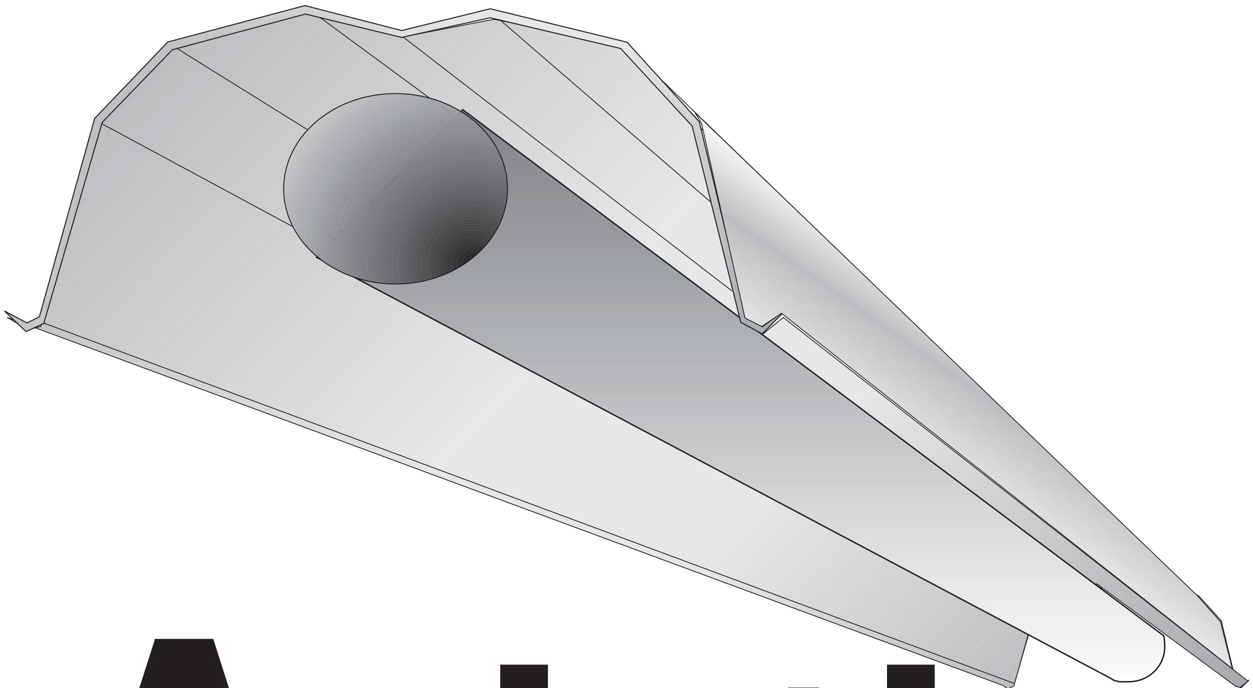

Aviation

Facilities Heating

An in-depth guide to using infrared heat in aviation facilities

ROBERTS GORDON

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www.rg-inc.com

Aviation
Facilities Heating

Introduction

Ever since the Wright Brothers' Maiden flight, there has been a need for buildings large enough to house and protect aircraft from the elements. Ever since the first hangar was built there has been a need for a reliable heating system.

In the space of 75 short years, the aviation industry has grown to the staggering number of over 2 billion passengers per year, with some of the worlds busiest airports handling over 1,000 flights a day. The number of passengers is estimated to increase by over 50% by the millennium.

To handle this increasing load, the airline industry must make some drastic changes.

It is becoming almost impossible to add more flights to the world's ever so crowded airways. Therefore, the only choice left to the airline industry is to increase the size of the aircraft. By increasing the size of the aircraft, new larger hangars must be built and strategically located. With new and larger hangars, the airline industry can then perform scheduled inspections and maintenance quickly and efficiently, in order for the aircraft to get back into the revenue producing service.

Increased passenger loading and larger aircraft bring about other changes to the airline industry. Runways will have to be straightened and lengthened. Many of today's airports are land locked, so that the only alternative for expansion is to move further out from the city limits. This move creates additional expenditures such as the need for new roads, parking ramps and the relocation of airline and airport employees to new housing neighborhoods.

As the aviation industry grows, new and larger aviation facilities are essential to its operation. With each new larger facility, the state of the art heating systems will also be required.

Just as significant advances have been made in the airline industry, significant advances have also been made in the space and heating industry. no longer can consulting engineers, architects, building designers and owners depend on the conventional heating system of old. Experienced and valuable aircraft technicians, expect and demand comfortable working conditions. Wider, higher and longer aircraft, need wider, higher and longer hangars with doors that essentially cover an entire wall. Coupled with these needs, is the fact that building and ventilation codes have become more stringent and have had larger impact on the environment.

Roberts-Gordon has kept abreast of these changes and remains a leader in the commercial space heating field. Working with consulting engineers, architects, building designers and owners through the years, we have economically and comfortably heated every size of aircraft hangar and other aviation facilities. At the end of this manual, you will find a list of over 800 airport and military facilities heated with our gas-fired, low intensity infrared heating systems.

Once a building has been designed and the heating system selected, the die is cast for many years to come. First cost is of importance to the owner, but lower first cost is soon forgotten if and when the heating system does not perform properly to produce adequate comforts or turns out to be very costly to operate.

This manual has been compiled to assist consulting engineers, architects, building designers and owners in sizing, designing and specifying the proper heating system for every type of aviation facility.

All of us at Roberts-Gordon are dedicated to helping you succeed in your endeavors. If we can be of any assistance or if we can answer any questions about low intensity infrared heating, please do not hesitate to give us a call.

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All claims related to gas-fired, low-intensity heating are predicated on the equipment being designed, installed, maintained and serviced properly by a qualified professional.

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Facilities Heating

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Aviation
Facilities Heating

General Advantages of CORAYVAC®

Safety

- No exposed flame
- 100% safety shut-off
- Zero pressure regulator
- Fully vented
- Outside combustion air option
- Low clearances to combustibles

Comfort

- Reduced heat stratification; more even heating throughout the building, including floors and equipment
- No blowing hot air spreading dirt, grit and dust throughout the hangar
- Small pumps result in low level operating noise
- Rapid heat recovery from opening of doors, etc.
- Warm floors means warm feet
- Warm tools means warm hands

Operation

- Fully prewired control panel box standard with each system
- Panel box compatible with all energy management systems
- Zone control by standard thermostat, sensor, night setback, 7 day timer, etc.; virtually all types of controls are compatible
- Direct spark to burner ignition
- Minimal maintenance; filter change on each burner every one to three years

Miscellaneous Hangar Advantages

- Approved with dual spectrum fire detection systems
- A.G.A. certified for use in aircraft hangars
- Deluge proof; in case of deluge discharge, change filters and system will operate normally
- Meets codes for aircraft hangar use including: military, B.O.C.A., A.G.A., and N.F.P.A.
- No valuable floor space required; system is out of the way in the roof structure
- Most easily serviced with man lift or cherry picker; no catwalks required
- Substantial fuel savings
- Aid in de-icing of planes and rapid drying of water from hangar floor

CORAYVAC® vs, Other Heating Systems

Underfloor Radiant

- CORAYVAC® generally has lower initial cost
- CORAYVAC® generally has lower operating cost
- CORAYVAC® is easier to service; underground service can be difficult
- CORAYVAC® has night set-back ability, underground does not due to extensive heat recovery time

Boiler Hot Water or Steam

- CORAYVAC® generally has lower initial cost
- CORAYVAC® generally has lower operating cost
- CORAYVAC® does not create problems with air stratification
- CORAYVAC® has rapid recovery time unlike the extensive recovery time of boiler systems
- CORAYVAC® requires no floor space - boiler system very often require a room of their own

Warm Air, Gas Fired Heaters

- CORAYVAC® generally has lower operational cost
- CORAYVAC® does not create air stratification
- CORAYVAC® has tremendous ability to heat floors as well as objects
- CORAYVAC® takes up no floor space - large warm air floor mounted units can take up a considerate amount of space
- CORAYVAC® has quicker hear recovery

High Intensity Infrared

- CORAYVAC® is a completely unexposed system, unlike high intensity which has exposed flames reaching temperatures of 1800°F
- CORAYVAC® flame is completely vented, high intensity is unvented and therefore cannot compensate for products of combustion which may cause corrosive con densation problems
- CORAYVAC® has lower clearances to combustibles compared to high intensity
- CORAYVAC®, due to lower temperature, does not interfere with fire temperature systems
- CORAYVAC® has more even heat, high intensity has drastic hot and cold spots
- CORAYVAC® generally has lower maintenance costs

CORAYVAC® vs. Other Low Intensity Systems

- CORAYVAC® is more efficient than other low intensity systems
- CORAYVAC® has optimal reflector design to properly direct heat
- CORAYVAC® burner in series design in unmatched in the industry for even radiant patterns
- CORAYVAC® is able to handle condensate
- CORAYVAC® has lower exhaust temperature relative to other low intensity systems
- Burner in series design allows system to perform if one burner fails; end burner only systems shut down completely if end burner fails
- CORAYVAC® has a full 15 year warranty
- CORAYVAC® has heavy duty long lasting construction compared to other low intensity systems
- CORAYVAC® has proven successful in hangar heating and other airport applications for over 30 years

All claims related to gas-fired, low-intensity heating are predicated on the equipment being designed, installed, maintained and serviced properly by a qualified professional.

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ROBERTS GORDON®

CoRayVac®

High Efficiency, Condensing Infrared Heating

Featuring Modulating Burners and Advanced Controls

800.828.7450

www.corayvac.com

CORAYVAC® Helps Reduce Energy Bills and Improve Comfort

CORAYVAC® gas-fired, low-intensity, infrared heating systems help provide custom comfort, while facilitating reduced energy consumption up to 50% and more! CORAYVAC® is a continuous burners-in-series vacuum-operated system that can be designed to condense. This efficient operating mode, combined with the principles of infrared energy, can result in considerable energy savings and comfort, while helping to lower your building's carbon footprint and environmental impact.

With the innovation of CORAYVAC®, Roberts-Gordon pioneered energy efficient low-intensity, infrared heating. Today, CORAYVAC® continues to innovate green products by offering a fully modulating infrared heating system.

LESS HEAT STRATIFICATION

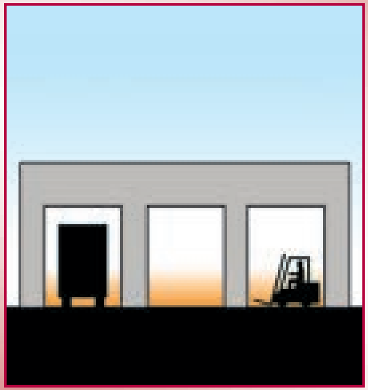
CORAYVAC® does not blow high temperature heated air that ends up rising to the ceiling. In fact, CORAYVAC® does not heat air. CORAYVAC® reflects and directs infrared energy toward the floor. The infrared energy is in the form of electromagnetic waves that can be directed and reflected like light. These waves travel through the air (not heating it) toward the floor until they strike solid objects. The objects are heated when they absorb the infrared energy. Floors, people and equipment below CORAYVAC® absorb and store heat, then re-radiate heat and warm the air by convection as air passes across the warm objects. Compared to other traditional heating systems, CORAYVAC® uses less energy to heat the area at occupant level. In addition, since there is no need for ceiling fans to push heat to the floor, electrical usage can be reduced.

REDUCED BUILDING HEAT LOSS

Because CORAYVAC® does not introduce high temperature air into the heated space, it generates less heat stratification. Air temperatures at the ceiling are lower than with other heating systems. Lower ceiling temperatures result in reduced heat loss through the roof and lowered building heat loss. Lowered building heat loss means less heat is needed to heat the same space.

FLOORS BECOME HEAT RESERVOIRS

The sun does not heat the earth's atmosphere directly; rather its infrared rays heat the earth, people and objects. CORAYVAC® uses less fuel than other heating systems because it heats a building and its occupants similar to how the sun heats the earth. With CORAYVAC®, floors and objects become massive secondary heat exchangers. These objects act as heat reservoirs, storing heat, then releasing it into the space by re-radiation and convection to raise space temperature at occupant level.

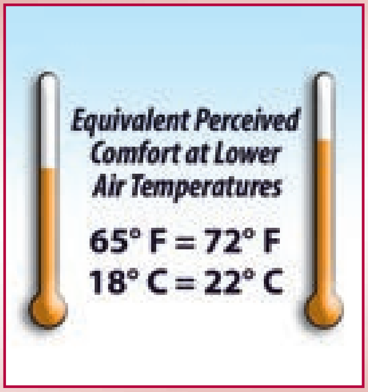


FREE ENERGY RECOVERY

In commercial and industrial buildings, rapid air changes and heat loss commonly occur when large doors are opened. As a result, valuable heated air escapes outdoors, wasting money. With air heating, more time and money is required for heat recovery because all the energy burned is used only to heat air, when the heated air is lost, no energy remains in the space. With CORAYVAC®, energy stored in floors and objects is re-used for faster energy recovery in the space, without burning more fuel.

GREATER COMFORT AT LOWER TEMPERATURES

To obtain fuel savings of up to 50% over conventional heating systems, it is essential to design an infrared system for maximum distribution and comfort. When designing systems for comfort, or reaching the operative temperature (T_0), designers need to maximize the mean radiant temperature (MRT) and depress the air temperature (T_{air}). For example, to reach a perceived comfort of 65° F (18° C), with infrared, the air temperature can be lowered to 55° F (12° C). This helps reduce energy costs!



Due to elevated mean radiant space temperature, building occupants feel the same amount of warmth when thermostats are set 5° to 10° F (-15° to -12° C) lower with CORAYVAC® than with other heating systems. Lower thermostat setpoint translates into additional energy savings.

CLEAN, QUIET, DRAFT-FREE HEAT

Since CORAYVAC® quietly warms objects without drafts or blowing air, heated areas are cleaner and quieter.

HIGH EFFICIENCY CONDENSING SYSTEM

CORAYVAC® is unique from other infrared heaters because it can be designed as a condensing system. Lowering exhaust temperatures puts more heat in the space and less wasted through the exhaust. This results in additional efficiency and fuel savings.

ENHANCED FUEL SAVINGS WITH MODULATION

CORAYVAC® modulating and building management controls package, called ULTRAVAC™, allow building owners to graduate to higher levels of comfort and energy efficiency. PC based centralized building management control and connectivity is provided in an easy-to-use Windows-based software package. These controls, coupled with proper burner modulation (continuous adjustment of fuel and combustion air), compound the energy saving benefits of CORAYVAC®. An economical CORAYVAC® modulating controls package is also available. CORAYVAC® helps provide a field-proven solution for today's green industrial and a variety of commercial buildings.

UNIFORM COMFORT

Continuous burners-in-series design with custom layout provides even heating and uniform comfort. CORAYVAC® systems are custom-engineered and designed to match the specific building plan and space requirements.

CORAYVAC® spreads a gentle blanket of low-intensity, infrared energy that directly warms people, floors and objects in a building. By more effectively delivering heat to the occupied area (floor level), CORAYVAC® offers many benefits that can result in improved conditions and greater fuel savings.

Proper design, installation, use and maintenance is necessary for optimum performance. This document is intended to assist licensed professionals in the exercise of their professional judgment.

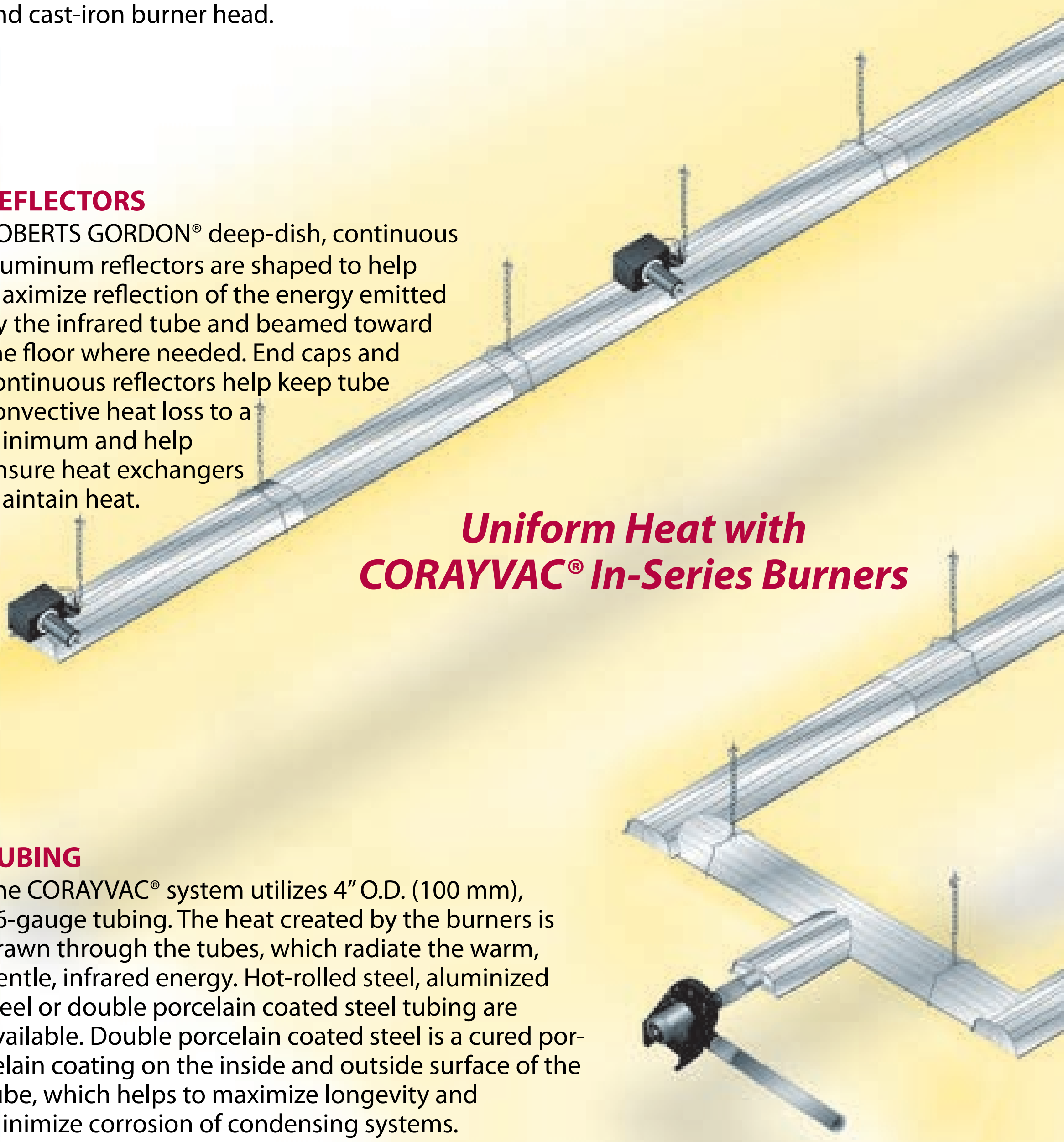
CORAYVAC® High Efficiency, Condensing Infrared System Features

BURNERS-IN-SERIES DESIGN

Located from 10 ft. - 70 ft. (3 m to 21.3 m) apart, CORAYVAC® burners constantly regulate the air-to-gas mixture to achieve the optimum ratio for clean, efficient combustion. Models are available with inputs of 20,000 through 120,000 Btu/h. Features include three-try direct spark ignition, pre-purge, filtered combustion air and cast-iron burner head.

REFLECTORS

ROBERTS GORDON® deep-dish, continuous aluminum reflectors are shaped to help maximize reflection of the energy emitted by the infrared tube and beamed toward the floor where needed. End caps and continuous reflectors help keep tube convective heat loss to a minimum and help ensure heat exchangers maintain heat.



Uniform Heat with CORAYVAC® In-Series Burners

TUBING

The CORAYVAC® system utilizes 4" O.D. (100 mm), 16-gauge tubing. The heat created by the burners is drawn through the tubes, which radiate the warm, gentle, infrared energy. Hot-rolled steel, aluminized steel or double porcelain coated steel tubing are available. Double porcelain coated steel is a cured porcelain coating on the inside and outside surface of the tube, which helps to maximize longevity and minimize corrosion of condensing systems.

VACUUM PUMPS

A vacuum pump draws the heat throughout the entire system. It exhausts products of combustion to the outdoors at temperatures typically below 150° F (66° C). 1/3-hp, 3/4-hp or 2-hp are available for various system sizes and layouts. Up to twelve heaters can be common vented with one vacuum pump. Design flexibility allows side wall venting, even in large buildings.

MODULATING BURNER CONTROLS

Designed for the energy conscious, ULTRAVAC™ Modulating Controls are Roberts-Gordon's energy saving control package. See the ULTRAVAC® pages of this brochure for details. Economical CORAYVAC® modulating controls package and basic controls are also available. See the accessories page of this brochure for details.

COUPLINGS

Heat exchanger tubing is connected together with couplings. Roberts-Gordon offers stainless steel couplings, lined couplings and damper couplings.

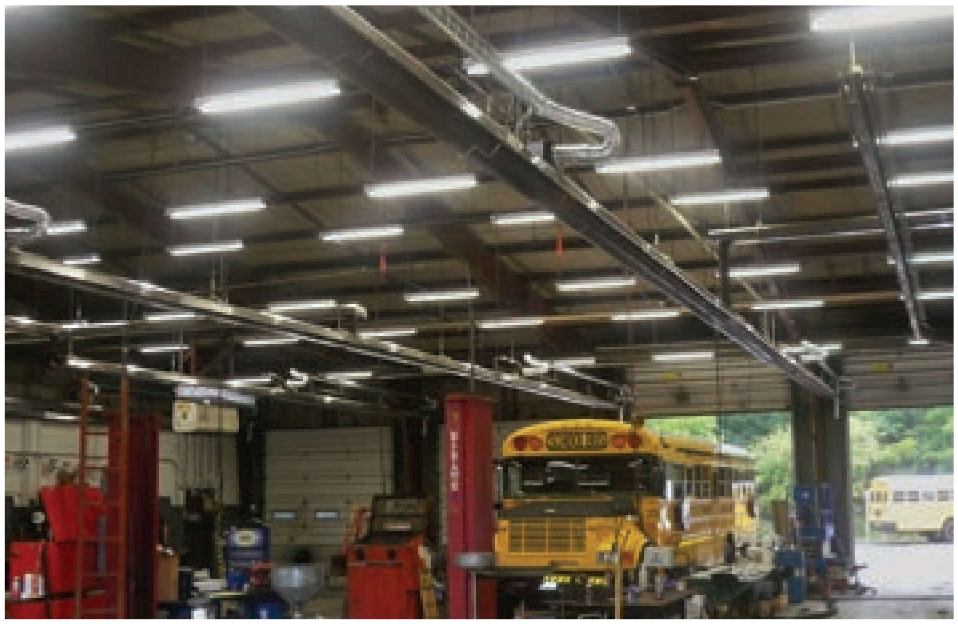
Condensing System - Designed to Condense for Optimum Fuel Saving Efficiency.

COMBUSTION CHAMBERS

Four types of combustion chambers are available for the CORAYVAC® system: cast-iron, hot rolled steel, aluminized steel and double porcelain coated steel. The heavy-duty, cast-iron combustion chamber can be fitted with schedule 40 pipe throughout the system. Double porcelain coated steel is a cured porcelain coating on the inside and outside surface of the chamber, helping to maximize longevity and minimize corrosion of condensing systems.

Warehouses / Distribution Centers

Sports Facilities



Vehicle Repair Shops

CoRa

For a Wide
Industrial and Com

CORAYVAC® can heat ar as well as provide sepa control for t

Machine Shops
Distribution Centers
Auto Dealerships
Vehicle Service Shops
Bus Garages
Fire Stations
Farm Buildings
Stores
Package/Parcel Hubs
Swimming Pools
Zoo

yVac®

e Range of
mmercial Buildings

n entire building evenly,
rate zone temperature
he building.

Metal Buildings
Loading Docks
Auto Body Shops
Truck Terminals
Parking Ramps
Sports Facilities
Workshops
Showrooms
Restaurants
Hockey Rinks
Animal Confinement Buildings

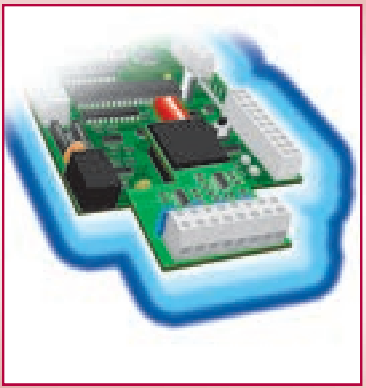
Aircraft Hangars

Manufacturing Plants

Equipment and Vehicle Storage Garages

UltraVac™

Obtain Even Greater Energy Savings with ULTRAVAC™ Controls!



Featuring fuel to air linkage technology, ULTRAVAC™ is a micro-processor based controls package designed to modulate CORAYVAC® systems. The controls provide proper modulation by varying system vacuum and adjusting gas and combustion air according to the indoor/outdoor temperatures and building heat loss. Matching system input to the building heat loss helps reduce heater cycling and temperature set point overshoot. ULTRAVAC™ helps increase the system efficiency and helps maximize fuel savings. The controls fully modulate burners between 60% and 100% of the burner's maximum rated input.

With the combined strengths of CORAYVAC® and ULTRAVAC™, buildings can be designed for comfort without the worry of high heating bills.

c UL US LISTED

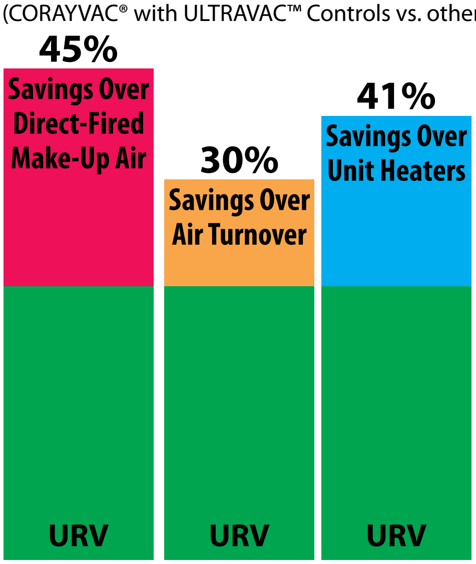
BURNER MODULATION FOR REDUCED FUEL AND ELECTRICAL USAGE

CORAYVAC® burners are equipped with a zero pressure regulator, which alters the amount of vacuum applied to the burner, thereby varying burner input. Altering vacuum also varies combustion air supplied to the burner. Since the fuel and air are changed proportionately, proper, efficient combustion can be achieved throughout the modulation range.

ULTRAVAC™ Controls utilize an energy saving programmable variable frequency drive (VFD) at the vacuum pump resulting in drastic electrical savings compared to a mechanical damper at the pump. The inefficient mechanical damper method of varying system vacuum, increases electrical consumption as the pressure drop across the damper increases.

FUEL SAVINGS*

(CORAYVAC® with ULTRAVAC™ Controls vs. others)

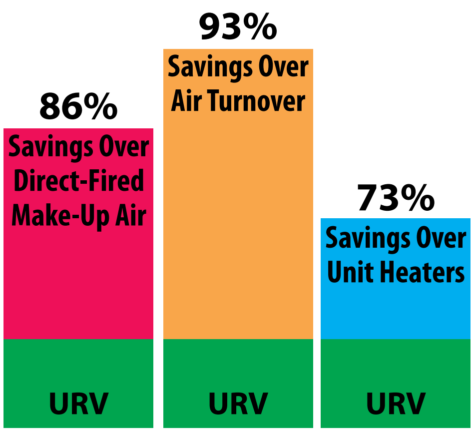


Seasonal Fuel Consumption

*Estimated savings, results may vary.

ELECTRICAL SAVINGS*

(CORAYVAC® with ULTRAVAC™ Controls vs. others)



Seasonal Electricity Consumption

*Estimated savings, results may vary.

CENTRALIZED BUILDING MANAGEMENT

ULTRAVAC™ provides networked and centralized building management from the convenience of your PC!

In addition to significant energy savings, ULTRAVAC™ controls are easy to use. Windows-based software provides simple point and click control and programming that is intuitive and easy to understand.

The software provides a graphical representation feature to show the entire building status at a glance. The controls continuously monitor system status and settings, allowing you to view indoor and outdoor temperatures or alter system settings or programming at any time.

CONNECTIVITY AND INTERFACE CONTROLS

Buildings today demand all sorts of control options based on the user's preference. ULTRAVAC™ controls offer a host of communication options for seamless integration with your controls network to best serve your individual needs:

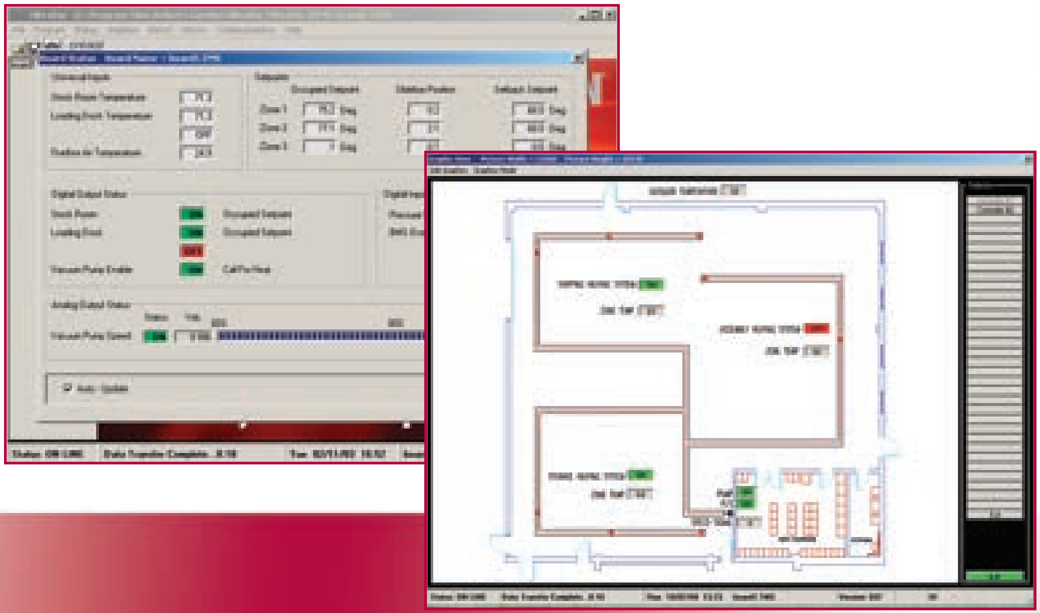
BACnet®

BACnet®: Interface ULTRAVAC™ with other building management control platforms with our BACnet® option.
TCP/IP (LAN): Connect to ULTRAVAC™ via your local area network of computers. Load ULTRAVAC™ software onto any computer on the network and control and view your heating system from your computer.
MODEM: Dial into ULTRAVAC™ from anywhere in the world via modem. Supplied as standard on all central controllers!
RS-485: Hard wire ULTRAVAC™ directly to your computer.

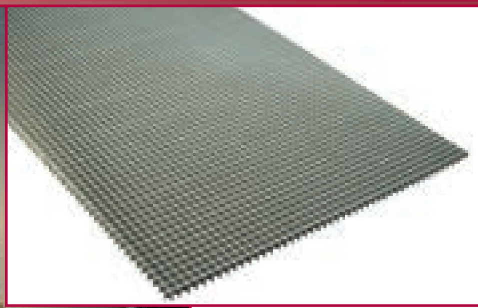
SECURITY AND TAMPER PROOF CONTROL

By networking controllers together, ULTRAVAC™ provides centralized control, helping to ensure security and tamper-proof management, as well as efficient operation of the CORAYVAC® heating system.

BACnet® is a registered trademark of ASHRAE. Roberts-Gordon LLC is not sponsored by or affiliated with ASHRAE.



CORAYVAC® High-Efficiency, Condensing Infrared Heating System Accessories

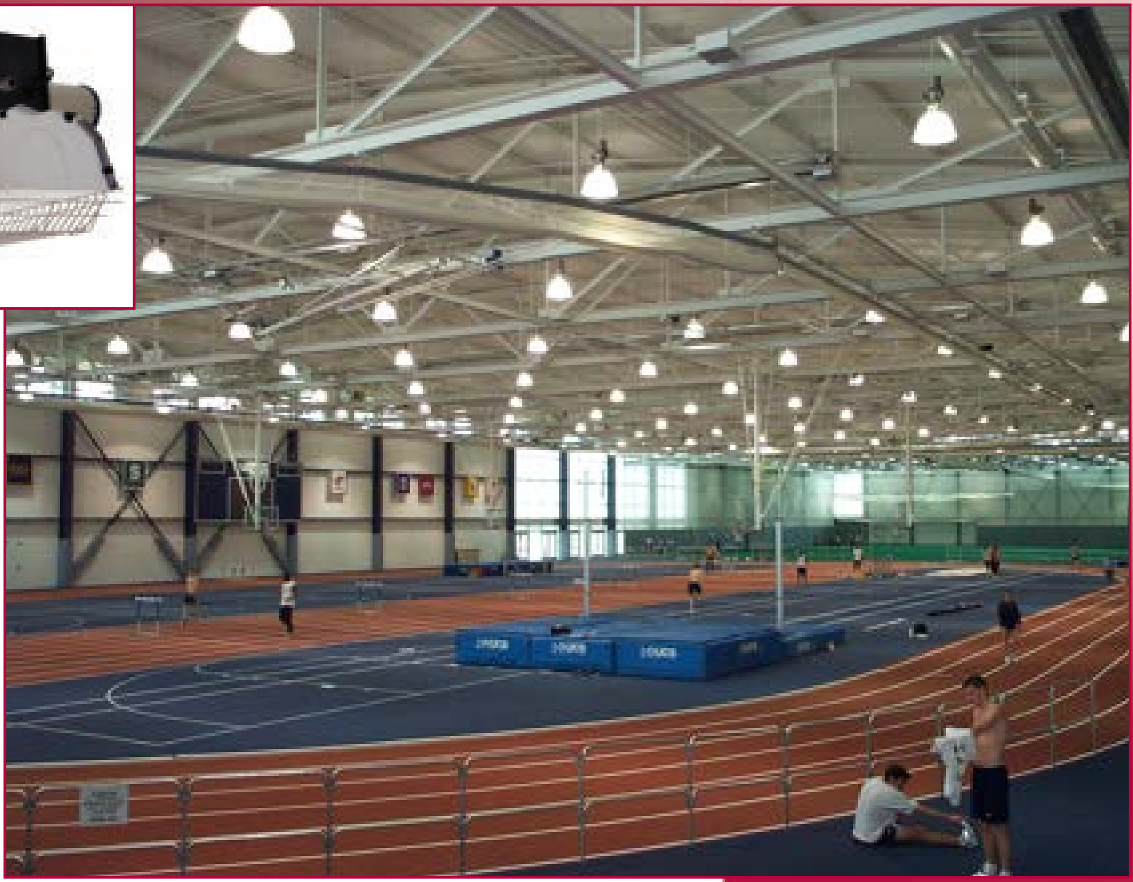


DECO GRILLE
Optional decorative two-foot grille for use with drop ceilings.

SIDE REFLECTOR
Optional side reflector extensions direct heat towards the floor and center of the building when CORAYVAC® is mounted near a wall.

PROTECTIVE GRILLE

Protective grilles conveniently attach to reflectors to cover the radiant tubing. This helps prevent items from coming in contact with the radiant tubes.



UNIVERSAL SHIELD

Universal shields are aluminum reflectors whose angle and height can be adjusted to direct heat to or away from a desired area. Universal shields are available with or without holes.

CONTROL OPTIONS

In addition to ULTRAVAC™, CORAYVAC® systems can also be controlled by CORAYVAC® modulating controls, a System Control or a relay. The System Control is an electronic control panel capable of controlling up to four zones of burners and two pumps.

Thank You for Your Business!

800.828.7450

www.corayvac.com

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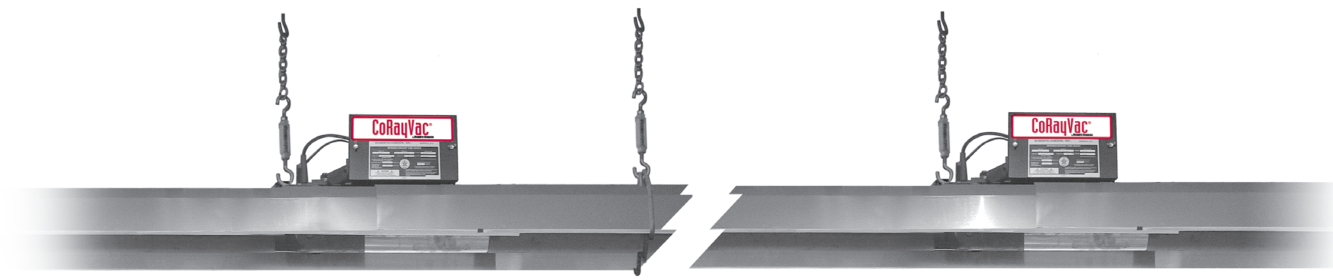
ROBERTS GORDON

CoRayVac®

Low-Intensity Continuous Infrared Heating System



- Variety of design options from custom engineered system
- Fuel savings and enhanced user comfort provided by burners-in-series design
- Excellent efficiency and ideal combustion from zero regulator incorporated in state of the art burner design
- Maximizes usable space with low clearances to combustibles
- Extra safety feature with zero regulator design
- Reduced building penetrations as a result of multiple burners per pump
- Environmentally friendly - meets stringent emission standards

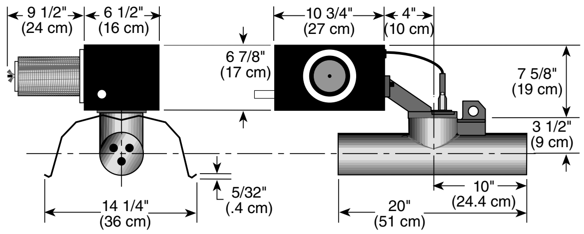
CUT ENERGY BILLS BY UP TO 50% WITH ROBERTS GORDON®
www.rg-inc.com

Quality in Any Language™

DESIGN CERTIFIED®

CERTIFIED®

ROBERTS GORDON

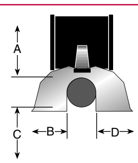


CORAYVAC®

Model		**B-2**	**B-4**	**B-6**	**B-8**	**B-9**	**B-10**	**B-12A**	**B-12**
Burners in a Branch*	max.	6	4	4	4	2	4	4	4
Radiant Tube Length Between Burners	[ft]								
	min.	10	12.5	20	20	25	30	35	35
	Recommended	15	20	25	30	30	40	50	50
	max.	20	25	35	45	50	60	70	70
Input (Btu/h) x (1000)		**20**	**40**	**60**	**80**	**90**	**100**	**110**	**120**
Inlet Pressure	[in wc] NG min.	4.5							
	LPG Propane min.	10.5							
	NG & LPG Propane max.	14							
Gas Connection	NPT	½"							
Fuel		NG or LPG Propane; B2 and B12A - NG Only; B12 - LPG Only							
Electrical Supply**		120 V, 60 Hz, 0.3 A (Connection Cord with Three-Prong Molded Plug)							
Burner Head		Cast Iron							
Combustion Chamber		16 Gauge Hot Rolled, Heat-Treated Aluminized, or Cast Iron							
Heat Exchanger Tubing	Radiant	4" dia, 16 Gauge Hot Rolled, Aluminized, Heat-Treated Aluminized, or 4" Schedule 40 Pipe							
	Tailpipe	4" or 6" dia, 16 Gauge Aluminized, Heat-Treated Aluminized							
Exhaust Flue	dia	4" or 6"							
Reflector and End Caps		.024 Aluminum [Optional - .024 Stainless Steel Type 304]							
Control System		Fully Automatic, Three-Try, 100% Shut-Off, Direct Spark Electronic Ignition Control							
Approved As		Indoor (Vented)							
Certification		ANSI Z83.20/CSA 2.34, 2.17							
Burner Weight	[lb]	19							
Warranty		Three-Year Limited (Refer to Installation, Operation and Service Manual for Details)							

*Pump type, system layout and environmental conditions may reduce maximum allowable burners in a branch. Refer to the CORAYVAC® Design Manual for complete design requirements or contact your ROBERTS GORDON® North American independent distributor for further assistance.
**Refer to Pump Spec Sheet for complete system electrical requirements.

Clearances to Combustibles ***[in]



Model		**B-2**	**B-4**	**B-6**	**B-8**	**B-9**	**B-10**	**B-12A**	**B-12**
Horizontal	A	4	4	4	4	4	4	4	4
	B	20	20	20	20	36	36	36	36
	C	48	48	48	48	60	60	60	60
	D	20	20	20	20	36	36	36	36

***Clearances B, C and D can be reduced by 50% for locations 25 ft (7 m) or more downstream of the burner. For other mounting options and associated clearances, complete installation, operation and service criteria, please see the current issue of the Installation, Operation and Service Manual.

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Further Information: Applications, engineering and detailed guidance on systems design, installation and equipment performance is available through ROBERTS GORDON® representatives. Please contact us for any further information you may require, including the Installation, Operation and Service Manual.

This product is not for residential use.

This document is intended to assist licensed professionals in the exercise of their professional judgement.

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Aviation

Facilities Heating

Case Histories

Radiant Heating System Mounted at 65 Feet Proves Itself During Record Cold Spell

Georgia isn't noted for winter snowfalls and extremely cold temperatures, but the week of March 7, 1993 was an exception.

Hurricane force winds coupled with record cold temperatures and blowing snow made weather conditions treacherous up and down the state. However, at Robins Air Force Base near Macon, Georgia, the innovative hangar heating system kept workers warm and comfortable even under these adverse weather conditions.

Three new 74 foot high hangars were built at "Robins" during the last year. A contingent consisting of a base civil engineer, several consulting engineers and i visited the hangars a few days after the storm. It was miserable outside. A cold wet rain soaked us as we ran from our van to the hangars. But when we stepped inside, it was like walking into Hawaiian sunshine.

The hangars were 372 feet wide. One was 200 feet long and the other, 400 feet long. A CoRayVac® gas-fired, low intensity infrared heating system was mounted at 65 feet above the finished floor. As we walked in the hangar, we could feel the radiant heat. There was no noise or drafty blowing air from the heating system, just silent, infrared heat warming all the object in the building.

CORAYVAC® heating systems are becoming more popular for economically heating high buildings. The infrared rays from their emitter tubes are directly downward. When they strike and object, the object gets warm and releases it's heat to the air. Air temperatures in infrared heated buildings are usually lower than when other types of heat are used. The phenomena is similar to standing outside on a spring day. The air might be 60 degrees, but you feel the warmth of the sun so you feel comfortable.

CORAYVAC® has another uniquely distinct feature. Because it is composed of smaller burners firing in series, as compared to systems with one big burner at one end of a long tube, CORAYVAC® provides uniform heat over the entire floor area of the hangar.

The overall results of the heating high buildings with CoRayVac® are numerous. CORAYVAC® costs much less to operate than many other heating systems. It produces quiet draft free heat, provides heat recovery when large doors are closed, and in most cases is cheaper to install than boilers with radiators or steam unit heaters.

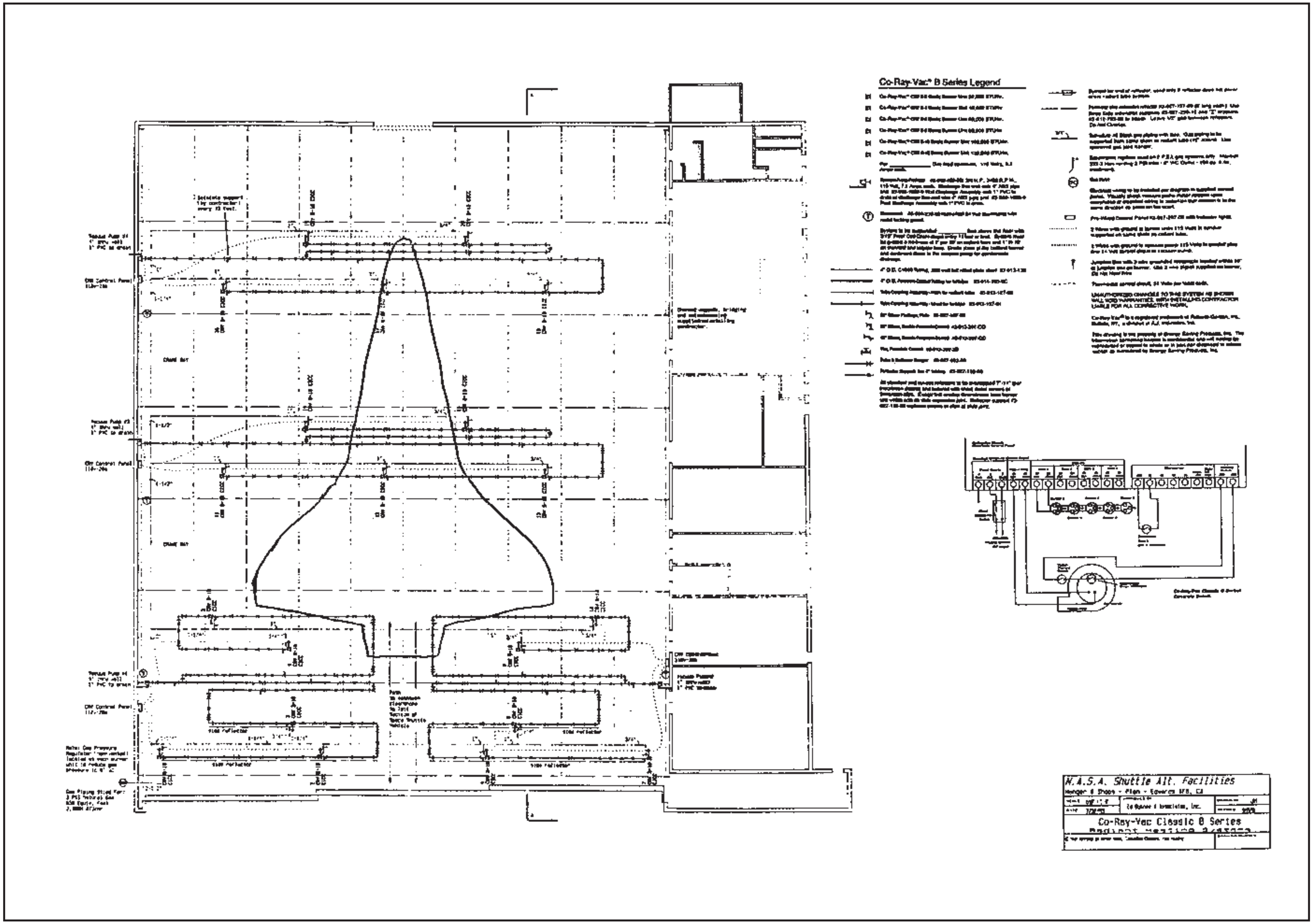
Attached are pictures showing the heating CORAYVAC® system mounted at 65 feet. It is above the overhead cranes. Pictures tell a lot, but they cannot describe the ideal comfort in these hangars. Perhaps it was best described by the building supervisor who told us, "I've been working at this base for over 13 years and this is the most comfortable building I've worked in."

John G. Berkhoudt, V.P.
National/International Accounts
Roberts Gordon, Inc.

CORAYVAC® Mounted at 65 feet
Robins Air Force Base

"I've worked on this base for 13 years and this is the most comfortable building I have worked in."

- Hangar Superintendent, after a record cold spell


Co-Ray-Vac® B Series Legend
N.A.S.A. Shuttle Alt. Facilities
Hanger & Shops - Plan - Edwards AFB, CA
Co-Ray-Vac Classic B Series

Chosen for safety and economy of operation, a CORYAVAC® system with eighteen cast iron “Classic” burners heats the NASA shuttle hangar at Edwards Air Force Base. Even in high bay buildings the fast warm up provides chill chasing warmth during cold nights and early mornings.

“It’s so quiet you don’t know it’s there.” That’s what visitors to the Canadian Warmplane Heritage Museum, near the Hamilton, Ontario, Canada are saying about the gas fired, low intensity infrared system.

Mounted high above the girders, enhanced with aluminium decorative grille, the system provides safe, quiet, draft free comfort in this beautiful new aviation museum.

CORAYVAC® Warms Desert Storm Troops Home to Niagara Falls

“It’s great to be home.” was heard over and over again as our men and women of the 914th Tactical Aircraft Group, Niagara Falls, NY embrace relatives, friends and souses, or lifted sons and daughters to their shoulders. Grown men cried, a lot of them.

And a high above, in silent witness hung our CORAYVAC® system, providing warmth to this memorable occasion.

This Air Force Reserve Hangar was originally heated with a combination system consisting of a “Hydronic Radiant Floor System” and hanging steam unit heaters. Users report that every year they had to purge the in floor heating system to start it up. The biggest problem was eliminating the air pockets in the tubes which were caused by oxygen diffusion. This can eventually lead to oxidation of boiler and tube components, resulting in premature systems failure. No matter how good the operating engineers were, they could never get rid of the oxygen diffusion problem. This fact, coupled with leaky tube problems, led to a decision to replace the floor heating system with CORAYVAC®.

Their steam unit heaters are still hanging, but since the CORAYVAC® heating system was installed they have nor been turned on. The CORAYVAC® provides all the heat needed. One of the most impressive changes was the fast heat recovery. Now, with CORAYVAC®, the hangar and planes warm up fast when brought in from the cold outdoors.

The Air Force Reservists tell the story about one night when it was 25°F outside, they brought in a cold KC130 aircraft covered with 3” of snow. In less than one hour the plane was de-iced, de-snowed and dry under the CORAYVAC®.

With in floor radiant heat the mechanics and technicians working on the floor complained that their backs were too warm while the front of their bodies were too cold. With the CORAYVAC® heating system they wear less clothing and are always comfortable.

CORAYVAC® Heats U.S. Thunderbirds

During the Air Show several years ago the US Air Force Precision Thunderbird flying team housed their aircraft in the Niagara Falls Air Force Reserve Hangar.

