. A gentle blanket of low-intensity infrared heat spreads warmth that is received directly by people, floor, and objects within the space. As radiant energy continues to build it is absorbed into the surrounding surfaces. That energy is then released, heating the air through convection and re-radiation. This increases the Mean Radiant Temperature (MRT), which is defined as the uniform temperature caused by the combination of heat transfer from objects and radiant energy. Just like receiving energy directly from the sun, the increased MRT allows occupants to feel maximum comfort at a reduced air temperature. Because infrared heating directly heats the floor, objects, and occupants in a space, there is little to no stratification, reducing building heat loss and providing heat where it is needed. Because of the principles of infrared, there are many benefits that include: rapid heat recovery, electrical savings, clean and quiet draft-free heat.

Warm Air Unit heaters waste fuel because warm air rises to the ceiling, due to increased stratification.
Gas-fired unit heaters push a large volume of heated air around the space. As the heated air is heated, the laws of physics take over and the result is heat stratification. Warm air rises to the ceiling where it is wasted. Furthermore, unit heaters heat a space by warming the air first, rather than the surfaces or occupants in the space. This can create drafts and uncomfortable hot and cold spots throughout the facility.

What is the Best Way to Heat a Space?

The goal of heating a space effectively is to maintain the Operative Temperature (To). Defined in ANSI/ASHRAE 55, **Operative Temperature** is how warm a space feels versus its actual temperature. Because radiant energy heats the surfaces directly, the average **MRT** of the space tends to be higher than the **Ambient Air Temperature (Ta)**. The formula below describes the relationship between **To**, **MRT**, and **Ta** when air movement across occupant level is less than 40 feet per minute.

Warm Air Heating

$$To = \frac{Ta + MRT}{2}$$

$$MRT = 65°F$$

$$Ta = 75°F$$

$$To = \frac{75°F + 65°F}{2} = 70°F$$

Due to lack of direct heat, temperatures of surfaces found in a space heated with warm air are lower than **Ambient Air Temperature** in that space. This means that given a **MRT** of 65°F, the ambient air of the space must be 75°F to obtain the 70°F perceived comfort.

Infrared Heating

$$To = \frac{Ta + MRT}{2}$$

$$MRT = 75°F$$

$$Ta = 65°F$$

$$To = \frac{65°F + 75°F}{2} = 70°F$$

By directly heating the surfaces in a space, the **MRT** is raised to 75°F. This means that to gain the same **Operative Temperature** of 70°F, the ambient air inside can be heated to 65°F. This is how, when using ROBERTS GORDON® infrared heating equipment, you can **turn your thermostat down 5°F and maintain the same comfort level!**

The majority of thermostats measure ambient temperature of air in a space. The necessary **Ambient Air Temperature** can be reduced due to the higher **Mean Radiant Temperature** achieved using ROBERTS GORDON® infrared heating equipment. As a result, your thermostat can be set lower while still maintaining the same comfort level. The US Department of Energy estimates that for every 1° F that the thermostat is lowered, a corresponding 3% reduction in fuel use is realized. This means that, by lowering the thermostat setting by 5° F, up to 15% can be saved on fuel usage when compared to fuel usage using warm air appliances for the same facility.

ASHRAE recognizes that infrared heating improves comfort and increases fuel savings when compared to other methods of heating.

As previously mentioned, the principles of infrared heating reduce the number of Btu/h needed to comfortably heat a space and save energy in the future, in contrast to other heating methods. The standard heat loss equations and methods typically used were developed with a greater emphasis on forced air convection appliances and fails to fully characterize infrared heaters. An ASHRAE study was conducted to determine an adjustment factor for input energy requirements and energy savings garnered from infrared applications in contrast to other types of heating systems. The study concluded from these, and other points, that the Btu/h input required for a space using traditional heating methods, such as warm air heating, can be reduced by 15% to 20% when considering infrared heating installations.

"Recognizing the reduced fuel requirement for these applications, ... it is desirable for manufacturers of radiant heaters to recommend installation of equipment with a rated output that is 80 to 85% of the heat loss calculated by methods described in Chapters 17 and 18 of the 2013 ASHRAE Handbook – Fundamentals."- 2016 ASHRAE Handbook (HVAC Systems and Equipment)

Building Comparison

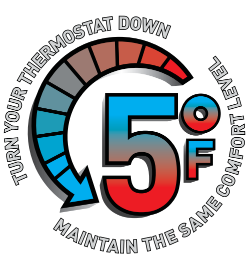
ROBERTS GORDON® infrared heating equipment will provide more comfort and fuel savings than any other heating method in the HVAC industry!