Notice the fresh air systems supplying each CORAYVAC® burner with fresh outside air for combustion. In this case, 4” diameter Schedule 20 ABS plastic tube was used for the air supply line. The fresh air system is pressurized with a special CORAYVAC® supplied blower. This way, if a leak does occur in the supply line, fresh air will be blown into the building instead of inside contaminated air being drawn into the burners. Outside air for combustion is commonly used in areas where the inside air might be contaminated with chemical or airborne particles.

It may be well to remind the readers that CORAYVAC® is not classified as explosion proof. If explosion proof equipment is required, CORAYVAC® cannot be used. In this case you can see the lights are not explosion proof, which is a good indication that CORAYVAC® can be used.

CORYAVAC® Heats Refueling Tanker Back From Desert Storm

The symbols painted on the side show how many successful missions the refuelling tanker made during the Desert Storm offensive. Men of the Pennsylvania Air national Guard are extremely proud of their contribution to this war effort.

They are also proud of their CORAYVAC® gas-fired, low intensity infrared heating system. Since this system was installed in 1985 there have been zero maintenance problems.

Consistent with US Air Force regulations for hazardous areas the CORAYVAC® system is equipped with an outside air supply system.

The safe, quiet, draft free CORAYVAC® heating system keeps planes, mechanics and technicians warm and comfortable even during cold Pittsburgh winters.

Air Frame and Jet Modification and Maintenance Center, Travis AFB, CA

As with many hangars of this type, overhead cranes are in constant use. Because a CORAYVAC® heating system consists of many burners firing in a series it creates an even pattern of radiant heat. This allowed the system to be installed around the perimeter of the building keeping the entire inside area warm.

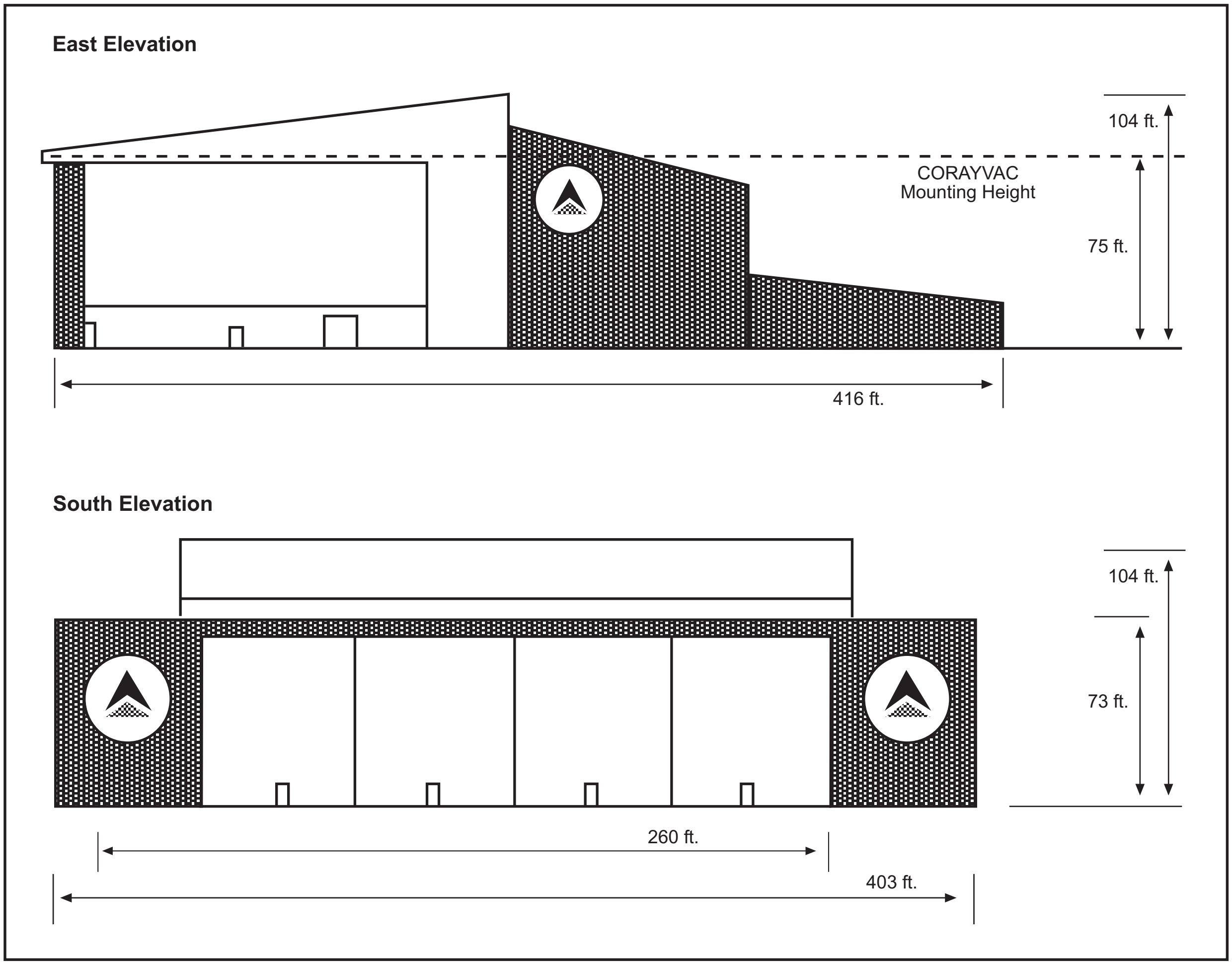
According to U.S. weather data, last winter was the coldest on record for Travis Air Force Base, getting down to 19° F. Even at those low temperatures the Base Engineer, Mechanics and Technicians reported short shirt sleeve comfort anywhere in the CORAYVAC® heated buildings.

USAF Corrosion Control Hangar, Mather AFB, Sacramento, CA

Old reliable B-52's are still doing a bang up job for the U.S. Air Force.

The CORAYVAC® installed in this corrosion control paint hangar is electronically controlled so that it is turned off when the painting and exhaust systems are turned on.

By pre-warming the aircraft, the paint flows onto the surface more evenly and has better adhesion.



Delta Airlines - Salt Lake City

The above drawings and following photographs show Delta Airlines' CORAYVAC® heated hangar facility in Salt Lake City, Utah. This building consists of a hangar, machine shop and a "cabin service area" where they store soft drinks and snacks for passengers.

The hangar portion is 287 ft. wide x 175 ft. deep with a roof that slopes from 104 ft. down to 83 ft. This area is heated with 52 model CORAYVAC® B12 burners each firing at 120,000 BTU/hr. for a total input of 6,240,000 BTU/hr.

To satisfy local code requirements, three 1,134,000 BTU warm air heaters were mounted near the ceiling. Their thermostats are set lower than the CORAYVAC® thermostat so they are only used if severe cold weather conditions occur and the large door is open for a long time.

The CORAYVAC® systems slope towards their vacuum pumps and are mounted 75 to 78 ft. above floor level. Even at t his mounting height the workers can feel the warm gentle heating rays at floor level. Because CORAYVAC® systems heat objects, the floor, planes and tools there is less wasted heat stratification near the ceiling.

The low intensity infrared heat rays also melt snow and ice off planes in a hurry.

Another extra benefit has been mentioned, and that is the fact that CORAYVAC® is quiet. Some hangar workers say that the large warm air heaters with large fans are very noisy and fatiguing. They appreciate the silent, draft-free warmth of the CORAYVAC® system.


DELTA

Northwest Airlines, Memphis, TN

This is another example of one of over 800 hangars heated with CORAYVAC® in North America.

Pilots, mechanics, airplane owners and airport managers familiar with CORAYVAC® consistently recommend it to others.

CORAYVAC® has earned a fine reputation for providing low cost comfort while operating for many years with no maintenance problems.

Baggage Train Facility,
Memphis/Shelby County Airport, TN

“Some baggage handlers have it made,” is what some visitors say when they tour Northwest Airlines baggage train unloading round table at the new Memphis/Shelby County Airport in Memphis, Tennessee.

On cold winter nights its nice come in under “synthetic sunshine” report the tractor drivers. “We are not sure how many more miles our passengers can get out of their luggage, but we know it helps to use CORAYVAC® warmed and dries carts.”

As you can see, the CORAYVAC® system was nestled up between the beams. Besides warming the baggage trains and drivers, it also helps to keep the ice and slush melted off the floor. Because many burners can be connected to one CORAYVAC® vacuum pump, very few exhaust openings needed to be made in the walls.

Weyerhauser Corporate Hangar, Seattle, WA

One glance and you know the Weyerhauser Corporation cares about their operation costs. Smooth, shiny oil proof floors, sky lights in the roof plus translucent panels high in the side walls provide free daytime lighting. A high efficiency CORAYVAC® heating system mounted in the ceiling provides low cost heat.

Due to CORAYVAC'S continuous deep reflector design, it is A.G.A. design certified, for mounting as close as 4" below combustible materials such as wood structural beams.

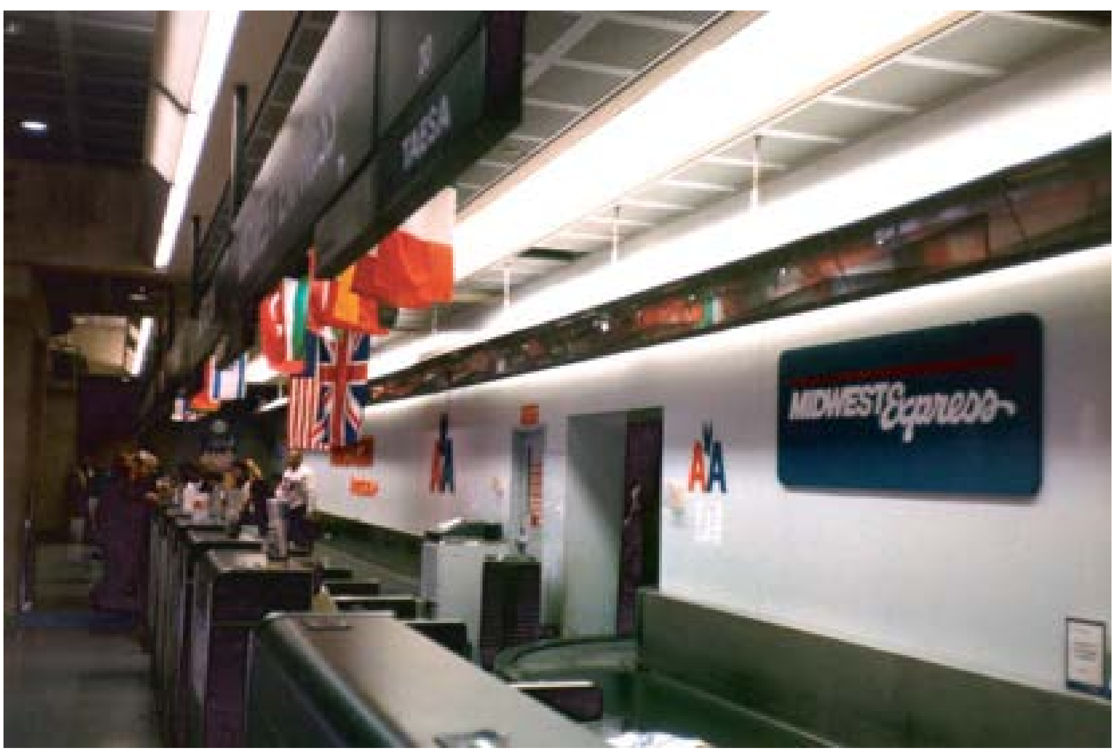
Heating system designers appreciate the fact that CORAYVAC® systems consist of several small input burners firing in a series resulting in more uniform heat distribution. This also reduces the "clearances to combustibles" below the system allowing high aircraft vertical and horizontal stabilizers to be "paint safe" under lower, properly designed heating systems.

MBB Helicopter Assembly Plant

Walk through this MBB Helicopter Assembly Plant and you will be impressed with its clean, efficient operation. Top grade technicians assemble these beautiful “Chopper” using the most precise tools and sensitive gauges. Stringent quality controls insure fail-safe operation.

MBB Helicopters use CORAYVAC® because they cannot afford to have dust interfere with assembly and testing. Traditional heating systems with air blowers spread dust and grit, and are much noisier than CORAYVAC®. CORAYVAC® allows MBB Helicopters to maintain “hospital clean” conditions throughout their facilities in both the U.S. and Canada.

CORAYVAC® Heats Philadelphia Airport Terminal "A" Ticketing Area



ECONOVAC® Heats American Airlines Hangar at LaGuardia Airport, NYC

Federal Express, Salt Lake City, UT

Besides heating Federal Express major Hub Facilities CORAYVAC® also heats many “City Stations” like this one.

In most cases engineers first calculate the heat loss of the building and then specify the quantity of heat needed to adequately match the heat loss. However, in this case the CORAYVAC® system was designed to heat only the area around the sorting belt. This kept installation and operating costs to a minimum.

Besides the sorting are CORAYVAC® is used in the truck service are of Federal Express “City Stations” where the system is designed to match the heat loss. Here again mechanics who previously worked elsewhere under other types of heat report they are more comfortable under CORAYVAC®.

Snow Melting, Parking Ramp, Denver, CO

With new larger terminals handling 20 to 30 million passengers per year, the cost of land escalating up beyond reason , and airports being located further beyond city limits, it becomes increasingly important to consider building multistory parking ramps.

In cold areas, ice on parking ramp inclines can be problem. This photograph shows how a parking ramp in downtown Denver solved their problem with Roberts-Gordon radiant heat.

Airport Runway Maintenance Vehicle Garage, O’Hare Airport

Chicago’s O’Hare Airport is one of the busiest airports in the world, handling over 1,000 flights a day. If and when it shuts down, it affects the entire national and international air transportation system.

O’Hare Airport is also located in a cold climate zone where winters are known to be severe. Runway maintenance equipment must be “able to roll” at a moments notice anytime, day or night, weekdays and weekends. That is why the CORAYVAC® heating system was selected.

Mounted at ceiling height, where no floor space is required, CORAYVAC beams its gentle heat down to warm the floor, snow removal equipment and mechanics. When a plow is out of service, it must be repaired immediately. The CORAYVAC® melts ice and snow off the truck in short order. Shirt Sleeve comfortable mechanics are then able to quickly determine the cause of the problem and fix the vehicle.

One other consideration in this facility was the fact that cold ice packed sand in roadway sanding trucks does not always flow smoothly through the sand dispersal mechanism. This results in uneven coverage of the roadways. Under CORAYVAC®, the sand stored in the trucks is warm and fluid.

In the garage shown above, CORAYVAC® input is calculated at 80% of the building heatloss and is the primary heating system. The make up air system is on a time clock which operates when people are in the building. Make up air input is calculated to meet code requirements of 2 CFM per square foot. The result of the CORAYVAC® system are clear:

- Snow melts off vehicles fast.
- Floors are warm.
- Fast heat recovery after trucks come in and doors are closed.
- No maintenance.

Ground Support Vehicle Service Building, Pittsburgh, PA

CORAYVAC® maintains quiet warmth in garages housing expensive de-icing and freight handling equipment. The even radiant heat keeps floors and vehicles warm and dry.

Mechanics report the quiet, draft free comfort produced by CORAYVAC® is far superior to any other type of heating systems they have worked under.

Airport Fire/Rescue Station, Seattle WA

Airport Emergency vehicles must be able to respond immediately when needed. Saving minutes means saving lives. That's one reason why hundreds of emergency vehicle stations are heated with CORAYVAC®. The radiant heat keeps diesel and gasoline engines warm and allows them to start quickly. Water and foaming agents in the tanks stay at consistent ready-to-use warm temperatures. When ice covered vehicles return to the station, the CORAYVAC® heat melts ice and snow quickly making the vehicles "emergency ready" in a very short time.

Entrances to stores, passengers terminals and customer pick-up area’s can be ideally heated with our gas fired, low intensity infrared heating system mounted over decorative aluminium grille in drop ceillings.

Besides providing incoming people with a feeling of warmth, the radiant heat beams down to warm and dry the floors during inclement weather.

Aviation

Facilities Heating

Basics of Infrared Heating

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Aviation

Facilities Heating

Basics of infrared Heating

What is infrared?

Infrared is the transmission of energy by means of electro magnetic waves (rays). When rays strike an object, they stimulate the molecules within the object, causing them to move rapidly and to generate heat. Infrared rays are invisible and travel at the speed of light in straight lines from the heat source to all surfaces and objects without heating the space (air), through which they pass. energy in the rays is safely absorbed by cool surfaces (floors, equipment, people), and conduction carries some of the heat deeper into surfaces, creating a reservoir of heat. The balance of the radiant energy is reflected from the heated surfaces to be absorbed by other cooler surfaces. The temperature of the air is raised by convection from heated surfaces.

Infrared heating equipment is mostly available today in two forms:

1. High Intensity Equipment
2. Low Intensity Equipment

High intensity equipment, identified by an open flame and high temperature (1800 °F) ceramic surface, is what many engineers associate with the term “infrared heat.” This type of equipment is mor suitable to a localized heating or “spot” heating application and represents only a small portion of the infrared heating equipment available to the heating system designer.

Low intensity equipment, identified by a flame contained within a tube or network of tubes at a reduced temperature (maximum 900°F - 1000°F), is now recognized as being an efficient means of heating an entire space. Heating a continuous span rather than a series of intermittent spots provides a level of comfort surpassed only by the sun.

Electromagnetic Spectrum

The Electromagnetic spectrum differentiates all known types of electromagnetic wave energy vis their wavelength as measured in microns. The shortest wavelength energy (1×10^{-8} microns) known as the cosmic ray, while the longest wavelength energy (5×10^{8} microns) known is the broadcast radio wave.

Visible light falls between these two extremes, having wavelengths between 0.4 and 0.7 microns. Infrared energy waves are slightly longer than visible light, having wavelengths from 0.7 to 400 microns. However, the majority of heat producing radiant energy falls within a much narrower wavelength range of 2 to 12 microns. It is important to consider the heat energy wavelength for the following reasons:

a.) The wavelength is directly related to the emitter source temperature, with higher temperature sources generally producing a majority of the energy at shorter wavelengths.

b.) The energy transfer to the solid body receiver can be affected by wavelength. Many materials more completely utilize energy provided at longer wavelengths (for example: concrete, water.)

The *Electromagnetic Spectrum* picture illustrates the electro magnetic spectrum as it is known today.

The *Infrared Spectrum* picture illustrates the infrared spectrum relative to common types of infra-red heating equipment available today.

Unity of Infrared

Nearly all manufacturers, designers, and users of radiant heating equipment agree that radiant heating can accomplish the same space heating job with less energy input than a convective heating system.

To better understand these results, it is necessary to review the manner in which radiant heating and convective heating appliances warm a space.

Convective Heating

Convective heating systems such as unit heaters or central furnaces deliver heat by first heating air to higher than comfortable temperatures. This hot air is then delivered to the space, either directly or through ducts, where it is then mixed with colder air. The warmer space air is supposed to heat occupants and objects by direct contact.

While appropriate for small spaces such as offices and residential units, convective heating has many disadvantages in large-space applications:

- Hot air tends to rise in a space. When ceiling heights are higher than normal, much of the warm air rises to the ceiling where it is not needed. This is called *stratification.*
- Some of the hot air is lost immediately through exfiltration before it has a chance to mix with colder air.
- Open doors, windows, etc., can drain a space of warm air within a matter of seconds. Heat recovery time can be very slow because the air must be heated over again.
- Convective air requires large amounts of air movement to work properly. This excess circulation is not only noisy, it helps spread dirt, grit, dust, pollen, and airborne bacteria and fungi.

Radiant Heating

Infrared energy from a radiant appliance heats objects, people and surfaces, not the air. The warm objects and floor convert this energy to heat which:

- Is absorbed into the objects and the floor, creating a heat reservoir.
- Warms the air near the objects and floor via convection.
- Is reradiated to occupants and other surfaces of the spaces.

The radiant energy received by the occupants, directly from the heater or indirectly from the heater via reradiation by the floor and objects, serves to increase the mean radiant temperature (MRT) of the occupant. In a manner similar to direct sunlight, the increased MRT allow the occupant to perceive a comfort condition at a much reduced air temperature (sometimes as much as 7° - 10°F lower.) The resulting reduced air temperature within the space provides the following advantages:

- Reduced stratification of air within the space.
- Reduced actual transmission heat loss due to lower temperature inside than assumed design condition, as well as substantially lower ceiling and upper sidewall temperature due to reduced stratification. (25° - 30°F lower is not unusual.)
- Reduced air change heat loss, to the extent that exfiltration through cracks or openings, near the roof, will be decreased due to decreased stack effect.
- Decrease the actual degree days experienced.

Each of the above advantages impacts favorably on fuel usage.

Methodology of Radiant Heating Appliances

All radiant heating appliances are not the same. Various material properties and performance criteria can be used to evaluate a radiant heating appliance relative to its major function, namely:

- Provide usable radiant energy to the space in sufficient quantity to provide comfort for the occupants.

Figure 1 is a visual representation of the factors that effect the performance of a radiant appliance. These few factors are reviewed briefly below.

Natural gas or L.P. fuel contains an inherent chemical heating value (approximately 100 BTU/cubic foot for natural gas and 2500 BTU/cubic foot for L.P. gas.) Of this total heating value available, only a percentage is available to the radiant heating appliance, the remainder being stack loss.

This percentage is known as thermal efficiency and is described as follows:

Thermal Efficiency = Total Input Energy - Stack Loss

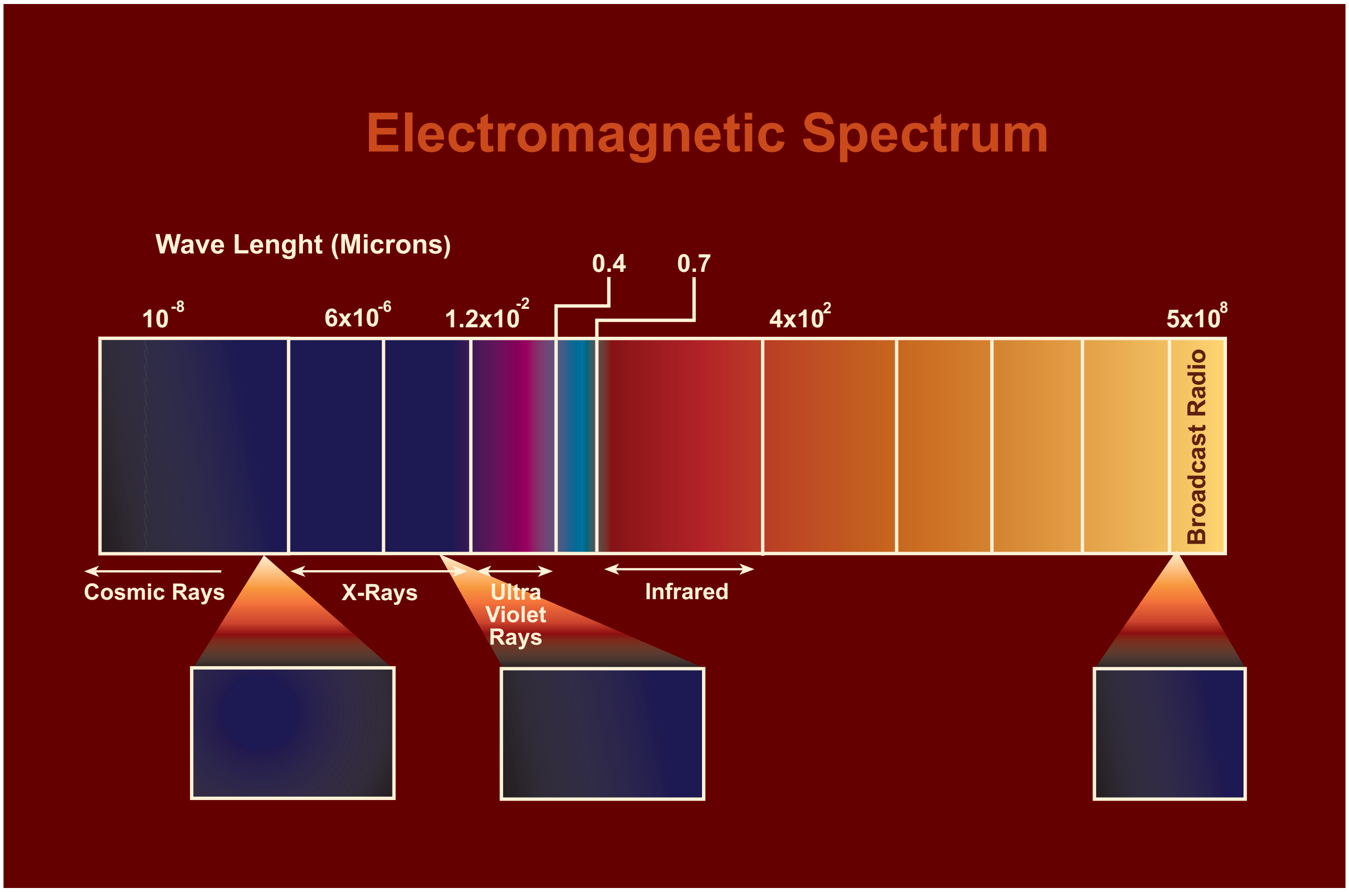
The tube is heated by the available energy from the fuel gas. A tube material property, called emissivity, helps determine the amount of energy that leaves the tube as radiant energy. The heat energy of the tube is dissipated by one of the following mechanisms:

1.) A portion of the energy is released as radiant energy directly to the space.
2.) A portion of the energy is released as radiant energy and is reflected by the fixture to the space.
3.) A portion of the energy from the tube is convected to the space.
4.) A portion of the energy is released tot he fixture and “bound back” into the tube.

The fixture efficiency is a measurement of the ability of the heating appliance to release radiant energy to the space. Note that the relationship of items 1 through 4 above can greatly influence the fixture efficiency. Equally influential to the fixture efficiency is the reflector material and the reflector shape. The property of the reflector material, known as reflectivity, and overall configuration of the reflector determine the amount of usable radiant energy delivered to the space.

The pattern efficiency of a radiant heating appliance is a measurement of the ability of a radiant heating fixture to deliver energy into a usable, specific distribution pattern in the space. it is this distribution pattern, together with a material property of people or objects in the space known as absorptivity, that determines how much of the radiant energy released by the heating appliance is utilized by the space to provide comfort to the occupants.

For comparison purposes, Figure 2 provides a visual representation of the methodology for a conventional air heating appliance.


Electromagnetic Spectrum
Wave Lenght (Microns)
0.4
0.7
10-8
6x10-6
1.2x10-2
4x102
5x108
Broadcast Radio
Cosmic Rays
X-Rays
Ultra Violet Rays
Infrared

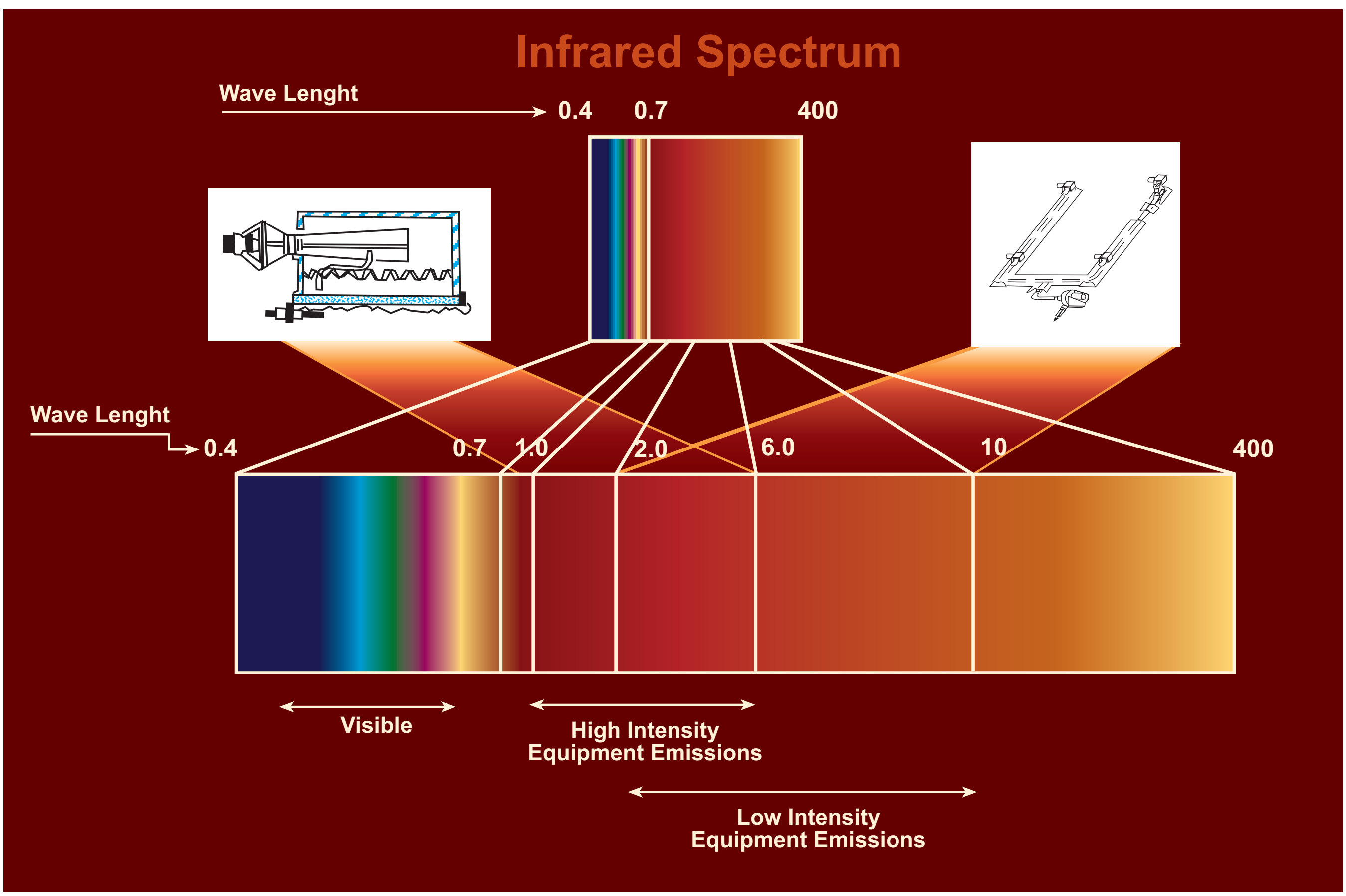

Infrared Spectrum
Wave Lenght
0.4
0.7
400
Wave Lenght
0.4
0.7
1.0
2.0
6.0
10
400
Visible
High Intensity Equipment Emissions
Low Intensity Equipment Emissions

Figure 1: Energy Flow Chart - Radiant Heating

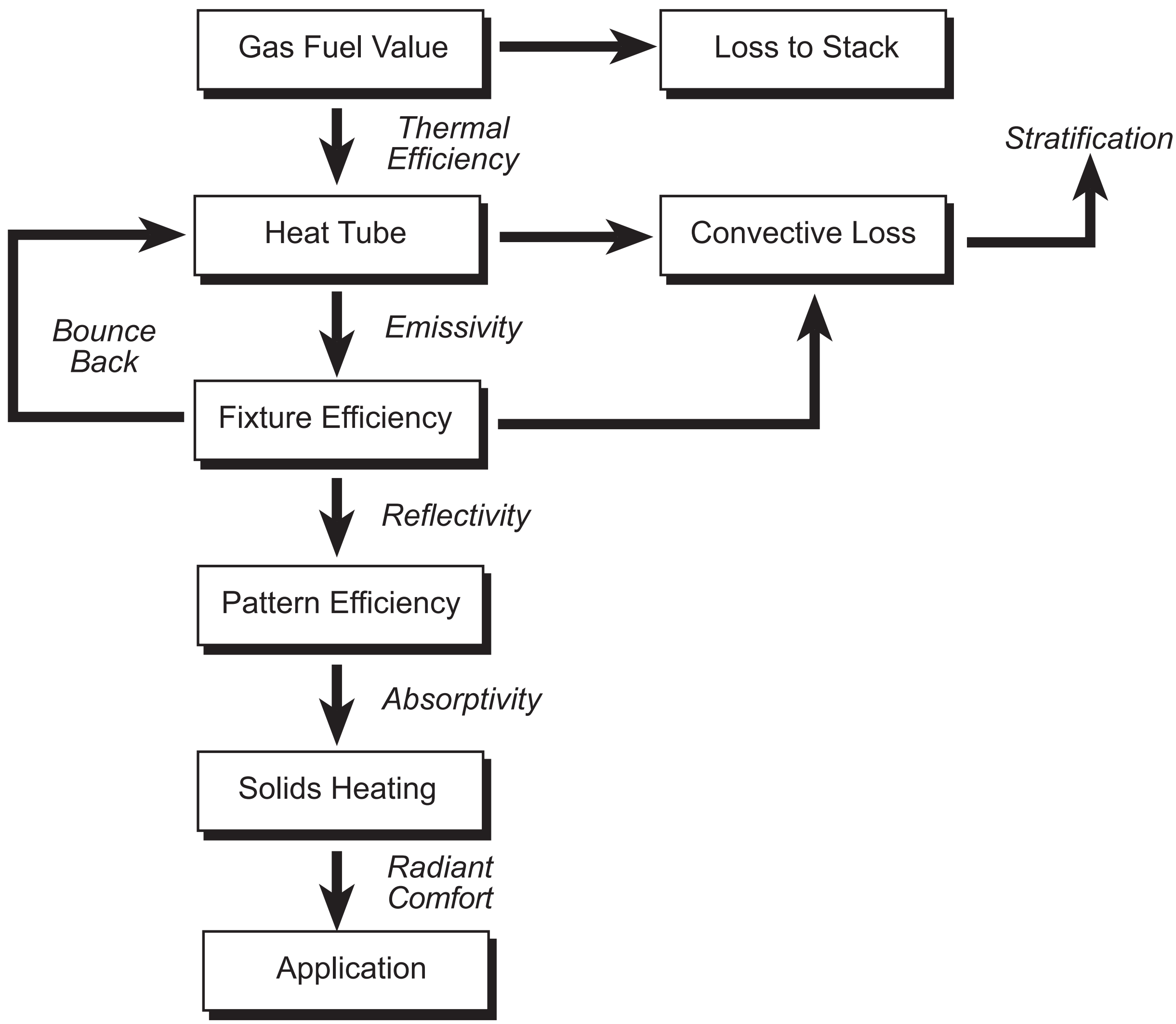
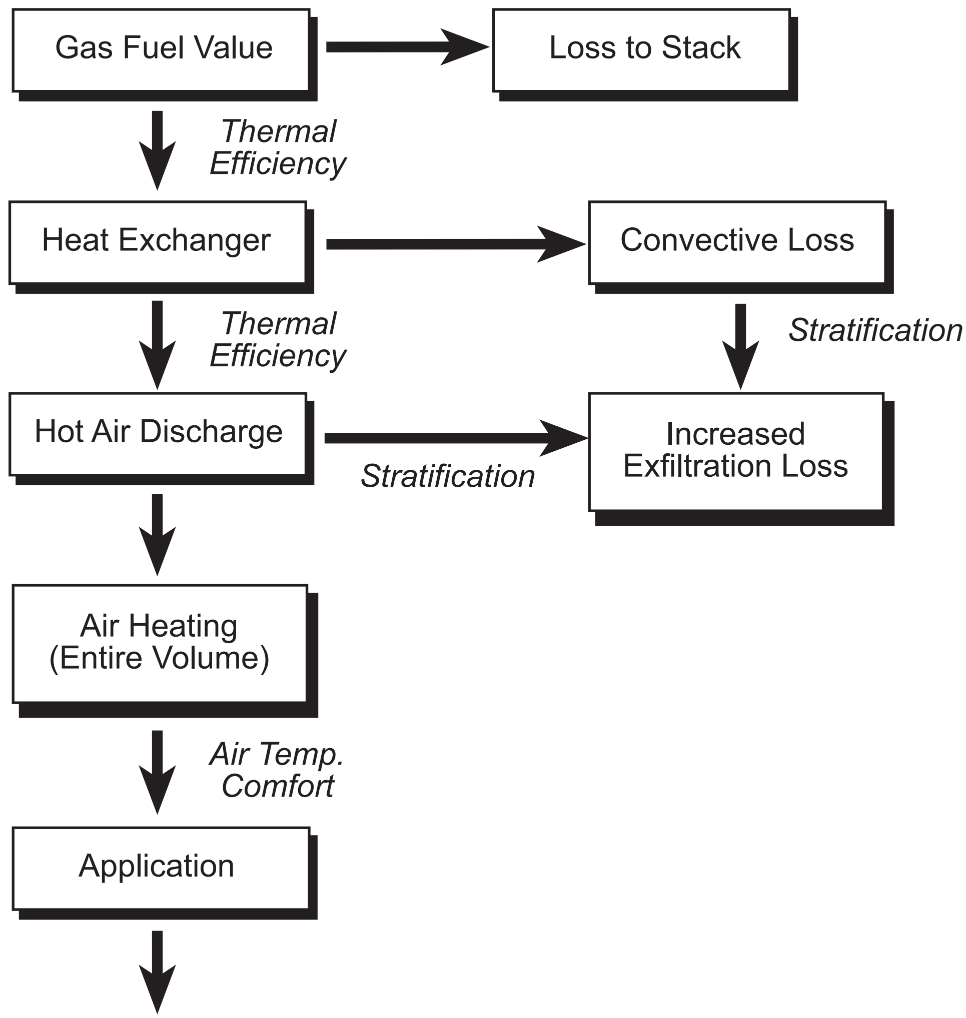


Figure 2: Energy Flow Chart - Conventional Air Heating



Aviation

Facilities Heating

Types of Radiant Heating Equipment

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Installation Code and Annual Inspections: All installation and service of ROBERTS GORDON® equipment must be performed by a contractor qualified in the installation and service of equipment sold and supplied by Roberts-Gordon LLC and conform to all requirements set forth in the ROBERTS GORDON® manuals and all applicable governmental authorities pertaining to the installation, service and operation of the equipment. To help facilitate optimum performance and safety, Roberts-Gordon LLC recommends that a qualified contractor conduct, at a minimum, annual inspections of your ROBERTS GORDON® equipment and perform service where necessary, using only replacement parts sold and supplied by Roberts-Gordon LLC.

Further Information: Applications, engineering and detailed guidance on systems design, installation and equipment performance is available through ROBERTS GORDON® representatives. Please contact us for any further information you may require, including the Installation, Operation and Service Manual.

These products are not for residential use.

This document is intended to assist licensed professionals in the exercise of their professional judgment.

Aviation
Facilities Heating

Types of Radiant Heating Equipment

ASHRAE Defined Types

All radiant heating appliance are not the same. A recognized method of classifying radiant heating systems is according to the operating temperature of the emitting surface. For example:

1. High and Medium Intensity	1500°F and above
2. Low Intensity	500°F - 1500°F
3. Low Temperature	120°F - 350°F

High and medium-intensity heaters usually take the form of open flame, unvented appliances with incandescent faces. Low intensity units redesigned to operate below incandescent temperatures and frequently use steel tube or pipe as an emitter. Low temperature radiant heating systems utilize large heated surfaces such as floors, walls, panels, or ceilings. The surface temperature is elevated by hot water piping or electrical resistance wire embedded in the surface.

ASHRAE recognizes three specific types of infrared heaters that are gas-fired:

Type 1: Indirect Fired Units

Type 1 is characterized by burning a gas-air mixture inside a tube or enclosure, which radiates its energy to the space. The products of combustion are generally vented to the outside. Typical operating surface temperatures do not exceed 1200°F.

Type 1a units utilize an atmospheric burner venting product of combustion upward. (for example, a patio heater)

Type 1b units utilize multiple vacuum assisted burners operating in a horizontal tube.

Type 1c unit utilize a power assisted (force draft) burner operating in a horizontal tube.

Type 2: Direct Fired Units

Type 2 is characterized by burning the gas-air mixture in a porous matrix of refractory material, which radiates its energy into the space. The products of combustion are vented into the space. Temperatures of operating Type 2 units range from 1600°F - 1800°F.

Type 3: Catalytic Units

Type 3 is characterized by mixing gas and air in the presence of a catalyst. The mixture oxidized without flame, and heat radiates into the space. The products of combustion are vented into the space. Temperatures of these catalytic units range from 650°F - 700°F.

Market Defined Types

The ASHRAE defined radiant heating appliances do not adequately reflect the recent evolution of new products as available in the marketplace.

The result is that the industry has moved beyond these definitions by introducing new appliances that fall into more than one of these categories. In addition, ASHRAE has not yet developed a way for the engineering community to distinguish between appliance performers within a category or between a category.

The most visible demonstration of this definition inadequacy exists within the increasingly popular ASHRAE Type 1b an Type 1c appliance market. Recently introduced radiant heating appliance have many characteristics of a Type 1b system, but not all of them. Specifically, lower efficiency of these systems do not provide for condensation of the combustion gases before exhaust.

Additionally, many manufacturers combine multiple, individual, non-condensing burner appliances on a common exhauster and represent the resulting system as a Type 1b condensing appliance. The lower efficiency of these systems more accurately reflects the performance characteristics inherent in a ASHRAE Type 1c appliance.

In order to differentiate these appliances, the market has defined a radiant heating appliance category between an ASRAE 1b and 1c. Burners in this category are referred to as Quasi-Type 1b/1c appliances.

Variation in market approach can be recognized as follows:

Description	Appliance Type
Engineered, custom designed, multiple burner, condensing appliances.	Type 1b
Engineered, custom designed, multiple burner, non-condensing appliances.	Quasi-Type 1b/1c
Factory assembled, single burner, non-condensing appliances.	Type 1c
Site-assembles, single burner, non-condensing appliances.	Quasi-Type 1b/1c or Type 1C
Factory assembled, open flame.	Type 2
Factory assembled, catalytic combustion.	Type 3

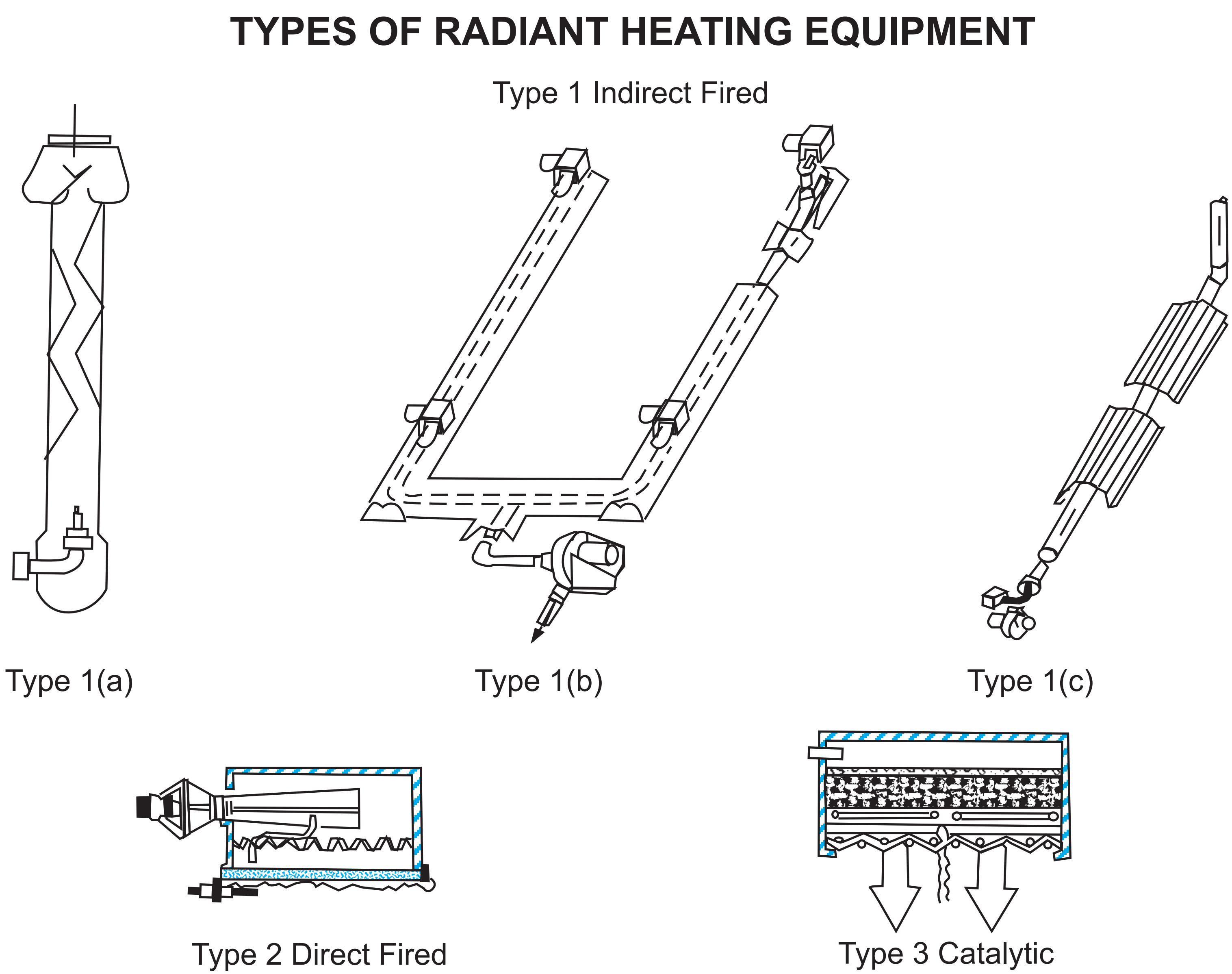

Figure 3: ASHRAE Heater Types

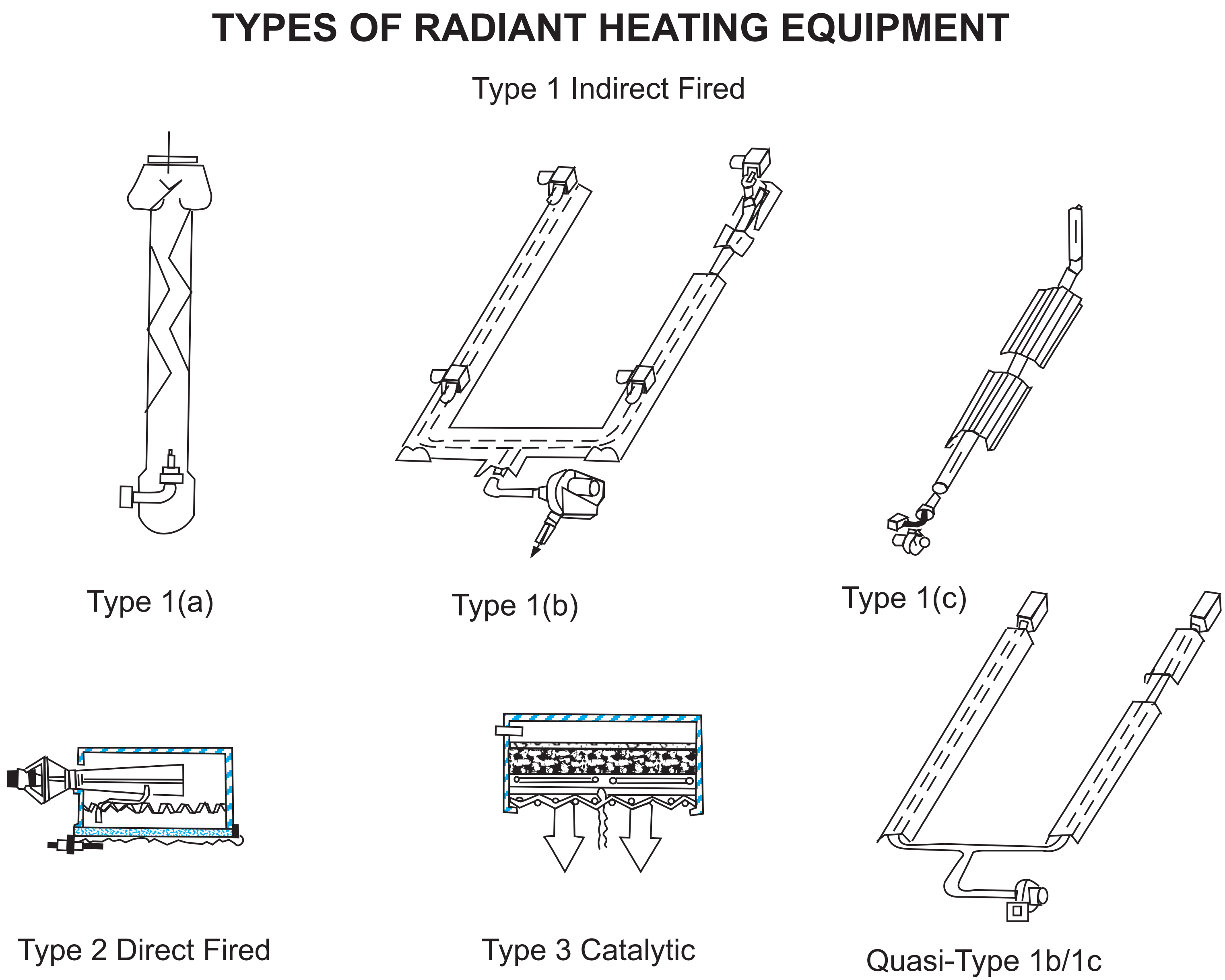

Figure 4: Market Defined Heater Types

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Concepts of CORAYVAC®

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Aviation
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Concepts of CORAYVAC®

Concept

The concept of CORAYVAC® is easy to understand. However, ti often means discarding old ideas because CORAYVAC® is a different kind of heating system. The things that make it different, make it better.

CORAYVAC® is a gas-fired, vacuum operated, low intensity radiant heating system incorporating a pateneted incremental burner system.

Gas-fired means it is fired with clean burning Natural or LPG gas.

Vacuum operated means that the vacuum pump draws all the products of combustion through the system ans completely expels it safely outdoors.

Low-intensity means the radiant surfaces of the heat exchanger tubes do not glow red, instead they operate a a lower temperature (less than 900°F) and radiate heat at lower intensity per square foot of radiating surface. Area coverage is provided by radiant heat from long runs of 4" O.D. steel tubing which are suspended from the ceiling on roof suppports. Reflectors are provided to direct the radiant heat downward to occupied areas.

Radiant refers to the heat radiated by the CORAYVAC® system. Because this heat is in the form of infrared rays, it does not directly heat the air. Instead, the rays heat objects such as the floor, cars, machines and people. The objects in turn heat the air.

Incremental burner system means that several burners can be located in a series in a radiant branch and fired in the same run of tubular steel heat exchanger that carries the combustion gases from upstream burners. Each of these burners in a radiant branch can be selected in terms of firing rate; also, the space between the burners can be adjusted. This permits a matching of heat gain to the heat loss for each area of the building. Firing burners in a series provides higher thermal and radiant efficiency and this is one of the patented features of CORAYVAC®.

A major characteristic of a properly designed low intensity radiant system is that the occupants are barely conscious of the radiant heating when the system is firing. They will feel little or no change when the thermostat is satisfied and the system is not firing. This combines the warm floors and draft free operation to improve the mean radiant temperature of the space which are the keys to the high comfort level and fuel utilization efficiency provided by CORAYVAC® heating.

The CORAYVAC® System

Each CORAYVAC® installation consists of one or more vacuum pump systems. Each of these consist of one vacuum pump, a pre-wired control panel, thermostat controls and a number of burner modules. It also includes the extended heat exchanger surface in a form of 4" O.D. steel or porcelain lined tubing or Schedule 40 black iron pipe with high efficiency aluminum reflectors over this heat exhcanger to reflect the radiant heat downward to the floor. The heat exchanger section nearest the the burners radiantes with the most intensisty and is called radiant pipe. This should be located over areas with the grates heat loss.

The balance of tubular or Schedule 40 pipe heat exchanger surface radiates with less intensity and is called tailpipe. This can be located in areas with lower heat loss.

There are minimum lengths of tailpipe prescribed in the design requirements. It is essential that these minimums be provided if the pump capacity is to be maintained and the best thermal efficiency is to be acheived.

While it is important to locate radiant tubes and tailpipe over areas with high heat loss, such as the perimeter of the building, it is not always essential to cover all areas directlty with radiant heat. Center areas and other areas of low heat loss can be adequately heated without direct coverage if the input system is adequate for the total building. However, in order to acheive the highest degree of comfort and fuel savings, it is recommended that the CORAYVAC® system be located to provide as complete and even a distribution as is practical. Diagram 1 illustrates componants od a typical CORAYVAC® system.

Safety

Safety has been a prime consideration in the design of the CORAYVAC® system as can be determined from a review of system features. This includes a pre-purge of the complete tube network with air prior to flame ignition. In each burner, there are two valves in a series that must be energized as well as the zero regulator. These devices, together with a vacuum pressure switch, ensure that there will be no gas flow unless the vacuum pump is operating. Additionally, slow opening gas valves provide smooth ignition and enhance reliability.

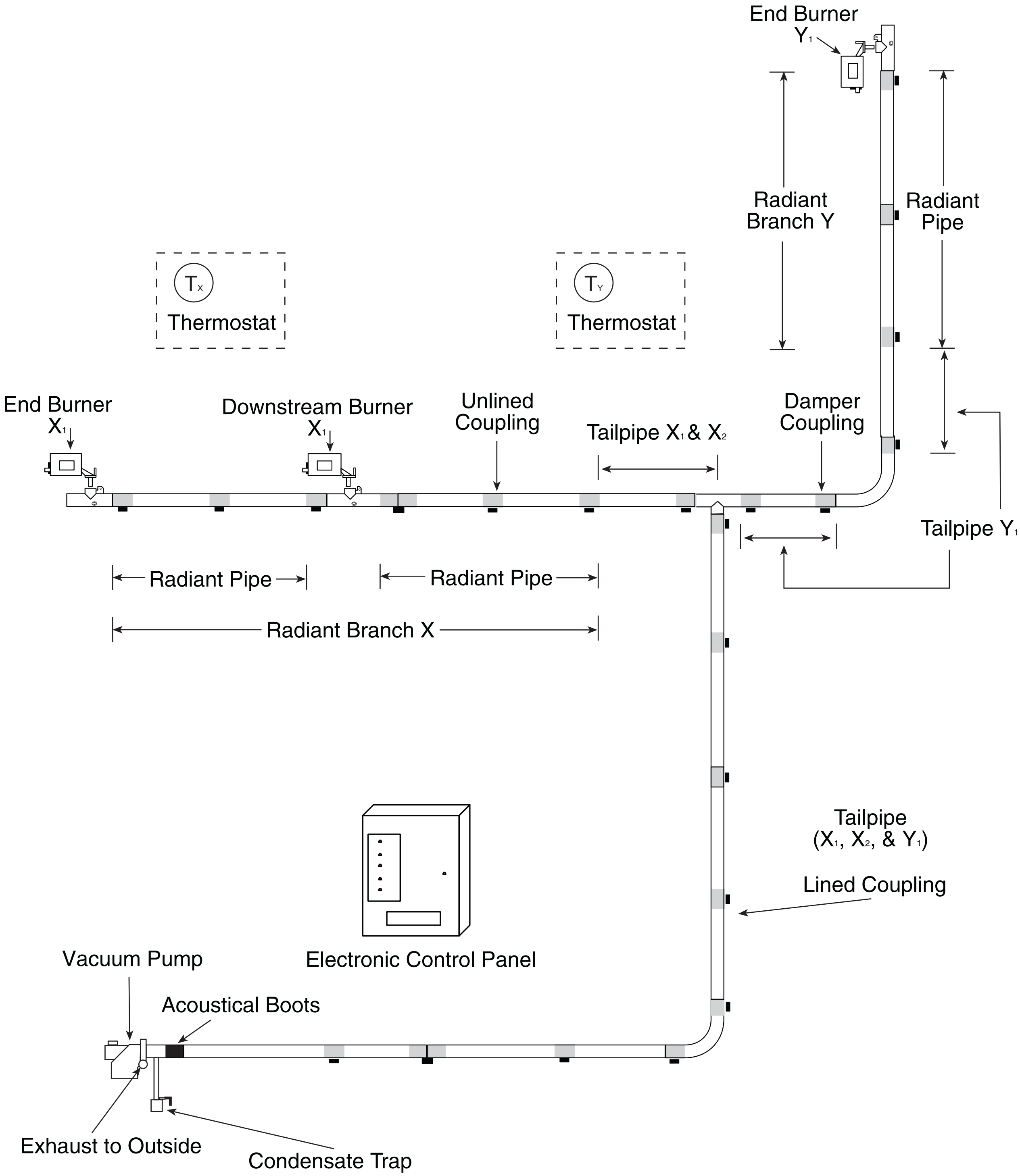
With CORAYVAC®, all equipment controls are A.G.A. gas design certified, both as individual parts and also as a complete heating system. Also, individual electrical componant parts are UL listed as applicable.

Zero Regulator

CORAYVAC® uses a 100% pre-mix burner with the input dependent on system vacuum. It is the only ture vacuum operated system available today in that both air and gas are pulled into the burner head by system negative pressure. With no vacuum, the zero regulator prevents gas flow. When vacuum is present, the burner fires and input increases ans vacuum increases. As the input increases, the amount of air also increases. Over the normal range of operating vacuum, the gas/air ratio is essentially linear.

This unique and patented feature provides optimum combustion conditionas at all times and is unaffected by fluctuations in fuel pressure, dirty air filters, changes in atmospheric pressure, wind velocity or other climatic conditions.

Figure 5: Illustrative View of CORAYVAC® System with One Vacuum Pump



NOTES:

1.) Damper coupling is required where the layout is asymmetrical (i.e. unequal flow unit from each burner branch.

2.) Reflectors and support system not shown.

3.) The radiant pipe is joined with unlined couplings. The tailpipe is porcelain lined and joined with lined couplings.

Safety

Most manufacturers, designers, and users of radiant heating equipment agree that the same space heating job can be accomplished with les input capacity with a radiant heating system than with convective heating systems such as unit heaters or central furnaces where heat is delivered by movement of heated air.

To better understand these results, it is neceassary to review the manner in which a radiant heating appliances warms a space.

Infrared energy from a radiant appliance heats objects, people and surfaces, not the air. The warm objects and floor convert this energy to heat which:

- Is absorbed into the objects and floor creating a heat reservoir.
- Warms the air near the objects and floor via convection.
- Is reradianted to occupants and other surfaces of the space.

The radiated energy received by the occupants, directly from the heater or indirectly from the heater via reradiantionf from the floor and objects, serves to increase the mean radiant temperature (MRT) of the occupant. in a manner similar to direct sunlight, the increased MRT allows the occupant to perceive a comfort condition at a much reduced air temperature (sometimes as much as 7° - 10°F lower.) The resulting reduced air temperature within the space provides the following advantages.

- Reduced stratification of air within space;
- Reduced actual transmission heat loss due to lower temperature inside than assumed design condition, as well as substantially lower ceiling adn upper sidewall temperature due to reduced stratification (25° - 30°F lower is not usual);
- Reduced air change heat loss, to the extent that exfiltration through cracks or openings, near the roof, will be decreased due to decreased stack effect.
- Decreases the actual degree days expreienced.

Each of the above advantages impacts favorably on fuel usage.

Selecting the Burners

The number of burners and firing rate for each must be specified for each design layout. In addition, an end vent plate must be provided for each end burner and this to match the firing rate of the end burner. The selection of a burner rate should be made foe each burner position according to factors such as:

- Heat gain required and didtribution of same.
- Mounting height available.
- Flow loading restrictions.
- Length of radiant branches.
- Distance required between burners.
- Desired radiation intensity.

In general, lower burner rates can be used for lower mounting heights or where lower heat gains are required. Higher burner rates are uased primarily with higher mounting heights or where high heat gain is required.

The quantity of burners required can be calculated by dividing the input rating of the selected sizes into the calculated CORAYVAC® system required installed capacity.

Flow Loading

The patented CORAYVAC® burner system allows a number of burners to be installed in series, in same radiant tube, resulting in a long, continuous radiant emitting surface, to give even heat distribution within the building.

To enable the burners to be correctly located within the tube, to maintain system operatingvacuum and obtain design flue gas temperatures at the vacuum pump, the design layout is based on a simplified flow principle using a “flow unit.”

The flow unit is defined as the amount of fuel/air mixture for a heat input rate of 10,000 BTU/Hr. This corresponds to a flow rate of 1.83 cfm at 65° - 70°F.

For the purpose of design, flow units are considered to ener the CORAYVAC® system in one of two ways:

- Through the burner.
- Through the end plate.

and exit the system as spent products of combustion via the vacuum pump.

Table 1 lists the flow unit values associated with each burner firing rate, its associated end vent, and minimum flow unit requirement entering a combustion chamber.

Figure 6 summarizes design and flow loading parameters for CORAYVAC® systems.

The purpose of the end vent air is to provide that part of the burner inlet flow required to dilute the hot combustion gases at the burner therby promoting uniform heating of the tube while avoiding excessive heating of the combustion chamber.

For the end burner, the burner inlet flow consists of the total of the end vent air plus the combustion gases from all upstream burners.

The requirments for minimum burner inlet flow is met if the inlet flow units entering the combustion chamber meets or exceeds the minimum as shown in Table 3.

Tadiant Branch Flow

The flow ina radiant branch consist od the end vent flow units plus the flow units of combustion air from all burners.

The limiting factor for maximum flow in the radiant section has been determined experimentally in terms of the maximum burner inlet flow units that can be tolerated without degradation of combustion characteristics at the last downstream burner. Also, if more thanthe maximum number of burners are installed per radiant branch, the vacuum loss across the additional burners will increase appreciably.

Figure 6: Design Parameters

Burner Model No.		B-4	B-6	B-8	B-10	B-12
Input BTU/Hr (1000's)		40	60	80	100	120
Flow Units per Burner		4	6	8	10	12
Flow Units per End Vent		10	15	20	20	20
Maximum No. Burners per Branch		4	4	3	3	2
Maximum Flow Units per Branch		26	39	44	50	44
Radiant Tube Lengths	Min.	12.5 ft.	20 ft.	25 ft.	30 ft.	35ft.
(Distance between Burners)	Max.	25 ft.	35 ft.	45 ft.	60 ft.	70 ft.
Tailpipe Length per Flow Units	Min.	1.2 ft.	1.2 ft.	1.2 ft.	1.2 ft.	1.2 ft.
	Max.	3.0 ft.	3.0 ft.	3.0 ft.	3.0 ft	3.0 ft.
Minimum Tube length from Burner						
Downstream to Elbow		5 ft.	10 ft.	10 ft.	15 ft.	15 ft.
Upstream to Elbow		2 ft.	2 ft.	2 ft.	2 ft.	2 ft.
Suggested Minimum Mounting Height		8 ft.	8 ft.	10 ft.	15 ft.	15 ft.

Table 1: Flow Unit Specifications

Model	Flow Unit per Burner	Flow Units per End Vent	Minimum Flow Units Entering Combustion Chamber
CRVB-4	4	10	10
CRVB-6	6	15	15
CRVB-8	8	20	20
CRVB-10	10	20	20
CRVB-12	12	20	20

This maximum flow in the radiat branch can be expressed for each burner firing rate by either a maximum number of burners per branch or the corresponding maximum number of flow units. Refer to Figure 6.

Tailpipe Flow

Excessive flow loading in a single section of tailpipe can cause low vacuum and lower effective pump capacity if care is not taken to observe the necessary design requirements.

It is important to check the length of tailpipe for each radiant branch, and verify taht it is within ± 5% of the specified length. If the proper end vent vacuum is to be maintained, the length of the tailpipe must not be excessive for the flow units being carried by that section of tailpipe. Refer to Figure 7 to determine adherence to vacuum line loss requiremets.

Vacuum Pump Capacity

The flow capacity of the vacuum pump is indicated in Table 2 as a function of installed altitude. When the CRV system is designed in accordance with the last set of instructions and is in proper operating condition, a vacuum from 2 to 3 inched w.c. will be obtainable at each end vent (i.e. at all burners).

Table 2: Vacuum Pump Capacity

Installed Altitude (above Sea level)	Maximum Capacity	Installed Altitude (above Sea Level)	Maximum Capacity
0 - 2000 ft.	110 flow units	5001 - 6000 ft.	90 flow units
2001 - 3000 ft.	105 flow units	6001 - 7000 ft.	85 flow units
3001 - 4000 ft.	100 flow units	7001 - 8000 ft.	80 flow units
4001 - 5000 ft.	95 flow units	8001 - 9000 ft.	75 flow units

There are a number of critical design requirements which, if not met, will reduce the vacuum obtainable and thereby the effective flow capacity of the vacuum pump.

These include:

- **Minimum Length of Tailpipe;** if less than the minimum length of tailpipe is provided per radiant branch, there will be insufficient cooling of the combustion gases and improper operation of the vauum pump.
- **Line Loss Check for Tailpipe** is applicable to sections of tailpipe which are common to two or more radiant branches (i.e. shared lengths). See Figure7.
- **Excessive Back Pressure** on a discharge line of a vacuum pump as caused by partial blockage or too much flow for length.
- **Air Leaks** in the system as caused by poor installation, missing view port windows in combustion chambers, leaky burner gaskets, missing or improperly installed end vent plates, poor joints at the couplings, obstruction inside the pipe, or incorrectly set dampers.
- **More Than Maximum Number of Burners** or flow units per raidant branch.
- **Excessive Number** of elbow of tee fittings.

If the distance required for the tailpipe to reach the pump position of the system is greater than allowed, then there are some alternatives:

a. Use separate branches of reduced flow units for half the distance and then tee together for the balance of the run.

b. Use separate branches from the pump each with less flow units. Then each branch could be longer than required.

Figure 6: Vacuum Line Loss Requirements for Tailpipe

NOTES:
- Readings for length and flow when plotted on a graph must fall on the OK side to avoid excessive vacuum losses.
- Lengths shown include allowance for 1 elbow every 50 ft.; deduct 15% of lenggth for each additional elbow used per 50 ft. of length.

Heat Exchanger Surface

The main purpose of the tailpipe and the radiant pipe is to provide sufficient heat exhcanger surface to transfer the heat from the flue gases to the tube wall where it can released from the outside surface of the tube as useful heat. Radiant pipe is defined as the tubing between burners firing in a radiant branch, plus the radiant tubing immediately following the last downstream burner. Tailpipe is defined as all the tubing between the radiant pipe and the vacuum pump.

Most of the radiant heat supplied by each burner is released from the outside surface of the radiant pipe; the balance is released by the tailpipe. The placement of radiant pipe to correspond to areas of major heat loss is the key to providing uniform comfort levels. The use of adequate tailpipe is the key to high combustion efficiency and proper operation of the vacuum pump.

Radiant Pipe

The considerations in selecting the length of the radiant pipe include the following:

Minimum - This provides for the highest level of average intensity per foot of radiant pipe and good uniformity between burners. This requires more tailpipe to maintain operating efficiency and pump capacity.

Maximum - This provides the lowest average value of intensity per foot of radiant pipe and consequently the largest span between burners. The intensity will be reduced slightly for the last 5-10 feet of radiant pipe before the next burner.

The length of radiant pipe required for burners varies according to the firing rates. Also, consideration has been given to usage of a standard 10 ft. or lengths that can be cut from same without waste. Refer to Figure 6.

When positioning radiant pipe to give the required radiant distribution it is important to consider:

- Clearance to adjacent combustive materials.
- Lighting equipment.

Tailpipe

The considerations in selecting the amount of tailpipe include the following:

Minimum - This is the minimum length of tailpipe to cool the flue gases sufficiently for proper operation of the vacuum pump. Excessive temperatures at the inlet to the pump will reduce the effective flow capacity and the vacuum abtainable system.

Maximum - The maximum limit established for the amount of tailpipe that can be used is defined in Figure 8. This permits the use of an extended connecting length of tailpipe is a branch of burners is remotely located which would otherwise require a seperate vacuum pump. It should be noted that if there are traces of corrosive contaminents in the combustion air, much of this longer section of tailpipe will be exposed to corrosive conditions due to low temperature in the end of the tailpipe.

In regard to the length of the tailpipe required per flow unit, there is a trade off between length of radiant pipe and length of tailpipe. Consequently, the requirements for tailpipe are stated below.

Tailpipe Length (with maximum length of radiant pipe)

Minimum	1.2 ft./Flow Unit
Maximum	2.5 ft./Flow Unit

Tailpipe Length (with minimum length of radiant pipe)

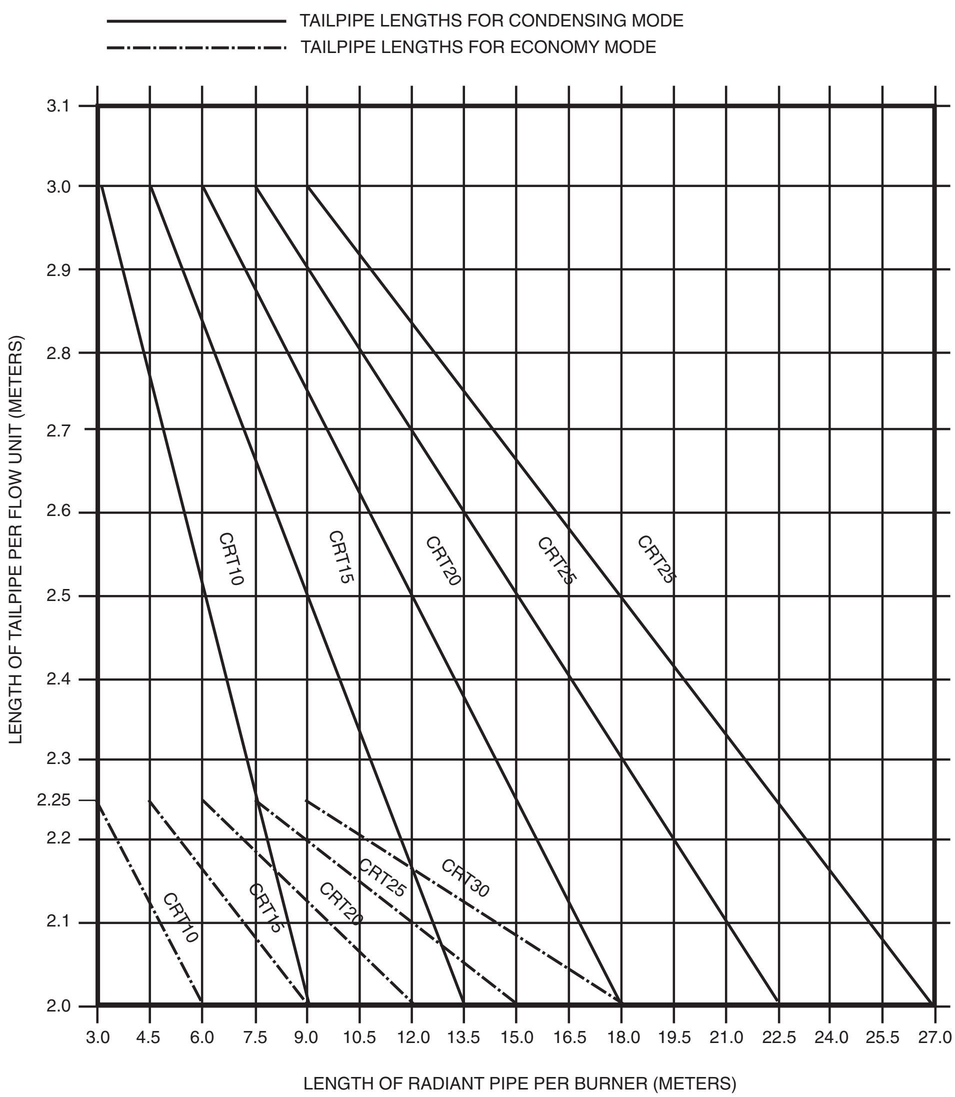
Minimum	2.0 ft./Flow Unit
Maximum	3.0 ft./Flow Unit

Figure 7 establishes a nominal length relationship between radiant pipe and tailpipe for each burner firing rate based on a mid-range thermal efficiency for condensing systems. Figure 9 relates the effect on system thermal efficiency of variations in radiant tailpipe lengths.

Note: When accounting for the required tailpipe lengths during the design process, it is important to verify that the tailpipe for each branch is at least equal to the specified minimum.

For radiant branches which are served by sharing tailpipe sections, the shared sections can be allocated to either branch with any distribution of length. The objective is to allocate the shared section in a way which permits the minimum length requirement to be met ofr all radiant branches served by that shared section. **The prime consideration is that each foot of shared section can be counted only once.**

Figure 7: Nominal Radiant/Tailpipe Requirements



Note: When accounting for the required tailpipe lengths during the design process, it is important to verify that the tailpipe for each branch is at least equal to the specified minimum.

Air Supply System

An air supply free of dust and corrosive contaminants is essential for proper operation and best life expentancy with any heating system. With Co-Ray-Vac there are two alternatives available to the designer for providing the air supply. These are:

- Individual filter for each burner. A single filter door is standard for each burner.
- Outside air system to duct air from an uncontaminated source. A single filter for each burner is used plus outside air supply to provide both combustion and end vent air. it must be determined that outside air is not contaminated by exhaust from the same building and/or neighboring buildings.

The first alternative above, is usable when the dust load is not excessive and there is not usage of corrosive contaminants such as solvents or vapors inside the building or in close proximity to the building. Vapors in close proximity could include exhaust air from a nearby factory such as chemical plant, a dry cleaner establishment,etc.

The second alternative must be used in all applications where corrosive contaminants my be present in the air in trace amounts (few parts per million) for several days or more per year during the heating season.

It is **important** for designers and owners of heating systems to note that the presence of traces of corrosive contaminants in the combustion air supply will greatly accelerate the rate of corrosion on heat exchanger surfaces and will shorten the useful life of the heating system accordingly. This is true regardless of wheather the heating system is Co-Ray-Vac, other infrared systems or conventional gas or oil fired equipment such as unit heaters, central boiler plant, etc.

Vith Co-Ray-Vac it is practical to provide an air supply system for filtered combustion air without any possibility of upsetting the fuel air mix as the filter loading increases. With the unique vacuum powered burners, the fuel air mix rate remains constant.

It can be expected that the use of an outside air system will reduce but not eliminate the corrosion.

In a way similar to the Co-Ray-Vac vacuum pump system also involves considerations os total flow units and acceptable combinations of duct lengths (and diameters) versus flow units carried. In certain circumstances it may be desireble to produce a fresh air inlet fan to pressurize the system. The small positive pressure is desirable and necessary to prevent the system from drawing in contaminated air.

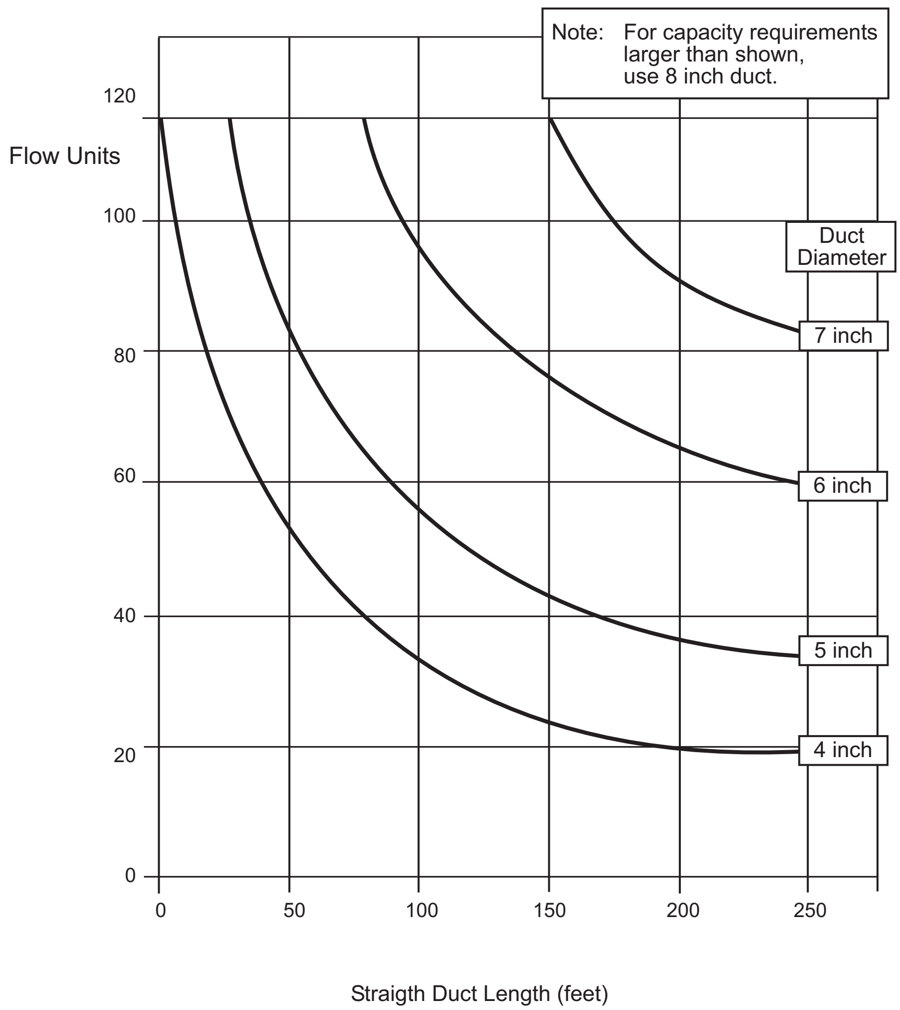
To size each section of pipe proceed as follows:

1) Calculate the required flow units at each outlet of the supply system.

2) Measure the longest run of pipe from thr blower to the most remote outlet. Use only this distance in figure 8 (or the next longer distance if the exact distance is not shown). This is to provide assurance that the preassure drop to the most remote outlet will not exceed 0.25” w. c. when all outlets are supplied.

3) To use figure 8, find the intersection point on the graph for the appropiate duct length and number of flow units. The duct size line above this intersection point indicates what size duct work should be used. Proceed in a similar manner for each outlet and each section of duct. For each section of duct, determine the total flow unit capacity supplied by that section.

Figure 8: Air Supply System Capacity by Lenght and Diameter (Based on 2.25” W.C. Maximum Line Loss)



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Heat Loss and Annual Fuel Use Calculations

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Building Heat Loss and Sizing the System

The building heat lost must be calculated in strict accordance with the current ASHRA (American Society of Heating, Refrigeration, and Air Conditioning Engineers) Guide. The Co-Ray-Van system is determined in concert with the required radiant adjustment to heat loss and height adjustment factors.

Radiant Adjustments to Heat Loss

The practice of applying and adjustment factor to heat loss calculations for radiant heating systems is well known within the radiant heating industry, having been used by manufacturers for over 25 years. Recently, a number of studies have been conducted to identify the values of the adjustment factor in the range of 0.8 to 0.85 depending on efficiency (higher efficiency uses lower factor). This adjustment can be more thoroughly understood when considering the following radiants effect issues:

Infrared energy heats objects, not the air;

Lower ambient air temperatures reduce the amount of air infiltration;

Less air stratification with radiant heat;

Lower ambient air temperatures reduce the transmission heat loss across walls and roof;

Elevated floor temperatures provide a thermal reserve capacity;

Increased mean radiant temperature allows occupants to perceive thermal comfort at all

the reduced air temperature.

Each of these issues impact favorably on the utilization of the installed capacity of the radiant heating system. This fact, together with the realization that the standard ASHRAE heat loss calculation methods (particularly the transmission heat loss coefficients) have been developed specifically for conventional hot air systems, demonstrates the need for the heat loss adjustment factor. For most Co-Ray-Vac systems, a 0.8 adjustments factor should be used.

Radiant Height Adjustment Factor

As discussed above, the installed capacity of radiant heating systems is typically reduced compared to the calculated heat loss due to the radiant effects associated with a properly designed radiant heating system. The ability of a radiant system to provide the advantages of these radiant effects rests largely with the ability of this system to establish a reserve heat capacity in the floor. Without this reserve capacity, radiant comfort cannot be achieved. (The exception is in station heating/spot heating applications where sufficiently high levels of direct radiation are received from the theater). The height adjustment factor is a means to insure adequate floor level radiant relationship of floor level intensity to height for single and multiple (overlapping) Co-Ray-Vac burner runs.

Additionally, higher mounting heights for radiant heating appliances increase the probability for direct energy loss due to exposure of longer wall surfaces. Proportionately, larger wall surfaces also remove energy from the floor to a larger degree, decreasing floor heat reservoir.

The increased input capacity recommended by a height adjustment factor is not extraneous as compared to the heat loss calculation. Rather, it is realization that in order to maintain radiant comfort conditions (and the economic benefits) a minimum radiant level must be maintained at the floor.

It is recommended that an adjustment to the heat loss of 1% per foot for mounting heights above 20 feet, be added up to 50 - 60 feet. Above this height, additional correction overstates the BTU requirement by the heat loss.

Example 1:

- Mounting height 30 feet	Heat Loss =	350,000	BTU/Hr
- Thermal Efficiency 90%, therefore 0.80 radiant heat loss	Radiant Adjustment	x .80	
		280,000	BTU/Hr
	1%/ft. Height Adjustment	x 1.10	
- Calculated heat loss 350,000 BTU/Hr	(30 ft. -20 ft.= 10 ft. x 1% = 10%)	308,000	BTU/Hr

Example 2:

- Mounting height 60 feet	Heat Loss =	500,000	BTU/Hr
- Thermal Efficiency 90%, therefore 0.80 radiant heat loss	Radiant Adjustment	x .80	
		400,000	BTU/Hr
	1% /ft. Height Adjustment	x 1.40	
- Calculated heat loss 350,000 BTU/Hr	(60 ft. - 20 ft.= 40 ft. x 1% = 40%)	560,000	BTU/Hr

Note in example 2, if requirement had been conventionally sized based on thermal output only, a nearly identical input requirement would result. For mounting heights above 50 - 60 feet, no further correction is generally provided.

The floor level radiant intensity is sufficient to establish a reserved capacity (hence radiant comfort);

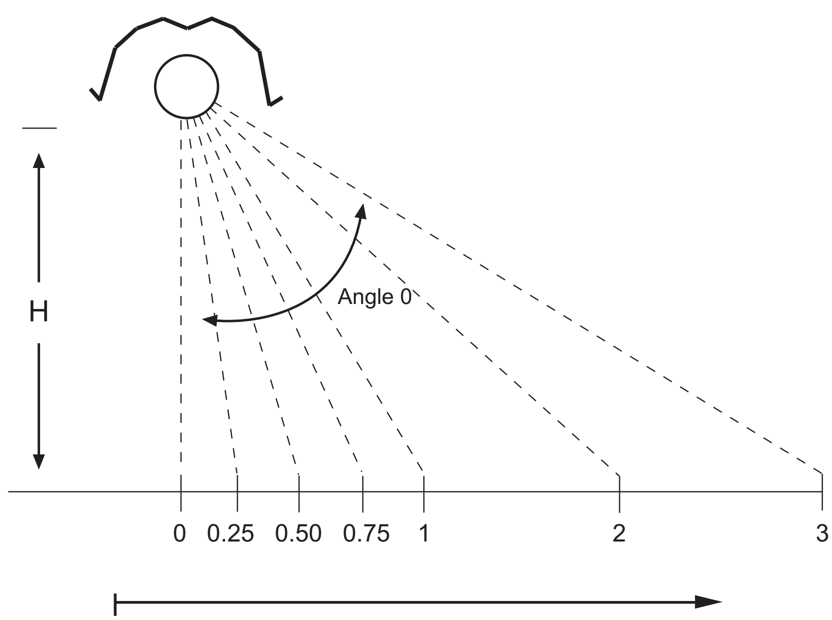
The heat loss requirement is satisfied based on thermal output.

For additional information on specific applications, the manufacturer should be consulted.

Table 1: Calculated Intensity Chart (Single Burner Runs)

Mounting Height (ft)	Intensity (Multiple of I*)						
	o = 0	D= .25H o= 14	D=.50H o = 26.7	D=.75H o = 36.9	D=1.0H o=45	D=2.0H o= 63.4	D=3.0H o = 71
8	2.000	2.000	1.600	1.400	1.200	0.300	0.100
12	1.333	1.330	1.064	0.930	0.798	0.200	0.067
16	1.000	1.000	0.800	0.700	0.600	0.150	0.050
20	0.800	0.800	0.640	0.560	0.480	0.120	0.040
30	0.533	0.533	0.426	0.373	0.320	0.080	0.027
40	0.400	0.400	0.320	0.280	0.240	0.060	0.020
50	0.320	0.320	0.256	0.224	0.192	0.048	0.016
75	0.213	0.213	0.171	0.150	0.128	0.032	0.011
100	0.160	0.160	0.120	0.108	0.096	0.024	0.008

Figure 1: Burner Location for Intensity Charts (Single Burner Run)



Horizontal distance from centerline of burner emitter at floor level
(in multiples of H).

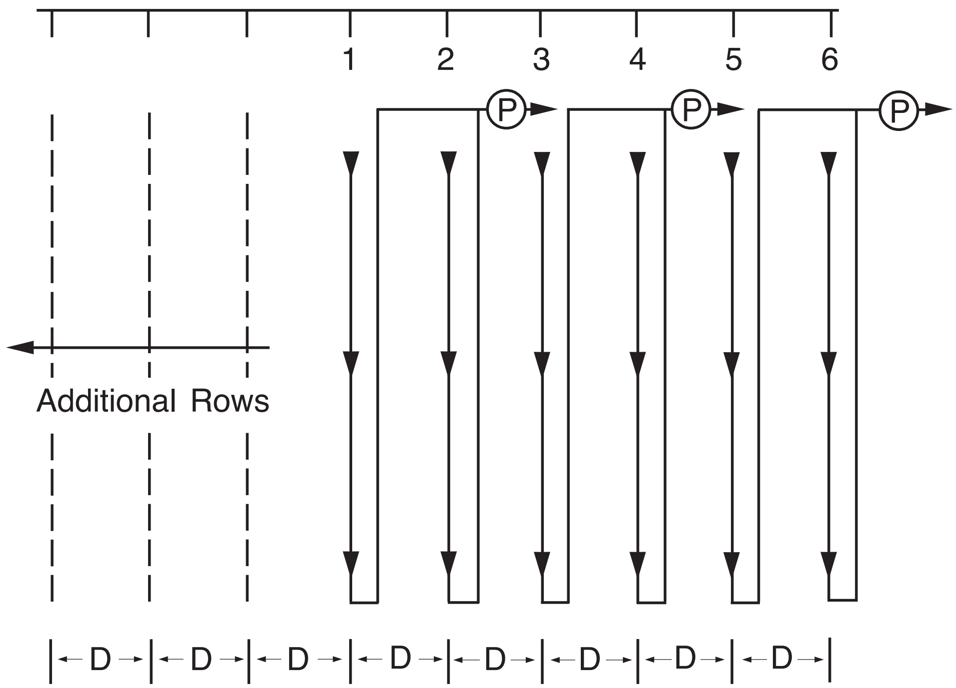
Table 1: **Calculated Intensity Chart** (Multiple Burner Runs)

Mounting Height (ft)	Intensity (Multiple of I*)					
	D= 0.25H	D=0.50H	D=0.75H	D=1.0H	D=2.0H	D=3.0H
8	19.80	9.934	6.534	5.000	2.600	2.100
12	13.17	6.610	4.344	3.326	1.730	1.397
16	9.620	4.710	3.240	2.500	1.300	1.050
20	7.920	3.974	2.614	2.000	1.040	0.840
30	5.109	2.511	1.711	1.333	0.693	0.560
40	3.960	1.986	1.306	1.000	0.520	0.420
50	3.232	1.590	1.110	0.800	0.416	0.336
75	2.111	1.059	0.695	0.533	0.277	0.224
100	1.584	0.762	0.554	0.400	0.208	0.168

Notes:

- This calculation assumes 100% of the output will be allocated to a floor area as defined by a 120 pattern width.
- The values shown include the overlap and are minimum values with at least two rows of burners on either side. The values of intensities are less between all other rows.
- With spacing of 3.0H between rows, the added intensity from adjacent rows of burners is less than 5%

Figure 2: **Burner Layout for Intensity Charts** (Multiple Burner Runs)



Horizontal distance from certerline of burner emitter at floor level (in multiples of Mounting Height).

Inside Temp ________________ F Outside Temp _____________F

Fuel Available ________________

Transmission Heat Loss Factors (Construction Detail)

Outside Surface[1]	Construction / Insulation	Doors: No xW xH	Windows: No xW xH
Roof/Ceiling			
Wall 1			
Wall 2			
Wall 3			
Wall 4			
Floor			

[1] If surface is inside, indicate with an asterisk.

Ventilation Heat Loss

Severe wind condition __________________

Protective wind breaks ________________________

Exhaust fans _____________________ cfm

Percent of time on for 8-hour period _____________

Vent openings ____________________ sq.ft.

Walls, roof _________________________sq. ft.

Missing windows__________________ sq. f

Crackage: _____low ____medium ____high

Door seals: _________ good _________poor

Rooms or partitions that reduce air changes during door openings: ___________ yes __________ no

Estimated door openings per 8-hour period _________

Minutes per opening ________________

Open elevator shafts, stairwells, etc.____

Summary

Estimated natural infiltration _______________air chg./hr__________________ CFH

Mechanical exhaust _____________________air chg./hr __________________ CFH

Estimated overall ______________________ air chg./hr __________________ CFH

(Use the larger of the above two: exhaust or infiltration)

Net Other Heat Gains (Losses): Attach detail sheet if yes

Loss	yes	no	Loss	yes	no
Usable Process Heat			Incoming Cold Masses		
Other Internal Heat Gain			Other Heaters		
Snow, Ice, Water to be Melted, Dried			Other		

Floor Plan: Sketch to scale and include:

1) Location and description of obstacles to be avoided and clearances required.
2) Areas of high and low heat loss, work stations, storage, or materials with unusual sensitivity to heat.
3) Possible locations for vacuum pumps and discharge lines.
4) Information on service for gas and electricity.

Additional Comments:

RG ROBERTS GORDON

AVIATION FACILITIES HEATING: Heat Loss Work Sheet

Job	Construction			Sheet of
				By
Contractor				Date
Sold By	Out. Temp	In. Temp	Temp Rise	Drwg. #

A Infiltration: #Air Changes ______________ x Volume ________x 0.018 x Temp Rise _____ . . = **A** _________

B Mech. Exhaust: CFM __________________ x Temp. Rise __________ . . . . = **B** _________

C If line A> line B, then enter line A. If B> line A, then enter line B . . . . = **C** _________

D Floor Loss: Perimeter _________________ x Factor __________________ x Temp Rise ____ . . = **D** _________

Bellow calculate transmission losses through all surfaces including walls, doors, roof, windows. Enter total loss in line E

Surface	Qty	x Width	x Lenght	= Area	x U Value	x Temp. Rise	= Transmission Loss
					Sub Total - Transmission Loss		

E Enter Transmission Loss Sub Total from worksheet above . . . . = **E** _________

F Net Other Losses (gains) . . . . = **F** _________

G Add Lines C,D,E and F. Enter the result . . . . = **G** _________

H Input Rate Without Height Correction: Multiply line G by 0.8 (Radiant Adjustment factor for Co-Ray-Vac . . . . = **I** _________

I Height Correction: 1% of Input Rate per foot of installation height over 20 feet . . . . = **J** _________

J Input Rate With height Correction: Add line H to line I . . . . = **K** _________

Walls-Mansory	4”	6”	8”	10”	12”
Brick, face common		0.68	0.48		0.35
Brick, common			0.41		0.31
Stone, Lime and Sand			0.67		0.55
Poudered Concrete, 30#/cu.ft.	0.19	0.13	0.10	0.80	
Poudered Concrete, 80#/cu.ft		0.31	0.25	0.21	0.18
Poudered Concrete, 140#/cu.ft		0.75	0.67	0.61	0.55
Concrete Block (solid)					
Gravel aggregate			0.52		0.47
Cinder regular			0.39		0.36
Light weight regular			0.35		0.32
Concrete Block (hollow with 4” facing brick or stone)					
Cinder aggregate	0.41		0.33		0.31
Light weith aggregate	0.35		0.30		0.28
Sand aggregate	0.49		0.41		0.38
Concrete Block (hollow)					
Cinder aggregate	0.59	0.51	0.39		0.37
Light wt. aggregate	0.47	0.43	0.36		0.33
Gravel aggregate			0.51		0.47

TYPICAL “U” VALUES

Materials		Inches of Insolation							
Insul.	Fiberglas	0	0.5	1.0	2.0	4.0	6.0	8.0	12.0
	Polystyrene	0	0.25	0.66	1.15	2.25	3.60	4.55	6.50
	Polyurethane	0	0.15	0.45	1.00	1.85	2.75	3.50	5.25
Building Material		Approximate “U” Values							
Walls	Aluminium or Steel over sheathing	.684	.346	.231	.139	.077	.053	. 041	.027
	Asbestos Siding, 1/4”	.943	.401	.255	.147	.080	.054	.041	.028
	Wood, solid or composite	.558	.310	.215	.133	.075	.052	.040	.027
	Steel, 1/4” Fiberglas or 1/16” Plastic	1.26	.449	.273	.153	.081	.055	.042	.028
Roof	With ceiling								
	Metal	.398	.253	.186	.121	.071	.050	.039	.027
	*Concrete 2”	.211	.162	.131	.095	.061	.045	.036	.025
	Wood 3/4” (built-up-deck)	.305	.212	.162	.111	.067	.048	.038	.026
	Without ceilling								
	Metal	.900	.393	.251	.146	.079	.054	.041	.028
	*Concrete 2”	.300	.209	.161	.110	.067	.048	.038	.026
	Wood 3/4” (built-up-deck)	.529	.301	.210	.131	.075	.052	.040	.027

* 30 lbs/ft³ density; for 140 lbs/ft³ use line for metal

Other Roof Surfaces:
Glass: single- 1.23 double- 0.65
Plastic: single- 1.15 double- 0.70

Floors (Slab):
TR(F)x linear exposure x faxtor
Insulated: 0.55
Uninsulated: 0.81

Other Wall Surfaces:
Glass : single-1.10 double- 0.58 4” block-0.60
Plastic: 6 mil-1.13 double-0.70 1/8” - 1.06
Wood and Metal Doors- 0.65

Prefab Concrete Panels-Insulated Core:

Thickness	lbs./ft²	“U” Value
2”	17	.270
3”	19	.138
4”	21	.092

Job: ____________________________________ Sheet ______________ of____________

____________________________________ By: ______________________________

Contractor: ______________________________ Date: ______________________________

____________________________________ Dwg*: ______________________________

HEATING EQUIPMENT

Proposed: ________________ U' *

Competition: ________________ U'

Existing: ________________ U'

FUEL COST

Natural: ________________ /Therm

Propane: ________________ /Gallon

Oil: ________________ /Gallon

Electric: ________________ /KWH

CLIMATE DATA

Degree days:________________

Design Temp:________________ F

Inside Temp: ________________ F

Temp Rise: ________________ F

Temp Rise: ________________ BTU/hr

ELECTRICAL USAGE

Proposed: ________________ /KWH (connected load)

Competition: ________________ /KWH

Existing: ________________ /KWH

BUILDING HEAT LOSS**

________________ BTU/hr

To calculate fuel usage follow procedure as outlined on Appendix pages ____

* See Page ____ for derivtion of U' factors

** From line G of the Heat Loss Worksheet

Fuel Utilization

Radiant heating has long been recognized as a cost effective method of providing heat. Determining fuel utilization characteristics for radiant heating is possible utilizing accepted ASHRAE methods. Because of this, fuel usage comparisons to conventional heating equipment can also be made.

The calculation section derives the necessary equations to calculate fuel usage. Because this calculation is applied to a design (maximum) heating load, and is subject to errors from a number of sources, namely:

1. Difference between historical and actual degree day number,
2. No consideration for effects of internal heat gains (from lights, etc.),
3. Difference between estimated and actual change air change or ventilation heat loss,

the estimated annual fuel usage calculated is usually conservative. ASHRAE has recently implemented a correction coefficient C_D, based on degree-days, to provide for more realistic fuel use estimates.

It is necessary to recognize the range of values that can exist for the fuel utilization factors, depending on application circumstances. As an application increases its dependency on radiant energy to provide comfort, a correspondingly larger fuel savings can be expected over conventional heating equipment.

The U-factor Section gives a comparative analysis for various types of heating equipment and includes consideration for opening costs as well as fuel costs.

Formula Derivation: R-g vs. ASHRAE

(Reference: 1985 Fundamentals, pp 28.2 - 28.3)

Roberts-Gordon Formula:

$$\text{(EQ 1)} \qquad F = \frac{U' \times N_b \times D \times 70°}{1000 \times DTR}$$

Where	**F**	**=**	Estimated Annual Fuel Consumption (units same as U’)
	U’	**=**	Factor for fuel unit usage per unit Heat Loss $\mathbf{N_U}$
	$\mathbf{N_b}$	**=**	Calculated Heat Loss at design temperatures
	D	**=**	Number of Degree Days Annual
	DTR	**=**	Design Template Rise
	$\mathbf{C_D}$	**=**	Empirical correction factor for heating effect vs. 65°F degree days, usually less than 1.0 and based on actual degree day (From Reference 6.1.1).

U’ Factor Definition Formula:

$$\text{(EQ 2)} \qquad U' = \frac{N_U \times C \times 24}{E \times 70° \times V}$$

Where	$\mathbf{N_U}$	**=**	Unit heat loss of 1000 BTU/hr with temperature rise of 70°F
	C	**=**	Experienced base correction factor based on reduction of ASHRAE calculated heat loss due to radiant effects
	E	**=**	Thermal Efficiency
	V	**=**	Heating value of fule used to define F in terms of fuel units rather than BTU

Substituting N_U into EQ 2

$$\text{(EQ 2a)} \qquad U' = \frac{100 \text{ BTU/hr} \times C \times 24}{E \times 70^\circ \times V}$$

When EQ 1 and EQ 2a are combined:

$$F = \frac{\dfrac{100 \times C \times 24 \;\; N_U \times C \times 24}{E \times 70^\circ \times V} \times N_b \times D \times 70^\circ}{1000 \times DTR} (C_D)$$

Simplifying:

$$\text{(EQ 3)} \qquad F = \frac{C \times 24 \times N_b \times D}{E \times DTR \times V} (C_D)$$

Compare at ASHRAE Formula:

$$\text{(EQ 4)} \quad E = \frac{H_L \times D \times 24}{\Delta t \times K \times V}$$

Where	**E**	**=**	Fuel or energy consumption (= F in R-G terminology)
	H_L	**=**	Calculated Heat Loss (= N_b in R-G terminology)
	D	**=**	Degree Days (= D in R-G terminology)
	Δt	**=**	Design temperature rise (= DTR in R-G terminology)
	K	**=**	A correction factor that includes effect of efficiency and other load performance factors (=E/C in R-G terminology
	C_D	**=**	Empirical correction factor for heating effect vs. 65°F degree days, usually less than 1.0 and based on actual degree day
	V	=	Heating value of fuel used to define E in terms of fuel rather than BTU

Substituting R-G terminology into EQ 4:

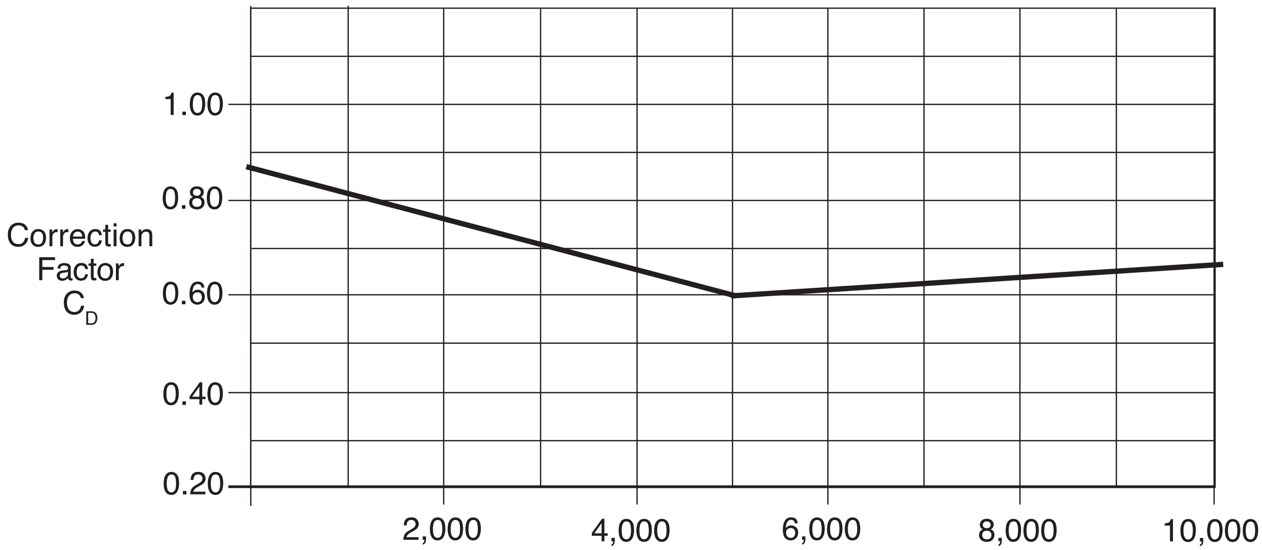
$$\text{(EQ 5)} \quad F = \frac{N_b \times D \times 24}{DTR \times E/C \times V} \, (C_D)$$

Rearranging EQ 5

$$\text{(EQ 6)} \quad F = \frac{C \times 24 \times N_b \times D}{E \times DTR \times V} \, (C_D)$$

Note that EQ3 and EQ6 are identical. Values of (CD) can be read from the following graph at the appropriate degree day value.