To prove this claim, Roberts-Gordon teamed up with the BUILDING PERFORMANCE TEAM to create an energy model that compares heating a facility with ROBERTS GORDON® CORAYVAC® against a common direct fired make up air system. Specializing in commercial and industrial building performance, the BUILDING PERFORMANCE TEAM is an industry leader in Building Energy Modeling. President of BPT, Jim Dirkes, has been awarded certification as a "Building Energy Modeling Professional" by ASHRAE, joining a small group of building modeling professionals in the world.

The energy model takes a typical 100,000 square foot warehouse using a combination of DesignBuilder (a 3D drawing tool), and EnergyPlus™, the US Department of Energy's energy analysis tool. EnergyPlus™ is specifically cited as an acceptable analysis tool for LEED projects and meets all of the LEED and ASHRAE 90.1 specifications. DesignBuilder integrates a simple drawing / sketching interface with EnergyPlus™ and has been documented to produce essentially identical results to standalone EnergyPlus™ analysis.

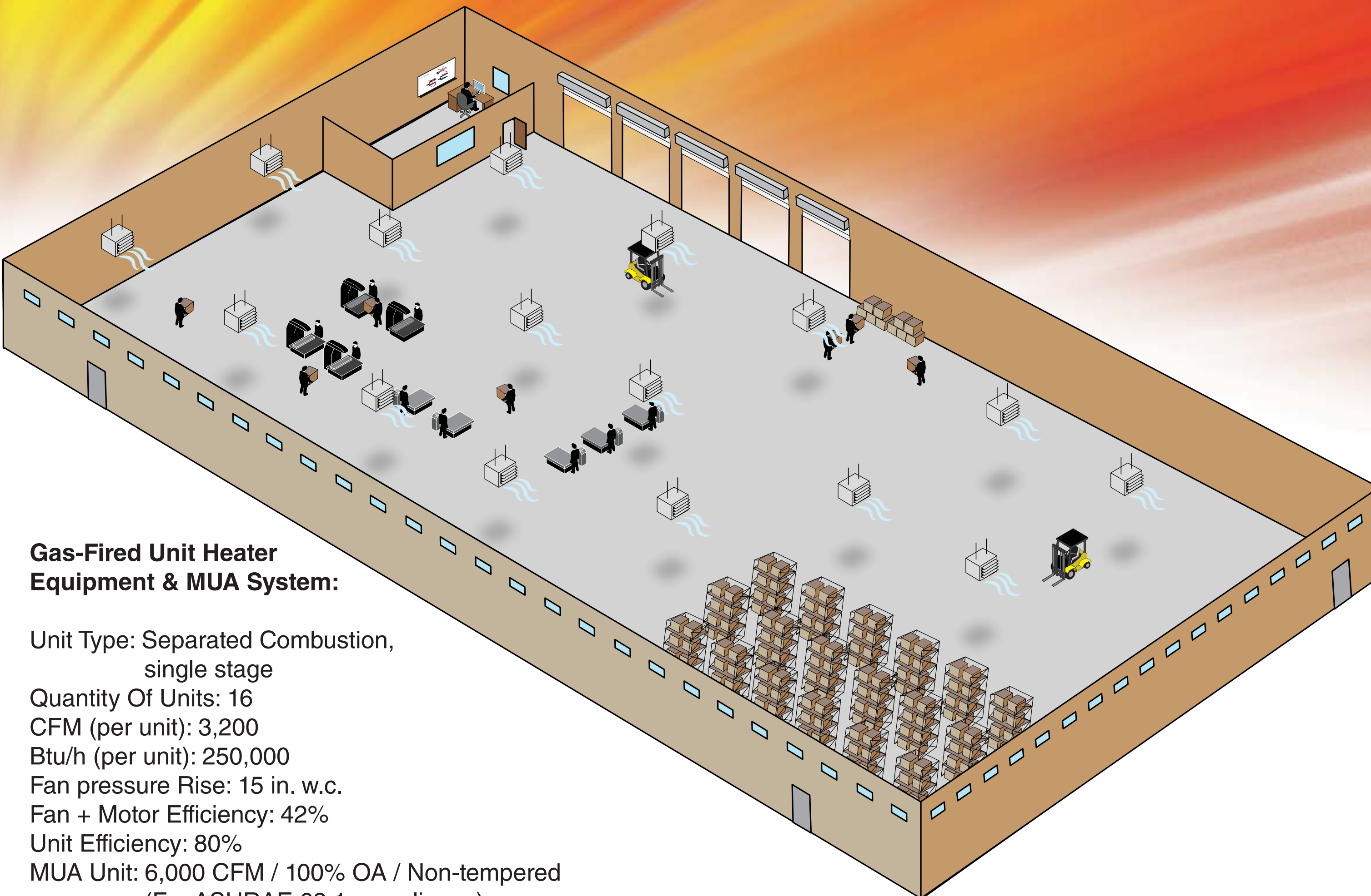
We paid close attention to detail by identifying all aspects of the application to determine energy usage. The construction of the warehouse will use insulation consistent with ASHRAE Standard 90.1-2010 for the building's climate zone located in Pittsburg, PA.