Correction Factor vs. Degree Days



U' Factors Calculation

Co-Ray- Vac Classic B Series:

C = 0.7
E = 0.9
V = 1000 (Natural Gas)

$$U' \quad \frac{1000 \times 0.7 \times 24}{0.9 \times 70° \times 1000} = 0.267 \quad \frac{\text{CF}}{\text{1000 BTU/hr Heat Loss}}$$

Air Rotation:

C = 0.9
E = 0.8
V = 1000 (Natural Gas)

$$U' \quad \frac{1000 \times 0.9 \times 24}{0.8 \times 70° \times 1000} = 0.386 \quad \frac{\text{CF}}{\text{1000 BTU/hr Heat Loss}}$$

In Floor Radiant:

C = 0.85
E = 0.65
V = 1000 (Natural Gas)

$$U' \quad \frac{1000 \times 0.85 \times 24}{0.65 \times 70^\circ \times 1000} = 0.451 \quad \frac{CF}{1000 \text{ BTU/hr Heat Loss}}$$

High Intensity Radiant:

C = 0.85
E = 0.92
V = 1000 (Natural Gas)

$$U' \quad \frac{1000 \times 0.85 \times 24}{0.92 \times 70^\circ \times 1000} = 0.317 \quad \frac{CF}{1000 \text{ BTU/hr Heat Loss}}$$

Illustrative Example

Opening expenses include both <u>fuel usage and costs</u> and <u>electric usage and demand costs.</u>

Fuel Usage Costs

Fuel usage can be determined via (EQ 1) by utilizing U' factors as derived above. As previously stated, (EQ 1) is interchangeable with accepted ASHARE procedures.

Fuel usage cost are determined by the following:

(EQ 7) CF = F x A

CF	=	Total annual fuel cost
F	=	Estimated annual fuel consumption
A	=	Cost per fuel unit (same units as F)

Electric Usage and Demand Costs

To determine electric costs, an estimate of equipment running time must be made. This can be accomplish as follows:

(EQ 8) $$TR = \frac{F}{N_b}$$

TR = Estimated annual equipment running time

F = Estimated annual fuel consumption (BTU's)

N_b = Calculated heat loss (BTU's)

Electric usage and demand costs are determined by the following:

(EQ 9) $$CE = (L \times TR \times KWC) + KWD$$

CE = total annual electric cost

L = Equipment connected electric load

TR = estimated annual equipment running time

KWC = Cost per electric unit (same units as L)

KWD = Demand charge per electric unit (same unit as L)

Typical Aircraft Hangar

Building Size	200 ft x 200ft
Building Height	40 ft
Calculated Heat Loss	2,143,000 BTU/hr
Design Temperature inside	65°F
Design Temperature outside	6°F
Degree Days (65° F Base)	6016/yr
Cost of Natural Gas	$0.04/therm
Cost of Electricity	$0.04/KWH
Annual Operating Hours	1181 hr/yr
CD (from graph A1)	0.62

Estimated of Annual Fuel Usage

For Co-Ray-Vac Classic B Series with Natural Gas

$$F = \frac{U' \times N_b \times D \times 70°}{1000 \times DTR} (C_D)$$

$$F = \frac{(0.267) \times (2{,}143{,}000) \times (6016) \times (70°)}{(1000) \times (59)} \times (0.62)$$

F = **2,532,088 cu. ft./ yr**

For Air Rotation with Natural Gas

$$F = \frac{U' \times N_b \times D \times 70°}{1000 \times DTR} (C_D)$$

$$F = \frac{(0.386) \times (2{,}143{,}000) \times (6016) \times (70°)}{(1000) \times (59)} \times (0.62)$$

F = **3,660,263 cu. ft./ yr**

Comparison of Annual Fuel Costs

Annual Fuel Cost for Co-Ray-Vac Classic B Series with Natural Gas

Primary Fuel: Natural Gas	CF	=	F x A	
	CF	=	2,532,088 cu. ft./yr x $\frac{\$0.40}{100 \text{ cu. ft.}}$	= **$10,128/yr**
Secondary Fuel: Electricity	CE	=	(L x TR x KWC) = KWD	
	CE	=	((4.1 kW/hr) x (1181 hr/yr) x ($0.04/kW)) + 0	
	CE	=	**$193/yr**	
Total Annual Opening Cost:	CT	=	CF + CE =	**$10,321/yr**

Annual Fuel Cost for Air Rotation with Natural Gas

Primary Fuel: Natural Gas	CF	=	F x A	
	CF	=	3,660,623 cu. ft./yr x $\frac{\$0.40}{100 \text{ cu. ft.}}$	= **$14,642/yr**
Secondary Fuel: Electricity	CE	=	(L x TR x KWC) = KWD	
	CE	=	((13.4 kW/hr) x (1181 hr/yr) x ($0.04/kW)) + 0	
	CE	=	**$633/yr**	
Total Annual Opening Cost:	CT	=	CF + CE =	**$15,275/yr**

Estimated Savings with Co-Ray-Vac

Air Rotation:	$15,275/yr
Co-Ray-Vac:	$10,321/yr
Estimated Annual Savings:	$4,954/yr

% Savings with C0-Ray-Vac: $\frac{\$4,954/\text{yr}}{\$15,275/\text{yr}}$ x 100 = **32.4%**

Aviation
Facilities Heating

Concepts of CO-RAY-VAC®:
B Series Classic
Specifications

Aviation

Facilities Heating

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CRV Classic Specifications: Part 2 - Products

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CRV Classic Specifications: Part 3 - Installation

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3.02 Field Quality Control

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 2. Provide VCR Training Tape

Specifications:

Co-Ray-Vac Classic “B” Series, All Schedule 40 Pipe Gas- Fired, Fully-Vented, Low-Intensity, Radiant Heating System

Part 1 - General

1.01 Work Included

A. Burner Units

B. Vacuum Pumps

C. Heat Exchangers

D. Reflectors

E. Controls

1.02 Submittals:

A. Product Data: Submit manufacture’s mechanical product data, including product description, technical data, and installation instructions.

B. Shop Drawings: Submit shop drawings showing complete details of installation of gas fired radiant systems, including layout, suspension, connections, vacuum pumps, burners, heat exchangers, and controls.

C. Wiring Diagrams: Submit wiring diagrams indicating power and control wiring required for system. Clearly differentiate between portions of wiring that are factory installed and portions to be field installed.

D. Certification: Submit copy of manufacturer’s current design certification from A.G.A>, covering all components approved for use as a gas radiant system.

E. Maintenance Data: Submit maintenance data and parts lists for each type and size of radiant heaters; including “troubleshooting” guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with the requirements of Schedule E, Materials Approval Submittal.

1.03 Quality Assurance:

A. Approved manufacturers: Infrared heating system shall be C0-Ray-Vac radiant heating system as manufactured by Roberts-Gordon, Inc., Buffalo, NY.

B. Manufacturer’s Qualification: Firms regularly engaged in manufacture of gas fired radiant system with characteristics, sizes, and capabilities requires, whose products have been in satisfactory use in similar service for not less than 15 years.

C. Alternate Manufacturers:

1. Other low intensity radiant systems of equal thermal efficiency and with the same or lower burner firing rate capacity, and with the radiant distribution pattern shown on drawing

may be acceptable provided they meet the intent of these specifications and prior approval in writing is obtained from the engineer at least twenty (20) days before the bid date. If such systems are approved, the contractor assumes responsibility for the design, performance and expense of same. The redesign system, gas piping, and electronic wiring shall be done by a registered engineer. Shop drawings of the entire new system shall be provided by this contractor. The contractor should state the amount to be credited to the owner due to this substitution.

2. Where approved substitutes are used, the contractor assumes all responsibility for physi cal dimensions and all other resulting changes. The responsibility extends to cover all extra work as necessitated by other trades as a result of the substitutions.

3. The engineer reserves the right to require the contractor to remove and replace any material or equipment which does not meet specifications or does not have any prior approval as a substitute item. Work shall be completed immediately without cost or inconvenience to the owner.

D. Codes and Standards:

1. ANSI Compliance: Construct, install, and certify gas fired radiant heaters in accordance with latest edition ANSI Z83.6a and/or ANSI Z83.6b as applicable).

2. A.G.A. Compliance: Provide A.G.A. Seal affixed to each burner name plate and vacuum pump assembly. Porvide A.G.A. certification of heater design as “Vented Infrared Heater.”

3. NFPA 54 Compliance: Install gas fires radiant systems in accordance with NFPA 54 “National Fuel Gas Code” (ANSI Z223.1 - latest edition).

4. NFPA 409 Compliance: Install gas fired radiant systems in accordance with NFPA 409 “Standard on Aircraft Hangers” (latest edition).

5. NFPA 54 Gas Piping Compliance: Install and connect gas piping to gas fired radiant system in accordance with NFPA 54 “National Fuel Gas Code” (ANSI Z223.1 - latest edition).

6. NFPA 70 Electrical Code Compliance: Install and connect electrical wiring to gas piping to gas fired radiant system in accordance with NFPA 70 “National Fuel Gas Code” (latest edition).

1.04 Delivery, Storage, and Heating:

A. Delivery materials to job site in original, new, and unopened packages and containers bearing manufacturer’s name, and label identifying contents.

B. Store materials so as to protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with water proof wrapping.

1.05 Warranty

Provide written warranty, by manufacturer, agreeing to replace/repair, within warranty period, components of gas fired systems furnished by manufacturer, which are defective in either material or workmanship, provided manufacturer's instruction for handling, protecting, and maintaining units have been adhered to during warranty periods follows:

A. 1. 15 years from date to final acceptance of entire radiant pipe network of 4 in. Schedule 40 ASTM A120 Radiant Pipe and Tail Pipe.

2. 15 years from date of final acceptance of cast iron combustion chambers.

3. 15 years from date of final acceptance of cast iron vacuum pump housing and scroll.

B. 1. 3 years from date of final acceptance of all other components including electrical.

Part 2 - Products

2.01 System

A. General:

1. <u>Condensing System</u>: Design gas fired radiant systems to operate such that water vapor present in products of combulsion will be condensed, and this heat of condensation will be extracted by the system and will be added to the heated.

2. <u>Vacuum Vented</u>: To preclude the possibility of combustion gases ecaping into the building, the entire system must be under a negative preassure at all times and vacuum vended to the outside atmosphere.

2.02 Equipment

A. <u>Burners</u>: provide burner assemblies consisting of heavy duty cast iron burner heads, pre-wired gas controls with direct spark ignition module, and combustion air filters.

1. Provide cast iron combustion chambers.
2. Provide minimum number of burners indicated to insure proper heat distribution. Fewer burners of larger capacity will not be accepted.
3. Burners shall be designed for firing in tandem without adverse effects from combustion gases from upstream burners.
4. Design firing rate of burners shall be 40,000, 60,000, 80,000, 100,000 or 120,000 BTU/hr.
5. <u>Premix Gas and Air:</u> provide burners to totally pre-mix air and gas required for combustion.
6. Constant Air/Gas radio: Provide burners designed to maintain contrast proportion of fuel gas to filtered combustion air. Introduce both fuel gas and air at atmospheric pressure, and establish flow metering orifices. Design so that if combustion air flow is impeded for any reason, gas flow rate will decrease in contrast proportion to maintain proper gas/air mixture for complete combustion.

B. <u>Burners Controls</u>:

1. Factory Wired: All burners shall be factory wired for 115 volts AC with transformer for 24 volts AC DSI operation and supplied with a grounded 24- 30" in. three wire pigtail located at the rear of burner.

2. Fail-Safe Controls: To assure a high degree of fail-safe operation, the design shall preclude main flow of gas if any of the following abnormal conditions occur:

   a. Power fails (gas valves in burners close in safe position).

   b. Main value fails in open position.

   c. Vacuum pump motor fails. (Vacuum proving switch cuts power to burners).

3. All gas vacuum-firing burner units shall be equipped with a Direct spark Ignition Module (DSI). The DSI module shall have a 15 second flame response time per ignition trial before lockout occurs. In addition, the DSI module shall be capable of a minimum of 3 trials for ignition to provide maximum reliability. The spark shall shut off when the burner flame is establish.

C. <u>Vacuum Pump</u>:

1. <u>Outdoor Venting</u>: The system shall vent all products of combustion outdoors by means of the vacuum pump.

2. <u>Motor</u>: Vacuum pump shall be equipped with a maximum of 3/4 horsepower, 60 hertz, 115 volts AC, 3450 RPM, single phase motor. This motor shall have thermal overload protection, high temperature sealed ball bearings, and shall be constructed in accordance with electric motor industry standards.

3. <u>Housing</u>: The scroll of this pump shall be cast iron with a minimum metal thickness of approximately 3/16 inch. The impeller wheel shall be pressure cast 319 alloy aluminium with a minimum metal thickness of approximately 3/32 inch.

4. <u>Vacuum Proving Switch</u>: As an additional safety measure there will be a low voltage (24 volts) interlock circuit from the vacuum proving switch (located at the inlet to the vacuum pump) to the control panel to prove pump operation.

5. <u>Acoustical Isolation</u>: The vacuum pump shall be acoustically isolated from the system with a flexible connector with a constant service temperature rating of 350°F minimum. The connection between the pump inlet and inlet and tail pipe is made with acoustic boot and clamps provided. The discharge connection is made with a 4.5 inch acoustic boot and schedule 40 steel pipe or 4 inch ABS schedule 5 pipe and fittings. The motor in the vacuum pump shall be secured with rubber mounts of acoustical isolation.

6. <u>Rotation</u>: vacuum pump motor requires a 1 wire grounded circuit 115 volts, single phase, 60 hertz for a maximum of 10 full load amps. This motor must have the same rotation to match the direction of the arrow on the fan scroll. If the motor is not rotating in this direction, it must be reversible by rewiring as shown on the motor nameplate.

D. Reflectors: Provide aluminium, or other highly radiant reflective material reflectors, installed over complete exchanger. Provide reflector joint pieces over heat exchanger fittings such elbows, crosses, and tees, so reflector covers heat exchanger continuously. In order to maximize radiant output and maximize convention losses, reflectors are to be deep dish design.

1. Over entire pipe network: Standard reflectors shall be installed on all radiant pipe as indicated on system layout furnished.

2. Over all fittings: All reflectors at elbows, tees, crosses, and vents and pipe to pump inlet shall have end caps to prevent convective heat from escaping.

3. Side Reflectors: System to have perimeter side extension reflector in certain areas of layout as shown on plan where specified. Side reflectors permanently attach to side of top reflector and are secured to the pipe by three side reflector supports and two “Z” clips for each 8 ft. section of side reflector. To prevent convection losses, tilting of reflectors will not be acceptable.

E. Outsider Air: provide A.G.A. approved fresh outside air system to supply each burner and end vent for the support of combustion.

F. Thermostats: provide where indicated, 24V thermostat, connected to control system. Mount thermostat 5 ft. 6 in. above finish floor or otherwise as noted on the drawing.

1. All thermostats are low voltage bi-mental action with heat anticipator. Low voltage thermostats shall be numbered instead of marked in degrees and shall not have thermometers. Low voltage fittings must follow local codes.

G. Panel Box:

1. Pre-wired Indicator Lights and 4 Temperature Zones: Pre-wired control circuits shall be supplied in a panel box with each vacuum pump. The panel box for the control of the burners shall provide relays and terminals to accommodate up to four temperature zones with thermostat and associated control circuits for the burners for each temperature zone. The control panel shall have indicator lights showing: Power On, Vacuum Pump On, 4-Zones in Operation.

2. Solid State Timer: Pre-purge of the system is obtained from the solid state timer relay located in the furnished panel. The first zone thermostat calling for heat will activate this relay, The pump motor will start and the vacuum proving switch after sensing a minus pressure of 2” in. water column completes the circuit to begin a pre-purge period. After approximately 45 seconds of pre-purge, the 115 volt control circuits will be activated and burners will light automatically. The burners will remain on until the thermostat is satisfied. At that time, the gas valve and DSI will drop out, the pump will continue to run to give a post-purge. This post-purge period of approximately 45 seconds on the last zone thermostat to be satisfied is internally provided by the solid state timer in the panel box.

3. Night Set Back: The low voltage control system furnished is designed to maintain the set point of the thermostat without additional controls added in the field. Night set-back of this system must not be turned off at night or weekends. (Night set-back of not over 5°F may be used on weekends or extended periods of time when the building is not occupied). Any automatic night set-back device would have to be installed outside the control panel and on the 24 volt circuit only to avoid violating A.G.A. certification.

H. Controls: Provide the following functions:

1. Pre-Purge: Pre-purge with air for period of at least 40 seconds (10 air changes minimum) all combustion chambers and heat exchanger pipes connected to vacuum pump prior to initiation of firing sequence.

2. Post-Purge: Post-purge with air for period of at least 40 seconds (10 air changes minimum) all combustion and heat exchanger pipes connected to vacuum pump after shut down of the last burner firing into the vacuum pump.

3. Vacuum Proving: Provide vacuum pump motors with centrifugal switch and/or vacuum proving switch to prevent energizing of gas valvus until pump motor is proven.

I. Radiant Piping - Heat Exchanger:

1. Radiant Pipe and Tail Pipe shall be new 4 in. black steel pipe ASA Schedule 40 ASTM A120 with an emissivity factor of 0.80 or greater. Aluminized pipe or tubing will not be acceptable due to its characteristically lower emissivity factor, Each threaded joint shall be wiped with “Never-Seez” high temperature pipe joint compound

2. Fittings: for radiant piping shall be 150-pound rated screwed malleable iron per Fed. Spec. WW-P521, Type I.

3. Hanging Materials: All systems pipe must be supported in accordance with acceptable practices, local codes, seismic requirements, applicable standards and as shown on plans. Pipe shall pitch down at least 1 in. in 20 ft. on radiant lines, and 2 in. in 2o ft. on manifold and tailfold and tailpipe lines towards vacuum pump.

4. End Vent Assembly: Each open end combustion chamber shall have an approved end vent and the reflector shall terminate with an end cap, and be installed according to manufacturer’s installation instruction and as shown on plans.

J. Condensate Piping:

1. Above Ground: copper tubing type M hard drawn.

   Fittings: ANSI/ASME 816.23 cast brass or ANSI /ASME 816.29, wrought copper

2. Below Ground: Schedule 40 PVC, ASTM D2729.

   Fittings: PVC. Joints: ASTM D2855, solvent weld.

PART 3 - Installation

3.01 Installation of gas Fired Radiant Systems

A. General: Install gas fired radiant systems as indicated, in accordance with manufacturer’s installation instructions, and in compliance with applicable codes and approvals.

B. Support: Suspend heat exchangers burners, gas piping, vacuum pumps, conduit, and reflectors from building substrate as indicated, if not indicated, in manner to provide durable and safe installation; and in accordance with manufacturer’s installation instructions. Mounting height to be a minimum ____________ feet from floor level.

C. Clearance to Combustibles: Do not exceed clearance to combustibles outlined and printed on burner nameplate, and in manufacturer's product data. Measure clearance distance from surface of heat exchangers or as indicated by approval agency's listing.

D. Venting: Install vent piping as indicated. Connect to vacuum pump outlet with 4.5 in. coupling. Terminate where indicated with bird screen cover.

E. Gas Piping: Install gas piping as indicated, and in accordance with manufacturer's installation instructions.

1. Local Codes: Gas supply piping must meet local requirements and be sized in accordance with BTU demand, available pressure, and total length of supply line required for the installation. Connection from supply line to burner unit must be made in accordance with installation instructions. Gas shut off cock, as supplied with unit, and controls in unit must not be subjected to more than 1/2 lb. or 14 in. W.C. preassure. If high pressure testing of gas supply line is required, this test must be made with a plug in the 1/2 inches branch line to each burner. Never test the gas line with the shut off cock in stalled or with the burner unit connected.

2. Dirt Legs: provide dirt legs at all gas risers.

F. Electrical Wiring: Install electrical wiring as indicated. Connect power wiring to burners and vacuum pumps, control wiring between burners, vacuum pumps, control panels, and thermostats, in accordance with manufacturer's wiring diagrams.

1. Provide outlet box with 3-wire grounded 155 VAC receptacle (NEMA Type 5-15R) within 12 in. of each burner.

G. Thermostats: Mount thermostats 5 ft. 6 in. above finished floor, if not otherwise indicated.

H. Thermostat Guards: All thermostats to be covered with a locking thermostat cover made hod 1/16 in. steel.

3.02 Field Quality Control

A. Start-Up: Start-up, test, and adjust gas fired radiant heaters in accordance with manufacturer's start-up instructions, and Utility Company's requirements. Check and calibrate controls, ad just burners if applicable according to manufacturer's instructions for maximum efficiency.

3.03 Closeout Procedures

A. Training: Provide services of manufacturer's technical representative for 1/2 day to instruct operating personnel in operation and maintenance of gas fired radiant, heaters.

1. Schedule training with operating building owner, provide at least 7 days notice.

2 Provide VCR Training Tape of system operation and service.

RG ROBERTS GORDON *15 Year Limited Warranty*

WARRANTY COVERAGE: Roberts- Gordon, Inc. ("Seller") provides warranty agreeing to replace/repair, within warranty period, the following components of Co-Ray-Vac Model B Cast Iron "Classic" Systems (the "Product") as follows:

1. 15 years from date to final acceptance of entire radiant pipe network of 4 in. Schedule 40 ASTM A120 Radiant Pipe and Tail Pipe.
2. 15 years from date of final acceptance of cast iron combustion chambers.
3. 15 years from date of final acceptance of cast iron vacuum pump housing and scroll.
4. 3 years from date of final acceptance of all other components including electrical.

Seller manufactures products which are designed to provide predetermined ranges of heat rises in various enclosures when properly used in systems designed by purchaser or others and installed by others. Seller makes no representation with respect to the effect upon enclosure, or upon any of the effects of the enclosure, including, without limitation, all plant or animal life, kept or processed in the enclosured in the limitations outlined bellow.

WARNING: This warranty is void if the products have been damage due to accident, abuse, mishandling or any other cause whatsoever other than defects in material or workmanship. Specifically, Seller's warranty shall not apply: (a) to damage to Products when used in an atmosphere containing halogenated hydrocarbons or other corrosive chemicals. Some compounds in the air can be ingested into the equipment and can cause an accelerated rate of corrosion of some of the Products. The use of such chemical compounds in or near the enclosure should be avoided where a longer life of the burner, tibing and other parts is deritable; (b) to Products which have been repaired or replaced with other than factory parts, modified in any way, misused or damaged, or which have been installed or used contrary to Seller's written instruction or manuals; or (c) to any damage resulting from improper service or a lack of proper maintenance.

LIMITATION OF WARRANTY: Other than as stated herein or in any other written warranty of seller, there are no other warranties of any kind whatsoever, express or implied, and all other express and all implied warranties of merchantability and or fitness for any particular purpose are hereby specifically disclaimed.

EXCLUSIVE REMEDY: The sole and exclusive remedy for any loss, damage or liability or otherwise, is limited to the obligation of seller to repair or replace parts, at its factory, of any product owned by original buyer and returned to seller's factory within fifteen (15) years after shipment to job site, transportation charges prepaid, which examination reveals to have been defective. Under no circumstances shall seller be liable for any loss, damage, costs, expenses, or incidental or consequential damages of any kind, in connection with the sale, installation, use, maintenance, or repair of any product.

BUYER RESPONSIBLE DATA: Seller and its representatives may furnish Buyer, upon Buyer's request, data relating to the function and use of Products. Seller shall not be liable for loss damage, cost, expenses or incidental or consequential damages of any kind, sustained directly or indirectly, by any person, or to any properly, if Buyer adopts and use such data in whole or in part.

LIMITATIONS ON AUTHORITY OF REPRESENTATIVES: No representative of Seller, other than an Executive Officer, has authority to change or extend these provisions. Change or extension shall be binding only if confirmed in writing by Seller's duly authorized Executive Officer.

Direct any questions or warranty to the original installer:

Company: ______________________________

Address: ______________________________

Phone: ______________________________

Or to: **Warranty Claims, Roberts-Gordon, Inc., 1250 William Street, Buffalo, NY 14206**

Specifying Engineer

MECHANICAL/ELECTRICAL SYSTEM FOR BUILDINGS AND PLANTS * A CAHNERS PUBLICATION

OFFICE OF THE PUBLISHER July 25, 1975

THE FEDERAL COURT VERIFIES THE SPECIFYING ENGINEER'S RESPONSIBILITY AND ACCOUNTABILITY-- CLEARLY AND STRONGLY--A PRECEDENT

On December 14, 1974, the Federal 1st Circuit Court affirmed a very important decision handed down by the United States District Court, Massachusetts in the case of Whitten Corp. vs. Paddock, Inc. (4/12/74). The U.S. Supreme Court several weeks ago rejected further appeal and Circuit Curt. The decision is unique in that it defines the Specifying Engineer's clear authority at the Federal level where relevant previous decisions have been at lower court levels.

Four major judgements regarding specifications develop from this landmark decision:

1. The court ruled that a proprietary specification **(one brand only)** is not a violation of any anti-trust law. Further, the court stated that trained professionals - specifiers- make inform judgements on the systems which best serve their clients' needs.

   Comment:

   Technically, few brands of M/E equipment are exactly alike...if the engineer decides to limit his specification to one source he has the responsibility to do so and to enforce it.

2. The court ruled that other suppliers can qualify as "or equal" ONLY when the specifier chooses to waive specifications or permits the supplier to also bid.

   Comment:

   It is clearly stated here that the contractor cannot decide that another supplier is "equal" to the brand specified--that the specifier is changed with this re sponsibility and judgement. Where "or equal" is stated in the specification it is the engineer's and not the contractor's decision as to what brands or suppliers qualify as equal or don't qualify as equal.

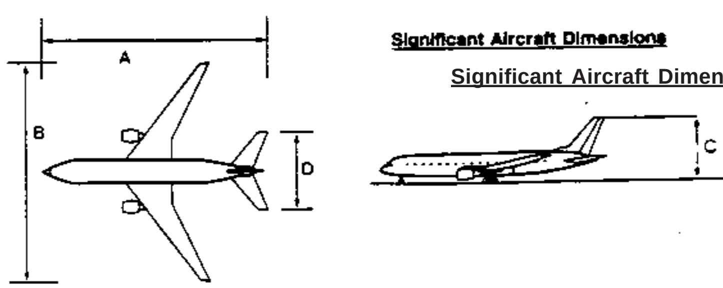
Aviation

Facilities Heating

Appendix

Roberts-Gordon INC
Aircraft Dimension

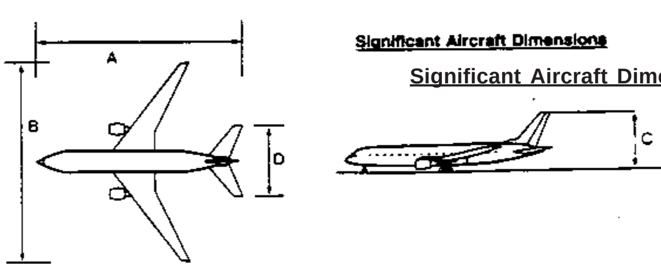
MODEL	TYPE	"A" FT	"A" IN.	"B" FT	"B" IN.	"C" FT	"C" IN.	"D" FT	"D" IN.
****MANUFACTUER AERONICA**									
11 AC CHIEF		20.0	4.0	36.0	1.0	8.0	9.0	0.0	0.0
11 CC SUPER CHIEF		20.0	7.0	36.0	1.0	8.0	9.0	0.0	0.0
15 AC SEDAN		25.0	3.0	37.0	5.0	10.0	3.0	0.0	0.0
7 AC CHAMP		21.0	5.0	35.0	0.0	8.0	9.0	0.0	0.0
7 CNN CHAMP		21.0	5.0	35.0	0.0	8.0	7.0	0.0	0.0
7 DC CHAMP		20.0	5.0	35.0	0.0	8.0	7.0	0.0	0.0
****MANUFACTUER AERBUS**									
A300-600R		117.0	5.0	147.0	1.0	54.0	3.0	0.0	0.0
***MANUFACTURER AIRCOPLE - ALOM**									
415-G		20.0	1.0	30.0	0.0	6.0	3.0	0.0	0.0
A-2		20.0	2.0	30.0	0.0	5.0	1.0	0.0	0.0
F-1		20.0	1.0	30.0	0.0	6.0	3.0	0.0	0.0
****MANUFACTUER BEAGLES**									
B-206- TURBO CHG. TWIN		33.0	8.0	45.0	9.0	11.0	4.0	0.0	0.0
****MANUFACTUER BEECH**									
100 KING AIR		39.0	9.0	45.0	10.0	15.0	4.0	0.0	0.0
1900 KING EXEC. LINER		57.0	10.0	54.0	6.0	14.0	11.0	0.0	0.0
200 SUPER KING AIR		43.0	9.0	54.0	6.0	15.0	0.0	0.0	0.0
300 SUPER KING AIR		43.0	8.0	54.0	5.0	15.0	0.0	0.0	0.0
400		48.0	10.0	43.0	6.0	13.0	10.0	0.0	0.0
400A		43.0	8.0	54.0	5.0	15.0	0.0	0.0	0.0
60 DUKE PRESSURIZED		33.0	10.0	39.0	3.0	12.0	4.0	0.0	0.0
65 QUEEN AIR		33.0	3.0	45.0	10.0	14.0	1.0	0.0	0.0



Significant Aircraft Dimensions

Roberts-Gordon INC
Aircraft Dimension

MODEL	TYPE	"A" FT	"A" IN.	"B" FT	"B" IN.	"C" FT	"C" IN.	"D" FT	"D" IN.
70 QUEEN AIR		35.0	6.0	50.0	3.0	14.0	3.0	0.0	0.0
80 QUEEN AIR		35.0	2.0	50.0	3.0	14.0	6.0	0.0	0.0
88 QUEEN AIR PRESSURIZED		35.0	6.0	50.0	3.0	14.0	3.0	0.0	0.0
90 KING AIR		35.0	6.0	45.0	1.0	14.0	8.0	0.0	0.0
99. AIRLINER & EXEC.		44.0	7.0	45.0	11.0	14.0	3.0	0.0	0.0
99A AIRLINER		44.0	7.0	45.0	11.0	14.0	3.0	0.0	0.0
A 65 QUEEN AIR		35.0	6.0	45.0	10.0	14.0	3.0	0.0	0.0
A 80 QUEEN AIR		35.0	6.0	50.0	3.0	14.0	3.0	0.0	0.0
A 90 KING AIR		35.0	6.0	45.0	1.0	14.0	8.0	0.0	0.0
A DUKE PRESSURIZED		33.0	10.0	39.0	3.0	12.0	4.0	0.0	0.0
A 100 KING AIR		39.0	11.0	45.0	11.0	15.0	5.0	0.0	0.0
B 50 TWIN BONANZA		31.0	5.0	45.0	2.0	11.0	5.0	0.0	0.0
B 60 DUKE PRESSURIZED		33.0	10.0	39.0	4.0	12.0	4.0	0.0	0.0
B 80 QUEEN AIR + SPEC - 1972		35.0	6.0	50.0	3.0	14.0	3.0	0.0	0.0
B 80 QUEEN AIR 1973 - 1978		35.0	6.0	50.0	3.0	14.0	8.0	0.0	0.0
B 90 KING AIR		36.0	6.0	50.0	3.0	14.0	8.0	0.0	0.0
B 99 AIRLINER		44.0	7.0	45.0	11.0	14.0	3.0	0.0	0.0
B100 KING AIR		39.0	11.0	45.0	11.0	15.0	5.0	0.0	0.0
B 200 SUPER KING AIR		43.0	9.0	54.0	6.0	15.0	0.0	0.0	0.0
B 200c		43.0	8.0	54.0	5.0	14.0	0.0	0.0	0.0
B300/350 SUPER KING AIR		46.0	8.0	57.0	11.0	14.0	4.0	0.0	0.0
C 50 BONANZA		31.0	5.0	45.0	2.0	11.0	5.0	0.0	0.0
C 90 KING AIR		35.0	6.0	50.0	3.0	14.0	3.0	0.0	0.0
D18 TWEEN BEECH		33.0	1.0	47.0	7.0	9.0	2.0	0.0	0.0
D 50 A.B.C. E TWIN BONANZA		31.0	5.0	45.0	9.0	11.0	5.0	0.0	0.0
DIANOND IA		48.0	10.0	43.0	6.0	13.0	10.0	0.0	0.0
E 18 SUPER TWIN BEECH		33.0	1.0	49.0	7.0	9.0	2.0	0.0	0.0
E 90 KING AIR		35.0	6.0	50.0	3.0	14.0	3.0	0.0	0.0
E.F.G. 50 TWIN BONANZA		31.0	5.0	45.0	9.0	11.0	5.0	0.0	0.0
SUPERCHANGED									
F 90 KING AIR		39.0	10.0	45.0	11.0	15.0	1.0	0.0	0.0
G 18 SUPER TWIN BEECH		35.0	2.0	49.0	6.0	9.0	4.0	0.0	0.0
H 18 SUPER TWIN BEECH		35.0	2.0	49.0	8.0	9.0	4.0	0.0	0.0
H.J. 5O TWIN BONANZA		31.0	5.0	45.0	9.0	11.0	5.0	0.0	0.0
SUPERCHARGED									
STARSHIP I		46.0	1.0	54.0	5.0	13.0	0.0	0.0	0.0

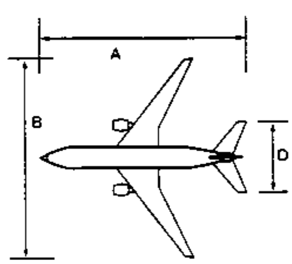


Significant Aircraft Dimensions

Roberts-Gordon INC

Aircraft Dimension

MODEL	TYPE	"A" FT	"A" IN.	"B" FT	"B" IN.	"C" FT	"C" IN.	"D" FT	"D" IN.
**** MANUFACTUER BOING**									
B727	200A	153.0	2.0	18.0	0.0	34.0	0.0	0.0	0.0
B727	200B	153.0	2.0	18.0	0.0	34.0	0.0	0.0	0.0
B727	100	153.0	2.0	18.0	0.0	34.0	0.0	0.0	0.0
B737	300	109.0	7.0	94.0	9.0	36.0	6.0	0.0	0.0
B737	200	100.0	2.0	93.0	0.0	37.0	0.0	0.0	0.0
B747	400	231.0	10.0	211.0	5.0	64.0	3.0	72.0	9.0
B747	SP	184.0	9.0	195.0	8.0	65.0	10.0	0.0	0.0
B757	200	155.0	3.0	124.0	10.0	54.0	1.0	50.0	0.0
B757	200	147.0	10.0	107.0	10.0	29.0	5.0	0.0	0.0
B767	300	180.0	3.0	156.0	1.0	52.0	7.0	61.0	1.0
B767	300ER	180.0	3.0	156.0	4.0	52.0	0.0	0.0	0.0
B767	200ER	159.0	2.0	156.0	4.0	52.0	5.0	0.0	0.0
B767	200	159.0	2.0	156.0	4.0	52.0	5.0	0.0	0.0
B777		240.0	6.0	196.0	11.0	60.0	3.0	70.0	0.5
**** MANUFACTUER CESSMA**									
120		20.0	9.0	32.0	8.0	6.0	3.0	0.0	0.0
140		20.0	9.0	32.0	8.0	6.0	3.0	0.0	0.0
140 A		20.0	9.0	33.0	3.0	6.0	3.0	0.0	0.0
150		21.0	0.0	33.0	4.0	6.0	1.0	0.0	0.0
150 A.-B. -C		23.0	9.0	32.0	5.0	8.0	5.0	0.0	0.0
150 D, -E, -F, -G		23.0	9.0	32.0	5.0	8.0	5.0	0.0	0.0
150 H, J, K (K HGT. 8' 8")		23.0	9.0	32.0	9.0	8.0	0.0	0.0	0.0
150 J FLOAT PLANE		24.0	1.0	32.0	9.0	9.0	1.0	0.0	0.0
150 L (71 HGT 8' 8")		23.0	9.0	33.0	2.0	8.0	0.0	0.0	0.0
150 M, A15OM AERONAT SPAN 32'9"		23.0	11.0	33.0	2.0	8.0	6.0	0.0	0.0
152, A152 (ALL W/CONICAL WING TIPS)		24.0	1.0	33.0	2.0	8.0	6.0	0.0	0.0
170, -A, B		25.0	0.0	36.0	0.0	6.0	5.0	0.0	0.0
172 B		26.0	5.0	36.0	0.0	8.0	6.0	0.0	0.0
172 C		26.0	5.0	36.0	0.0	8.0	6.0	0.0	0.0
172 I SKYWALK		26.0	11.0	36.0	2.0	8.0	11.0	0.0	0.0
172 K 7 L FLOAT PLANE		26.0	7.0	35.0	9.0	10.0	0.0	0.0	0.0



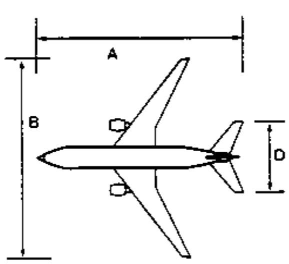
Significant Aircraft Dimensions

Significant Aircraft Dimensions

Roberts-Gordon INC

Aircraft Dimension

MODEL	TYPE	"A" FT	"A" IN.	"B" FT	"B" IN.	"C" FT	"C" IN.	"D" FT	"D" IN.
172 K & L SKYHAWK		26.0	11.0	35.0	9.0	8.0	9.0	0.0	0.0
172 M FLOAT PLANE (1973)		27.0	0.0	35.0	9.0	9.0	11.0	0.0	0.0
172 M FLOAT PLANE (1974-76)		27.0	0.0	35.0	10.0	9.0	11.0	0.0	0.0
172 M SKYHAWK		26.0	11.0	35.0	10.0	8.0	10.0	0.0	0.0
172 P II SKYHAWK		26.0	11.0	35.0	10.0	8.0	10.0	0.0	0.0
172 RG II CUTGLASS		25.0	5.0	35.0	10.0	10.0	10.0	0.0	0.0
172, -A		25.0	0.0	36.0	0.0	8.0	5.0	0.0	0.0
172, -D, -E, -F, -G, -H		26.0	6.0	36.0	2.0	8.0	11.0	0.0	0.0
172N-P/ HAWK 100 (FLOAT PLANE 1978 & UP)		26.0	8.0	35.0	10.0	11.0	11.0	0.0	0.0
172/ HAWK 100 THRU 80		26.0	11.0	35.0	10.0	8.0	10.0	0.0	0.0
175 C		25.0	0.0	36.0	0.0	8.0	5.0	0.0	0.0
175, -A, -B		25.0	0.0	36.0	0.0	8.0	5.0	0.0	0.0
177 B CARDENAL (THRU 74)		27.0	3.0	35.0	6.0	8.0	7.0	0.0	0.0
177 CARDENAL		27.0	0.0	35.0	7.0	9.0	1.0	0.0	0.0
177 CARDENAL (1975-78 SPECS)		27.0	3.0	35.0	6.0	8.0	7.0	0.0	0.0
177 R.G. CARDENAL		27.0	3.0	35.0	6.0	8.0	7.0	0.0	0.0
177 R.G. CARDENAL (1972-78)		27.0	3.0	35.0	6.0	8.0	7.0	0.0	0.0
177A CARDENAL		27.0	0.0	35.0	7.0	9.0	1.0	0.0	0.0
180		26.0	0.0	36.0	0.0	7.0	5.0	0.0	0.0
180 A, -B, -C, -D, -E, -F		26.0	0.0	36.0	0.0	7.0	5.0	0.0	0.0
180 G, -N		25.0	6.0	36.0	2.0	7.0	6.0	0.0	0.0
180J, K AMPHIB (WATER)		27.0	0.0	35.0	10.0	12.0	2.0	0.0	0.0
180J, K		25.0	8.0	35.0	10.0	7.0	9.0	0.0	0.0
180J, K (SKI)		27.0	10.0	35.0	10.0	7.0	9.0	0.0	0.0
180K-78 UP AMPHIS AND FLOAT		27.0	6.0	35.0	10.0	12.0	8.0	0.0	0.0
182		26.0	0.0	36.0	0.0	8.0	5.0	0.0	0.0
182 N SKYLANE		28.0	1.0	35.0	10.0	8.0	9.0	0.0	0.0
182A, B, C, D		26.0	0.0	36.0	0.0	8.0	5.0	0.0	0.0
182E, F, G, H		27.0	4.0	36.0	2.0	9.0	0.0	0.0	0.0
182J, K, L, M (SKYLANE)		28.0	5.0	36.0	2.0	8.0	1.0	0.0	0.0
182P, Q THRU 1980		28.0	0.0	35.0	10.0	9.0	3.0	0.0	0.0
182Q II (1981 & UP)		28.0	0.0	35.0	10.0	9.0	3.0	0.0	0.0
185 A, B, C, D, SKYWAGON		25.0	5.0	36.0	0.0	7.0	6.0	0.0	0.0
185 E SKYWAGON		25.0	6.0	36.0	2.0	7.0	7.0	0.0	0.0
A 185 E SKYWAGON		25.0	6.0	36.0	2.0	7.0	9.0	0.0	0.0



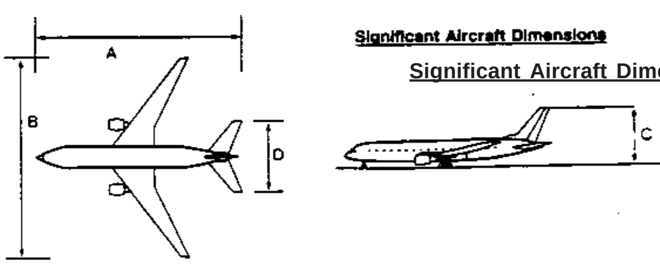
Significant Aircraft Dimensions

Significant Aircraft Dimensions

Roberts-Gordon INC

Aircraft Dimension

MODEL	TYPE	"A" FT	"A" IN.	"B" FT	"B" IN.	"C" FT	"C" IN.	"D" FT	"D" IN.
7 GCAA		22.0	8.0	33.0	5.0	6.0	8.0	0.0	0.0
7 GCB SKYTRAC		22.0	9.0	34.0	5.0	6.0	1.0	0.0	0.0
7 GCBC CITABRIA		22.0	7.0	34.0	3.0	6.0	7.0	0.0	0.0
7 GCBC WITH EDO FLOATS		22.0	7.0	35.0	5.0	6.0	8.0	0.0	0.0
7 KCAB CITABRIA		22.0	8.0	33.0	5.0	6.0	8.0	0.0	0.0
****MANUFACTUER DE HAVILLAND**									
DHC 6-200 TWIN OTTER		51.0	9.0	65.0	0.0	18.0	7.0	0.0	0.0
DHC 6-300 TWIN OTTER (THRU 1976)		51.0	9.0	65.0	0.0	18.0	7.0	0.0	0.0
DHC 6-300 TWIN OTTER STD.		51.0	9.0	65.0	0.0	19.0	6.0	0.0	0.0
****MANUFACTUER EMBRAER**									
EMB - 111OP1 BANDEIRANTE		49.0	6.0	50.0	3.0	16.0	2.0	0.0	0.0
****MANUFACTURER EXCALIBUR**									
EXCALIBUR '800' CONV. BEECH TWIN BONANZA		31.0	5.0	46.0	0.0	11.0	3.0	0.0	0.0
EXCALIBUR CONV. BEECH TWIN BONANZA		31.0	5.0	46.0	0.0	11.0	3.0	0.0	0.0
QUEEN AIR '800' CANV. BEECH 65, A65, 70, 80		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
QUEEN AIR '8800' CONV. BEECH A80, B80		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
**** MANUFATUER FALCON**									
2000		63.0	1.0	63.0	5.0	22.0	11.0	0.0	0.0
900		63.0	4.0	63.0	5.0	24.0	9.0	0.0	0.0
FALCON FAN F "20"		53.0	3.0	53.0	5.0	17.0	5.0	0.0	0.0
FALCON FAN JET "10"		45.0	3.0	42.0	10.0	15.0	2.0	0.0	0.0
FALCON FAN JET "20" (76-77)		45.0	6.0	42.0	9.0	14.0	6.0	0.0	0.0
FALCON FAN JET "50" (3 ENG-FAN JET)		60.0	9.0	61.0	10.0	22.0	11.0	0.0	0.0
FALCON FAN JET C "20"		56.0	3.0	53.0	6.0	17.0	8.0	0.0	0.0
FALCON FAN JET D "20"		56.0	3.0	53.0	6.0	17.0	8.0	0.0	0.0
FALCON FAN JET F "20" (THRU 1975)		56.0	3.0	53.0	5.0	17.0	5.0	0.0	0.0

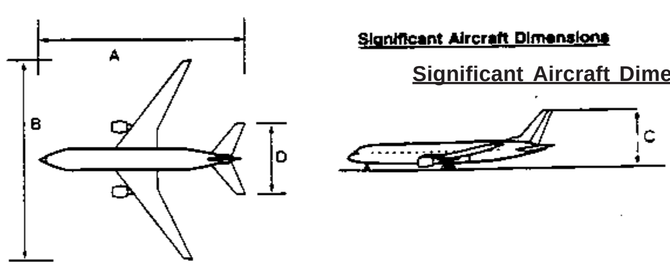


Significant Aircraft Dimensions

Roberts-Gordon INC

Aircraft Dimension

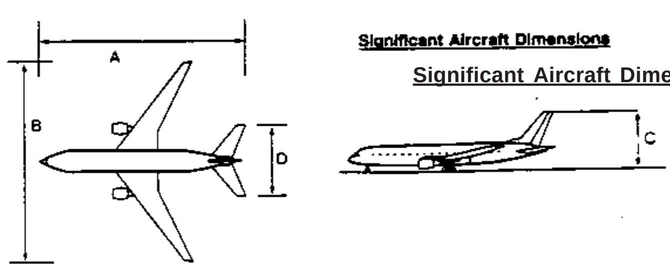
MODEL	TYPE	"A" FT	"A" IN.	"B" FT	"B" IN.	"C" FT	"C" IN.	"D" FT	"D" IN.
**** MANUFACTUER GATES LEAR JET**									
23 TWIN JET		43.0	2.0	37.0	5.0	12.0	0.0	0.0	0.0
24B		43.0	3.0	35.0	7.0	12.0	7.0	0.0	0.0
24C		43.0	3.0	35.0	6.0	12.0	6.0	0.0	0.0
24D (1973 THRU 1975)		43.0	3.0	35.0	7.0	12.0	3.0	0.0	0.0
24E		43.0	3.0	35.0	6.0	12.0	3.0	0.0	0.0
24F		43.0	2.0	35.0	6.0	12.0	3.0	0.0	0.0
24 TWIN JET		43.0	2.0	35.0	7.0	12.0	6.0	0.0	0.0
25 B&C (THRU 1972)		47.0	6.0	35.0	6.0	12.0	6.0	0.0	0.0
25 B (1973 THRU 1975)		47.0	6.0	35.0	7.0	12.0	3.0	0.0	0.0
25 C (1973 THRU 1975)		47.0	6.0	35.0	7.0	12.0	3.0	0.0	0.0
25 D, F		47.0	7.0	35.0	0.0	12.0	3.0	0.0	0.0
25 G		47.0	7.0	35.0	7.0	12.0	3.0	0.0	0.0
28 LONGHORN		47.0	7.0	43.0	9.0	12.0	3.0	0.0	0.0
29 LONGHORN		47.0	7.0	43.0	9.0	12.0	3.0	0.0	0.0
31		48.0	8.0	43.0	9.0	12.0	3.0	0.0	0.0
35		48.0	7.0	39.0	5.0	12.0	3.0	0.0	0.0
35 A		48.0	8.0	39.0	6.0	12.0	3.0	0.0	0.0
36		48.0	7.0	39.0	5.0	12.0	3.0	0.0	0.0
36 A		48.0	8.0	39.0	6.0	12.0	3.0	0.0	0.0
55		55.0	1.0	43.0	9.0	14.0	8.0	0.0	0.0
****MANUFACTUER GULFSTREAM AG-CATS**									
G164-450 AG-CAT		24.0	4.0	35.0	11.0	11.0	0.0	0.0	0.0
G164A-220 AG-CAT		24.0	4.0	35.0	8.0	10.0	9.0	0.0	0.0
G164A-245 AG-CAT		24.0	4.0	35.0	8.0	10.0	9.0	0.0	0.0
G164A-275 AG-CAT		24.0	4.0	35.0	8.0	10.0	9.0	0.0	0.0
G164A-275 AG-CAT		24.0	4.0	35.0	8.0	10.0	9.0	0.0	0.0
G164A-300 AG-CAT		24.0	4.0	35.0	8.0	10.0	9.0	0.0	0.0
G164A-600 AG-CAT		24.0	4.0	35.0	11.0	11.0	10.0	0.0	0.0
G164B-450 AG-CAT SPRAYER		25.0	7.0	42.0	3.0	11.0	0.0	0.0	0.0
G164B-525		26.0	1.0	42.0	3.0	0.0	0.0	0.0	0.0
G164B-600 AG-CAT SPRAYER		25.0	7.0	42.0	3.0	11.0	0.0	0.0	0.0
G164C-600 AG-CAT SPRAYER		30.0	0.0	42.0	3.0	11.0	5.0	0.0	0.0



Significant Aircraft Dimensions

Roberts-Gordon INC
Aircraft Dimension

MODEL	TYPE	"A" FT	IN.	"B" FT	IN.	"C" FT	IN.	"D" FT	IN.
**** MANUFACTUER GULFSTREAM AMERICAN**									
1000 JET PROP		42.0	11.0	52.0	1.0	14.0	11.0	0.0	0.0
112		24.0	11.0	32.0	9.0	8.0	5.0	0.0	0.0
112A		24.0	10.0	32.0	9.0	8.0	5.0	0.0	0.0
12B		25.0	1.0	35.0	7.0	8.0	5.0	0.0	0.0
112TC, -A, ALPINE		25.0	1.0	35.0	7.0	8.0	5.0	0.0	0.0
114		25.0	1.0	32.0	9.0	8.0	5.0	0.0	0.0
114A, GRAN TURISMO		25.0	1.0	32.0	9.0	8.0	5.0	0.0	0.0
500		35.0	1.0	49.0	0.0	14.0	5.0	0.0	0.0
500 A		35.0	1.0	49.0	5.0	14.0	5.0	0.0	0.0
500 B		35.0	1.0	49.0	5.0	14.0	9.0	0.0	0.0
500 $ SHRIKE COMMANDER & (ESQUIRE - 1976)		36.0	10.0	49.0	1.0	14.0	6.0	0.0	0.0
500 U		35.0	1.0	49.0	11.0	14.0	6.0	0.0	0.0
520		35.0	5.0	44.0	1.0	14.0	5.0	0.0	0.0
560		35.0	5.0	44.0	1.0	14.0	5.0	0.0	0.0
560 A		35.0	1.0	44.0	1.0	14.0	5.0	0.0	0.0
560 A-HC		35.0	1.0	49.0	0.0	14.0	5.0	0.0	0.0
560 E		35.0	1.0	49.0	0.0	14.0	5.0	0.0	0.0
560 F		35.0	5.0	49.0	5.0	14.0	5.0	0.0	0.0
680 E		35.0	5.0	49.0	0.0	14.0	5.0	0.0	0.0
680 F		35.0	5.0	49.0	5.0	14.0	5.0	0.0	0.0
680 FL COURSER		41.0	6.0	49.0	3.0	14.0	6.0	0.0	0.0
680 FL GRAND		41.0	3.0	49.0	5.0	14.0	5.0	0.0	0.0
680 FL GRAND		41.0	3.0	49.0	5.0	14.0	5.0	0.0	0.0
680 FLP PRESSURIZED GRAND		41.0	3.0	49.0	6.0	14.0	9.0	0.0	0.0
680 SUPER		35.0	1.0	44.0	1.0	14.0	5.0	0.0	0.0
680 T PROP JET		41.0	3.0	49.0	6.0	14.0	6.0	0.0	0.0
680 W TURBO II PROP JET		43.0	0.0	44.0	0.0	14.0	6.0	0.0	0.0
681 HAWK, 681 TURBO CAOMMANDER		43.0	0.0	44.0	1.0	14.0	6.0	0.0	0.0
685 PRESSURIZED		43.0	0.0	46.0	7.0	14.0	11.0	0.0	0.0
690A, POP JET		44.0	4.0	46.0	7.0	14.0	10.0	0.0	0.0
690B, I, II POP JET		44.0	4.0	46.0	8.0	14.0	11.0	0.0	0.0
720 ALTI-CRUISER		35.0	1.0	49.0	0.0	14.0	5.0	0.0	0.0
840 JET PROP		42.0	11.0	52.0	1.0	14.0	11.0	0.0	0.0
980 JET PROP		42.0	11.0	52.0	1.0	14.0	11.0	0.0	0.0
AA - 1 YANKEE		19.0	3.0	24.0	5.0	6.0	8.0	0.0	0.0

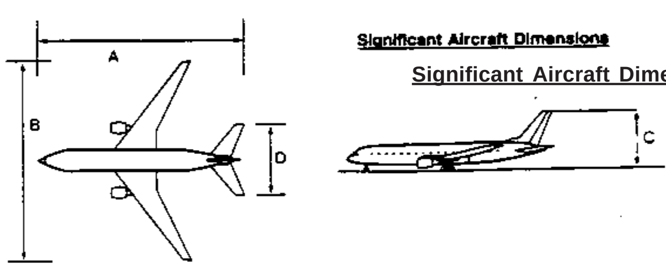


Significant Aircraft Dimensions

Roberts-Gordon INC

Aircraft Dimension

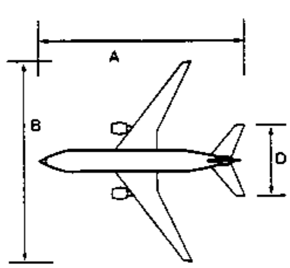
MODEL	TYPE	"A" FT	IN.	"B" FT	IN.	"C" FT	IN.	"D" FT	IN.
AA - 1A TRAINER		19.0	3.0	24.0	5.0	6.0	8.0	0.0	0.0
AA - 1B TRAINER		19.0	2.0	24.0	5.0	7.0	6.0	0.0	0.0
AA 1C LYNX		19.0	2.0	24.0	5.0	7.0	6.0	0.0	0.0
AA 1C/T - CAT		19.0	2.0	24.0	5.0	7.0	6.0	0.0	0.0
AA5 TRAVELER		22.0	0.0	31.0	5.0	8.0	0.0	0.0	0.0
AA5A CHEETAN		22.0	0.0	31.0	6.0	7.0	6.0	0.0	0.0
AA5B TIGER		22.0	0.0	31.0	6.0	7.0	7.0	0.0	0.0
G I		63.0	9.0	78.0	4.0	23.0	4.0	0.0	0.0
G II		79.0	11.0	68.0	10.0	24.0	6.0	0.0	0.0
G III		83.0	1.0	77.0	10.0	24.0	4.0	0.0	0.0
G IV		88.0	4.0	77.0	10.0	24.0	10.0	0.0	0.0
GA - 7 COUGAR (TWIN)		29.0	7.0	36.0	9.0	10.0	4.0	0.0	0.0
TR - 2AA 1B		19.0	2.0	24.0	5.0	7.0	6.0	0.0	0.0
** MANUFACTUER ISRAEL COMMODORE JET									
1121 JET COMMANDER		50.0	5.0	43.0	3.0	15.0	9.0	0.0	0.0
CJ 1121 B COMMODORE JET COMMANDER		50.0	5.0	43.0	3.0	15.0	9.0	0.0	0.0
CJ 1123		52.0	3.0	44.0	8.0	15.0	9.0	0.0	0.0
WESTWIND II		52.0	3.0	44.0	10.0	15.0	9.0	0.0	0.0
**MANUFACTUER LAKE									
C - I AMPHIBIAN		23.0	6.0	34.0	0.0	8.0	1.0	0.0	0.0
C - IV AMPHIBIAN		23.0	6.0	34.0	0.0	8.0	1.0	0.0	0.0
LA - 4 AMPHIBIAN		24.0	11.0	38.0	0.0	9.0	4.0	0.0	0.0
LA - 4 SEAPLANE		24.0	11.0	38.0	0.0	8.0	5.0	0.0	0.0
LA - 4 TURBO - LAKE		24.0	11.0	38.0	0.0	9.0	4.0	0.0	0.0
LA - 4 - 200 BUCCANEER		24.0	11.0	38.0	0.0	9.0	4.0	0.0	0.0
LA - 4 - 200 BUCCANEER 1973 & PRIOR		24.0	11.0	38.0	0.0	9.0	4.0	0.0	0.0
** MANUFACTUER LUSCOMBE									
8 A		19.0	8.0	34.0	7.0	6.0	1.0	0.0	0.0
8 E		19.0	8.0	34.0	7.0	6.0	1.0	0.0	0.0
8 F		20.0	0.0	35.0	0.0	6.0	3.0	0.0	0.0



Significant Aircraft Dimensions

Roberts-Gordon INC
Aircraft Dimension

MODEL	TYPE	"A"		"B"		"C"		"D"	
		FT	IN.	FT	IN.	FT	IN.	FT	IN.
** MANUFACTUER LAKE									
C -I AMPHIBIAN		23.0	6.0	34.0	0.0	8.0	1.0	0.0	0.0
C -IV AMPHIBIAN		23.0	6.0	34.0	0.0	8.0	1.0	0.0	0.0
LA - 4 AMPHIBIAN		24.0	11.0	38.0	0.0	9.0	4.0	0.0	0.0
LA - 4 SEAPLANE		24.0	11.0	38.0	0.0	8.0	5.0	0.0	0.0
LA - 4 TURBO LAKE		24.0	11.0	38.0	0.0	9.0	4.0	0.0	0.0
LA - 4 - 200 BUCCANEER		24.0	11.0	38.0	0.0	9.0	4.0	0.0	0.0
LA - 4 - 200 BUCCANEER 1973 & PRIOR		24.0	11.0	38.0	0.0	9.0	4.0	0.0	0.0
** MANUFACTUER LUSCOMBE									
8 A		19.0	8.0	34.0	7.0	6.0	1.0	0.0	0.0
8 E		19.0	8.0	34.0	7.0	6.0	1.0	0.0	0.0
8 F		20.0	0.0	35.0	0.0	6.0	3.0	0.0	0.0
** MANUFACTUER MAULE									
M - 4 & M - 4C JETASEN		22.0	0.0	29.0	8.0	6.0	2.0	0.0	0.0
M - 4 180C ASTRO ROCKET		22.0	6.0	29.0	8.0	6.0	2.0	0.0	0.0
M - 4 210C ROCKET		22.0	0.0	29.0	8.0	6.0	2.0	0.0	0.0
M - 4 220C STRATA ROCKET		22.0	0.0	29.0	8.0	6.0	2.0	0.0	0.0
M - 5 210 LUNAR ROCKET		22.0	9.0	30.0	10.0	6.0	4.0	0.0	0.0
M - 5 220C LUNAR ROCKET		23.0	2.0	30.0	10.0	6.0	4.0	0.0	0.0
M - 5 235C		23.0	6.0	30.0	10.0	6.0	4.0	0.0	0.0
** MANUFACTUER MCDONNELL DOUGLAS									
DC10 - 10		182.0	3.0	155.0	4.0	37.0	5.0	0.0	0.0
DC10 - 30		181.0	3.0	155.0	4.0	37.0	5.0	0.0	0.0
MD - 11		201.0	4.0	169.0	10.0	57.0	11.0	0.0	0.0
MD - 82		147.0	10.0	107.0	10.0	29.0	5.0	0.0	0.0
MD - 83		147.0	10.0	107.0	10.0	29.0	5.0	0.0	0.0
MD - 90 530		147.0	10.0	107.0	10.0	29.0	5.0	0.0	0.0
MD - 90 250		147.0	10.0	107.0	10.0	29.0	5.0	0.0	0.0
** MANUFACTUER MITSUBISHI									
MARQUISE (MU-2B-60)		39.0	5.0	39.0	2.0	13.0	8.0	0.0	0.0
MU-2B, -2D		33.0	3.0	39.0	2.0	13.0	0.0	0.0	0.0
MU-2F		33.0	3.0	39.0	2.0	12.0	11.0	0.0	0.0



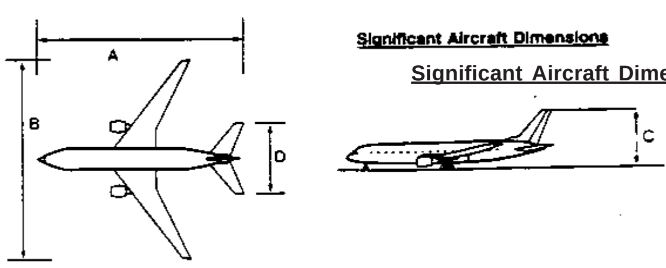
Significant Aircraft Dimensions

Significant Aircraft Dimensions

Roberts-Gordon INC

Aircraft Dimension

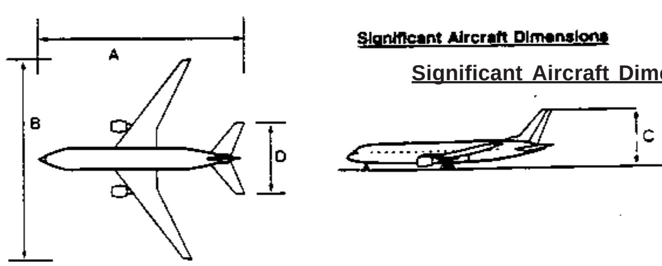
MODEL	TYPE	"A"		"B"		"C"		"D"	
		FT	IN.	FT	IN.	FT	IN.	FT	IN.
MU - 2G		39.0	5.0	39.0	2.0	13.0	8.0	0.0	0.0
MU - 2J		39.0	5.0	39.0	2.0	13.0	8.0	0.0	0.0
MU - 2K		33.0	3.0	39.0	2.0	12.0	11.0	0.0	0.0
MU - 2L, -2M		39.0	5.0	39.0	2.0	13.0	8.0	0.0	0.0
MU - 2M, - 2P		33.0	3.0	39.0	2.0	12.0	11.0	0.0	0.0
MU - 300 DIAMOND I		48.0	4.0	43.0	5.0	13.0	9.0	0.0	0.0
SOLITAIRE (MU- 2B-40)		33.0	3.0	39.0	2.0	12.0	11.0	0.0	0.0
** MANUFACTUER MOONEY									
231 (M20K) TURBO CHG.		25.0	5.0	36.0	1.0	8.0	4.0	0.0	0.0
A 2-A CADET		20.0	0.0	30.0	0.0	6.0	3.0	0.0	0.0
M-10 CADET		20.0	8.0	30.0	0.0	6.0	3.0	0.0	0.0
M-20-A MARK 20A		23.0	1.0	35.0	0.0	8.0	3.0	0.0	0.0
M-20-B MARK 21		23.0	2.0	35.0	0.0	8.0	4.0	0.0	0.0
M-20-C MARK 21		23.0	2.0	35.0	0.0	8.0	4.0	0.0	0.0
M-20-C RANGER (THRU 76)		23.0	2.0	35.0	0.0	8.0	4.0	0.0	0.0
M-20-D MASTER		23.0	2.0	35.0	0.0	8.0	4.0	0.0	0.0
M-20-E SUPER 21		23.0	2.0	35.0	0.0	8.0	4.0	0.0	0.0
M-20-G SUPERSMAN		24.0	3.0	35.0	0.0	8.0	4.0	0.0	0.0
M-20- MARK 20		23.0	1.0	35.0	0.0	8.0	3.0	0.0	0.0
M-200-E CHAPARRAL		23.0	2.0	35.0	0.0	8.0	4.0	0.0	0.0
M-20-C RANGER (77-78)		23.0	2.0	35.0	0.0	8.0	4.0	0.0	0.0
M-20F EXECUTIVE 21		24.0	0.0	35.0	0.0	8.0	4.0	0.0	0.0
M-22 PRESSURIZED		26.0	1.0	35.0	0.0	9.0	1.0	0.0	0.0
M-20-B MARK 21		23.0	2.0	35.0	0.0	8.0	4.0	0.0	0.0
M18 MITE		17.0	7.0	26.0	1.0	6.0	2.0	0.0	0.0
M20J "201"		24.0	8.0	36.0	1.0	8.0	4.0	0.0	0.0
** MANUFACTUER NAVON									
A		27.0	3.0	33.0	3.0	8.0	5.0	0.0	0.0
B		27.0	3.0	33.0	3.0	8.0	5.0	0.0	0.0
G, G-1 RANGEMASTER		27.0	5.0	34.0	5.0	8.0	5.0	0.0	0.0
H, RANGEMASTER (1975-76)		27.0	5.0	34.0	9.0	8.0	6.0	0.0	0.0
** MANUFACTUER PILATUS									
PC 61 B2-N4		35.0	9.0	52.0	1.0	10.0	6.0	0.0	0.0
PC 7 TURBO TRAINER		32.0	1.0	34.0	1.0	10.0	6.0	0.0	0.0



Significant Aircraft Dimensions

Roberts-Gordon INC
Aircraft Dimension

MODEL	TYPE	"A" FT	"A" IN.	"B" FT	"B" IN.	"C" FT	"C" IN.	"D" FT	"D" IN.
PA 23 D, E AZTEC		31.0	2.0	37.0	2.0	10.0	3.0	0.0	0.0
PA 23 F TURBO AZTEC		31.0	2.0	37.0	4.0	10.0	1.0	0.0	0.0
PA 23 - 150 APACHE		27.0	4.0	37.0	1.0	9.0	6.0	0.0	0.0
PA 23 - 160 G, -H APACHE		27.0	4.0	37.0	1.0	9.0	6.0	0.0	0.0
PA 23 - 235 APACHE		27.0	7.0	37.0	1.0	10.0	3.0	0.0	0.0
PA 24 - 180 COMANCHE		24.0	9.0	36.0	0.0	7.0	3.0	0.0	0.0
PA 24 - 250 COMANCHE		24.0	1.0	36.0	0.0	7.0	3.0	0.0	0.0
PA 24 - 260, B -260		25.0	3.0	36.0	0.0	7.0	3.0	0.0	0.0
PA 24 - 400, COMACHE		25.0	8.0	36.0	0.0	7.0	1.0	0.0	0.0
PA 24 - C 260 COMACHE		25.0	8.0	36.0	0.0	7.0	3.0	0.0	0.0
PA 25 150 PAWEE		24.0	7.0	36.0	2.0	7.0	2.0	0.0	0.0
PA 25 - 235 C, D PAWEE		24.0	8.0	36.0	2.0	7.0	2.0	0.0	0.0
PA 25 - 260 C, D PAWEE		24.0	7.0	36.0	2.0	7.0	2.0	0.0	0.0
PA 28 140 CHEROKEE CRUISER		23.0	3.0	30.0	0.0	7.0	3.0	0.0	0.0
PA 28 140 CHEROKEE LOW GROSS		23.0	3.0	30.0	0.0	7.0	3.0	0.0	0.0
PA 28 140, B, C, D, E		23.0	3.0	30.0	0.0	7.0	3.0	0.0	0.0
PA 28 140-4 CHEROKEE-HIGH GROSS		23.0	3.0	30.0	0.0	7.0	3.0	0.0	0.0
PA 28 B, C 180 CHEROKEE		23.0	3.0	30.0	0.0	7.0	3.0	0.0	0.0
PA 28 C 150 CHEROKEE		23.0	3.0	30.0	0.0	7.0	3.0	0.0	0.0
PA 28 C 150, B 150 CHEROKEE		23.0	3.0	30.0	0.0	7.0	3.0	0.0	0.0
PA 28 C 160 CHEROKEE		23.0	3.0	30.0	0.0	7.0	3.0	0.0	0.0
PA 28 C 160 B 160 CHEROKEE		23.0	3.0	30.0	0.0	7.0	3.0	0.0	0.0
PA 28 D 180 , E, F, G		23.0	5.0	30.0	0.0	7.0	3.0	0.0	0.0
PA - 28- 151 "WARRIOR"		23.0	8.0	35.0	0.0	7.0	3.0	0.0	0.0
PA - 28- 161 "WARRIOR II"		23.0	10.0	35.0	0.0	7.0	4.0	0.0	0.0
PA - 28- 180 CHALLENGER & ARCHER		24.0	0.0	32.0	0.0	7.0	8.0	0.0	0.0
PA - 28- 180R &RB ARROW		24.0	2.0	30.0	0.0	8.0	0.0	0.0	0.0
PA - 28- 181 ARCHER II		23.0	10.0	35.0	0.0	7.0	5.0	0.0	0.0
PA - 28- 200 R ARROR II (1973-76)		24.0	6.0	32.0	0.0	8.0	0.0	0.0	0.0
PA - 28- 200 & RB ARROW		24.0	2.0	30.0	0.0	8.0	0.0	0.0	0.0
PA - 28- 201T TURBO DAKOTA		25.0	0.0	35.0	0.0	7.0	7.0	0.0	0.0
PA - 28- 235 "CHANGER"		24.0	1.0	32.0	0.0	7.0	8.0	0.0	0.0
PA - 28- 235 B CHEROKEE		23.0	8.0	32.0	0.0	7.0	3.0	0.0	0.0
PA - 28- 235 C & D, E & F		23.0	7.0	32.0	0.0	7.0	3.0	0.0	0.0
PA - 28- 235 PATHFINDER		24.0	1.0	32.0	0.0	7.0	5.0	0.0	0.0



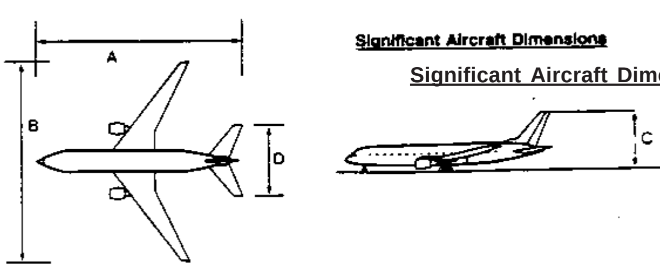
Significant Aircraft Dimensions

Significant Aircraft Dimensions

Roberts-Gordon INC

Aircraft Dimension

MODEL	TYPE	"A" FT	"A" IN.	"B" FT	"B" IN.	"C" FT	"C" IN.	"D" FT	"D" IN.
PA-28-236 DAKOTA		24.0	8.0	35.0	5.0	7.0	2.0	0.0	0.0
PA-28 R, -RT, 201T TURBO ARROW III, IV		27.0	4.0	35.0	5.0	8.0	4.0	0.0	0.0
PA-28 R, 201 ARROW III, 28RT- 201 ARROW IV		27.0	0.0	35.0	5.0	8.0	4.0	0.0	0.0
PA-30 B TWIN COMACHE		25.0	1.0	36.0	0.0	7.0	3.0	0.0	0.0
PA-30 C TURBO TWIN COMACHE		25.0	1.0	36.0	8.0	8.0	2.0	0.0	0.0
PA-30 C TWIN COMACHE		25.0	1.0	36.0	0.0	8.0	2.0	0.0	0.0
PA-300 B TURBO TWIN COMACHE		25.0	1.0	36.0	8.0	7.0	3.0	0.0	0.0
PA-31 P PRESS NAVAJO		34.0	5.0	40.0	7.0	13.0	3.0	0.0	0.0
PA-31 T-620 CHEYENNE II		34.0	8.0	42.0	8.0	12.0	9.0	0.0	0.0
PA-31 T-620 XL CHEYENNE II XL		36.0	10.0	42.0	8.0	12.0	10.0	0.0	0.0
PA-31- 300 NAVAJO		32.0	6.0	40.0	6.0	13.0	0.0	0.0	0.0
PA-31- 310 TURBO NAVAJO		32.0	6.0	40.0	6.0	13.0	0.0	0.0	0.0
PA-31- 310 TURBO NAVAJO B,C		32.0	7.0	40.0	8.0	13.0	0.0	0.0	0.0
PA-31- 325 NAVAJO C/R		32.0	7.0	40.0	8.0	13.0	9.0	0.0	0.0
PA-31- 350 CHLEFTAIN		34.0	7.0	40.0	8.0	13.0	0.0	0.0	0.0
PA-31T- 500-1CHEYENNE I		34.0	8.0	40.0	8.0	12.0	9.0	0.0	0.0
PA-32 - 260 (1974-78)		27.0	7.0	32.0	8.0	8.0	2.0	0.0	0.0
PA-32 - 260, C, D, E & 1973 (C/S PROP)		27.0	7.0	32.0	8.0	7.0	9.0	0.0	0.0
PA-32 - 300		27.0	8.0	32.0	10.0	8.0	2.0	0.0	0.0
PA-32 - 300, B, C, D, E CHEROKEE SIX		27.0	7.0	32.0	8.0	7.0	9.0	0.0	0.0
PA-32 - 301 SARATOGA		27.0	8.0	36.0	2.0	8.0	2.0	0.0	0.0
PA-32 - 301T TURBO SARATOGA		28.0	2.0	36.0	2.0	8.0	2.0	0.0	0.0
PA-32R, RT II-300 LANCE		28.0	3.0	32.0	10.0	9.0	6.0	0.0	0.0
PA-32R-301 SARATOGA SP		27.0	8.0	36.0	2.0	8.0	6.0	0.0	0.0
PA-32R-301 T TURBO SARATOGA SP		28.0	4.0	36.0	2.0	8.0	6.0	0.0	0.0
PA-32RT-300T TURBO LANCE II		29.0	0.0	32.0	10.0	9.0	6.0	0.0	0.0
PA-34 C/R SENECA (1973-1974)		28.0	6.0	38.0	11.0	9.0	11.0	0.0	0.0
PA-34 - 200 C/R SENECA (1972)		28.0	6.0	38.0	11.0	9.0	11.0	0.0	0.0
PA-34 - 220 C/R SENECA III		28.0	7.0	38.0	11.0	9.0	1.0	0.0	0.0
PA-34 - 220T SENECA III		28.0	7.0	38.0	11.0	9.0	11.0	0.0	0.0
PA-36 - 285 BRAVE		27.0	4.0	39.0	0.0	7.0	5.0	0.0	0.0
PA-36 - 300 BRAVE		26.0	10.0	38.0	10.0	7.0	6.0	0.0	0.0



Significant Aircraft Dimensions

ISSUED EVERY THREE YEARS

BOCA

BUILDING OFFICIALS & CODE ADMINISTRATORS INTERNATIONAL, INC.

CHAPTER 4
VENTILATION

SECTION 401
GENERAL

401.1 Scope. This chapter shall govern the ventilation of spaces within a building intended to be occupied. This chapter does not govern the requirements for smoke control systems.

401.2 Ventilation required. Every space shall be ventilated by natural means in accordance with Section 402 or by mechanical means in accordance with Section 403.

401.3 When required. Ventilation shall be provided during the periods that the room or space is occupied.

401.4 Vestibule ventilation. Vestibule ventilation for smoke proof enclosures shall be in accordance with the building code.

401.5 Installation. The requirements of Chapter 3 shall apply to ventilation equipment.

401.6 Ducts. Ducts and plenums used in ventilation system shall be constructed of approved materials, and braced, supported, joined, assembled and sealed as required in Chapter 6.

401.7 Opening location. Outside air exhaust and intake openings shall be located a minimum of 10 feet (3048mm) from lot lines or buildings on the same lot. Where openings front on a street or public way, the distance shall be measured to the center line of the street or public way.

Exception: Use Group R-3.

401.7.1 Intake openings. Mechanical and gravity outside air intake openings shall be located a minimum of 10 feet (3048 mm) from any hazardous or noxious contaminant is located within 10 feet (3048 mm) of an intake opening, such opening shall be located a minimum of 2 feet (610mm) below the contaminant source.

401.7.2 Exhaust openings. Outside exhaust openings shall be located in exterior walls shall be located so as not to create a nuisance. Exhaust air shall not be directed onto walkways.

401.8 Outside opening protection. Air exhaust and intake openings located in exterior walls shall be protected with corrosion-resistant screens, louvers and grilles having a minimum opening size of 1/4 inch (6.4 mm) and a minimum opening size of 1/2 inch (12.7mm), in any dimension. Openings shall be protected against local weather conditions. Outdoor air exhaust and in the openings shall meet the provisions for exterior wall opening protectives in accordance with the building code.

401.8.9 Contaminat sources. Stationary local sources producing air-bone particulates, heat, odors, fumes, spray, vapors, smoke or gases in such quantities as to be irritating or injurious to health shall be provided with an exhaust system in accordance with Chapter 5 or a means of collection and removal of the contaminants. Exhaust required by this section shall discharge directly to an approved location at the exterior of the building.

Section 402
NATURAL VENTILATION

402.1 General. Natural ventilation of an occupied space shall be through windows, doors, louvers or other openings to the outdoor air.

402.2 Ventilation area required. The minimum openable area to the outdoors shall be 4 percent of the floor area being ventilated.

402.2.1 Adjoining spaces. Where rooms and spaces without openings to the outdoors are ventilated through an adjoining room, the opening to the adjoining rooms shall be unobstructed and shall be unobstructed and shall have an area not less than 8 percent of the floor area of the interior room or space, but not less than 25 square feet (2.3m^2). The minimum openable area to the outdoors shall be based on the total floor area being ventilated.

402.2.2 Openings below grade. Where openings below grade provide required natural ventilation, the outside horizontal clear space measured perpendicular to the opening shall be one and the half times the depth of the opening. The depth of the opening shall be measured from the average adjoining ground level to the bottom of the opening.

402.3 Contaminants exhausted. Naturally ventilated spaces having contaminants present shall comply with the requirement of the Section 401.9.

402.3.1 Bathrooms. Rooms containing bathtubs, showers, spas and similar bathing fixtures shall be mechanically ventilated in accordance with Section 403.

402.4 Openings on yards or courts. Where natural ventilation is to be provided by openings onto yards or courts, such yards or courts shall comply with the requirements of the building code.

402.5 LP-gas distribution facilities. LP-gas distribution facilities shall be ventilated in accordance with NFPA 58.

SECTION 403
MECHANICAL VENTILATION

403.1 Ventilation system. Mechanical ventilation shall be provided by a method of supply air and return or exhaust air. The amount of supply air shall be approximately equal to the amount of return and exhaust air. The system shall not be prohibited from producing a negative or positive pressure. The ventilation system shall be designed and installed in accordance with Chapter 6.

The required rate of ventilation shall be continuous during the period the building is occupied, except where otherwise stated.

Ventilation supply systems shall deliver the required rate of supply air to the zone within the occupied space between 3 inches (76 mm) and 73 inches (1829 mm) above the floor and more than 2 feet (610 mm) above the floor and more than 2 feet (610 mm) from the enclosing walls.

403.2 Outdoor air required. The minimum ventilation rate of required outdoor air shall be determined in accordance with Section 403.3.

Exception: Where the registered design demonstrates that an engineered ventilation system design will prevent the maximum concentration of contaminants from exceeding that obtainable by the rate of outdoor air ventilation determinated in accordance with Section 403.3, the minimum required rate of outdoor air shall be reduced in accordance with such engineered system design.

403.2.1 Recirculation of air. The air required by Section 403.3 shall not be recirculated as a component of air to building spaces, except that:

1. Ventilation air shall not be recirculated from one dwelling to another or to dissimilar occupancies.
2. Supply air to a swimming pool and associated deck areas shall not be recirculated unless such air is dehumidified to maintain the relative humidity of the area at 60 percent or less and such recirculation is in accordance with Section 401.9. Air from this area shall not be recirculated to other spaces.

403.2.2 Transfer air. Except where recirculation from such spaces is prohibited by Table 403.3, air transferred from occupied spaces is not prohibited from serving as makeup air for required exhaust system in such spaces as kitchens, baths, toilet rooms, elevators and smoking lounges. The amount of transfer air and exhaust air shall be sufficient to provide the flow rates as specified in Sections 403.3 and 403.3.1

403.3 Ventilation rate. The minimum amount of outdoor air required for ventilation shall be determined in accordance with Table 403.3 based on the occupancy of the space and the occupant load or other parameter as states therein. The occupant load utilized for design of the ventilation system shall not be less than the number determined from the estimated maximum occupant load rate indicated in Table 403.3. Ventilation rates for occupancies not represented in table 403.3 shall be determined by an approved engineering analysis.

Exception: The occupant load is not required to be determined, based on the estimated maximum occupant load rate indicated in Table 403.3 where approved statistical data document the accuracy of an alternate anticipated occupant density.

TABLE 403.3
REQUIRED VENTILATION OUTDOOR VENTILATION AIR

OCCUPANCY CLASSIFICATION	ESTIMATED MAXIMUM OCCUPANT LOAD PERSONS PER 1,000 SQUARE FEET*	OUTDOOR AIR (cubic feet per minute (cfm) per person) UNLESS NOTED
Correctional facilities		
Cells	20	20
Dining halls	100	15
Guard stations	40	15
Dry cleaners, laundries		
Coin-operated dry cleaner	20	15
Coin-operated laundries	20	15
Commercial dry cleaner	30	30
Commercial laundry	10	25
Storage, pick up	30	35
Education		
Auditoriums	150	15
Classroom	50	15
Corridors	--	0.10 cfm/ft.^{2}
Laboratories	30	20
Libraries	20	15
Locker rooms	--	0.50cfm/ft.^{2}
Music rooms	50	15
Smoking lounges*	70	60
Training shops	30	20
Food and beverage service		
Bars, cocktail lounges	100	30
Cafeteria, fast food	100	20
Dinings rooms	70	15
Kitchens (cooking)[f]	20	15
Hospitals, nursing and convalescent homes		
Autopsy rooms[b]	--	0.50cfm/ft.^{2}
Medical procedure rooms	20	15
Operating rooms	20	30
Patient rooms	10	25
Physical therapy	20	15
Recovery an ICU	20	15
Hotels, motels, resorts, dormitories		
Assembly rooms	120	15
Bathrooms[b]	--	35 cfm per room
Bedrooms	--	30 cfm per room
Conference rooms	50	20
Dormitory sleeping areas	20	15
Gambeling casinos	120	30
Living rooms	--	30 cfm per room
Lobbies	30	15
Offices		
Conferences rooms	50	20
Office spaces	7	20
Reception areas	60	20
Telecommunication centers and data entry	60	20

(continued)

TABLE 403.3 - continued
REQUIRED VENTILATION OUTDOOR VENTILATION AIR

OCCUPANCY CLASSIFICATION	ESTIMATED MAXIMUM OCCUPANT LOAD PERSONS PER 1,000 SQUARE FEET*	OUTDOOR AIR (cubic feet per minute (cfm) per person) UNLESS NOTED
Private dwellings, single and multiple		
Living areas[c]	Based upon number of bedrooms. First bedroom:2: each additional bedroom: 1	0.35 air changes per hour* or 15 cfm per person. whichever is greater
Kitchens	--	100 cfm intermittent or 25 cfm continuous:
Toilet rooms and bathrooms	--	Mechanical exhaust capacity of 50 cfm intermittent or 20 cfm continuous
Garages, separate for each dwelling	--	100 cfm per car
Garages, common for multiple units[b]	--	1.5 cfm/ft^2
Public spaces		
Corridors and utilities	--	0.05 cfm/ft^2
Elevators	--	1.00 cfm/ft^2
Locker and dressing rooms[b]	--	0.05 cfm/ft^2
Toleite rooms[b]	--	75 cfm per water closet or urinal
Smoking lounges[b]	70	60
Retail stores, sales floors and showroom floors		
Basement and street	--	0.30 cfm/ft.^{2}
Dressing rooms	--	0.20 cfm/ft.^{2}
Malls and arcades	--	0.20 cfm/ft.^{2}
Shipping and receiving	--	0.15 cfm/ft.^{2}
Smoking lounges*	70	60
Storage rooms	--	0.15 cfm/ft.^{2}
Upper floors	50	0.20 cfm/ft.^{2}
Waterhouse	--	0.05 cfm/ft.^{2}
Specialty shops		
Automotive service stations	--	0.15 cfm/ft.^{2}
Barber	25	15
Beauty	5	25
Clothiers, furniture	--	0.30 cfm/ft.^{2}
Florists	8	15
Hardware, drugs, fabrics	8	15
Pet shops	--	1.00cfm/ft.^{2}
Reducing salons	20	15
Supermarkets	8	15

(continued)

TABLE 403.3 - continued
REQUIRED VENTILATION OUTDOOR VENTILATION AIR

OCCUPANCY CLASSIFICATION	ESTIMATED MAXIMUM OCCUPANT LOAD PERSONS PER 1,000 SQUARE FEET*	OUTDOOR AIR (cubic feet per minute (cfm) per person) UNLESS NOTED
Theaters		
Auditoriums	150	15
Lobbies	150	20
Stages, studios	70	15
Tickets booths	60	20
Transportation		
Platforms	100	15
Vehicles	150	15
Waiting rooms	100	15
Tickets booths	60	20
Workrooms		
Bank vaults	5	15
Darkrooms	--	0.50 cfm/ft.^{2}
Duplicating, printing	--	0.50 cfm/ft.^{2}
Meat processing[c]	10	15
Pharmacy	20	15
Photo studios	10	15
Sports and amusement		
Ballrooms and discos	100	25
Bowling alleys (seating areas)	70	25
Game rooms	70	25
Ice arenas	--	0.50 cfm/ft.^{2}
Playing floors (gymnasiums)	8	15
Spectator areas	150	15
Swimming pools (pool and deck areas)	--	0.50 cfm/ft.^{2}
Storage		
Repair garages, public garages (enclosed)[d]	--	1.5 cfm/ft.^{2}
Warehouses	5	10

For SI: 1 cubic foot per minute = 0.0004719 m^3/
1 cubic foot per minute per square foot = 0.00508 m3/(s . m2).
°C.= [(°F. -32]/1.8

[a] Based upon net occupied heater or conditioned space.
[b] Mechanical exhaust required and recirculation is prohibited
[c] Spaces unheated or maintained bellow 50°F. are not covered by these requirements unless the occupancy is continuous.
[d] Public parking garages shall be ventilated in accordance with Section 403.5 where the ventilation system is operated by an automatic carbon monoxide detection device.
[e] Where the ventilation rate is expressed in cfm/ft^2 such rate is based upon cubic feet per minute per square foot of the floor area being ventilated.
[f] The sum of the outdoor and the outdoor and transfer air from adjacent spaces shall be sufficient to provide an exhaust rate of not less than 1.5 cubic feet per minute per square foot.

403.3.1 System operation. The minimum of outdoor air required to be supplied by the ventilation system during its operation shall be based on the rate per person indicated in Table 403.3 and the actual number of accordance with Section 403.3.

403.3.2 Common ventilation system. Where spaces having different ventilation rate requirements are served by a common ventilation system, the ratio of outdoor air to total supply air for the system shall be determined based on the space having the largest outdoor air requirement or shall be determined in accordance with the following formula:

$$Y = \frac{x}{(1+x-z)}$$

where:

$Y = V_o / V_{st}$ = corrected fraction of outdoor air sys tem supply.

$X = V_{on} / V_{st}$ = uncorrected fraction of outdoor air in system supply.

$Z = V_{oc} / V_{sc}$ = fraction of outdoor air in critical space. The critical space with the greatest required fraction of outdoor air in the supply to this space.

V_{sc} = correct total outdoor airflow rate

V_{st} = total apply flow rate, i.e.,the sum of all apply for all branches of the system.

V_{om} = sum of outdoor airflow rates for all branches on system.

V_{oc} = outdoor airflow rate required in critical spaces

V_{sc} = supply flow rate in critical space.

403.4 Contaminants. Where the concentration of common contaminants in the outdoors air exceeds the levels indicated in Table 403.4, air filtration and other means of removal of contaminants shall be employed to bring the outdoor air quality into compliance with this section.

403.5 Public garages. Mechanical ventilation systems for public garages are not required to operate continuously where the system is arranged to operate automatically upon detection of a concentration of carbon monoxide of 25 parts per million by approved automatic detection devices.

403.5.1 Minimum ventilation. Automatic operation of the system shall not reduce the ventilation rate below 5 cfm (0.0024 m^3/s) per person and the system shall be capable of producing a ventilation rate of 1.5 cfm per square foot (0.0076 $m^3/s \cdot m^2$) of the floor area.

SECTION 404
VENTILATION OF UNINHABITED SPACES

404.1 General. Uninhabited spaces, such as crawl spaces and attics, shall be provided with natural ventilation openings as required by the building code or shall be provided with a mechanical exhaust and supply system. The mechanical exhaust rate shall be not less than 0.02 cfm per square foot (0.00001 $m^3/s \cdot m^2$) of horizontal area and shall be automatically controlled to operate when the relative humidity in the space served exceeds 60 percent.

TABLE 403.4
MAXIMUM CONTAMINANT CONCENTRATIONS IN OUTDOOR AIR

CONTAMINANT	LONG TERM			SHORT TERM		
	Concentration averaging			Concentration averaging		
	Microgram per cubic meter	Parts per million	Time periods	Microgram per cubic meter	Parts per million	Time periods
Sulfur dioxide	80	0.03	1 year	365[a]	0.14[a]	24 hours
Particles[d] (PM10)	50[b]	—	1 year	150[a]	—	24 hours
Carbon monoxide	—	—	—	40,000[a]	35[a]	1 hour
Carbon monoxide	—	—	—	10,000[a]	9[a]	8 hours
Oxidants (ozone)	—	—	—	235[c]	0.12[c]	1 hour
Nitrogen dioxide	100	0.055	1 year	—	—	—
Lead	1.5	—	3 months	—	—	—

[a] Not to be exceeded more than once per year.

[b] Arithmetic mean.

[c] Compliance is attained where the number of days per calendar year with hourly average concentrations above 0.12 parts per million (235 micrograms/m3) does not exceed I.

[d] Particulate matter smaller than 10 micrometers (PM 10)

ASHRAE LOGO

ASHRAE
STANDARD

Ventilation
for Acceptable
Indoor Air Quality

Approved by the ASHRAE Standards Commitee March 1, 1989; approved by the Board of Directors June 29, 1989.

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of the lung. Particles greater than 10 micrometers aerodynamic diameter are not respirable.

Vapor: a substance in gas form, particularly one near equilibrium with its condensed phase, which does not obey the ideal gas laws; in general, any gas below its critical temperature.

4. CLASSIFICATION

This Standard specifies alternative procedures to obtain acceptable air quality indoors:

4.1 Ventillation Rate Procedure: Acceptable air quality is achieved by providing ventilation air of the specified quality and quality to the space (see 6.1). or

4.2 Indoor Air Quality Procedure: Acceptable air quality is achieved within the space by controlling known and specifiable contaminants (see 6.2).

Whenever the Ventilation Rate Procedure is used, the deign documentation should clearly state that this method was used and that the design will need to be re-evaluated if, at a later time, space use changes occur or if unusual contaminants or unusually strong sources of specific contaminants are to be introduced into the space. If such conditions are known at the time of the original design, the use of the Indoor Air Quality Procedure may be indicated.

The Indoor Air Quality Procedure could result in a ventilation rate lower than would result in increased ventilation requirements. Change is space use, contaminants, or operation may require a re-evaluation of the design and implementation of needed changes.

5. SYSTEMS AND EQUIPMENT

5.1 Ventiling systems may be mechanical or natural. When mechanical ventilation is used, provision for air flow measurement should be included. When natural ventilation and infiltration are relied upon, sufficient ventilation shall be demostrable. When infiltration and natural ventilation are insufficient to meet ventilation air requirements, mechanical ventilation shall be provided. The use of energy recovery ventilation shall be provided. The use of energy recovery ventilation systems should be considered for energy conservation purposes in meeting ventilation requirements.

5.2 Ventiling systems shall be designed and installed so the ventilation air is supplied throughout the occupied zone. The design documentation shall state assumptions that were made in design with respect to ventilation rates and air distribution.

5.3 ventilating systems shall be designed and installed so that they do not cause conditions that conflict with ASHRAE Standard 55-1981, “Thermal Environmental Condition for Human Occupancy” (Ref, I).

5.4 When the supply of air is reduced during times the space is occupied (e.g., in variable-air-volume system), provision shall be made to maintain acceptable indoor air quality throughout the occupied zone.

5.5 Ventilating systems should be designed to prevent re-entrainment of exhaust contaminants, consideration or freeze-ups (or both), and growth of microorganisms. Makeup air inlets and exhaust air outlets shall be located to avoid contamination of the makeup air. Contaminers from another sources such as cooling towers, sanitary vents, vehicular exhaust from parking garages, loading docks, and street traffic should be avoided. This is a special problem in buildings where stack effect draws contaminants from these areas into the occupant space. Where soils contain high concentrations of random, ventilation practices that place crawlspaces, basements, or underground duct work below atmospheric pressure will tend to increase radon concentrations in buildings and should be avoided (see Appendix C).

5.6 Ventilating ducts and plenums shall be constructed and maintained to minimize the opportunity for growth and dissemination of microorganisms through the ventilation system. Construction also shall comply with applicable standards such as NFPA 90A, 90B, and SMACNA (Refs. 2-6).

5.7 Contaminants from stationary local sources within the space shall be controlled by collection and removal as close to the source as practicable. (See Ref. 7, “Industrial Ventilation - Manual of Recommended Practice”)

5.8 Fuel-burning appliances, including fireplaces located indoors, shall be provided with sufficient air for combuction and adequate removal of combustion products. When infiltration supplies all or part of the combustion air, the supply rate of air shall shall be demostrable (Appendix B shows one method of demostrating adequate combustion air). The operation of clothes dryers and exhaust fans may be require introduction of traditional makeup air to avoid interference with the fuel-burning appliances. Combustion system, kitchen, bathroom, and clothes dryers vents shall not be exhausted into attics, crawlspaces, or basements.

5.9 Airbone particulate contaminants vary in any size, as shown in Fig. 2. Microorganisms, dusts, fumes, smoke, and other particulate matters may be captured by air filters. Many bacteria (99% exceed 1 micrometer in size) are attached to larger particles such as human skin flakes. Viroses generally occur in clusters or in and on other particles. Lung-damaging particles that may be retained in the lungs are 0.2 to 5 micrometers in size (see Fig. 2). When it is necessary to remove particulates contaminants, air filters or dust collectors should be used. Dust collectors not air filters, should be used anywhere the dust loading equals or exceed 10mg/m^3 (4 grains/100ft^3). Air filters and dust collectors shall be selected for the particle size and loading encountered. Filters shall be tested in accordance with ASHRAE Standard 52-57 (Ref 8) or MIL Std 282 (Ref. 9). Dust collectors may be wet, dry, or electrostatic as required by particle size and loading *(see Table 1, Chapter II. ASHRAE handbook-1983 Equipment Volume(Ref. 10)* relative humidity in occupied spaces and low velocity ducts and plenums exceeds 70%, fungal contamination (for example, mold, mildew, etc) can occur. Special care should be taken to avoid entrainment of moinsure drift from cooling towers into the makeup air and building vents.

6. PROCEDURES

Indoor air quality is a function of many parameters including outdoor air quality, the design of enclosed spaces, the design of ventilation system, the way this system is operated and maintained, and the precense of sources and contaminants and the strength of such sources. Thi standards deals with the design of aventilation system as it is affected by all these factors, so that an acceptable level of indoor air quality can be provided. Design documentation shall clearly state which assuptions were used in the design so that the limits of the system in revolving contaminats can be evaluated by others before the system is operated in a different mode or before new sources are introduced into the space.

Indoor air should not conatined conatminants that exceed concentrations known to impair health or cause disconfort to occupants. Such contaminants include various gases, vapors, microorganisms, smoke, and other particulate matter. These may be present in make up air or tretment components. Deleterious factors include toxity, radioactivity, potencial to induce infection or allegies, irritants, extreme thermal conditions, and objectionable odors.

The Ventilation Rate Procedure (6.1) provides one way to achieve acceptable air quality. This procedure prescribes the rate at which ventilation air must be delivered to a space and various meaans to condition ataht air. The ventilation rates in Table 2 are derives from physiological considerations, subjective evaluations, and professional judgments (see Refs 12-18).

TABLE 1

National Primary Ambient-Air Quality Standards
for Outdoor Air as Set by the
U.S. Environmental Protection Agency (Ref 19)

Contaminant	LONG TERM			SHORT TERM		
	Concentration averaging			Concentration averaging		
	ug/m³	ppm		ug/m³	ppm	
Sulfur dioxide	80	0.03	1 year	353	0.14	24 hours
Total Particulate	75[a]	—	1 year	260	—	24 hours
Carbon monoxide				40,000	35	1 hour
Carbon monoxide				10,000	9	8 hours
Oxidants (ozone)				235[b]	0.12[b]	1 hour
Notrogen dioxide	100	0.055	1 year			
Lead	1.5	—	3 months[c]			

[a] Arithmetic mean

[b] Standard is attained when expected number of days per calendar maximal hourly average concentnrations above 0.12 ppm (235 ug/m²) is equal to or less than 1, as determined by Appendix H to subchapter C, 40 CFR 50

[c] Three-month period is a calendar quarter

The Indoor Air Quality Procedure (6.2) provides an alternative performance method of achieving acceptable air quality. This procedure uses one or more guidelines for the specification of acceptable concentrations of certain contaminants in indoors air but does not prescribe ventilation rates or air treatment methods.

6.1 Ventilation Rate Procedure: This procedure prescribes:

- the outdoor air quality acceptable for ventilation.
- out door air treatment when necessary
- ventilation rates for residential, commercial, industrial, institutional, vehicular, and industrial spaces.
- criteria for reduction of outdoor air quantities when recirculated air is treated by contaminant-removal equipment.
- criteria for available ventilation when the air volume in the space can be used as a reservoir to dilute contaminants.

6.1.1 Acceptable Outdoor Air. This section describes a three- step procedure by which outdoor air shall be evaluated for acceptability.