Both HVAC systems are in compliance with ASHRAE Standard 90.1 (Energy Standard for Buildings Except Low-Rise Residential Buildings) and ASHRAE Standard 62.1 (Standard For Ventilation And Indoor Air Quality). Included here and in each of the following systems, will be separate HVAC for the offices.



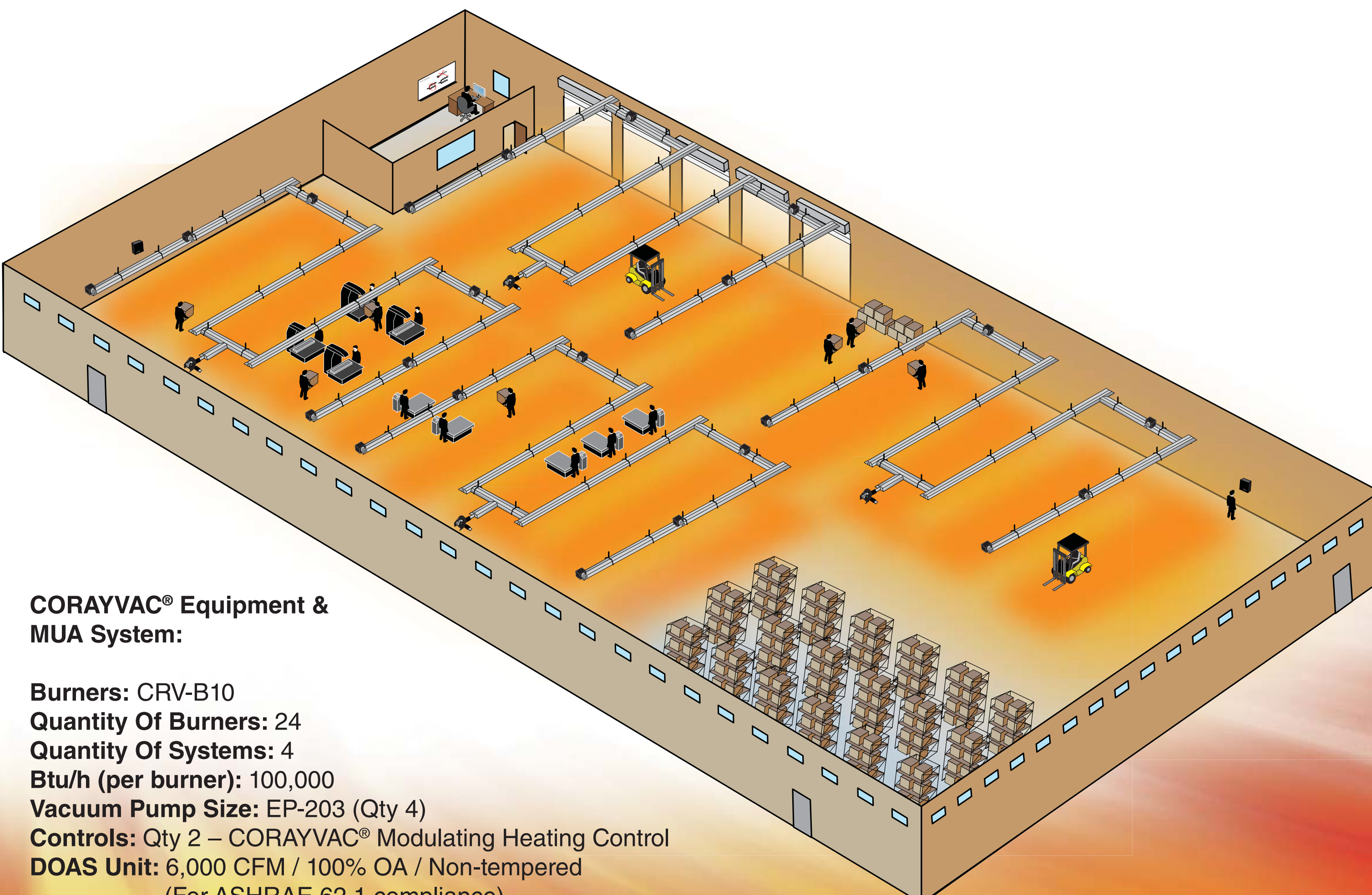
Building Design Parameters

Heating Setpoint (Occupied / Unoccupied): 68° F / 60° F
Occupancy Schedule: Monday – Friday 0800-2000, Saturday 0900-1300, Sunday n/a
Number Of Occupants During Occupancy: 15-20
Number Of Heating Zones: CORAYVAC® - 2 / Unit Heaters – N/A
Warehouse Dimensions: 500'x200'x28'
Climate Zone: 5A (Pittsburgh, PA)
Building Insulation: Walls R-20 / Roof R-20
Floor: Concrete
Lighting: 0.66w/sq. ft.
Building Infiltration: 0.3 AC/hr
Office AC EER / IEER: 11.2 / 11.4
Notes: 5 dock doors. Door opening frequency factored into building infiltration.



Gas-Fired Unit Heater Equipment & MUA System:

Unit Type: Separated Combustion,
single stage
Quantity Of Units: 16
CFM (per unit): 3,200
Btu/h (per unit): 250,000
Fan pressure Rise: 15 in. w.c.
Fan + Motor Efficiency: 42%
Unit Efficiency: 80%
MUA Unit: 6,000 CFM / 100% OA / Non-tempered
(For ASHRAE 62.1 compliance)



CORAYVAC® Equipment & MUA System:

Burners: CRV-B10
Quantity Of Burners: 24
Quantity Of Systems: 4
Btu/h (per burner): 100,000
Vacuum Pump Size: EP-203 (Qty 4)
Controls: Qty 2 – CORAYVAC® Modulating Heating Control
DOAS Unit: 6,000 CFM / 100% OA / Non-tempered
(For ASHRAE 62.1 compliance)

Heating System Comparison Summary - Annual		
	Unit Heaters	CORAYVAC®
	Energy (kWH)	Energy (kWH)
Heating	902,659	384,443
Office Cooling	3,899	3,899
Interior Lighting	142,773	142,773
Interior Equipment	21,986	21,986
MUA and Office Rooftop	33,193	33,193
Hot Water Distribution Pumps	1	1
Water Systems	2,514	2,514
Net Total	1,107,025	588,809
CORAYVAC® Energy Savings	46.81%	

Annual Energy Costs*		
	Unit Heaters	CORAYVAC®