Step1: Contaminants in outdoor air do not exceed the concentrations listed in Table 1 as determined by one of the following conditions:

(a) monitoring data government pollution-control agencies, such as the U.S. environmental Protection Agency (EPA) or equivalent state or local environmental protection authorities, show that the air quality of the area in which the ventiling system is located meets the requirements of Table 1. Conformity of local air to these standards may be determined by reference top the records of local authorities or of the national Aerometric Data bank, Office of Air Quality Planning and Standards, EPA, research Triangle Park, NC 27711, or

(b) The ventilating system is located in a community similar in population, geographic and meteorological settings, and industrial pattern to a community having acceptable air quality as determined by authorities having jurisdiction, or

(c) The ventilating system is located in a community with a population of less than 20,000 people, and the air is not influenced by one or more sources that cause substantial contamination, or

(d) Air monitoring for three consecutive months, as required for inclusion in the National Aerometric Data Bank, shows that the air quality meets or exceeds the requirements of Table 1 (as specified in Ref 19)

Step 2: If the outdoor air is thought to contain any contaminants not listed in Table 1, guidance on acceptable concentration levels may be obtained to Appendix C.

Outdoor air requirements for ventilation of industrial building occupancies not listed in Table 2

TABLE 2

OUTDOOR AIR REQUIREMENTS FOR VENTILATION*

2.1 COMMERCIAL FACILITIES (offices, stores, shops, hotels, sports facilities)

Application	Estimated Maximum** Occupacy P/100 ft² or 100m²	Outdoor Air Requirements cfm/ person	L/s* person	cfm/ft²	L/s· m²	Comments
Dry Cleaners, Laundries						Dry- cleaning processes mayrequire more air.
Commercial laundry	10	25	13			
Commercial dry cleaner	30	30	15			
Storage, pick up	30	35	18			
Coin-operated laundries	20	15	8			
Coin-operated dry cleaner	20	15	8			
Food and Beverage Service						
Dining rooms	70	20	10			
Cafeteria, fast foot	100	15	8			
Bars, cocktail lounges	100	15	8			Supplementary smoke-removal equipment may be required.
Kitchens (cooking)	20	30	15			Makeup air for hood exhaust may require more ventilating air. The sum of the outdoor air and transfer air of acceptable quality from adjacent spaces shall be surfficient to provide an exhaust rate of not less than 1.5 cfm/fm² (7.5 L/s·m²).
Garages, repair, Service Stations						Distribution among people must consider worker location and concentration of running engines; stands where engines are run must incorporate systems for positive engine exhaust withdrawal. Contaminant sensors may be used to control ventilation.
Enclosed parking garage				1.50	7.5	
Auto repair rooms				1.50	7.5	
Hotels, Motels, Resolts, Dormitories				**cfm/room**	**L/s· room**	Independent of room size.
Bedrooms				30	15	
Living rooms				30	15	
Baths				35	18	Installed capacity for interminent use.
Lobbies	30	15	8			
Conference rooms	50	20	10			
Assembly rooms	120	15	8			
Dormitory sleeping areas	20	15	8			See also food and beverage services, merchandising, barber and beauty shops, garages.
Gambeling casinos	120	30	15			Supplementary smoke-removal equipment may be required.
Offices						
Office space	7	20	10			Some office equipment may require local exhaust.
Reception areas	60	15	8			
Telecommunication centers						
and data entry areas	60	20	10	**cfm/ft²**	**L/s· m²**	
Conference rooms	50	20	10			Supplementary smoke-removal equipment may be required.
Public Spaces						
Corridors and utilities				0.05	0.25	
Public restrooms, cfm/wc or urinal		50	25	0.5	2.5	Mechanical exhaust with no recirculation is recommended.
Locker and dressing rooms						
Smoking lounge	70	60	30			Normally supplied by transfer air, local mechanical exhaust; with no recirculation recommended.
Elevators				1.00	5.0	Normally supplied by transfer air.

* Table 2 prescribes supply rates of acceptable outdoor air required for acceptable indoor air quality. These values have been chosen to control CO_2 and other contaminats with an adequate margin of safety and to account for health variations among people, varied activity levels, and a moderate amount of smoking. Rational of CO_2 control is presented in Appendix D.

** Net occupiable space.

may be determined by procedures presented in 1986 Industrial Ventilation-A Manual of Racommended Practice, 1986 ed., published by the American Conference of Governmental Industrial Hygienists (ACGIH) (Ref 7).

Step 3: If after completing steps 1 and 2 there is still a reasonable expectation that the air is unacceptable, sampling shall be conducted in accordance with NIOSH procedures (see Refs 21 and 22). Local and national aerometric data banks may contain information on some unregulated pollutants. Finally, acceptance outdoor air quality should be evaluated using the definition for acceptable indoor air quality in Section 3.

TABLE 2

OUTDOOR AIR REQUIREMENTS FOR VENTILATION*

2.1 COMMERCIAL FACILITIES (offices, stores, shops, hotels, sports facilities)

Application	Estimated Maximum** Occupacy P/100 ft² or 100m²	Outdoor Air Requirements cfm/ person	L/s* person	cfm/ft²	L/s· m²	Comments
Retail Stores, Sales Floors, and Show Room Floors						
Basement and Street	30			0.30	1.50	
Upper floors	20			0.20	1.00	
Storage rooms	15			0.15	0.75	
Dressing room				0.20	1.00	
Malls and arcades	20			0.20	1.00	
Shipping and receiving	10			0.15	0.75	
Warehouses	5			0.05	0.25	
Smoking lounge	70	60	30			Normally supplied by transfer air, local mechanical exhaust; exhaust with no recirculation recommmended.
Specialty Shops						
Barber	25	15	8			
Beauty	25	25	8			
Reducing salons	20	15	8			
Florist	8	15	8			Ventilation to optimize plant growght may dictate requirements.
Clothiers, furniture				0.30	1.50	
Hardware, drugs, fabric	8	15	8			
Supermarkets	8	15	8			
Pet shops				1.00	5.00	
Sports and Amusement						
Spectators areas	150	15	8	0.50	2.50	
Game rooms	70	25	13			When internal combustion engines are operated for maintenance of playing surfaces, increased ventilation rates may be required.
Ice arenas (playing areas)						
Swimming pools (pools and deck arena)						
Playing floors (gymnasium)	30	20	10			Hihgher values may be required for humidity control.
Ballroomms and discos	100	25	13			
Bowling alleys (seating areas)	70	25	13			
Theaters						
Tickets booths	60	20	10			Special ventilation will be hneeded to eliminate special stage effects (eg., dry ice vapors, mists, etc.)
Lobbies	150	20	10			
Auditorium	150	15	8			
Stages, studios	70	15	8			
Transportation						Ventilation within vehicles may require special considerations.
Waiting rooms	100	15	8			
Platforms	100	15	8			
Vehicles	150	15	8			
Workrooms						
Meat processing	10	15	8			Spaces maintained at low temperatures (-10°F, or -23°C to + 10°C) are not covered by these requirements unless the occupancy is continuous. Ventilation from adjoining spaces is permissible. When the occupancy is intermittent, infiltration will normally exceed the ventilation requirement. (See Ref 18).

* Table 2 prescribes supply rates of acceptable outdoor air required for acceptable indoor air quality. These values have been chosen to control CO_2 and other contaminats with an adequate margin of safety and to account for health variations among people, varied activity levels, and a moderate amount of smoking. Rational of CO_2 control is presented in Appendix D.

** Net occupiable space.

6.1.2 Outdoor Air Treatment. If the outdoor air contaminant levels exceed the values given in 6.1.1 (Table 1), the air should be treated to control the offending contaminants. Air-cleaning systems suitable for the particle size encounted should be treated to control the offending contaminants. Air-cleaning systems suitable for the particle size encounted should be used. For removal of gases and vapors, appropriate air- cleaning systems should be used. Where the best available, demonstrated, and proven technology does not allow for the removal of contaminants, the amount of outdoor air may be reduced during periods of high contaminant levels, such as those generated by rush-hour traffic. The need to control offending contaminants may depend on local regulations that require specific control measures.

6.1.3 Ventilation Requirements. Indoors air quality shall be considered acceptable if the required rates of acceptable outdoor air in Table 2 are provided for the occupied space.

TABLE 2

OUTDOOR AIR REQUIREMENTS FOR VENTILATION*

2.1 COMMERCIAL FACILITIES (offices, stores, shops, hotels, sports facilities)

Application	Estimated Maximum** Occupacy P/100 ft^2 or 100m^2	Outdoor Air Requirements				Comments
		cfm/ person	L/s* person	cfm/ft^2	L/s· m^2	
Photo studios	10	15	8			
Darkrooms	10			0.50	2.50	
Pharmacy	20	15	8			
Bank vaults	5	15	8			
Duplicating, printing				0.20	1.00	Installed equipment must incorporate positive exhaust and control (as required) of undesirable contaminants (toxid or otherwise).
2.2 INSTITUTIONAL FACILITIES						
Education						
Classroom	50	15	8			
Laboratories	30	20	10			Special contaminant control system may be required for processes or functions including laboratory animal occupancy.
Training shop	30	20	10			
Music rooms	50	15	8			
Libraries	20	15	8			
Locker rooms				0.30	1.50	
Corridors				0.10	0.50	
Auditoriums	150	15	8			
Smoking lounges	70	60	30			Normally supplied by transfer air. Local mechanical exhaust with no recirculation recommended.
Hospitals, Nursing and Contravalescent Homes						
Patient rooms	10	25	13			Special requirements or codes and pressure relationships may determine minimum ventilation rates and filter efficiency. Procedures generating contaminants may require higher rates.
Medical procedure	20	15	8			
Operating rooms	20	30	15			
Recovery and ICU	20	15	8			
Autopsy rooms				0.50	2.50	Air shall not be recirculated into other spaces.
Physical Therapy	20	15	8			
Correctional Facilities						
Cells	20	20	10			
Dining halls	100	15	8			
Guard stations	40	15	8			

* Table 2 prescribes supply rates of acceptable outdoor air required for acceptable indoor air quality. These values have been chosen to control CO_2 and other contaminats with an adequate margin of safety and to account for health variations among people, varied activity levels, and a moderate amount of smoking. Rational of CO_2 control is presented in Appendix D.

** Net occupiable space.

Exceptions:

1. Where unusual indoor contaminants or sources are present or anticipated, then shall be controlled at the source or the procedure of 6.2 shall be followed.

2. For those areas within industrial facilities not covered by Table 2, refer to TLVs- *Threshold Limit Values and Biological Explosure Indicates for 1986-87,* American Conference of Governmental Industrial Hygienists (Ref. 23).

Table 2 lists the required ventilation rates in cfm (L/s) per person or cfm/ft^2 (L/s · m^2) for a variety of indoor spaces. In most cases, the contamination produced is presumed to be in proportion to the number of persons in the space. In other cases, the contamination is presumed to be chiefly due to another factors and the ventilating rates given are based on more appropriate parameters. Where appropriate, the table lists the estimated density of people for design purposes.

When occupant density differs from that in Table 2, use the per occupant ventilation rate for the anticipated occupancy load. The ventilation rate for the anticipated occupancy load. The ventilation rates for specified occupied spaces listed in Table 2 were selected to reflect the consensus that the provision of acceptable outdoor air at these rates would achieve an acceptable level of indoor air quality by reasonably controlling CO_2, particulates, odors, and other contaminants common to those spaces. (Appendix D shows the out door air needed to control occupant-generated CO_2 under various conditions).

Human occupants produce carbon dioxide, water vapor, particulates, biological aerosols, and other contaminants. Carbon dioxide concentration has been widely used as a indicator of indoor air quality. Comfort (odor) criteria are likely to be satisfied if the ventilation rate is set so that 1000 ppm CO_2 is not exceeded. In the event CO_2 is controlled by any method other than dilution, the effects of possible elevation of other contaminants must be considered. (see Refs 12-18).

TABLE 2.3[a]

OUTDOOR AIR REQUIREMENTS FOR VENTILATION OF RESIDENTIAL FACILITIES

(Private Dwellings, Single, Multiple)

Application	Outdoor Air Requirements	Comments
Living areas	0.35 air changes per hour but not less than 15 cfm (7.5 L/s) per person	For calculating the air changes per hour, the volume of the living spaces shall include all areas within the conditioned space. The ventilation is normally satisfied by infiltration and natural ventilation. Dewllings with tight enclosures may require suplemental ventilation supply for fuel-burning appliances, including fireplaces and mechanically exhausted appliances. Occupant loading shall be based on the number of bedrooms as follows: first bedroom, two persons; each additional debrooms, one person. Where higher occupant loadings are known, they shall be used.
Kitchens[b]	100 cfm (50 L/s) intermittent or 25 cfm (12L/s) continuous or openable windows	Installed mechanical exhaust capacity[c]. Climatic conditions may affect choise of the ventilation system.
Baths, Toilets[b]	50 cfm (25L/s) intermittent or 20 cfm (10L/s) continuous or openable windows	Installed mechanical exhaust capacity[c].
Garages:		
Separate for each dwelling unit	100 cfm (50L/s) per car	
Common for several units	1.5 cfm/ft^2 (7.5 L/s · m^2)	See “Enclosed parking garages,” Table 2.1

[a] In using this table, the outdoor air is assumed to be acceptable.

[b] Climatic conditions may affect choise of ventilation option chosen.

[c] The air exhausted from kitchens, bath, and toilete rooms may utilize air supplied through adjacent living areas to compensate for the air exhausted. The air supplied shall meet the requirements of exhaust systems as described in 5.8 and be of sufficients quantities to meet the requirements of this table.

6.1.3.1 Multiple Spaces. Where more than one space is served by a common supply system, the radio of outdoor to supply air required to satisfy the ventilation and thermal control requirements may differ from space to space. The system outdoor air quality shall then be determined using Equation 6-1 (see Refs 24 and 25)

$$Y = X / [1 + X - Z] \qquad (6\text{-}1)$$

where

$Y = V_{ot} / V_{st}$ = corrected fraction of outdoor air system supply.

$X = V_{on} / V_{st}$ = uncorrected fraction of outdoor air in system supply.

$Z = V_{oc} / V_{sc}$ = fraction of outdoor air in critical space. The critical space with the greatest required fraction of outdoor air in the supply to this space.

V_{ot} = correct total outdoor airflow rate

V_{st} = total supply flow rate, i.e.,the sum of all apply for all branches of the system.

V_{om} = sum of outdoor airflow rates for all branches on system.

V_{oc} = outdoor air flow rate required in critical spaces

V_{sc} = supply flow rate in critical space.

Equation 6-1 is plotted in Fig.3. The procedure is as follows:

1. Calculate the uncorrected outdoor air fraction by dividing the sum of all the branch outdoor air requirements by the sum of all the branch supply flow rates.

2. Calculate the critical space outdoor air fraction by dividing the critical space outdoor air requirements by the critical space supply flow rate.

3. Evaluate Equation 6-1 or use Fig.3 to find the corrected fraction of outdoor air to be provided in the sytem supply.

Rooms provided with exhaust air systems, such as kitchens, baths, toilet rooms, and smoking lounges, may utilize air supplied through adjacent habitable or occupiable spaces to compensate for the air exhausted. The air supplied shall be of suffiencient quality to meet the requirements of Table 2. In some cases, the number of persons cannot be estimated accurately or varies considerably. In other cases, a space may require ventilation to remove contamination generated within the space but unrelated to human occupancy (e.g., outgassing from building materials or furnishings). For these cases, Table 2 lists quantities in cfm/ft^2 (L/s · m^2) or an equivalent term. If human carcinogens or other harnful contaminat standards or guidelines (e,g., OSHA, EPA) must supersede the ventilation rate procedure.

When spaces are unoccupied, ventilation is not generally required unless it is needed to prevent accumulation of contaminants injurious to people, contents, or structure. Design documentation shall specify all significant assumptions about accupants and contaminants.

6.1.3.2 recirculation Criteria. The requiremnts for ventilation air quantities given in Table 2 are for 100% outdoor air when the outdoor air quality meets the specifications for acceptable outdoor air quality given in 6.1.1. While these quantitites are for 100% outdoor air, they also set the amount of air required to dilute contaminants to acceptable levels. Therefore, it is necessary thet at least this amount of air be delivered to the conditiones space at all times the building is in use except as modified in 6.1.3.4.

Properly cleanend air may be recirculated. Under the ventilation rate procedure, for other than intermittent variable occupancy as defined in 6.1.3.4, outdoor air flow rates may not be reduced below the requirements in Table 2. If cleaned, recirculated air is used to reduce the outdoor air flow rate bellow the values shown in Table 2, the Air Quality Procedure, 6.2, must be used. The air-cleaning system for the recirculated air may be located in the recirculated air or in the mixed outdoor and recirculated airstream (see Fig.1).

The recirculation rate for the system is determinated by the air-cleaning system efficiency. The recirculation rate must be increased to achieve full benefit of the air-cleaning system. The air-cleaning used to clean recirculated air should be designed to reduce particulate and, where necessary and feasible, gaseous contaminants. The system shall be capable of providing indoor air quality equivalent to that obtained using outdoor air at rate specified in Table 2. Appendix E may be referenced for assistance in calculating the air flow requirements for commonly used air distribution system.

6.1.3.3 Ventilation Effectiveness, E: Outdoor air for controlling contaminants concentration can be used for dilution or for sweeping the contaminants from their source. The values in Table 2 define the outdoor air needed in the occupied zone for well-mixed conditions (ventilation effectiveness approaches 100%). The ventilation effectiveness is defined by the fraction of the outdoor air delivered to the space that reaches the occupied zone.

Ventilation effectiveness may be increased by creating a plug flow situation. If flow pattern is such that the ventilation air flows past the contaminant source

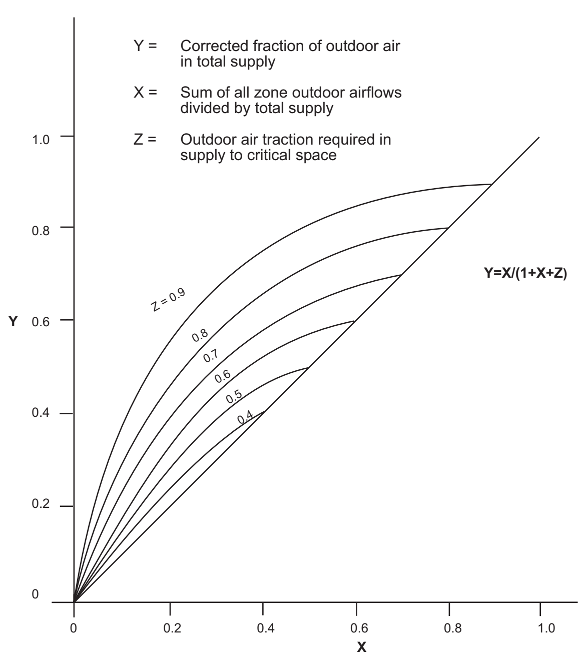

Fig. 3 Ventilation Reduction in Multiple Spaces Supplied from a Common Source

and sweeps the contaminant toward an exhaust, the contaminant toward an exhaust, the contaminat concentration in the exhaust can be greater than that for the well-mixed condition. Ventilation effectiveness can then be greater than the which would be realized with perfect mixing. Local exhaust systems operate in this way. With perfect mixing between the ventilation air and the air in space, ventilation effectiveness is 100%. With perfect mixing between, $E_{v=}$ 1.0. It is, however, not uncommon to find some of the ventilation air bypassing the occupants (moving from supply to exhaust without fully mixing in the occupied zone) and achieving E, values as low as 0.5 (see Ref 26). Such flow conditions should be avoided. The ability of the ventilation air to mix in the occupied zone can be improved through recirculation or active mixing of the air in the space. Additional information about ventilation effectiveness can be found in Appendix F.

6.1.3.4 Intermittent or variable occupancy. Ventilating systems for spaces with intermittent or variable occupancy may have their outdoor air quality adjusted by use of dampers or by stopping and starting the fan system to provide sufficient dilution to maintain contaminant concentrations within acceptable levels at all times. Such system adjustment may lag or should lead occupancy depending on the source of contaminants and the variation in occupants or their activities, do not present a short-term health hazard, and are equivalent to acceptable outdoor air, the supply of outdoor air may lag occupancy. When contaminants are generated in the space or the conditioning system indepent of occupants or their activities, supply of outdoor air should lead occupancy so that acceptable conditions will exist at the start of the occupancy. Figures 4 and 5 show lag or lead times needed to achieve acceptable conditions for transmitent occupancy (see Appendix G for rationale). Where peak occupancies of less than three hours duration occur, the outdoor air flow may be determined on the basics of average occupancy for buildings for the duration of operation system, provided the average occupancy used is not less than one-half the maximum. Caution should be exercised for spaces that are allowed to lag and may be affected, due to preassure differences, by contaminants entering from the adjacent spaces, such as parking garages, restaurants, etc.

6.2 Indoor Air Quality Procedure: This procedure provides an alternative performance method to the Ventilation Rate Procedure for achieving acceptable air quality. The Ventilation Rate procedure described in 6.1 is deemed to provide acceptable indoor air quality, ipso facso. Nevertheless, that procedure, through prescription of required ventilation rates, provides only an indirect solution to the control of indoor contaminants. The Indoor Air Quality Procedure provides a direct solution by restricting the concentration of all known contaminants of concern to some specified acceptable levels. It incorporates both quantitative and subjective evaluation.

6.2.2 Subjective Evaluation. Various indoor air contaminants may give rise to odor that is of unacceptable intensity or character or that irritates the eyes, nose, or throat. In the absence of objective means to assess the acceptability of such contaminants, the judgment of acceptability must necessarily derive from subjective evaluations of impartial observers. One method that may be used for measuring subjective response is described in Appendix C. Caution should be used in any subjective evaluation procedure to avoid unacceptable concentrations of other contaminants.

6.2.3 Air Cleaning. Recirculation criteria are defined in 6.1.3.2 for use with the Ventilation Rate Procedure. Recirculation with air-cleaning systems is also an effective means for controlling contaminants when using the Indoor Air Quality Procedure. The allowable contaminants concentration in the occupied zone can be used with various system models in Appendix E to compare the required outdoor air flow rate. The air-cleaning system efficiency for the trouble some contaminants present, both gaseous and particulate, may be adequate to satisfy the Indoor Air Quality criteria of 6.2.1 and 6.2.2. However, contaminants that are not appreciably reduced by the air-cleaning system may be controlling factor in design and prohibit the reduction of air below that set by Ventilation Rate Procedure.

6.3 Design Documentation Procedures. Design criteria and assumptions shall be documented and should be made available for operation of the system within a reasonable time after installation. See Sections 4 and 6 as well as 5.2 and 6.1.3 regarding assumptions that should be detailed in documentation.

7. REFERENCES

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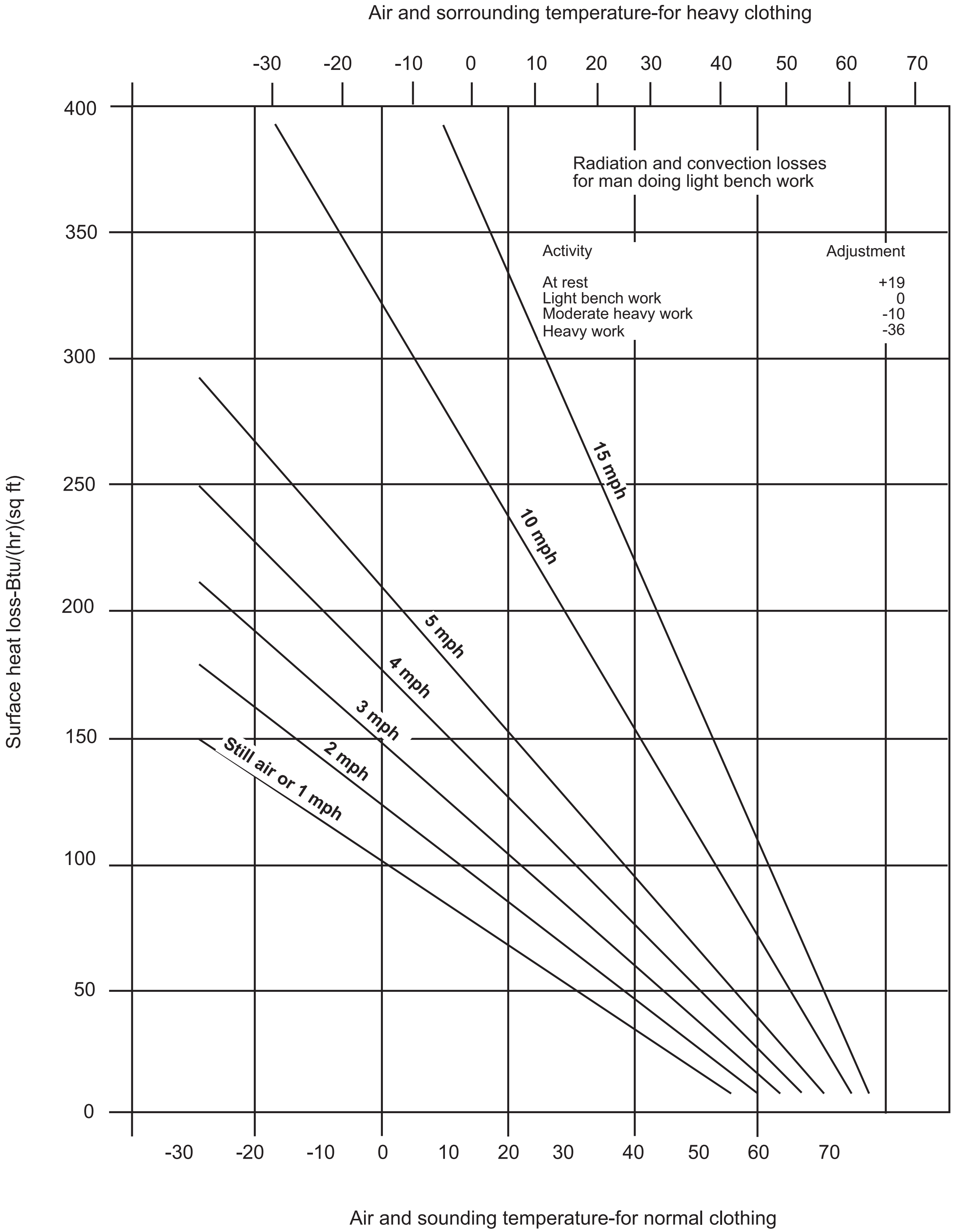

Air and sorrounding temperature-for heavy clothing
-30 -20 -10 0 10 20 30 40 50 60 70
Radiation and convection losses
for man doing light bench work
Activity Adjustment
At rest +19
Light bench work 0
Moderate heavy work -10
Heavy work -36
15 mph
10 mph
5 mph
4 mph
3 mph
2 mph
Still air or 1 mph
Surface heat loss-Btu/(hr)(sq ft)
400 350 300 250 200 150 100 50 0
-30 -20 -10 0 10 20 30 40 50 60 70
Air and sounding temperature-for normal clothing

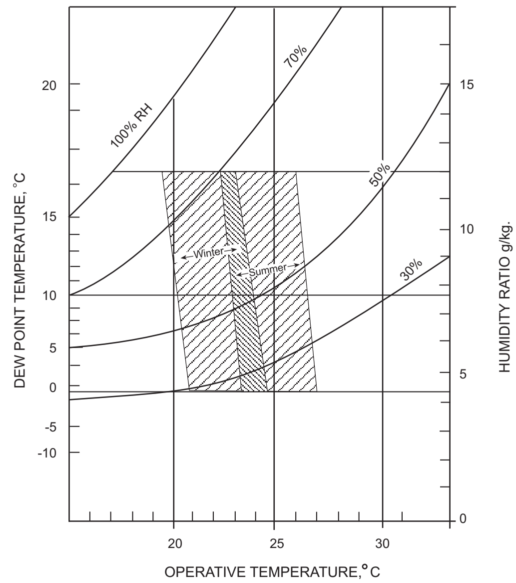


Fig.15 Acceptable Ranges of Operative Temperature and Humidity for Persons Clothed in Typical Summer and Winter Clothing, at Light, Mainly Sedentary, Activity (<1.2 met)

(Ref. Ch. 8 - 1985 ASHRAE Fundamentals Handbook)

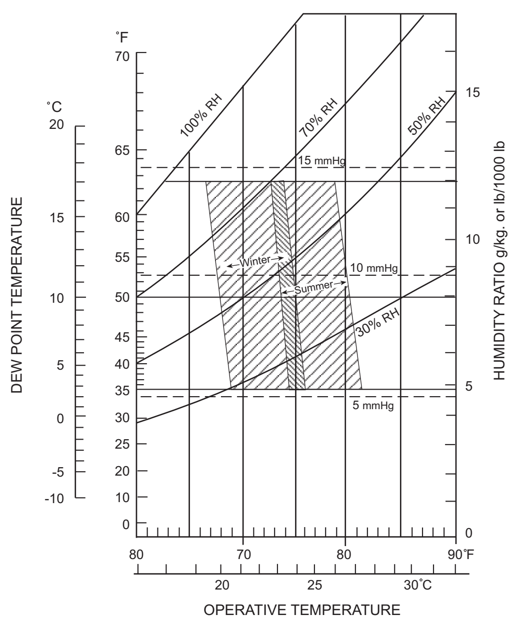


Fig.4 ASHRAE Comfort Chart Modified for Radiant Heating

(Ref. Ch. 16 - 1987 ASHRAE HVAC System & Application Handbook)

UNIFORM MECHANICAL CODE

Uniform Building Code Logo

IAPMO Logo

309.0 Electrical Connections

Equipment regulated by this code requiring electrical connections of more than 50 Volts shall have a positive means of disconnect adjacent to and in sight from the equipment served. A 120-Volt receptacle shall be located within 25 feet (7620 mm) of the equipment for service and maintenance purposes. The receptacle need not to be located on the same level as the equipment. Low voltage wiring of 50 Volts or less within a structure shall be installed in a manner to prevent physical damage.

310.0 Condensate Wastes and Control

310.1 Condensate Disposal. Condensate from air-cooling coils, fule-burning condensing appliances and the overflow from evaporative coolers and similar water-supplier equipments shall be collected and discharged to an approved plumbing fixture or disposal area. The waste pipe shall have a slope of not less than 1/8 inch per foot (10.5mm/m) or one percent slope and shall be approved corrosion-resistant material not smaller as required in either Section 310.3 or 310.4 below for air-cooling coils or condening fuel-burning appliances, repectively. Condensate or waste water shal not drain over a public way.

310.2 Condensate Control. When a cooling coil or cooling unit is located in an attic or furred space where damage may result from condensate overflow, and additional water-tight pan of corrosion-resistant metal shall be installed beneath the cooling coil or unit top to catch the overflow condensate due to a clogged primary condensate drain, or one pan with a standing overflow and a separate secondary drain may be provided in lieu of secondary drain pain pipe, minimum 3/4-inch (19.1 mm) minimal pipe size, discharging at a point which can be readily observed.

This requirements is in addition to the requirements in Sections 310.3 and 310.4.

310.3 Condensate Waste Sizing. Condensate waste pipes from air-cooling coils shall be sized in accordance with equipment capacity as follows:

Equipment Capacity in Tons of Refrigeration (kW)	Minimum Condensate Pipe Dianeter (mm)
Up to 20 (Up to 70.34)	3/4 (19.1)
21 -40 (73.85-140.67)	1(25.4)
41-90 (144.19-316.6)	1-1/4 (144.19-316.6)
91-125 (320.03-439.6)	1-1/2 (320.03-439.6)
126-250 (443.12 -879.2)	2 (443.12 -879.2)

The size of condensate waste pipes may be one unit oa a combination of units, or as recommeded by the manufacturer. The capacity of waste pipes assumes a 1/8 inch per foot (10.5 mm/m) or onne percent slope, with the pipe running three-quarter full:

Outside Air - 20%		**Room Air - 80%**	
DB	WB	DB	WB
90°F	73°F	75°F	62.5°F
(32.2°C)	(22.8°)	(23.9°C)	(16.9°F)

Condensate drain sizing for other slopes or other conditions shall be approved by the Administrative Authority.

310.4 Fuel-Burning Appliance Condensate Drains. Candensate drain lines from individual fuel-burning condensing appliances shall be sized according to the manufacturers' recommendations. Condensate drain lines serving more than one appliance shall be approved by the Administrative Authority prior to installation.

311.0 Personnel Protection

A suitable and substantial metal guard shall be provided around exposed fly-wheels, fans, pulleys, belts and moving machinery which are portions of a heating, ventilating or refrigerating system.

312.0 Air Filters

312.1 Air filters shall be installed ina heating, cooling or make-up air system. Such filters shal comply with the standard, Air Filter Units, Test performance of, which is referenced in Chapter 16, Part II, as Class I or II filters.

Exception: Systems serving single guest rooms or dwelling units shall not required a listed filter.

x 25.4 for mm

TABLE 3-1
Standard Installation Clearances in Inches for Unlisted Heat - Producing Appliances
See Section 304.0.

RESIDENTIAL-TYPE APPLIANCES	FUEL	APPLIANCE: ABOVE TOP OF CASING OR APPLIANCE	APPLIANCE: FROM TOP AND SIDES OF WARM-AIR BONNET OR PLENUM	APPLIANCE: FROM FRONT[1]	APPLIANCE: FROM BACK	APPLIANCE: FROM SIDES
BOILERS AND WATER HEATERS						
Steam Boilers - 15 psl (103.4 kPa)	Automatic Oil or					
Water Boilers-250°F (121°C)	Comb. gas-Oil	6		24	6	6
Water Heaters-200°F (93°C)	Automatic Gas	6		18	6	6
All Water Walled or Jacketed	Solid	6		48	6	6
FURNANCES - CENTRAL; OR HEATERS - ELECTRIC CENTRAL WARM -AIR FURNACES						
Gravity, Upflow, Downflow,	Automatic Oil or					
Horizontal and Duct Warm - air	Comb. Gas - Oil	6[2]	6[2]	24	6	6
250°F(121°C) max.	Automtic Gas	6[2]	6[2]	18	6	6
	Solid	18[3]	18[3]	48	18	18
	Electric	6[2]	6[2]	18	6	6
FURNANCES-FLOOR						
For mounting in Combustible Floors	Automatic					
	Comb. Gas-Oil	36		12	12	12
	Automatic Gas	36		12	12	12
ROOM HEATERS[4]	Oil or Solid	36		24	12	12
Circulating Type	Gas	36		12	12	12
Radiant or Other Type	Oil or Solid	36		36	36	36
	Gas	36		36	18	18
	Gas with double metal or ceramic back	36		36	12	18
Fireplace Stove	Solid	48[5]		54	48[5]	48[5]

(continued)

x 25.4 for mm

TABLE 3-1 (Continued)
Standard Installation Clearances in Inches for Unlisted Heat - Producing Appliances

COMMERCIAL INDUSTRIAL - TYPE APPLIANCES ANY AND ALL PHYSICAL SIZES EXCEPT AS NOTED		APPLIANCE				
	FUEL	OF CASING OR APPLIANCE	FROM TOP AND SIDES OF WARM-AIR BONNET OR PLENUM	WARM-AIR FROM FRONT[1]	FROM BACK	FROM SIDES
UNIT HEATERS						
Floor mounted or Suspended- Any Size Suspended-100 cu. ft. (2832 m^3) or less	Steam or Hot Water	1			1	1
	Oil or Comb.					
Suspended-100 cu. ft. (2832 m^3) or less	Gas-Oil	6		24	18	18
	Gas	6		18	18	18
Suspended-Over 100cu.ft.(2832m^3)	All Fuels	18		48	18	18
Floor Mounted - Any Size	All Fuels	18		48	18	18
RANGES- RESTAURANT-TYPE						
Floor Mounted	All Fuels	48		48	18	18
OTHER LOW-HEAT INDUSTRIAL APPLIANCES						
Floor Mounted or Suspended	All Fuels	18	18	48	18	18

COMMERCIAL INDUSTRIAL - TYPE APPLIANCES ANY AND ALL PHYSICAL SIZES EXCEPT AS NOTED		APPLIANCE				
	FUEL	ABOVE TOP OF CASING OR APPLIANCE[10]	FROM TOP AND SIDES OF WARM-AIR BONNET OR PLENUM	FROM FRONT[1]	FROM BACK[10]	FROM SIDES[10]
BOILERS AND WATER HEATERS						
Over 50 psl (345 kPa) Over 100 cu. ft. (2832 m^3) 36	All Fuels	48		96	36	36
OTHER MEDIUM-HEAT INDUSTRIAL APPLIANCES						
All Sizes	All Fuels	48	36	96	36	36
INCINERATORS						
All Sizes	All Fuels	48		96	36	36
INDUSTRIAL- TYPE HIGH-HEAT APPLIANCES HIGH- HEAT INDUSTRIAL APPLIANCES						
All Sizes	All Fuels	180		360	120	120

(continued)

x 25.4 for mm

TABLE 3-1 (Continued)

Standard Installation Clearances in Inches for Unlisted Heat - Producing Appliances

RESIDENTIAL-TYPE APPLIANCES	FUEL	APPLIANCE: ABOVE TOP OF CASING OR APPLIANCE	FROM TOP AND SIDES OF WARM-AIR BONNET OR PLENUM	FROM FRONT[1]	FROM BACK	FROM SIDES	
RADIATORS Steam or Hot Water	Steam or Hot	36		6	6	6	
RANGES - COOKING STOVES						Firing Side	Opp. Side
	Oil36	30[7]			9	24	18
	Gas	30[7]			6	6	6
	Solid Clay-Lined Fireport	30[7]			24	24	18
	Solid Unlined Fireport	30[7]			36	36	18
	Electric	30[7]			6	36	
INCINERATORS Domestic Types	All Fuels	30[8]		48	36	36	

COMMERCIAL INDUSTRIAL - TYPE APPLIANCES ANY AND ALL PHYSICAL SIZES EXCEPT AS NOTED	FUEL	APPLIANCE: OF CASING OR APPLIANCE[9]	FROM TOP AND SIDES OF WARM-AIR BONNET OR PLENUM	WARM-AIR FROM FRONT[1]	FROM BACK	FROM SIDES[9]
BOILERS AND WATER HEATERS 100 cu. ft. (2.832 m^3) or less Steam, any pressure	All Fuels	18		48	18	18
50 psi (345 kPa) or less Any size	All Fuels	18		48	18	18

Footnotes for Table 3-1

[1]The minimum direction shall be that necessary for servicing the appliance, including access for cleaning and normal care, tube removal, etc.

[2]For listed oil, combination gas-oil, gas or electric furace this dimension may be 2 inches (50.8 mm) if the furace limit control cannot set higher than 250°F (121°C), or this dimension may be 1 inch (25.4mm) if the limit cannot be set higher than 200°F (93°C), or the appliance shall be market to indicate that theoutlet air temperature cannot exceed 200°F ((3°C).

[3]The dimension may be 6 inches (152.4 mm) for an autimatically stoker-fired forced-warm-air furnace equipped with 250°F (121°C) limit control and with barometic draft control operated by draft intensity and permanently set to limit draft to a maximum intensity of 0.13-inch (3.3 mm) water gage.

[4] Unlisted appliances shall be installed on noncombustible floors and may be installed on protected combustible floors. Heating appliances approved for installation on protected combustible flooring shall be so constructed that flame and hot gases do not come in contact with the appliance base. Protection for combustible floors shall consist of 4-inch (102 mm) hollow masonry covered with sheet metal at least 0.021 inch (0.53 mm) thick (No. 24 manufacturer's standard gage). Masonry shall be permanently fastened in place in an approved manner with the ends unsealed and joints matched so as to provide free circulation of air through the masonry. Floor protection shall extend 12 inches (305 mm) at the sides and rear of the appliance, except that at least 18 inches (457 mm) shall be on the appliance-opening side or sides measured horizontally from the edges of the opening.

[5] The 48-inch (1219mm) clearance may be reduced to 36 inches (914 mm) when the protection equivalent to that provided by (a)-(g) of Table 3-2 is applied to the combustible construction.

[6] Steam pipes and hot water heating pipes shall be installed with a clearance of at least 1 inch (25.4 mm) to all combustible construction or material, except that at the points where pipes carrying steam at not over 15 pounds gage pressure (103.4 kPa) or hot water emerge from a floor, wall or ceiling, the clearance at the opening through the finish floorboards or wall-ceiling boards may be reduced to not less than 1/2 inch (12.7 mm). Each such opening shall be covered with a plate of non-combustible material. Such pipes passing through stock shelving shall be covered with not less than 1 inch (25.4 mm) of approved Insulation.

Wood boxes or casings enclosing uninsulated steam or hot water heating pipes are places shall be lined with metal or insulating millboard.

Coverings or insulation used on steam or hot water shall be of material suitable for the opening temperature of the system. The Insulation or jackets shall be of noncombustible materials, or the insulation or jackets and lap - seal adhesives shall be tested as a composite product. Such composite product shall have a flame - spread rating of not more than 25 and a smoke-developed rating not to exceed 50 when tested in accordance with UBC Standard No. 42 -1.

[7] To combustible material or metal cabinets, if the underside of such combustible material or metal or metal cabinet is protected with insulating millboard at least 14 inch (6.4 mm) thick covered with sheet metal or not less than 0.013 inch (0.33 mm) (No. 28 gage), the distance may be reduced to 24 inches (610 mm).

[8] Clearance above charging door shall be at least 48 inches (1219 mm).

[9] If the appliance is encased in brick, the 18-inch (457 mm) clearance above and at the sides and rear may be reduced to 12 inches (0,30 mm).

[10] If the appliance is encased in brick, the clearance above may be reduced to 36 inches (914 mm) and at the sides and rear may be reduced to 18 inches (457 mm).

Conversion Factors

PRODUCT	PRODUCT CODE	BTU Content	
		FACTOR	UNITS
Electricity	ELC	11.6	MBTU/MWH
Natural Gas	NAG	1.031	MBTU/MCF
Coal, Anthracite	ANC	25.4	MBTU/Short Ton
Coal, Bituminous	COL	24.4	MBTU/Short Tone
Purchased Steam/Hot Water	SHW	1340	MBTU/Pound of Steam Delivered
Fuel Oil	FSD FSR	5.825 6.287	MBTU/Barrel MBTU/Barrel
Propane/LPG/Butane	PPG	95000	MBTU/Gallon
Photovoltaic	PHO	3412	MBTU/KWH
Solar Thermal	SOL	1	MBTU/MBTU
Wind Power	WND	3412	MBTU/KWH
Wood	WOD	17.0	MBTU/Short Ton
Geothermal	GEO	1340	MBTU/Pound of Steam Delivered
Geothermal Electricity	GLC	1340	MBTU/MWH
Refuse Derived Fuel	RDF	14.4	MBTU/Short Ton
Hydroelectric	HYD	3412	MBTU/KWH
Fuel Oil Reclaimed	FOR	5.0	MBTU/Barrel
Solid Waster (Typical)	MSW	8.5	MBTU/Short Ton

Logo

AIR NATIONALGUARD
FACILITY ENERGY PLAN

MARCH 1981

OUTSIDE AIR VENTILATION STANDARDS

SELECTED FUNCTIONAL AREA	CFM/OCCUPANT	ESTIMATED SF/OCCUPANT	CFM/SF
Auditorium (No Smoking)	5	6.7	0.75
Automivile Shop			
Repair Area	--	--	1.50
Office Area	7	50.0	0.14
Chapel	5	6.7	0.75
Classroom	5	20.0	0.25
CCTV Studio	20	50.0	0.40
Computer Room	5	50.0	0.10
Conference Room	20	14.3	1.40
Dark Room	10	20.0	0.50
Dinning Hall	10	14.2	0.70
Dormitory	5	50.0	0.10
Drafting Room	7	50.0	0.14
Flight Control Center	20	45.0	0.44
Gymnasium	5	15.0	0.33
Hangar- Bay Area	20	500.0	0.02
Indoor Target Range	20	14.3	1.40
(Behind firing line only)			
Keypunch Room	7	33.3	0.21
Kitchens	25	50.0	0.50
Libraries	7	50.0	0.14
Lockers Room	(30.00/locker)	50.0	0.60
Machine Shop	15	20.0	0.75
Mechanical Equipment Room	5	200.0	0.03
Medical Facilities			
Waiting Area	10	33.3	0.30
Laboratories	25	33.3	0.75
Offices	7	100.0	0.07
Ozalid Print Room	7	50.0	0.14
Parachute Wrapping and Storing	5	100.0	0.05
Ready Room, Day Room, etc.	7	25.0	0.28
Repair Shops (A/C Maint, Avionics, etc.)	5	33.3	0.15
Shower Room	10	10.0	1.00
Telephone Swichboard Room	7	20.0	0.35
Telephone Swichgear Room	7	--	--
Teletypewrite Room	15	--	--
Toilets	15	10	1.50
Utility Room	5	200	0.03
Warehouse	7	200	0.04

DEPARTMENT OF AIR FORCE
Headquarters, US Air Force
Washington DC 20330

AF MANUAL 88-15

8 January 1975

FACILITY DESIGN AND CONSTRUCTION

AIR FORCE DESIGN MANUAL - CRITERIA AND STANDARDS FOR AIR FORCE CONSTRUCTION

This manual contains construction criteria and standards applicable to structures, utilities, and other facilities and services at Air Force installations. It also applies to the Air national Guard and Air Force Reserve projects. It will be used by all persons and agencies responsible for Air Force construction. Recommendations for changes should be forwarded to IIQ USAF/FREE Wash DC 20330. This manual implements the applicable portions of DOD Issuances: 41445.19, 11 December 1969, and CI: 4270.1 - M, I October 1972; 5100.50, 24 May 1973; 5500.5. 24 May 1965, and CI.

(4) National Fire Protection Association, Standards No. 31, 86A, 54, 58, and 409.

(5) National Board Inspection Code by National Board of Boiler and Pressure Vessel Inspectors.

(6) American National Standards. Institute (ANSI) A 13.1 for identification of piping systems. (See attachment 4)

(7) Standards of the Expansion Joint Manufactures, Expansion Joint Manufacturers, 331 Madison Ave., New York, NY 10017.

b. Calculations. For heat loss computation, see AFM 88.8, Chapter 1, and ASHRAE Guide.

(1) Outside design temperatures will comply with the 971/2% column of AF 88-8, Chapter 6. The 99% column will be used for facilities requiring close temperature control or for buildings using 100% outside air. Upon request to HQ USAF/PREE data will be provided for installations not listed in AFM 88-8, Chapter 6. The request for design temperatures must include for each installation the longitude and latitude to the nearest 5 minutes and geographical elevation in feet.

(2) ASHRAE Guide will be followed for calculating the heat loss estimated. Particular consideration will be given to the orientation of the facility with respect to the prevailing wind, the type of construction and the utilization of the facility.

(3) Generally inside design temperatures will be as follows:

Administrative, living quarters, classrooms__70°F

Hangar, Shop and Warehouse areas:

(a) Where people work seated or standing without getting much exercise_____60°F

(b) Where people get exercise in such work as sorting, packing, crating, collecting, etc____55 to 60°F

Medical Facilities, see Chapter 6

Areas requiring only protection from freezing_____40°F

5.4. Heating System

a. General: Heating systems shall be (1) as simple as passible, consistent with safety, economy, and performance required to suit the particular application; (2) properly zoned to provide satisfactory heating levels for different heating levels of different sun explosure; and (c) capable of maintaining the inside design temperature while operating at rated capacity under design condition.

b. Warm Air: Supplied by direct fired furnaces or indirect heat exchanges utilizing steam or hot water as heating medium.

c. Wet Heat:

(1) Hot Water:

(a) Low temperature: up to 250 °F

(b) Medium temperature: above 250°F to 350°F

(c) High temperature: above 350°F

(2) Steam:

(a) Low Pressure: 0 to 15 pounds per square inch gage (psig)

(b) High Pressure Steam: (Medium pressure range) 15 10 50 psig.

(c) High Pressure Steam: 50 psig and greater.

d. Systems for Medical Facilities:

(1) Generally two steam pressure are adequate. When electric sterilizers are used, one steam pressure will be specified.

(2) Steam sterilizers will required a boiler operating pressure of 75 psig. Utilize a pressure reducing station if lower pressure steam requirement also exists.

5-5. Application of Systems:

a. Normal Space Heating:

(1) Modulated circulating low temperature hot water systems utilizing direct radiation of convectors in heated space will be utilized for comfort heating where the outside heating design temperature is +20°F or colder.

(2) Perimeter baseboard heating will be used for buildings in areas with a 20°F or colder outside heating design temperature, when an air conditioning system is not provided. Consideration will be given to its use in other locations to blanket large glass areas.

(3) One pipe forced low temperature hot system may be used on zones or circuits not exceeding 100,000 BTUH.

(4) The use of medium or high temperature water as a heating medium will be restricted to large space heaters, exchangers and radiation specifically designed for its use.

(5) Direct fired warm air heating systems will be limited to buildings with a total heat loss of 400,000 BTUH or less at locations where the outside heating design temperature is +20°F or warmer.

(6) Floor, wall or ceiling type radiant heating except as noted below will not be used without prior approval of HQ USAF/FREE.

(7) Unit heaters, indirect and direct fired type, will generally be used in shop and warehouse areas. Unit heaters will not be used in shop and warehouse areas. Unit heaters will not be used in administrative, school and similar areas.

(8) Direct fired heaters and furnaces are prohibited in areas subject to hazardous concentrations of flammable gases, vapors, or dust; this prohibition includes aircraft hangars and automotive garages.

(9) In air-conditioned buildings, a combination heating and cooling system will be used to the maximum extent possible, and 126, when specifically determined by the local base civil engineer and approved by the host major command.

... and 126, when specifically determined by the local base civil engineer and approved by the host major command.

(3) Communications and Navigational Aids, Category Code Numbers 131, 132, 134, and 135. Provide maintenance spare unit as determined by the local base civil engineer and approved by the host major command on a case-by-case basis.

(4) Airfield Lighting. Category Code Number 136.

(5) operational Facilities, Category Code Numbers 141, 149, 151, 154, 159, 163, and 164, on a case-by-case basis as determined by the local base civil engineer and approved by the host major command.

(6) Maintenance and Production Facilities, Category Code Numbers 211 to 219 inclusive, for quality process control, fail-safe shutdown, security and safety as determined on a case-by-case basis by the local base civil engineer and approved by the host major command.

(7) Research, Development, and Test Facilities, Category Code Numbers 310 to 390 inclusive, for quality process control, fail-safe shutdown, preservation of Research and Development (R&D) test results, security and safety as determined on a case-by-case basis by the local base civil engineer and approved by the host major command.

(8) Supply Facilities. Category Code Numbers 411 to 452 inclusive, for direct tactical support, security, preservation of storage, and safety, as determined on case-by-case basis by the local major command.

(9) Composite Medical Facilities. Emergency power shall be provided for composite Medical Facilities, Category Code 510-001. HQ USAF/PREE and SGHF will review and approve requests for emergency power for any other medical facilities. Emergency power design criteria are specified in this chapter, paragraph 7-15, entitled, Composite Medical Facilities Emergency Power.

(10) Utilities and Ground Improvements, Category Code Numbers 811 to 890, inclusive, for initial start-up, control, and complete operational essential plants and systems. For noncritical plants and systems, provide for fail-safe shutdown, control safety and security as determined on a case-by- case basis by the local base civil engineer and approved by the host major command.

7-10. Hazardous Areas:

a. Requirements. Unless otherwise authorized, wiring materials and equipment within hazardous areas shall conform to the requirements for the particular harzard involved as specified in the National Electrical Code.

b. Hangers and Docks

(1) The following spaces are considered to be class 1, division 1, group C of hazardous locations:

(a) The main hangar or dock area inclosed by the building walls, exclusive of adjoining rooms and extending from the floor to the top of the highest, hangar door, except for the space within 2 feet of the wall above a 4-foot level. (Special situations wherein encroachment may be acceptable due to particular aircraft size or configuration will be referred to AF/PREE).

(b) The space below a 4 foot level from the floor in adjacent areas not to cut off from the main area by doors or walls.

(c) The space below an 18 inch level from the floor in adjacent areas cut off from a main area by a minimum 4 foot elevation or by walls not subject to fume leakage are considered nonhazardous unless the usage of the specific area itself is hazardous.

(3) All fixed electrical equipment and wiring should be located outside the hazardous space, wherever possible. If, in spacial cases, it is necessary to encroach into the hazardous space for installation of nonexplosion proof equipment, such equipment will be confined to the space 5 feet or more above the upper surface, or 5 feet or more horizontally out from the edges of the wings, fuselage, or any part of the aircraft which normally contain fuel tanks or vents for the largest aircraft that can be accommodated in the facility.

(4) Where docks and hangars are used for fuel system and fuel cell repair the above criteria are applicable, provided other special treatment requirements (vapor detection, fuel disposal, and approved exhaust air movements) are also met.

(5) Except as specifically state above, all remaining electrical wiring and equipment shall meet requirements of the National Electrical Code.

c. POL Areas. Electrical equipment will be explosion proof as approved for class 1, group C, division 1, locations when installed under the following conditions.

(1) In below-grade housing or pits.

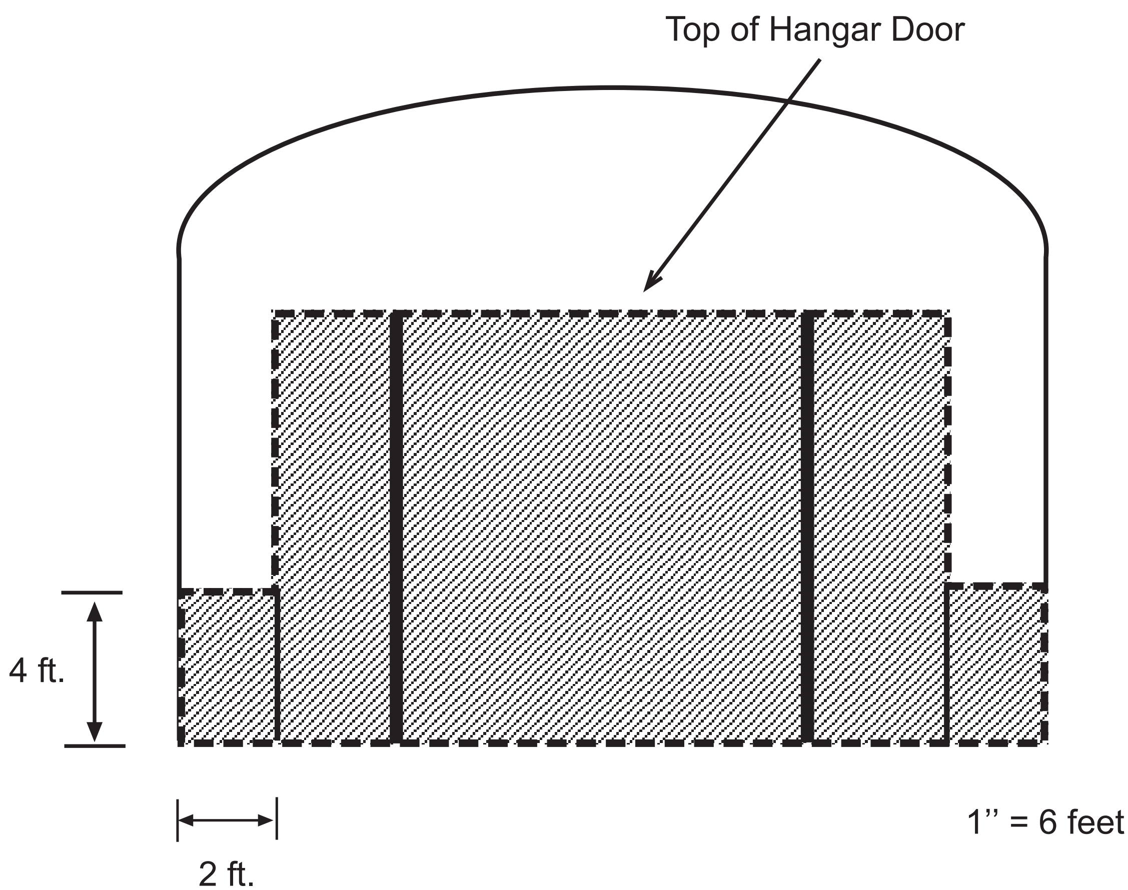
(2) In above-grade pump rooms, valve rooms, and similar areas.

(3) Within 20 feet or vents for underground tanks.

(4) Within dikes of above-ground tanks.

(5) Within 50 feet of tank loading or unloading outlets.

d. When required for industrial areas, explosion-proof lighting fixtures will be of incandescent type. Fluorescent type is not permitted in these areas.



Hazardous Areas (shown shades) as defined in
Paragraph 1a per Section 7-10 AFM 88-15(4)

Chapter 12
GAS SUPPLY AND DISTRIBUTION

12-1. Types of Gas.

Natural Gas, liquefied petroleum gas, and manufactured gas are used for fuels at the Air Force bases. Gas may be used when economically justified and there is reasonable assurance that the supply will be available for the life of the plant. All natural gas, liquefied petroleum gas, and manufactured gas used on an Air Force Base must be odorized. If the gas is not odorized by the source of supply, equipment for odorizing will be included as a part of base gas distribution system.

12-2. Types of Systems for Air Force Installations:

a. High-Pressure Lines. The principal function of high pressure gas lines is crosscountry transmission. When necessary, they may be used to connect the distribution system with the gas company's transmission line, but they will not be used in this distribution itself. The location of high-pressure transmission lines will be carefully planned to minimize the danger of line breakage and danger of fire from a rupture in a high-pressure transmission lines.

b. Medium-Pressure Distribution Lines. Design pressures for a distribution system will not exceed 50 pounds per square per inch gage. In medium pressure distribution, a service regulator is required on each service line to control the pressure delivered to the user.

c. Low-Pressure Distribution Lines. Less than 1.5 psig and is not recommended for general use at Air Force installations.

d. Interruptible gas services are contracted for on the basis of use during off peak demands on the supplier's system. Standby fuel must be provided (See chapter 5).

e. Firm service (may be available in gas field areas) provides that gas will be supplied at all times when it is available to other customers.

f. Liquified petroleum gas (LPG) is not generally used except for isolated buildings and special purposes. However, it is permitted when economically feasible, subject prior approval from PREE. Where it is used, it is supplied to individual buildings by a central air mix plant and a low-pressure distribution system. This type of system is required so that LPG may be procured in bulk quantities at favorable costs.

g. Manufactured gas seldom is used because of its costs and lack of availability. Where it can be supplied at economical rates, it is used generally for cooking and hot water heating only.

12-3 Basis of Design:

a. American National Standards Institute Inc. (ANSI) Standard B31.8

b. AFM 88-8, chapter 5 and AFM 88-12-chapter 1

c. Corrosion Control for metallic pipe and facilities will be provided in accordance with paragraph 10-16 of the manual and AFM 88-9, chapter 4, Corrosion Control.

d. National Fire Protection Association Standard No. 54 and ANSI Standard Z83.1.

12-4 General and Specific Guidance for Selection and Use of material, Equipment, and Systems:

a. All ferrous gas mains and fittings located underground will be coated and wrapped, and cathodically protected.

b. Wall openings for all underground gas pipe entering buildings will be sealed.

c. Nonmetallic pipe (plastic) used to avoid metallic corrosion problems can be installed in gas systems subject to the provisions of ANSI Standard B31.8

d. Gas lines will never be installed under buildings.

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UR CLAS E F T O

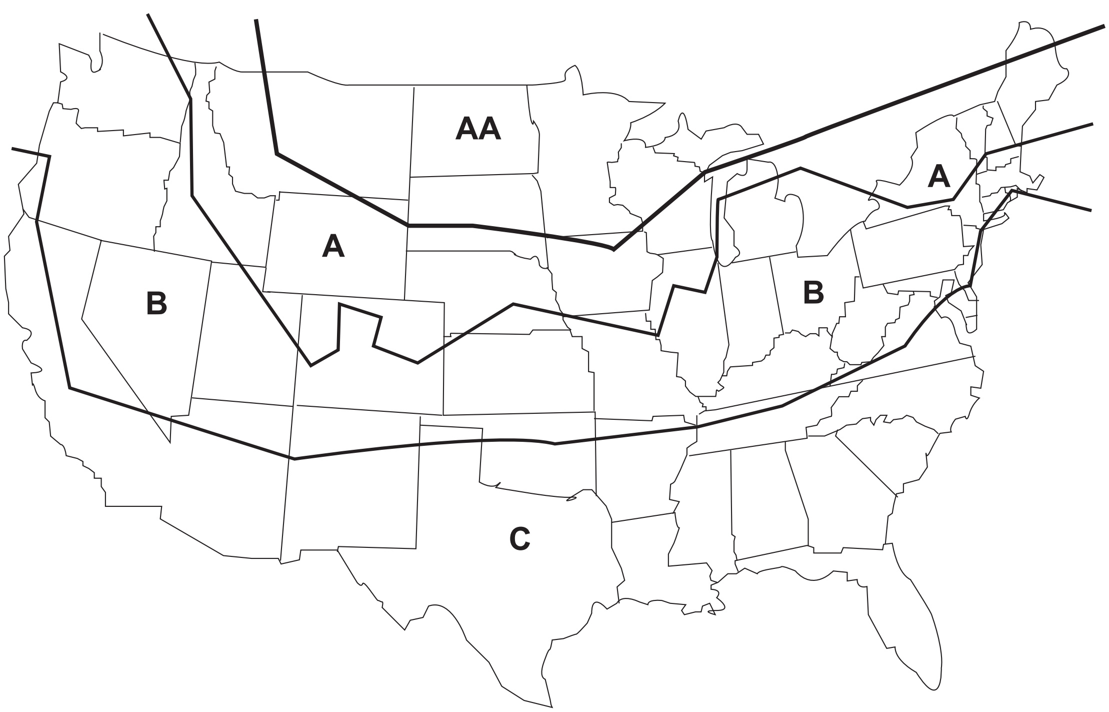
SUBS: CHANGE TO IMAC 79-2, 26 DEC 72, TO AFM 88-15

WHEN REVISION OF AFM 88-15 IS COMPLETED, IT WILL REFLECT THE FOLLOWING CONTEXT; DIRECT FIRE HEATERS AND FURNACES RE PROHIBITED IN AREAS SUBJECT TO HAZARDOUS CONCENTRATION OF FLAMABLE GASES, VAPORS, OR DUSTS, SUCH AS AIRCRAFT HANGARS. THIS PROHIBITION DOES NOT APPLY TO VEHICLE MAINTENANCE SHOPS WHEN THE EQUIPMENT IS INSTALLED IN COMPLIANCE WITH PROVISIONS OF NFPA AND NEC APPLICABLE TO SUCH SHOPS. USE OF APPROVED GAS OR OIL FIRED RADIANT TUBE HEATING SYSTEMS WHERE THE AIR SUPPLY FOR THE IGNITION SOURCE AND THE DISCHARGE OF THE PRODUCTS OF COMBUSTION ARE BOTH EXTERNAL TO THE BUILDING ARE ALSO PERMITTED IN AIRCRAFT HANGARS WHEN INSTALLED IN ACCORDANCE WITH NFPA 409.

Characterization of Four Climate Zones

Roberts-Gordon Heating Systems can be separately designed in the four climate zones with the following ASHRAE listed 99% Dry Bulb outside design temperature.

Heating Zone	Temperature Range
Zone AA	-20°F to 0°F
Zone A	+1°F to +10°F
Zone B	+11°F to +20°F
Zone c	+21°F and above



Degree Day Information

State	Heating Degree Day Base					Design Temp. Dry Bulb	Design Temp. Dry Bulb	Cooling Degree Day Base				
	65	60	55	50	45	99%	97%	65	60	55	50	45
Alabama												
Bimingham	2844	1995	1233	838	488	17	21	1928	2916	4073	5403	6877
Huntsville	3302	2414	1670	1103	686	11	16	1808	2747	3828	5090	6492
Mobile	1684	1062	619	330	148	25	29	2577	3780	5162	6698	8342
Montgomery	2269	1508	945	547	282	22	25	2238	3302	4568	5991	7551
Alaska												
Anchorage	10911	9122	7492	6081	4896	-23	-18	0	36	224	647	1279
Annette	7053	5315	3773	2513	1543			14	99	386	940	1808
Barrow	202265	18440	16615	14803	13009	-45	-41	0	0	0	13	44
Barter Island	19994	18169	16344	14528	12738			0	0	0	9	44
Bether	13203	11404	9685	8140	6835			0	26	142	411	938
Bettles	15925	14180	12548	11060	9718			17	97	289	626	1110
Big Delta	13698	11985	10410	8977	7735			34	145	395	787	1370
Cold Bay	9865	8040	6230	4532	3096			0	0	16	138	533
Fairbanks	14345	12661	11115	9714	8451	-51	-47	52	196	467	898	1468
Gulkana	13938	12162	10507	8985	7648			9	63	228	537	1027
Homer	10364	8539	6745	5133	3840			0	0	24	240	777
Juneau	9007	7222	5557	4107	2925	-4	-1	0	39	197	573	1219
King Salmon	11582	9773	8047	6563	5304			0	12	112	465	1023
Kodiak	8860	7049	5327	3819	1593	10	13	0	7	117	436	1032
Kotzebue	16039	14237	12491	10852	9337			0	23	102	288	598
McGrath	14487	12736	11107	9634	8348			14	88	284	642	1184
Nome	14325	12503	10721	9047	7528	-31	-27	0	0	46	197	503
St. Paul Island	11119	9294	7469	5667	4021			0	0	0	24	199
Shemya	9735	7910	6085	4298	2693			0	0	0	30	254
Summit FAA	14368	12556	10790	9146	7640			0	10	71	253	578
Takeetna	11708	9934	8306	6848	5609			6	57	254	260	1207
Unalakleet	14027	12238	10515	8943	7565			0	31	138	391	842
Yakutat	9533	7711	5942	4420	3181			0	0	56	362	947
Arizona												
Flagstaff	7322	5776	4421	3267	2299	-2	4	140	416	894	1562	2418
Phoenix	1552	899	431	165	45	31	34	3508	4680	6039	7596	9297
Prescott FAA	4456	3303	2321	1507	883	4	0	882	1560	2400	3414	4612
Tucson	1752	1050	541	229	65	28	323	2814	3937	5253	6765	8431
Winslow	4733	3623	2683	1882	1249	5	10	1203	1921	2902	3828	5018
Yuma	1005	507	211	59	8	36	39	4195	5518	7045	8719	10498
Arkansas												
Fort Smith	3336	2442	1687	1075	613	12	17	2022	2949	4015	5239	6595
Little Rock	3354	2442	1687	1075	624	15	20	1925	2843	3908	5128	6496
California												
Bakersfield	2185	1367	760	371	147	30	32	2179	3185	4400	5835	7437
Bishop	4313	3179	2230	1437	848			1037	1728	2603	2641	2876
Blue Canyon	5704	4271	3037	1015	1206			302	698	1283	2079	2106
Daggett FAA	2203	1420	824	410	166			2729	3765	5004	6415	7996
Eureka	4679	2925	1494	607	194	31	33	0	55	460	1414	2816
Fresno	2650	1724	995	493	205	28	30	1671	2563	3667	4986	6525
Long Beach	1606	772	292	70	8	41	43	985	1982	3325	4928	6696
Los Angeles Intl.	1819	833	295	66	7	41	43	615	1464	2755	4348	6115
Los Angeles C.C	1245	522	158	26	0	37	40	1185	2289	3747	5442	7244
Mount Shasta	5890	4458	3215	2177	1338			286	680	1263	2045	3035
Oakland	2909	1570	714	263	61	34	36	128	622	1598	2963	4587
Red Bluff	2688	1762	1018	505	208			1904	2803	1895	5196	6727
Sacramento	2843	1837	1043	493	186	30	32	1159	1971	3011	4286	4812
Sacramento City	2587	1627	893	406	148			1291	2158	3249	4584	6151
Sandberg	4427	3177	2107	1250	622			800	1274	2123	3100	4293
San Francisco AP.	1507	648	213	42	9	35	38	722	1694	3084	4746	6532
San Francisco FB.	3080	1576	608	169	25			39	368	1230	2619	4298
Santa Maria	3053	1624	690	229	42	31	33	84	484	1377	2738	4380
Stockton	2806	1835	1072	537	219	28	30	1259	2100	3167	4455	5968

Degree Day Information

State	Heating Degree Day Base					Design Temp. Dry Bulb	Design Temp. Dry Bulb	Cooling Degree Day Base				
	65	60	55	50	45	99%	97%	65	60	55	50	45
Colorado												
Alamosa	8609	7029	5654	4473	3457	-21	-16	88	329	780	1428	2227
Colorado Springs	6473	5131	3954	2949	2089	-3	2	461	945	1592	2417	3383
Denver-Stapleton	6016	4723	3601	2653	-5		1	625	1159	1857	2739	3759
Denver-City	5505	4246	3175	2271	1533			742	1312	2071	2993	4074
Eagle	8426	6864	5505	4319	3317			117	385	845	1487	2313
Grand Junction	5605	4441	3425	2551	1814	2	7	1140	1810	2619	3565	4653
Pueblo	5394	4221	3220	2351	1628	-7	0	981	1632	2456	3412	4514
Conneccticut												
Bridgeport	5461	4264	3216	2321	1583	6	9	735	1362	2140	3064	4152
Hartford	6350	5085	3871	3005	2173	3	7	584	1143	1855	2715	3706
District Columbia												
Wash DC (Dulles)	5005	3881	2898	2054	1380			940	1636	2474	3458	4616
Wash DC (Nat AP)	4211	3182	2293	1563	984	14	17	1415	2210	3152	4237	5489
Delaware												
Wilmington	4980	3824	2839	2003	1330	10	14	992	1697	2537	3525	4675
Florida												
Apalachicola	1361	792	426	189	67			2663	3930	5377	6967	8669
Dayton Beach	897	480	215	71	25	31	32	2929	4321	5881	7563	9341
Fort Myers	457	189	56	9	0	41	44	3711	5265	6958	8741	10553
Jacksonville	1327	788	429	194	70	29	32	2596	3890	5349	6938	8641
Key West	59	7	0	0	0	55	57	4838	6660	8474	10299	12124
Lakeland	678	330	128	40	7	39	41	3929	4774	6398	8135	9927
Miami	206	54	8	0	0	44	47	4038	5715	7494	9306	11131
Orlando	733	370	151	48	9	35	38	3226	4686	6291	8016	9806
Pensacola	1578	991	575	302	135	29	33	2695	3932	5341	6893	8551
Tallahassee	1563	996	550	279	116	27	30	2563	3792	5200	6755	8415
Tampa	718	364	151	50	14	36	40	3366	4836	6447	8172	9963
West Palm Beach	299	88	27	0	0	41	45	3786	5408	7159	8960	10785
Georgia												
Athens	2975	2084	1370	830	462	18	22	1722	2661	3767	5052	6508
Atlanta	3095	2189	1461	911	524	17	22	1589	2511	3604	4880	6316
Augusta	2547	1729	1106	652	348	20	23	1995	2999	4204	5573	7094
Columbus	2378	1600	1010	593	313	21	24	2143	3188	4429	5831	7375
Macon	2240	1492	934	536	271	21	25	2294	3373	4643	6068	7626
Rome	3342	2422	1653	1068	637			1615	2514	3576	4816	6210
Savannah	1952	1258	751	413	185	24	27	2317	3444	4766	6248	7851
Hawaii												
Hilo	0	0	0	0	0	61	62	3066	4887	6712	8537	10362
Honolulu	0	0	0	0	0	62	63	4221	6046	7871	9696	11521
Kahului	0	0	0	0	0			3732	5555	7380	9205	11030
Lihue	0	0	0	0	0			3719	5535	7360	9185	11010
Idaho												
Boise	5833	4533	3399	2434	1626	3	10	714	1233	1929	2793	3811
Idaho Falls	8619	7129	5800	4609	3590	-11	-6	237	573	1064	1703	2511
Lewiston	5464	4168	3050	2112	1366	-1	6	657	1186	1886	2780	3856
Pocatello	7063	5687	4454	3401	2504	-8	-1	437	883	1477	2252	3177
Illinois												
Cairo	3833	2895	2090	1447	925			1806	2687	3710	4893	6197
Chicago Midway	6127	4952	3912	2998	2219	-5	0	925	1575	2361	3272	4317
Chicago O'Hare	6497	5245	4163	3220	2404	-8	-4	664	1243	1986	2863	3872
Decatur	5344	4247	3293	2461	1778	-3	2	1197	1925	2797	3791	4932
Moline	6395	5202	4170	3263	2462	-9	-4	893	1530	2324	3236	4262
Peoria	6098	4930	3910	3013	2239	-8	-4	968	1631	2431	3360	4412
Rockford	6845	5600	4507	3555	2713	-9	-4	714	1298	2032	2899	2883
Springfield	5558	4437	3468	2615	1913	-3	2	1116	1821	2670	3654	4772

Degree Day Information

State	Heating Degree Day Base					Design Temp. Dry Bulb	Design Temp. Dry Bulb	Cooling Degree Day Base				
	65	60	55	50	45	99%	97%	65	60	55	50	45
Indiana												
Evansville	4624	3578	2685	1929	1327	4	9	1364	2139	2064	4140	5367
Fort Wayne	6209	4992	3930	2996	2193	-4	1	748	1358	2117	2008	4030
Indianapolis	5577	4430	3431	2568	1856	-2	2	974	1653	2478	2441	4554
South Bend	6462	5213	4118	3156	2333	-3	1	695	1271	2002	2865	3867
Iowa												
Burlington Radio	6149	4988	3970	3077	2308	-7	-3	994	1657	2466	2296	4447
Des Molines	6710	5521	4470	3546	2728	-10	-5	928	1561	2335	3225	4243
Dubuque	7277	5992	4871	3893	3028	-12	-7	606	1146	1850	2697	3657
Mason City	7901	6586	5430	4425	3529	-15	-11	580	1088	1763	2581	2508
Soiux City	6963	5745	4674	3738	2898	-11	-7	932	1545	2298	3182	4177
Spencer	7770	6474	5329	4334	3448			641	1171	1857	2685	3620
Waterloo	7415	6153	5040	4070	3199	-15	-10	675	1236	1950	2806	3760
Kansas												
Concordia	5623	4498	3509	2646	1912			1302	1998	2832	3795	4886
Dodge City	5046	3963	3011	2184	1512	0	5	1411	2153	3022	4025	5176
Goodland	6119	4891	2804	2857	2041	-5	0	925	1515	2253	3131	4139
Russell FAA	5312	4220	3259	2423	1735	0	4	1485	2219	3081	4076	5210
Topeka	5243	4152	3203	2378	1700	0	4	1361	2093	2974	3974	5112
Wichita	4687	3654	2750	1977	1346	3	7	1673	2464	3364	4438	5638
Kentucky												
Covington	5070	3965	3001	2189	1527	1	6	1080	1798	2654	3672	4834
Lixington	4729	3652	2743	1963	1350	3	8	1197	1941	2858	2904	5120
Louisville	4640	3584	2676	1906	1303	3	10	1268	2032	2942	4005	5227
Louisiana												
Alexandria	2200	1443	880	490	234	23	27	2193	3260	4525	5958	7531
Baton Rouge	1670	1036	582	295	120	25	29	1585	3775	5150	6685	8340
Lake Charles	1498	908	500	240	91	27	31	2739	3978	5291	6956	8638
New Orleans Aud	1343	805	439	202	82			2876	4166	5622	7215	8916
New Orleans N O	1465	893	492	239	96	29	33	2706	3960	5383	6956	8638
Shreveport	2167	1438	883	490	233	20	25	2538	3634	4906	6335	7903
Maine												
Bangor	7950	6496	5222	4103	3122	-11	-6	268	640	1194	1896	2470
Caribou	9632	8044	6634	5409	4319	-18	-13	128	365	784	1379	2118
Old Town FAA	8648	7133	5800	4628	3589			209	519	1016	1660	2454
Portland	7498	6035	4764	3658	2705	-6	-1	252	616	1169	1890	2758
Maryland												
Baltimore	4729	3631	2682	1873	1236	10	13	1108	1840	2708	3728	4918
Massachusetts												
Blue Hill	6335	5020	3885	2895	2071			457	968	1659	2493	3498
Boston	5621	4383	3313	2405	1659	6	9	661	1250	2000	2920	4000
Nantucket	5929	4520	3323	2311	1513			284	708	1332	2143	3170
Worchester	6848	5498	4326	3296	2421	0	4	387	863	1514	2303	3159
Michigan												
Alpena	8518	6982	5635	4473	3464	-11	-6	208	497	981	1642	2459
Detroit	6419	5167	4072	3113	2280	3	6	654	1227	1061	2832	3815
Flint	7041	5705	4540	3529	2540	-4	1	438	923	1586	2399	3335
Grand Rapids	6801	5514	4383	3396	2524	1	5	575	1108	1807	2646	3598
Houghton Lake	8347	6861	5579	4455	3486			250	590	1132	1832	2689
Lansing	6904	5608	4464	3470	2595	-3	1	535	1059	1747	2578	3528
Marquette	8351	6835	5517	4379	2278	-12	-8	216	531	1031	1725	2549
Muskegon	6890	5550	4390	2272	2482	2	6	469	953	1620	2428	3360
Sault Ste Marie	9193	7614	6215	5017	3971	-12	-8	139	386	816	1443	2217
Traverse City	7698	6272	5035	3953	3013	-3	1	376	773	1362	2101	2989

Degree Day Information

State	Heating Degree Day Base					Design Temp. Dry Bulb	Design Temp. Dry Bulb	Cooling Degree Day Base				
	65	60	55	50	45	99%	97%	65	60	55	50	45
Minessota												
Duluth	9756	8185	6793	5581	4540	-21	-16	176	425	864	1482	2259
Intl. Falls	10547	8995	7623	6413	5348	-29	-25	176	454	908	1523	2283
Minn.-St. Paul	8159	6842	5677	4668	3765	-16	-12	585	1097	1758	2575	3491
Rochester	8227	6868	5682	4643	3733	-17	-12	474	943	1579	2370	3280
St. Cloud	8868	7481	6255	5181	4241	-15	-11	426	862	1468	2220	3098
Mississippi												
Jackson	2300	1548	988	590	319	21	25	2316	3394	4664	6086	7639
Meridian	2388	1621	`042	623	339	19	23	2231	3289	45438	5940	7483
Missouri												
Columbia	5078	3997	3964	2259	1605	-1	4	1269	2009	2901	2919	5089
Kansas City	5161	4089	3157	2351	1694	2	6	1421	2169	3061	4085	5249
St. Joseph	5435	4341	3378	2544	1847	-3	2	1334	2064	2925	3911	5046
St. Louis	4750	3701	2798	2031	1419	3	8	1475	2252	3174	4232	5445
Springfield	4570	3517	2611	1844	11235	3	9	1382	2149	3068	4126	5342
Montana												
Billings	7265	5898	4697	3641	2766	-15	-10	498	951	1581	2354	3298
Butte	9717	8059	6557	5225	4078	-24	-17	58	222	545	1038	1718
Cut Bank	9033	7474	6096	4907	3886	-25	-20	140	406	856	1489	2299
Dilon	8354	6821	5457	4255	3237			199	492	953	1570	2382
Glasgow	8969	7572	6329	5238	4302	-22	-18	438	867	1449	2185	3074
Greatt Falls	7652	6248	5022	2965	3074	-21	-15	339	760	1365	2132	3066
Havre	8687	7282	6073	5005	4104	-18	-11	395	818	1432	2191	3113
Helena	8190	6710	5389	4247	3258	-21	-16	256	606	1105	1786	2629
Kalispell	8554	6959	5542	4304	3233	-14	-7	117	348	755	1342	2096
Lewiston FAA	8586	7038	5676	4487	3467	-22	-16	192	168	933	1567	2379
Miles City	7889	6562	5392	4369	3479	-20	-15	752	1252	1905	2706	3641
Missoula	7931	6410	5066	2884	2876	-13	-6	188	497	970	1616	2428
Nebraska												
Grand Island	6420	5224	4166	3239	2434	-8	-3	1036	1662	2428	3326	4245
Lincoln Ap	6218	5062	4040	3139	2362			1148	1809	2611	3536	4585
Lincoln	6012	4875	3870	2993	2234	-5	-2	1187	1865	2685	3634	4701
Norfolk	6981	5745	4663	3710	2863	-8	-4	925	1520	2263	3131	4118
North Platte	6743	5470	4345	3354	2509	-8	-4	802	1359	2060	2898	3874
Omaha-Eppley	6049	4907	3911	3037	2290			1173	1862	2691	2637	4715
Omaha-North	6601	5400	4349	3427	2624	-8	-3	949	1573	2346	3249	4270
Scottsbluff	6774	5473	4304	3289	2415	-8	-3	666	1188	1845	2653	3605
Valentine	7300	6006	4859	3847	2956			736	1267	1945	2758	3692
Nevada												
Elko	7483	6027	4714	3586	2625	-8	-2	342	706	1228	1910	2785
Ely	7814	6327	5004	3826	2829	-10	-4	207	550	1052	1694	2526
Las Vegas	2601	1770	1120	625	306	25	28	2946	3938	5114	6443	7950
Lovelock FAA	5990	4695	3550	2579	1747	8	12	684	1217	1894	2743	3740
Reno	6022	4612	3387	2360	1534	5	10	329	739	1344	2150	3140
Tonopah	5900	4610	3492	2532	1723	5	10	631	1167	1869	2739	3753
Winnemucca	6629	5241	3994	2931	2015	-1	3	407	845	1423	2185	3096
New Hampshire												
Concord	7360	5967	4757	3682	2762	-8	-3	349	781	1294	2150	3051
Mt. Washington	13878	12053	10253	8534	6960			0	0	25	132	379
New Jersey												
Atlantic City	4946	3783	2784	1941	1267	10	13	864	1533	2349	3339	4485
Atlantic City Marina	4693	3534	2530	1713	1076			835	1503	2317	3333	4517
Newark	5034	3911	2920	2074	1391	10	14	1024	1721	2543	3533	4677
Trenton	4947	3818	2832	1996	1323	11	14	968	1661	2493	25482	4643

Degree Day Information

State	Heating Degree Day Base					Design Temp. Dry Bulb	Design Temp. Dry Bulb	Cooling Degree Day Base				
	65	60	55	50	45	99%	97%	65	60	55	50	45
New Mexico												
Albuquerque	4292	3234	2330	1557	963	12	16	1316	2080	2996	4053	5288
Clayton	5207	3999	2966	2089	1374			767	1380	2176	3120	4231
Roswell	3697	2729	1898	1226	706	13	18	1560	2417	3412	4566	5872
Truth or Consequences	3392	2447	1636	1007	542			1558	2429	3447	4647	6008
Tucmcari FAA	4047	3015	2135	1415	858	8	13	1357	2148	3096	4200	5467
Zuni FAA	5815	4507	3381	2437	1648			473	983	1685	2567	3605
New York												
Albany	6888	5596	4451	3457	2597	-6	1	574	1111	1787	2619	3583
Binhamton	7285	5908	4714	3677	2767	-2	1	369	820	1452	2231	3151
Buffalo	6927	5591	4429	3403	2508	2	6	437	928	1590	2388	3319
Massena FAA	8237	6827	5596	4510	3552	-13	-8	343	759	1352	2088	2958
New York Cent Park	4848	3739	2771	1958	1299	11	15	1068	1784	2636	3653	4814
New York JFK	5184	4023	2994	2130	1422	12	15	861	1520	2321	3278	4395
New York LaGuardia	4909	3787	2806	1980	1311	11	15	1048	1752	2587	3589	4740
Oswego East	6792	5444	4274	3243	2376	1	7	435	915	1570	2360	3319
Rochester	6719	5417	4285	3291	2434	1	5	531	1062	1750	2580	3549
Syracuse	6678	5379	4250	3267	2429	-3	2	551	1081	1778	2621	3607
North Carolina												
Ashville	4237	3129	2224	1488	937	10	14	872	1587	2508	3595	4868
Cape Hattleras	2731	1846	1166	702	380			1550	2485	3635	4991	6500
Charlotte	3218	2300	1552	984	585	18	22	1596	2503	3579	4842	6263
Greensboro	3825	2811	1984	1324	825	14	18	1341	2158	3149	4318	5640
Raleigh-Durham	3514	2542	1744	1123	670	16	20	1394	2242	3273	4482	5850
Wilmington	2433	1632	1028	610	321	23	26	1964	2995	4225	5622	7162
North Dakota												
Bismark	9044	7656	6425	5326	4374	-23	-19	487	928	1518	2248	3116
Fargo	9271	7891	6663	5573	4615	-22	-18	473	919	1515	2251	3122
Minot FAA	9407	7964	6685	5564	4573	-24	-20	370	758	1299	2002	2837
Williston	9161	7753	6504	5387	4450	-25	-21	422	841	1415	2128	3011
Ohio												
Akron-Canton	6224	4971	3883	2936	2129	1	6	634	1205	1943	2820	3839
Cincinnati Abbe Obs	4844	3763	2830	2040	1412			1188	1931	2819	3964	5060
Cincinnati AP	5070	3965	3001	2189	1527	1	6	1080	1798	2654	3672	4834
Cleveland	6154	4901	3819	2876	2079	1	5	613	1183	1926	2807	3836
Colombus	5702	4513	3480	2597	1846	0	5	809	1449	2244	3183	4257
Dayton	5641	4483	3468	2600	1866	-1	4	936	1603	2414	3370	4460
Mansfield	5818	4618	3573	2679	1917	0	5	818	1445	2225	3153	4219
Toledo Express	6381	5136	4049	3091	2274	-3	1	685	1268	2001	2870	3977
Youngstown	6426	5145	4032	3054	2232	-1	4	518	1065	1774	2621	3623
Oklahoma												
Oklahoma City	3695	2760	1962	1326	809	9	13	1876	2768	3788	4980	6289
Tulsa	3680	2750	1950	1306	778	8	13	1949	2850	3865	5052	6347
Oregon												
Astoria	5295	3620	2233	1215	570	25	29	13	159	596	1415	1598
Burns	7212	5740	4436	3299	2343			289	649	1168	1851	2724
Eugene	4739	3313	2141	1226	607	22	17	239	638	1286	2201	3417
Maecham	7863	6249	4817	3556	2495			103	317	712	1275	2034
Medford	4930	3614	2496	1577	882			562	1077	1779	1685	3813
North Bend	4688	2985	1642	756	292			0	131	597	1553	2913
Pendelton	5240	3968	2868	1970	1264	-2	5	656	1211	1935	2858	3982
Portland	4792	3385	2234	1333	708	17	23	300	711	1378	2309	3520
Redmond	6643	5106	3767	2621	1680			170	459	943	1620	2512
Salem	4852	3424	2246	1317	667	18	23	232	620	1272	2169	3355
Sexton Summit	6430	4859	3477	2311	1374			137	381	837	1499	2386

Degree Day Information

State	Heating Degree Day Base					Design Temp. Dry Bulb	Design Temp. Dry Bulb	Cooling Degree Day Base				
	65	60	55	50	45	99%	97%	65	60	55	50	45
Pennsylvania												
Allentown	5827	4618	3550	2633	1843	4	9	772	1392	2150	3053	4088
Bradford	7804	6294	5006	3894	2931			170	482	1022	1735	2596
Erie	6851	5485	4304	3283	2411	4	9	373	832	1482	2282	3235
Harrisburg	5224	4087	3097	2238	1541	7	11	1025	1711	2545	3511	4644
Philadelphia	4865	3753	2788	1965	1312	10	14	1104	1817	2671	3679	4849
Pittsburg City	5278	4135	3138	2294	1603			948	1630	2456	3440	4573
Pittsburg AP	5930	4694	3637	2720	1938	1	5	647	1240	2004	2914	3961
W-Barre-Scranton	6277	5018	3928	2972	2149	1	5	608	1181	1909	2778	3783
Williamsport	5981	4757	3695	2764	1971	2	7	698	1299	2059	2952	3986
Rhode Island												
Block Island	5771	4432	3289	2306	1517			359	844	1523	2368	3409
Providence	5972	4682	3565	2599	1803	5	9	532	1067	1774	2625	3662
South Carolina												
Charleston	2146	1406	864	496	240	24	27	2078	3163	4454	5903	7478
Charleston City	1904	1230	741	412	188	25	28	2354	3502	4839	6334	7937
Columbia	2598	1738	1154	686	374	20	24	2087	3094	4292	6547	7156
Florence	2566	1748	1127	676	374	22	25	1952	2960	4171	5538	7060
Gmvle-Spartenburg	3163	2246	1493	921	519	18	22	1573	2477	3552	4809	6229
South Dakota												
Aberdeen	8617	7267	6078	5014	4087	-19	-15	566	1046	1678	2440	3337
Huron	8055	6751	5600	4852	3678	-18	-14	711	1239	1912	2714	3541
Pierre	7677	6401	5271	4273	3409	-15	-10	858	1406	2102	2928	3839
Rapid City	7324	5982	4799	3762	2868	-11	-7	661	1148	1786	2575	3511
Sioux Falls	7838	6543	5401	4394	3498	-15	-11	719	1253	1933	2146	3681
Tennessee												
Bristol	4306	3255	2373	1646	1093	9	14	1107	1880	2823	3922	5197
Chattanooga	3505	2574	1785	1180	737	13	18	1636	2526	3566	4791	6169
Knoxville	3478	2557	1775	1187	744	13	19	1569	2475	3518	4753	6135
Memphis	3227	2352	1624	1058	640	13	18	2029	2984	4077	5339	6744
Nashville	3696	2758	1964	1338	852	9	14	1694	2576	3613	4812	6151
Oak Ridge	3944	2955	2119	1445	933			1367	2202	3187	4338	5656
Texas												
Abilene	2610	1801	1162	664	342	156	20	2466	3481	4670	5995	7498
Amarillo	4183	3156	2278	1548	976	6	11	1433	2230	3177	4274	5527
Austin	1737	1097	620	316	127	24	28	2903	4095	5443	6962	8600
Bronwsville	650	336	146	54	19	35	39	3874	5385	7020	8753	10543
Corpus Christi	930	514	243	98	28	31	35	3474	4880	6438	8111	9872
Dallas	2290	1544	949	526	250	18	22	2755	3835	5973	6467	8016
Del Rio	1523	923	494	230	80	26	31	3363	4596	5986	7548	9222
El Paso	2678	1833	1149	653	326	20	24	2098	3077	4229	5548	7048
Fort Worth	2382	1616	1007	562	274	17	22	2587	3542	4862	6239	7775
Galveston	1224	704	369	157	54	31	36	3004	4312	5800	7413	9139
Houston	1434	864	471	215	81	27	32	2889	4147	5576	7150	8835
Laredo No 2	876	481	230	87	32	32	36	4137	5568	7143	8824	10593
Lubbock	3545	2603	1807	1163	666	10	15	1647	2535	3559	4745	6068
Lufkin	1940	1253	173	385	163	25	29	2592	3730	5033	6512	8114
Midland	2621	2808	1159	656	333	16	21	2245	3258	4434	5757	7258
Port Arthur	1518	924	504	238	86	16	27	2798	4028	5431	6990	8669
San Angelo	2240	1498	918	493	227	18	22	2702	3798	5031	6432	7993
San Antonio	1570	956	518	242	92	25	30	2994	4206	5594	7146	8818
Victoria	1227	702	364	150	51	29	32	3140	4440	5925	7537	9262
Waco	2058	1357	807	437	195	21	26	2863	3988	5271	6717	8303
Wichita Falls	2904	2061	11384	832	451	14	18	2611	3594	4741	6015	7458

Degree Day Information

State	Heating Degree Day Base					Design Temp. Dry Bulb	Design Temp. Dry Bulb	Cooling Degree Day Base				
	65	60	55	50	45	99%	97%	65	60	55	50	45
Utah												
Blanding	6163	4869	3732	2757	1912			600	1129	1827	2670	3646
Bryce Canyon	9133	7450	5949	4616	3480			41	193	505	1005	1686
Cedar City	6137	4833	3690	2717	1897	-2	5	615	1130	1813	2671	3678
Milford	6412	5109	3957	2969	2121			688	1212	1885	2721	3704
Salt Lake City	5983	4733	3633	2676	1864	3	8	927	1502	2221	3094	4108
Wendonver	5760	4558	3511	2621	1870			1137	1760	2538	3475	4547
Vermont												
Burlington	7876	6488	5270	4190	3246	-12	-7	396	833	1440	2180	3066
Virginia												
Lynchburg	4233	3172	2269	1536	966	12	16	1100	1861	2783	3873	5128
Norfolk	3488	2516	1710	1100	663	20	22	1441	2284	3315	4530	5918
Richmond	3939	2916	2061	1388	866	14	17	1353	2157	3127	4276	5580
Roanoke	4207	3234	2326	1580	1001	12	16	1030	1778	2690	3771	5029
Wallops Island	4240	3170	2268	1531	987			1107	1865	2788	3881	5149
Washington												
Olympia	5530	3970	2653	1617	854	16	22	101	365	880	1657	2731
Omak	6858	5476	4253	3230	2355			522	965	1573	2367	3324
Quillayute	5951	4232	2750	1603	813			8	116	458	1137	2172
Seattle-Tacoma	5185	3657	2386	1416	731	21	26	129	423	984	1832	2981
Seattle-(Urban)	4727	3269	2091	1194	602	22	27	183	549	1197	2127	3358
Spokane	6835	5420	4173	3088	2188	-6	2	388	797	1377	2120	3040
Stampede Pass	9400	7643	6006	4532	3256			16	83	274	623	1176
Walla Walla	4835	3616	2600	1760	1126	0	7	862	1471	2279	3260	4457
Yakima	6009	4655	3483	2502	1688	-2	5	479	945	1604	2452	3455
West Virginia												
Beckey	5615	4356	3279	2390	1652	-2	4	490	1061	1809	2745	3833
Charleston	4590	3500	2590	1809	1216	7	11	1055	1790	2699	3750	4981
Elkins	5975	4659	3533	2616	1834	1	6	389	905	1601	2508	3555
Huntington	4624	3533	2624	1843	1249	5	10	1098	1829	2746	3790	5020
Parkersburg	4817	3720	2786	1987	1363	7	11	1045	1770	2657	3686	4888
Wisconsin												
Eau Claire	8388	7033	5832	4786	3860	-15	-11	459	928	1554	2332	3231
Green Bay	8098	6689	5473	4405	3478	-13	-9	368	805	1411	2168	3066
La Crosse	7417	6158	5050	4088	3219	-13	-9	695	1264	1978	2841	3798
Madison	7730	6373	5188	4156	3250	-11	-7	460	923	1572	2361	3279
Milwaukee	7444	6080	4898	3860	2946	-8	-4	450	911	1554	2342	3252
Wyoming												
Casper	7555	6167	4914	3813	2857	-11	-5	458	895	1468	2193	3061
Cheyenne	7255	5825	4562	3452	2512	-9	-1	327	734	1288	2003	2886
Lander	7869	6471	5207	4080	3140	-16	-11	383	814	1376	2078	2965
Rock Springs	8410	6922	5592	4412	3393	-9	-3	227	563	1059	1703	2515
Sheridan	7708	6298	5024	3935	3000	-14	-8	446	860	1411	2147	3037

Degree Day information is extracted from a publication entitle “Degree Days Selected Bases” that is available from the National Climatic Center, U.S. Department of Commerce, National Oceanic & Atmospheric Administration.

Design Temperature Dry Bulb is extracted from the 1989 ASHRAE Handbook of Fundamentals Section 24.4 table 1 of Climatic Conditions for the United States

Aviation
Facilities Heating

User List:
Commercial Aviation Installations

All claims related to gas-fired, low-intensity heating are predicated on the equipment being designed, installed, maintained and serviced properly by a qualified professional.

Installation Code and Annual Inspections: All installation and service of ROBERTS GORDON® equipment must be performed by a contractor qualified in the installation and service of equipment sold and supplied by Roberts-Gordon LLC and conform to all requirements set forth in the ROBERTS GORDON® manuals and all applicable governmental authorities pertaining to the installation, service and operation of the equipment. To help facilitate optimum performance and safety, Roberts-Gordon LLC recommends that a qualified contractor conduct, at a minimum, annual inspections of your ROBERTS GORDON® equipment and perform service where necessary, using only replacement parts sold and supplied by Roberts-Gordon LLC.

Further Information: Applications, engineering and detailed guidance on systems design, installation and equipment performance is available through ROBERTS GORDON® representatives. Please contact us for any further information you may require, including the Installation, Operation and Service Manual.

These products are not for residential use.

This document is intended to assist licensed professionals in the exercise of their professional judgment.