Electricity Cost	$19,291	$19,108
Natural Gas Cost	$23,448	$10,196
Total Energy Cost	$42,739	$29,304
CORAYVAC® Annual Energy Savings	$13,435	
CORAYVAC® Annual energy Saving Percentage	31.43%	

*Based on estimated costs: $.06 - kWh / $10 -kW for electricity / $7.50 per million BTU for gas - (USD)

CORAYVAC® provides and will continue to provide unmatched energy efficient comfort and energy savings for years to come!

While this document is believed to contain correct information, it is important to note that no energy assessment, regardless of software, can be expected to precisely duplicate conditions that will occur in an actual building. Of the available energy modeling software, EnergyPlus™ is clearly the leader in modeling capability. The information in this document was prepared by recognized EnergyPlus™ expert users and are confident that we can represent the energy characteristics of each building very well.

Energy models are not intended or expected to match exactly with actual energy use for succeeding years (past the initial assessment year) unless they are updated regularly. They ARE expected to provide a reasonable basis from which to judge overall patterns and enable comparison of design options. Building aspects that change and affect modeling results include:

- **Patterns of occupancy and lighting**
- **Equipment, including office PCs and copiers, may change and operating patterns may also change.**
- **Weather patterns vary from year to year. Our energy models use the actual weather that occurs during a specific billing period. Succeeding years will differ.**
- **Equipment efficiencies, control sequences and controls calibration vary over time.**

We've taken exceptional steps to represent the performance of these heating systems fairly. Building results may vary. Nonetheless, we think you'll find that our comparison is useful. Let's talk!

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