AVIATION FACILITIES

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
ALABAMA				
	Service Enterprise (Hangar)	Chatom, AL	2 CTH 80 LP	3/1/89
	Huntsville Hospital Hangar	Huntsville, AL	2 CTH 125 LP	1/1/90
ALASKA				
27	Anchorage Int'l Airport-	Alaska Airlines - Cargo Ctr/ Truck Area - Anchorage, AK 907/243-3322	28 CRV6 - 60	
"	Servair, Inc.	International Airport - Anchorage, AK	1 RTH 150A	7/87
		Maint. Shop	1 RTH R100	
"	Anchorage Int'l Airport	Concourse - Anchorage, AK 907/276-3642	20 CRV3-40	1996
"	Anchorage Int'l Airport	80331 Satellite Terminal Anchorage, AK 907/276-3642	10 CRV 5-40	
"	Merrill Field - Stoddard Aero Svc - Helicopter Hangar	2550 E 5th Ave - Anchorage, AK 907/272-2327	18 CRV3-40	
"	Merrill Field - Era Helicopter	6160 S Airpark Dr _ Anchorage, AK 907/272-5422	18 CRV - 4-40	
"	Era Helicopter	Anchorage, AK	5 RTH-75	3/78
27	Merrill Field - Merrill Flight Svc - Anchorage, AK		16 CRV4-40	
"	Merrill Field - Evergreen Helicopters of Alaska Inc. - hangar	1935 Merrill Field Dr, Anchorage, AK 907/276-2452		
"	Merrill Field	Ocean Technology Ltd - Hangar, Anchorage, AK 907/272-5425	12 CRV4-40	
"	Alaska Helicopter - Hangar	Rapsberry 7 Sand lake Rd - Anchorage, AK 907/243-3404	4 CRV4-40	1979
27	Lake Hood Airstrip & Seaplane Base - US Fish & Wildlife Dept.	Hangar - Anchorage, AK 907/243-43-4336	19 LCRV3-40	
"	University of Alaska	Aviation Hangar, Anchorage, AK 907/276-3624	9 CRVA-2	4/81
"	Alaska Bush Carriers -	Aircraft Maint. Hangar 4801 Aircraft Dr- Anchorage, AK 907/423-3127	6 CRVA-2	
"	Soldotna Airport Missionary Aviation Repair	Box 511, Soldotna, AK 99669 (Mar) Hangar	6 CRV5-40	9/82
"	Alvin Pierle	Box 1771, Soldotna, AK 99669 907/262-7456	1 RTH-150 1 RTH-75	10/83
"	Chugiak Airport	Chugiak, AK	3 CRVA-8 LP	6/80
"	Williams Air Service	Wassilla, AK	1 CRVA-6	3/81
"	Barrow Air Service	Barrow, AK 907/276-2980	20 CRV5-40	8/83
"	Airtek Inc.	Soldotna, AK 907/347-2186	5 CRVA-8	10/85

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
ARIZONA				
10	Jacob Engineering - Hangar	1304 Red Baron Dr. - Payson, AZ, 85541 602/747-2014	5 CRVA-4 LP 2 CRVA-6 LP	11/84 “
30	Tucson Int’l Airport	Maintenance Garage, Tucson AZ, 85706 602/573-8100	1 CTH 125 N	7/87
30	Arizona Air - Craftsmen	Repair Shop - Sedona Airport, West Sedona, AZ	4 CRV E240 LP	10/1/89
30	Temp Control of Prescot	Hangar, 422 N. Arizona Prescott, AZ	3 CRV E300 Nat.	0/1/90
71	Hertz Service Center	Phoenix, AZ	1 CRV E360 1 CTH2-60	8/91
ARKANSAS				
36	Crain Industries	PO BOX 6207 - Ft Smith, AR, 72903	4 CRVA-8	3/82
“	Jones Hangar	Fayetteville, AR	4 CRVA-8	3/83
“	Brunnet - Lay Aircraft Hangar	Springdale Airport, Airport Rd. Springdale, AR, 72764 (501/756-0880)	6 CRVB-8	5/86
“	Walmart Hangar	Bentonville, AR	6 RTH 150A N	12/86
“	All Craft Hangar	Rogers, Arkansas	2 R-50	2/87
“	Arkansas Modification Ctr.	Hangar - Little Rock, AR 72202 501/372-1501	31 CRV6-60 6 CRV B10 Nat.	5/79 12/87
“	Falcon Jet Airport Fac.	PO BOX 967 Little Rock, AR	12 CRV B13 Nat. 2 CRV E180 Nat.	1/1/88 9/1/88
“	Arkansas Modifications	Hangar PO BOX 3356 Little Rock	6 CRV B10 Nat.	12/1/89
“	Stephens Hangar	Adams Field, Little Rock, AR	4 CRV B12 Nat.	4/1/90
“	TCBY Hangar	Adams Field, Little Rock, AR	2 CRV B10 Nat. 2 CRV B12 Nat.	9/1/89
CALIFORNIA				
16	Lockheed Aircraft	Ontario, CA	38 CRV6-60 64 CRVA-6 8 CRVA-8	1979 3/83 “
16	Hughes Aircraft Co.	3242 Veteran Ave. -Los Angeles, CA		
8	Osterland Enterprises	Hangar- Beckworth, CA 96129 Area 2	4 CRV5-40	9/81
“	US Postal Svc - Hangar	2000 Royal Oaks Dr. Sacramento CA 95813 916/921-4542	2 RTH 75A	12/84
16	U.S. Navy CBC	Port Hueneme, CA 93043 805/982-5087	4 RTH-R8 LP	
16	Schlaman A/C for Lockheed	4000 Alamo, Riverside, CA 92501 714/784-0811	24 CRV A8 Nat. 6 RTH R-50	1987
16	Airflite Bldg #2	2700 E. Wardlow Rd. Long Beach, CA 94621 415/569-7036	12 CRV A6 nat. 9 RTH 150	1987

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
CALIFORNIA (CONT'D)				
8	Federal Express Hangar Area 2	10 Alan Shepard Way, Oakland Metroplex Oakland CA 94621 415/569-7036	25 CRV B10 Nat. 9 RTH 150	10/87
8	Sacramento Metro Airport	Fire, Crash & Rescue Facility	2 CRV B6 Nat.	12/1/88
8	Ameriflight, Inc.	Oakland Hangar #2 381 Stockton Ave. San Jose, CA	4 CRV E180 Nat.	12/1/89
16	Pacific SW Airmotive	Hangar - 7007 Consolidated Way San Diego, CA	4 CRV 40 Nat.	1/1/91
27	Massey Aviation	Delano, CA 93215	2 RTH 75 Nat.	1/79
COLORADO				
26	Monford Hangar	Greeley Co.	4 CRV4-40	1979
"	Martin Aviation	"	2 CRV6-60 2 CRV4-40	1970 "
"	Centenial Airport	Wayne Robert's Hangar Littleton, CO	2 CRVA-8	3/83
"	"	John Miller's Hangar, Littleton, CO	2 CRVA-8	3/83
"	"	Hoaghland Hangar, Littleton, CO	2 CRVA-8	3/83
"	"	Love's Hangar, Littleton, CO	14 CRVA-8	1980
"	"	Kooi Brothers Hangar, Littleton, CO	4 CRVA-6 &	3/83
"	"	Charles Chancellon Hangar, Littleton, CO	2 CRVA-8	3/84
"	"	Dwayne Albrecht Hangar Littleton, CO	2 CRVA-8	3/83
"	"	Dusty Rhode Hangar Littleton, CO	2 CRVA-8	3/83
"	"	Marty Platt Hangar Littleton, CO	2 CRVA-7	3/83
"	"	Bill Nickle's Hangar Littleton, CO	2 CRVA-6	3/83
"	"	Combs-Gates Hangar Littleton, CO	12 CRVA-8	7/82
"	"	AERO Services 13100 Control Towel Rd, Littletown CO 303/799-0040	24 CRVA-8 1 CRVA-4 1 CRVA-6	7/83 "
"	"	US West Corporate Hangar	20 CRV B10	
"	David K. Allen Hangar	685 Winding Hills Road, Monument, CO	1 CTH 125	1/9/90
26	Frontier Delta Air Cargo Bldg.	8850 Smith Rd., Denver	14 CRVA-8 11 CRVA-6	4/83
26	Municipal Airport	Aero Rampart - Colorado Springs CO	4 CRV6-60 2 RTH	1978 1976

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
COLORADO (CONT'D)				
"	Municipal Airport Rampart Aviation	Colorado Springs, CO	12 CRV4-40	1972
"	Municipal Airport Air West Hangar	Colorado Springs, CO	6 CRV6-60	1977
"	Colorado Springs Airport	Colorado Springs, CO	1 RTH-75	1/83
"	Westaire Aviation Hangar	Colorado Springs, CO	8 CRVA-6 & 8 CRVA-8	3/82
26	Municipal Airport	Airwest Hangar, Colorado Springs, CO	10 CRV6-60	1976
"	John Janitell Jr.	Ranch Hangar - Fountain, CO	3 CRV6-60	1979
"	Maintenance Hangar	Calahan, CO	2 RTH	1979
"	Maintenance Hangar	Durango, CO		1979
"	Eagle Air Charter	Gypsum, CO	3 CRVA-8	1980
"	Municipal Airport	Monarch Aviation, Grand Junction, CO	16 CRV6-60 3 CRVA-8	1977 1980
"	Greeley Hangar	Greeley, CO	4 CRVA-6 1 RTH-75	10/82
"	Greeley Hangar - Aerial Spray	Greeley, CO	4 CRVA-4	4/83
"	Greeley Aerial	Greeley, CO	8 CRV4-40 1 CRV6-60	1976
"	Beegles Aircraft Service	Hangar - Greeley, CO	4 CRV A4 & 4 CRV A6	2/82
"	Beegles Aircraft Service	Hangar - Greeley, CO	3 CRVA-6 2 CRV5-40	1980
"	Gary Meermans - Hangar	15871 Duquesne, Brighton, CO 303/659-5530	2 RTH-75 N	3/84
"	Bulder Municipal Airport P &H Hangar	P & H Aviation, Boulder, CO 80301	3 RTH-150	12/83
"	Jeffco Airport	Aero Associates Hangar Broomfield, CO 80020	4 CRVA-6 4 CRVA-8 3 CRV6-60	7/83 " 1977
"	Jeffco Airport	Turbowest - Broomfield, CO 80020	7 CRV6-60	1978
"	Jeffco Airport	Denver Air Services	10 CRV6-60	1979
"	Tri County Air	Erie, CO	7 CRV6-60	1978
"	Erie Air Park	Olmstead Aviation, Lafayette, CO	7 CRV-600	3/79
"	Aero Systems - Hangar	Erie, CO	5 CRV6-60	4/79
"	Airwest Helicopters	Ft. Collins, CO	7 CRV6-60	1976
"	Double Eagle Properties	Ft. Collins, CO	3 CRV4-40 2 CRV6-60 4 CRVA-8	6/79 " 1980
"	Vintage Aircraft	Ft. Collins, CO	10 CRVA-6	1980
"	Archeleta Cty. Airport	Nichols Hangar, Pagosa Springs, CO 303/247-8235	5 CRVA-6 N 5 CRVA-8 N	8/84
"	Business Aircraft Sales Hangar	3100 Airport Rd. Boulder, CO 303/444-5560		9/86

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
COLORADO (CONT'D)				
"	Stapleton Int'l Airport	Atlas Aircraft - Denver, CO	2 RTH 75 N	9/86
"	Stapleton Int'l Airport	City & County of Denver	18 CRV B10 & 8 RTH-150	9/87
"	Stapleton Int'l Airport	City & County of Denver (Retrofit Boiler in Old Hangar)	112 CRV B12 HDS	11/89
"	Jefferson City Airport	National Center for Atmospheric Research Broomfield, CO	10 CRV-A 2 RTH-150	10/88
"	Jefferson City Airport	Paragon Ranch	6 CRV-A6	
CONNECTICUT				
38	North Canaan Aviation Hangar	68 Holmes Rd., Newington, CT 06512 203/795-0846	2 E-120 LP	11/86
38	Sikorsky Memorial Airport Aircraft Maintenance	Lordship Blvd., Stratford, CT 06497 203/874-4747	5 CRV A-8 N	3/87
38	Liveed Airport	Hangar 40 Thompson Ave. East haven, CT	6 CTH125 Nat.	11/1/88
DELAWARE				
17	Campbell Soup Hangar	Wilmington Airport, Wilmington, DE	9 CRV A-8 Nat.	11/86
DISTRICT OF COLUMBIA				
17	U.S. Park Police Heliport	900 Anacostia Dr. SE	6 CRV A6 Nat.	12/1/88
GEORGIA				
	Pitts Aviation Hangar	6365 McDonough Dr, Norcross GA 30091	4 RTH	5/82
IDAHO				
27	Gustin Aviation	Lewiston Airport, Lewiston, ID	4 CRV A-8	2/85
26	Rexburg Airport	Aero Technicians - Rexburg, ID 83440	1 CRV A-6	9/83
26	Rexburg Airport	Rexburg Airport School - Rexburg, ID	6 CRV 4-40	1977
27	Kootenai City Airport Hagfdone Construction Jet Hangar	Coeur D'Alene, ID	4 CRV 6-60	6/79
27	Lewiston Airport	Lewiston Airport Rd., Lewiston ID 83501 208/374-2816	4 RTH-50	9/85
26	Queen Bee Air Specialties Rigby Airport	PO BOX 245, Rigby, ID 83442	2 CRV E120 Nat.	11/85
27	CDA Mines	Hangar - Coeur D'Alene, ID	2 CRV E120 Nat.	12/1/89
27	Idaho Forest Products	Corporate Hangar - Kootenai CO Airport Dr. - Hayden Lake, ID	6 CTH2 80 Nat.	4/1/90
27	Antique Bi-Plane Hangar	Salmon, ID	2 CTH 80 LP	3/1/91

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
ILLINOIS				
23	Midway Airport	Sears Corporate Hangar , Chicago, IL 5130 West 63rd St. - 60638 (312)585-1282 John Cunninham	33 CRVA-8 N	Fall '83
"	DuPage Airport - Plane Master Inc.	Rt 64 West - Chicago, IL	18 RTH-75A	9/82
"	Bloomington/Normal Airport	Route #9 East, Bloomington, IL 61701 309/662-18811 Jeff Schultes	20 CRV6-60	
"	Blomington/Normal Airport Britt Airways Hangar #1 Britt Airways Hangar #2	Route #9 East, Bloomington, IL 60701 309/662-1811		
"	Bloomington/Normal Airport AG Chem Equipment Co.	Route #9 East, Bloomington	10 CRVA-4	11/82
"	Waukegan Airport Everco Indus. Hangar	Waukegan, IL 60085 (312)249-4425 Ray Beffel	10 CRV6-60	11/78
"	Waukegan Memorial Airport	Waukegan, IL 60085 312/ 937-5132 Bill Bailey	CRVB-10) CRVB-12) 12	
"	Waukegan Memorial Airport American Hospital Supply	Waukegan, IL 60085		
"	Waukegan Memorial Airport Corporate Aircraft Services	Waukegan, IL 60085 312/ 249-4455 Larry Morrison		
"	Waukegan Memorial Airport Square D Hangar	Waukegan, IL 60075 312/ 379-2600		
"	Waukegan Memorial Airport	Baxter Travenol Hangar, Waukegan, IL 60085 312/ 336-6170 Rich Manegello		
"	Waukegan Memorial Airport	Morton Thiokol Hangar, Waukegan IL 60085 312/ 244-9130 Dale Burkholder		
"	Waukegan Memorial Airport	P.C.I. Hangar, Waukegan, IL 60085 312/ 537-8800 Lanny Morrison		
18	Decatur Airport	Airport Rd., Decatur, IL 217/428-2423	25 RTH-75	7/83
"	DeKalb AG Research Hangar	Sycamore Rd., Dekalb, IL 50115 815/635-6676 Stand Bozdech	12 RTH-75	1979
"	Civic Memorial Airport	Aero Services, E Alton	6 CRVA-8	101/79
"	Coles County Airport	Matton, IL	10 CRVA-8	12/80
"	Bi-State Parks Airport	Midcoast Aviation Hangar Cahokia, IL	6 RTH-150	5/84
23	Sandwich Airport Hangar	Route #34 - Sandwich, IL 60548 312/552-8904	2 CRVB-12 N	2/85
77	Midcoast Aviation	Centerville, IL	6 RTH 150 N	5/86
"	Midcoast Aviation	B1- State Airport, Cahokia, IL	6 RTH 150 N	5/86

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
“	Capitol Airport - Hangar	N. Walnut St., Springfield IL 62702	9 CRVB-10 & 12 N	
23	Enery Worldwide Freight Terminal	401 West Touhy Ave. - DesPlaines, IL 60016 312/635-6676 Ken Bodhardy		
“	Kankakee Valley Airport	Route #1, Kankakee, IL 60901 815/471-3560		
“	Monarch Air Services Hangar #2	Midway Airport, 5293 South Central Chicago, IL 60638 312/471-3560		
“	Beatrice Corporate Hangar	MIdway Airport, 5713 South Central Ave. Chicago, IL 60638		
“	Beckett Aviation Hangar	Midway Airport, Chicago, IL 60638		
“	Morgandale Enterprises Hangar	4 Chandelle, Hampshire, IL 60140 312/683-3832 Howard Morgan		
“	O’Hare Mintenance Complex	Mannheim & Lawrence Ave. Chicago, IL 60666		
77	Williamson City Airport	Hangar Route #3, Box 351 Marion, IL	7 CRV A6 Nat.	11/1/88
23	Federal Express	Pkg. Distribution Bloomington Airport	1 CTH 80 Nat. 2 CTH125 Nat.	11/1/88
23	United Airlines #1	Cargo Bldg. - O’Hare Cargo Rd.	78 CRV B10 Nat	6/1/88
23	Aviation Management	Hangar - Lansing Municipal Airport	8 CTH 125 Nat.	3/1/89
23	Waukegan Airport Hangar	3500 N Mcagree Rd., Waukegan, IL	RTH 150B	2/1/89
23	Alberto Culver Hangar	1120 S. Milwaukee - Wheeling, IL	6 CTH 125 Nat.	12/1/89
23	Marshall City Airport	Hangar - Lacon, IL	4 CRV B12 Nat.	9/1/89
23	Federal Express Chicago Metroplex	Fed. Ex. freight terminal O’Hare Int’l Airport	14 CRV B12 Nat.	8/1/89
23	A G T Maintenance	Maint. garage - O’Hare Airport	4 CRV B10 Nat.	11/1/89
23	Marshall City Airport	Mechanic Shop - Lacon, IL	4 CRV B12 Nat	9/1/89
INDIANA				
23	F.T.I. Aviation Hangar Gary Municipal Airport	Gary, IN 46400 129/944-1210 Joseph Herron		
23	S.E. Green Hangar Gary Municipal Airport	6100 West Industrial Hwy. Gary, IN 46401 219/944-6545 Dr. Wm. Douglas		
76	Nel Sineone Corporate Hangar	3050 S. High School Rd. Indianapolis, IN	4 CRVB-10 N 8 CRVB-12	9/86
23	Gary Municipal Airport	F.T.I. Aviation - Gary, IN	13 CRVA-8	3/81
76	Hulman Airport	Terre haute, IN	10 CRV6-60	
“	Terry Airport	Zionsville, IN (2 Bldgs)		
“	Bloomington Airport	Bloomington, IN (2 Bldgs)		
“	Muncie Airport	Muncie, IN (2 Bldgs)		
“	Franklin Airport	Franklin, IN (2 Bldgs)		

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
ILLINOIS (CONT'D)				
"	Huntingburg Airport	Huntington, IN		
42	Hap's Aerial Enterprises	7001 Airport Dr, Clarksville, IN	16 CRV 5-40	1985
	Osborn Enterprises	Clark Co. Airport, Sellersburg, IN 47172	16 CRV 5-40 Nat.	2/86
76	Eagle Creek Aviation	4101 Dandy Trail Indianapolis, IN	4 CRV B-10 Nat. 2 CRV B-12 Nat.	1/87
42	Aircraft Specialists	Hangar Clark Co. Airport	18 CRV 5-40 Nat.	8/1/89
IOWA				
1	Cedar Rapids Municipal Airport	United Airlines - Cedar Rapids, IA	3 CRV 4-40A	1/70
1	Jerry Ovel Aircraft Hangar	Cedar Rapids, IA	2 CRV 4-40 P	1/70
1	Moore Helicopter Service	R.R. #4 Creston, IA 50801 515/782-4089	1 CRV E-180 LP	2/85
1	Graham Aviation Service Municipal Airport	Sioux City, IA 51102 712/227-4372	1 CRV E-120	9/85
1	Meredith Corp. - Hangar	3333 Army Post Rd., Des Moines, IA 50321 515/285-6904	8 CRV A-8	6/85
1	Boone Municipal Airport	Boone, IA	4 CRV 4-40A	12/77
1	Wins Over Iowa	PO Box 149, Boone, IA 50036 515/432-6440	4 CRV 4-40	11/77
1	Mason City Municipal Airport	Mason City, IA	9 CRV 5-40	8/81
1	Municipal Airport Crash, Fire & Rescue	Mason City, IA 50401 Equipment Storage Bldg.	4 CRV 5-40	12/82
1	Algona Municipal Airport	Algona, IA	9 CRV 4-40	8/76
1	Webster City Airport	Webster City, IA 50595	3 CRV A-6	3/83
1	Iowa Public Service Co. Corporate Hangar	Sioux City, IA 51102	12 CRV 6-602 2 CRV 4-40	
1	Graham Flying Service	Sioux City, IA	127 CRV 4-40	4/70 & 7
1	Motorized Gliders of Iowa	South Shore Dr. Clear Lake, IA 50428	11 CRV A-6	12/82
2	City of Chariton Hangar	Highway #34 West, Chariton, IA	4 CRV B12 LP	1/1/90
2	Rolscreen Air Hangar	Pella, IA	4 CRV B6 Nat. 2 CRV B8 Nat.	9/1/90
2	Floyd Gustafson Hangar	Storm Lake Airport, IA	2 CTH2 150 LP	12/1/90
	Hangar	Spencer Airport, Spencer, IA	7 CRV A8 LP	12/1/90
2	City of Des Moines	Des Moines Int'l Airport	6 CRV A8 Nat.	6/1/90
KANSAS				
1	Mid-Continent Airport Ryan Aviation - Hangars Goldust Inc.	Hangar 17 & 19 1953 N. Santa Fe, Wichita, KS 67214	19 CRV A-6	5/85
14	Beach Aircraft	PO Box 85, Wichita, KS 67201 316/689-6925	1 E-240	9/87
3	Metro Topeka	Maint. Shop Forbes Field/ Bldg. 186 Topeka, KS	1 RTH R8 Nat. 5 CTH 125 Nat.	1/1/88

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
KANSAS (CONT'D)				
3	United Beechcraft	Hangar Mid-Continent Airport Wichita, KS	4 CRV E240 Nat. 8 CRV E360	8/1/88
3	Craig Hangar	Ind Airport - Lawrence, KS	2 CTH 125 Nat.	3/1/89
3	Boeing Hangar	PO Box 7730 - Wichita, KS	28 CRV B12 Nat.	8/1/89
3	Cessna Aircraft Co.	Mid-Continental Airport Wichita, KS	18 CRV E240 Nat. 36 CRV E360 Nat.	4/1/91
3	Executive Beachcraft Inc.	Hangar - 10 Richards Rd., Kansas City	6 CRV B10 Nat.	9/1/90
KENTUCKY				
42	Ft. Knox	Maint. Shop & Warehouse	16 CRV 5-40	12/81
"	Mc Alpine Locks	USA Corps. Engrs. boat storage	4 CRV 5-40	11/83
"	Ft. Campbell	Tactical Equipment Shop	20 CRV B12	9/86
"	ICH/NTS Hangar	Standiford Field - Louisville, KY	8 CRV B12	9/87
"	Andolex Hangar	Standiford Field - Louisville, KY	4 CRV B12	9/87
LOUISIANA				
9	Warehouse	New Orleans Airport 504/341-8526	2 RTH 75 2 RTH 50	12/86
9	Chevron Hangar	New Orleans, LA	7 CTH 125 Nat.	1/1//90
MARYLAND				
17	Washington City, Airport	Maint. Bldg. Hagerstown, MD 27140	3 CRV A-8 LP	2/84
17	Glen L. Martin State Airport McCormick Co. Inc.	701 Wilson Pt. Rd., Middle River MD 21220 301/574-7474, 7475, 7476	9 CRV A-8	
17	Glen L. Martin State Airport Crown Central Petroleum	701 Wilson Pt. Rd., Middle River MD 301/391-0500	11 CRV A-8	
17	Glen L. Martin State Airport Crown Central Petroleum	701 Wilson Pt. Rd., Middle River MD 301/391-4680	9 CRV A-8	
52	Westinghouse Electric	baltimore, MD	18 B-10	1989
17	Glen L. Martin State Airport Easco Hangar	701 Wilson Pt. Rd., Middle River MD 301/291-6886	9 CRV A-8	
17	Glen L. Martin State Airport USF & G	701 Wilson Pt. Rd., Middle River MD 301/574-3933	12 CRV A-8	
51-52	Kelly Springfield Tire Hangar	800 Kelly Rd., Cumberland, MD 21402 -0098 301/777-6623	3 CRV A-4 3CRV A-6 5 CRV A-8	10/83 10/83 7/86
51-51	Wimico Co. Airport Henson Hangar	Airport Fire Station, Airport Rd. PO Box 1897, Salisburry, MD 21801 301/749-3187	3 CRV A-8	12/84
17	Henson Airlines	BWI Airport - Baltimore MD 21240 PO BOX 18555 301/465-0066	4 RTH 75 2 RTH 75 A	11/85 1/86
17	C. Albert Matthews Inc. Easton Airport	South Street Extended Kemp Lane - Easton, MD 21601 301/166-5314	9 CRVA-8	6/85

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
MARYLAND (CONT'D)				
17	Martin Marietta Corp.	Middle River, MD 21220 301/686-4532	20CRV A-6 Nat.	3/86
17	Int'l Teamsters Union	Hangar - Balt/Washington Airport	9 RTH 150B Nat.	12/1/88
17	Clark Construction	Corporate Hangar - Easton Airport Easton, MD	5 CTH 150 LP	11/1/90
MASSACHUSETTS				
38	Beverly Municipal Airport Maintenance Bldg.	L.P. Henderson Rd., Beverly, MA 617/922-4280	4 CRV A-2,4 & 6	6/84
MICHIGAN				
68	Taubman Hangar	6556 Highland, Pontiac, MI 48054	15 CRV A-8	1/82
68	Haigh Ind Hangar	Howell, MI	10 CRV A-6	11/79
68	Willow Run Airport	Jetway Hangar, Ypsilanti, MI	26 CRV 6-60	6/79
68	Gerber Products	7804 W. 60th St., Fremont, IL 49412 616/887-9978	6 CRVA-8	12/82
68	Tecmseh Prods. Air Hangar	Stone Rd., Tecumseh, MI 49286	6 CRV A-6 5 CRV A-8	10/81
49	Ford Airport	Superior Aviation, Iron Mt., MI 49801		
68	Whirlpool Hangar	Ross Field - benton Harbord, MI	12 CRV A-8 Nat.	1/84
68	Kent County Airport	Rapid Air Service - 5500 44th St. SE Grand Rapids, MI	6 CRV B10 Nat. 14 CRV B12 Nat.	10/1/87
68	Tradewinds Aviation Inc.	6320 Highland Road, Waterford, MI	6 CTH 125 Nat.	11/1/88
68	Chrysler Penstar Aviation	7310 Highland Rd. Waterford, MI	6 CRV B12 Nat.	4/1/90
68	Air Rescue Hangar	6500 Highland RD. Pontiac, MI	4 CRV B12 Nat. 2 CTH 150 Nat.	5/1/90
68	Gratiot Com. Airport	Hangar - 3399 W. Seaman Rd., Alma, MI	4 CRV B12 Nat.	6/1/90
68	Rockwell Hangar	7515 Astro Dr. North, Waterford, MI	8 CTH 125 Nat.	7/1/90
68	Marine City Aviation	Hangar - Metro Airport - Romolus, MI	1 CTH 80 Nat. 10 CRV B12 Nat.	8/1/90
68	Mantar Hangar	7177 Airport Dr., Marine City, MI	4 CRV B12 Nat.	11/1/90
68	AMR - Combs Hangar	Kent Cty. Airport - Grand Rapids, MI	24 CRV B12 Nat.	12/1/90
MINNESOTA				
37	Municipal Airport Thief River Aviation	Thief River Falls, MN	8 CRV 4-40	
37	Warroad Airport	Warroad, MN	5 CRV 6-60	
37	Alexandria Municipal Airport	Alexandria, MN	8 CRV 6-60	7/76
37	Benson Municipal Airport	Benson, MN		
2	Anoka Airport	Anoka, MN		
2	United Power Assoc. Hangar	Anoka, MN	4 CRV 6-60	12/79
2	University of MN. Hangar	Anoka, MN		

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
MINNESOTA (CONT'D)				
2	Litchfield Municipal Airport	Johnson Bros., - Litchfield, MN	8 CRV 6-60	
2	Flying Cloud Airport	Cherne Hangar - Eden Prairie, MN	13 CRV A-6	12/80
2	Flying Cloud Airport	Elliot Beechcraft - Eden Prairie, MN	8 CRV B-12	10/83
2	Downtown Airport - Holman Field - M.A.C. maint. Garage	St. Paul, MN	7 CRV 6-60	10/82
2	Exec-U-Air	St. Paul, MN	16 CRV 6-60	9/78
2	Roy Olson Aviation	Hackensack, Mn	2 CRV A-8	
2	Fleming Field - Air Service Inc. Hangar	So. St. Paul, MN	2 CRV E-120 Nat. 3 CRV E-180 Nat.	1/85
2	Johnson Aero Repair	Route 1, BOX 188, Wheaton, MN 6112/563-4855	3 CRV A-8 LP	1/85
1	City of Montivideo - Hangar	Montivideo, MN 56265 507/637-8002	8 CRV 4-40 LP	3/78
2	Maple Lake Hangar	Maple Lake, MN	2 CRV E-180	12/85
2	Confederate Air Force Hangar #3	Fleming Field, So. ST. Paul, MN 55075	2 E-180	11/85
2	Becoh Transportation	Hangar - 13397 Pioneer Trail Eden Prairie, MN	4 CRV E360 Nat	10/1/88
2	Johnson Bros. Hangar	Litchfield, MN	6 CRV A8 Nat 1 CTH 60 Nat	11/1/89
2	St. Marys hospital	Hangar East 4th St. Duluth, MN	3 CRV B8 Nat	12/1/89
2	Capre Aircraft Float Mfg.	Hangar, Bramdon, MN	2 CRV E180 LP	12/1/89
2	Albert lea Airport	Hangar - 400 Airport RD. - Albert Lea, MN	6 CRV B10 Nat	1/1/90
2	Federal Express	Loading Dock - 7301 26 Ave. South Mpls., MN	3 CRV B8 15 CRV B10 Nat.	8/1/90
2	Bill Nelson Hangar	Pine City, MN	2 CRV 180 Nat.	9/1/90
2	Rochester Municipal Airport	Truck Garage - Rochester Airport	4 CRV B10 Nat.	9/1/90
MISSISSIPPI				
68	Air Repair Municipal Airport	Cleverland, MS 601/846-0228	1 RTH R-50	1/86
MISSOUIRI				
77	Spirit od St. Louis Airport	Southwesttern Bell Hangar, Chesterfield, MO 63017	22 CRV B-12 Nat.	6/87
1	Springfield Flying Service	Springfield, MO	7 CRV A-6	2/80
1	TWA Targo Bldg.	Kansas City, MO	44 CRV 4-40	1977
18	Purcell Tire - Hangar	300 Hall St., Potosi, MO 63664 314/468-2131	2 RTH 75 Nat.	10/84
77	Spirit of St. Louis Airport	Wings of Hope, Chesterfield, MO 63017	4 RTH-R-100 Nat.	
	Spirit of St. Louis Airport	Murphy Co. - Private	4 RTH R100	
	Spirit of St. Louis Airport	American Jet Aviation	20 CRV 6-60	
	Spirit of St. Louis Airport	Midcoast Aviation	20 CRV A-8	
3	Spencer Aircraft Maint.	Hangar - Butler Memorial Airport	1 CTH 125 Nat.	11/1/88
3	Central Missouri State	Hangar - Warrensburg, MO	4 CRV E240 Nat.	4/1/90

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
MONTANA				
26	Municipal Airport Executive Aviation	Missola, MT	8 CRV 6-60	1979
26	Municipal Airport Airport Service Bldg.	Belgrade, MT	3 CRV 6-60	1979
26	Montana Air National Guard Fuel Cell Maint. Bldg.	Great Falls, MT 406/727-4650	6 CRV A-67 8 Nat.	5/84
37	Steel Structures - Airport Facilty	Buildings, MT	5 CRV A-8	5/81
NEBRASKA				
1	Lincoln Air	Lincoln, NE	6 CRV A-8	11/80
1	Lincoln Airport Authoroty	Freight Terminal - Lincoln, NE	10 CRV A-6 & 8 Nat.	
1	Antelope City Airport	Neligh, NE	4 CRV 4-40	10/77
1	Trego Aviation	Lexington, NE	8 CRV 4-40	10/77
1	Aurora Airport	Aurora, NE	8 CRV 4-40	10/77
1	Cosad Airport	Cozad, NE	7 CRV 6-60	
1	York Airport	120 5th St., York, NE 68467	7 CRV A-8 Nat.	1/85
1	Eppley Airport - Cargo Area	Eppley Air Field terminal Express Omaha, NE 402/342-1911	3 CRV A-2 Nat. 15 CRV A-6 Nat. 4 CRV A-8 Nat.	5/85
NEVADA				
26	Elco Flying Service	Ely, Nevada	4 CRV A-8	10/83
NEW HAMPASHIRE				
38	Wang Lab Inc. Corporate Hangar	5 C Industrial Dr.- Grenier Field Londonberry, NH 617/656-1283	12 CRV A-8 LP	6/86
38	Grenier Field Pittsburgh Shawmut	manchester, NH	7 CRV A-8	12/82
38	Pittsburgh & Shawmut Coal	5 C Industrial Dr. - Manchester, NH 603/669-6178	7 CRV A-8 Nat.	10/84
38	G.F.W. Aeroservices	Perimeter Rd., Nashua, NH 03063 603/883-6372	1 E-120 Nat.	1/86
38	Clay Aircraft Inc.	Perimeter Rd. Nashua, NH 03063 603/881-8793	3 RTH 100 Nat.	11/86
38	C.M. Lovett Aviation Specialist	Route 32, Keene, NH 03431 603/652-8506	2 RTH 150 LP	1/87
38	Davidson Flight Services	Nashua Airport, Nashua, NH 03060 603/882-2021	9 CRV A-8 Nat.	
38	Northwest Aero Service Manchester Airport	846 Sheppard Dr., Manchester, NH 03103 603/623-8319	1 CTH -125 Lp	9/87
NEW JERSEY				
51	Reese Aircraft	Hangar - Robbinsville Airport Trenton, NJ	6 CRV A6 Nat.	12/1/88
83	Federal Express GSE	Sorting Facility Newark, NJ	6 CRV B8 Nat.	7/1/89

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
NEW JERSEY (CONT'D)				
83	Federal Express Phase 3	Sorting Facility - Newark Int'l Newark, NJ	2 CRV B4 Nat. 6 CRV B6 Nat. 4 CRV B10 Nat. 11 CRV ?	7/1/89
83	Essex City Inprov. Authoroty	Hangar, 125 Passaic Ave. Fairfield, NJ	3 CTH2 150 Nat.	11/1/90
51	Inductotherm	Hangar - Rancocas, NJ	3 CRV E300 Nat.	11/1/90
51	West Jersey Hospital	Hangar - Evesham Ave. Voorheese Twnshp	2 CTH 80 Nat.	1/1/91
83	Essex City. Airport	Hangar #1	9 CTH2 150 Nat.	2/1/91
NEW MEXICO				
26	Consolidated Flight Terminal (10 Airlines)	Albuquerque, NM	10 CRV 6-60 15 CRV 4-40	1977
26	Municipal Airport	Aztec Airport Fire Station Aztec, NM	3 RTH	1978
26	Holloman AFB	Alamagordo, NM	7 CRV 6-60 24 CRV B-10	1978 1985
26	Taos Municipal Airport	Taos. NM	1 RTH	1980
26	Kirtland AFB	Ross Aviation	CRV	
26	Cutter Flying Service	Hangars 1 & 2 - Albuquerque	CRV	
26	Crest View Aviation	Albuquerque, NM	RTH	
NEW YORK				
	Wendell F. Coye Contractor	Private hangar - New York	8 CRV 4-40	10/72
24	JT's Aero Maint.	2400 Colby St., - Brockport, NY 14420 716/637-3534 or 757-9257	2 RTH-75	1/82
24	Palmer Aviation	Wellsville, NY	9 CRV 4-40	11/71
24	Wellsville Municipal	Alleghany, NY 716/593-3350	12 CRV 4-40	11/71
83	Sunset Aviation	Stormville, NY 12582	8 CRV 4-40	1978
24	City of Hornell Hangar	Aircraft Service - Hornell, NY 14843	6 CRV 6-60	10/74
24	Town of Dansville Hangar	Aircraft Service- Dansville, NY 14437	12 CRV 4-40	2/73
24	Penn Yan Airport	Seneca Foods Corp. - Penn Yan, NY 14527	9 CRV 4-40 4 CRV 4-40 8 CRV 6-60	12/72 9/74 1/79
4	Envirogas helicopter Hangar	Elmview Dr., Hamburg, NY 14075	2 CRV A-4 Nat. 2 CRV A-6 nat. 2 CRV A-4 & A-6 N	12/82 12/84
24	Eastman Kodak Hangar	Rochester, NY	60 CRV 4-40	1/74
24	Rochester Airport	New Fire Crash & Rescue Station Rochester, NY	12 CRV 4-40	1/74
24	Federal Express	Scottsville Rd., Rochester, NY	10 CRV A-8 1 RTH 75	5/83

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
NEW YORK (CONT'D)				
4	Greater Buffalo Int'l Airport - Sandbay Area	Genesee Street, Buffalo, Exit 42 716/632-3115	4 RTH-150A	9/84
4	Chautauqua Cty. Airport	Equipment maint. Bldg. Jamestown, NY 14701	16 CRV A-2 Nat.	9/84
24	Niagara Falls Int'l	Niagara Falls, NY 14304 Base Supply Bldg. 600 Airport facility - whse.	3 CRV A-4 Nat.	12/85
4	Niagara Falls Int'l	Tactical Air Lift Bldg. # 850	36 CRV A6 Nat.	4/1/88
4	Niagara Falls Int'l	Porter Road - Niagara Falls, NY	2 CTH 125 Nat.	12/1/89
24	Pre - Tec Rochester Monroe County Airport	Warehouse - 1200 Brooks Ave., Rochester, NY 14624 716/436-2701	8 RTH-150 N 6 CRV E180 N	1/87
83	American Express	Hangar - Stweward Airport - Newbury NY	23 CTH 125 Nat.	1/1/88
24	FBO Terminal	Hangar - Fulton Cty. Airport - Johnstown, NY	4 CRV A6 Nat. 5 CRV A8 Nat.	3/1/88
24	Bausch & Lomb	Hangar - 1295 Scottsville Rd. Rochester, NY	16 CRV B10 Nat.	2/1/89
24	Aujet Terminal Hangar	Albany Cty. Airport, Albany, NY	6 CRV E360 Nat.	5/1/89
24	Brian Meurus Inc.	Industrial Park - Warren Co. Glen Falls, NY	1 RTH 150B Nat.	10/1/89
24	National Warplane Museum	Aircraft Museum - Big Tree Lane Geneseo, NY	2 CTH 80 Nat.	3/1/90
4	Chatuaqua Co. Airport	Turner Road, Jamestoen, NY	2 CRV A2 Nat. 2 CRV A4 Nat.	7/1/90
4	Comute Air	Hangar - Clenton Cty. Airport Flattasburg	2 CTH 150 LP	12/1/90
83	Cessna Citation	Hangar - stewart Air Base Newburgh, NY	24 CRV B8	5/20/88
	Akron Airport	Hangar - Akron, Ny	2 RTH- 75A	
24	Broome Cty. Airpot	Johnson Cuty, NY 13790	18 CRV-A6 LP	10/80
	Broome Cty. Airport	Hangar # 1 Johnson City, NY	7 CRV A6 LP 12 CRV A8 LP	7/84
	Broome Cty. Airport	Hangar # 2 Birghamton City, NY	3 CRV A4 LP 24 CRV A8 LP 15 CRV A8 LP	11/81
	Broome Cty. Airport	Crash/Rescue, Johnson City, NY	2 CRV A4 LP 5 CRV A6 LP	5/87
	Chemung Cty. Airport	Vehicle Storage 312, Horseheads, NY	12 CRV A6 N 1 RTH 75A 2 RTH 150A	11/85
	Corning Glas Works Hangar	Chemung Co. Airport, Horseheads, NY	40 CRV A4-40 N	5/72
	Cortland Cty. Airport	Admin. Hangar Bldg., Corlandville, NY	4 CRV A40A N	10/78
	Elisha Payne Airport	Hamilton, NY 13346	8 CTH 125 LP	11/89

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
NEW YORK (CONT'D)				
	Empire Aero Services	Sair Aviation #3, Malden Rd.,	4 CRV A4 N	9/80
		Syracuse, NY	14 CRV A6 N	
	National Guard Aircraft	Maintenance Dock, Hancock Field	4 CRV A4 N	6/85
	National Guard	Aircraft maint. Hancock Field	22 CRV 4-40 N	9/68
		N. Syracuse, NY		
	Oswego Cty. Airport Hangar	Fulton, NY 13069	4 CRV 4-40 N	2/80
24	Sydney Airport	4 Riverside Rd., Sidney, NY	14 CRV 6-60 LP	12/75
	City of Syracuse	Service & Maint. Bldg.,	4 CRV A4 N	5/84
	Handcock Int'l	N. Syracuse, NY 13212	6 CRV A6 N	
	City of Syracuse	Sand Dome, N. Syracuse, NY	2 RTH 75A N	2/85
	Hancock Int'l		4 RTH 150A N	
	Tompkins Cty. Airport	Crash/Fire, Itaca,	4 CRV A4 LP	10/80
		NY 14850	6 CRV A6 LP	
	U.S. Air Facility	Hancock Field, N. Syracuse, NY	3 CTH 2-80 N	10/89
			1 CTH 1-100 N	
	U.S. Aircraft	Maint. dock, Hancock Field	4 CRV A4 N	1/85
		N. Syracuse, NY	8 CRV A6 N	
NORTH DAKOTA				
37	N. D. Air Guard	Fargo, ND	6 CRV A-8	6/85
	Airport Facility			
37	Municipal Airport	Pietsch Flying Ser. Minot, ND	6 CRV 4-40	
37	Tri State Aviation	Wahapton, ND	2 CRV A-8	10/82
37	Und Hangar	Grand Forks, ND	15 CRV A-8	12/79
37	Hector Airport - Air Mech.	Fargo, ND	4 CRV A-8.	
2	Minot Int'l Airport	Terminal Baggage Facility	4 CRV B6 Nat.	12/1/90
		Minot, ND	2 CRV B8 Nat.	
OHIO				
68	TAS Aviation Inc.	1400 Leason Ave. - Van Wert,	1 E-120	
		OH 45891 419/238-5255	1 E-180	
68	Port Columbus Int'l Airport	725 N. Hamilton Rd.	25 CRV A-8	11/82
	Lane Aviation Corp.	Colombus, OH 43219		
68	Puralator Curier Corp.	4275 E. 17th Ave. Colombus,	4 RTH-150	11/82
		OH 43219 614/471-4132		
68	Executive Jet Aviation	Port Colombus Int'l Airport	24 CRV 6-60	4/79
68	Ohio State University Airport	Colombus, Ohio	12 CRV 6-60	1/79
68	Auglaize County Airport	New Knoxville, Ohio	6 CRV A-8	
68	New Knoxville Airport	New Knoxville, Ohio 45817	1 RTH-75	1/83
	Kane Aircraft Hangar			
68	Williams Cty. Airport	Bryan, Ohio	12 CRV 4-40	
	ARO Corp. Hangar			
68	Rallph Haven Corp. Hangar	Williams County Airport - Bryan OH	8 CRV 4-40	
68	Henry County Airport	Napoleon, Ohio	5 CRV 4-40	
68	Beckett Aviation	Vienna, Ohio		
68	Larsdown Airport	Midtown Aviation - Youngstown		

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
OHIO (CONT'D)				
68	Tri City Airport	Westville, Ohio		
68	Hamilton Airport	Hamilton, Ohio		
	2 Hangars owned by Pat Hogan			
68	Gale Eickmeir Hangar	Rt. 1 Rd. 5 Malinta, OH 43535	1 RTH 75 LP	1/86
68	Minster Machine Hangar	Minster, Ohio		
68	Cessna Great Lakes Svc. Ctr.	Toledo, Ohio	17 CRV A-8	6/80
68	Toledo Express Airport	Sheller Globe Hangars, Swanton, OH	19 CRV A-8	1980
68	Geauga County Airport	Fire Aviation - Middlefield, OH	12 CRV A-4 Nat.	3/84
68	Wright Bros. Hangars	3700 McCauly Dr. Vandalia, OH	12 CRV A-6	11/81
68	Don Scott Airfield	Worthington Steel Industries Hangar, OH	21 CRV	9/79
68	Delaware Airport - Hangar	Delaware, Ohio	4 CRV	12/76
68	Akron- Canton Airport	North Canton, Ohio	2 CRV 6-60	1/79
68	Grimes Mfg. Co. Hangar	Urbana, Ohio	3 CRV A-6 4 CRV A-8	
68	U.S. Cargo Air Service	Colombus Airport, Colombus OH 614/497-1279	4 RTH 75 LP	1/86
68	Federal Express	Rickenbacker Airport Colombus, Ohio	25 RTH R-50 Nat. 30 CRV E180 Nat. 10 CRV R-120 Nat.	8/85
68	Griffinz Flying Service	Cleverland Rd., Sandusky, OH 44870 419/626-1586	2 CRV E Nat	
68	Rohrer Corp. Hangar	Wadsworth Airport, Weber Dr.	2 CRV E-120 Nat.	10/85
76	Ohio State University	2090 W. case Rd. - Colombus, OH	12 CRV 6-60 8 CRV B12 nat. 16 CRV A6	1/79 5/86 7/91
68	U.S. Post Office Air Mail Facility	Port Colombus Int'l Airport 4299 Sawyer Road - Colombus, OH	4 CRV E180 Nat.	7/1/88
68	Ohio University Hangar	Albany Airport - Albany, OH 45710	8 CRV B12 Nat	8/1/88
68	Hogan Air	1707 N Verity Pkwy - Middletown, OH	12 RTH 150B Nat	12/1/88
68	St. Vincent Life Flt. Hangar	2213 Cherry St. - Toledo, OH	4 CRV E360 Nat.	10/1/89
68	George Whysail Hangar	CO. Rd. B & 20-2, Archibold, OH	2 CRV E240 Lp	11/1/89
68	Comair Hangar	Cincinnati Int'l Airport PO Box 75021 Cincinnati, OH	25 CRV A8 Nat.	1984
OKLAHOMA				
68	M G Helicopters	Helicopter Hangar & Service Vandalla, OH	4 CRV B8 nat	1/1/90
68	Rickenbacker Aviation Ctr.	Hangar - 3100 E London - Groveport Rd. Columbus, OH	4 RTH 75 Nat.	12/1/90
28	Tulsa Int'l Airport Facility Hangar	Swiftlite Hangar #20 - Tulsa, OK	4 RTH 150 7 RTH 75	11/85
28	American Airlines	3800 N Mingo Rd., Tulsa, OK	8 CRVA-6 Nat	6/86

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
OKLAHOMA (CONT'D)				
28	Will Rogers Airport Corporate Hangars	Oklahoma City, OK	6 CRV A-8	6/82
"	Reading & Bates Corp.	3520 Sheridan, Tulsa, OK 74115	16 CRV A-8	8/82
"	Wiley Post Airport Jet Away Mgnt. Inc.	Hangar #5, Bethany, OK 73008	26 CRV A-8	6/83
"	Tulsa Int'l Airport Improvement Trust - Hangar	Tulsa Airport - Hangar #11 Tulsa, OK 918/383-5025	16 CRV B-10 N	12/84
"	Jones Airport - Slim Haney Inc. - Hangar	Tulsa, OK	2 RTH-75 N	12/84
"	Army Aviation Support Facility - Heloport	Lexington, Ok	22 B-10	10/85
OREGON				
27	Erickson Air Crane	3100 Will Springs Rd. Central Pt. OR 97502 503/664-5544	6 RTH 75A Nat.	10/86
27	Federal Express Hangar	8025 N. E. Airport Way Portland, OR 503/282-6215	8 CRV A-60	2/80
27	Hillsboro Airport Louisiana Pacific	Hillsboro, OR 503/640-1766 Corporate Jet Hangar & Maintenance	16 CRV 5-40	4/80
27	Aurora Aviation Hangar Cessna Dealer,	22885 Airport Rd. NE, Aurora, OR 503/222-1754	3 CRV A-6	2/81
27	Horizon Air	4601 N.E. Elrod Rd. - Portland, OR Portland Int'l Airport	4 CRV A-6	1/80
27	Aurora Airport Truck Repair	Columbia helicopters Aurora, OR 97002 503/657-1111	6 CRV 4-40	
27	Erickson Air Crane Hangar	Medford Airport, Medford, OR	1 CTH 80 Nat.	11/1/89
27	Albany Airport	Shop - 3520 Knox Buttle Rd. Albany, OR	2 CTH2 80 nat 1 CTH2 100 Nat 1 CTH2 125 Nat	9/1/90
27	Klamath Aircraft	Hangar - 6701 Rand Way, Klamath Falls	4 CRV B10 Nat	11/1/90
27	Erickson Air Crane Hangar	Medford Airport - Medford, OR	8 CTH 125 Nat.	5/11/89
27	Pendlenton Air Motive	Municipal Airport - Hangar Pendlenton, OR	6 RTH75 Nat	12/79
27	Sports Air Travel	Troutdale Airport, Troutdale, OR	4 RTH-75 nat	6/82
27	Wellons Inc. Hangar	Portland Int'l Airport 14440 SW Edy Sherwood, OR 97140	1 RTH-R8	2/88
PENNSYLVANIA				
51-52	Nat'l Intergroup Hangar Alleghany County Airport	West Miffling, PA	4 CRV A-8 8 CRV A-10	6/86
"	Alleghany County Airport Pittsburgh Instittute	West Mifflin, PA	12 CRV 6-60	2/80
"	Alleghany Int'l Airport	Hangar Road, Pittsburgh, PA	35 CRV A-8 4 CRV A-6	1/83 "
"	K - AIr Hangar	Latrobe, PA 15650	9 CRV A-8	1/84

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
PENNSYLVANIA (CONT'D)				
"	La Trobe Airport - SW Jack-Hangar	Latrobe, PA 15650	12 CRV A-8	10/84
"	Songer Hangar	Washington, PA	4CRV A-6	11/82
"	MBB Helicopter	West Chester, PA	5 CRV A-6 1 CRV A-4	
"	Testa Hangar	Washington County Airport, PA	4 CRV A-8	10/85
"	Scaife Hangar	Latrobe, PA	12 CRV A-8	11/85
"	Westmoreland Hospital Assn. Helicopter Hangar	Greensburg, PA	CRV E-180	12/85
"	Federal Express - Airport Warehouse	951 Postal Rd. LYP III Allentown, PA	8 RTH-75A N	3/1/86
"	PA Nat'l Guard Bldg. #312	Wllow Grave, PA 19010	6 CRV A6	11/86
"	Somerset County Airport	Maint. Bldg. Rt. 281 North Somerset, PA	4 CRV A-8 LP	8/87
51	H.I.A.	Kerek Air Job Hangar - Middletown, PA	4 CRV E180 Nat.	
51	Suburban Airlines	Hangar - Reading Airport - Reading, PA	11 CTH 125 Nat	2/1/88
51	I S C Hangar	Lititz, PA	9 RTH 75A Nat.	3/1/88
51	Augusta Aviation	N.E. Airport, Philadelphia, PA	8 CTH 125 nat.	5/1/88
51	Willow Grove NAS	Hangar 190, RT. 611 - Willow Grove, PA	4 CRV E240 Nat 16 CRV E360 Nat	6/1/88
51	Dick Cutler Res. Hangar	Elephat Rd. - Dublin, PA	1 CTH 125 Nat	9/1/88
51	Suburban Propane	Hangar - lancaster, PA	2 RTH R10 LP	10/1/88
51	AG-Rotor Inc.	Helicopter Hangar PO Box 578 Route 15 South - Gettsburg, PA	3 RTH 75A Nat	10/1/88
51	Westmoreland Hospital	Hangar - 532 W Pittsburgh St. Greensburg, PA	1 CRV E120 Nat	1/1/89
51	Air Charter Services	Hangar - Washington Cty. Airport Washington, PA	3 CRV B10 nat.	3/1/87
51	Westinghouse Hangar	County Airport, Pittsburgh, PA	29 CRV B10 Nat	12/1/89
51	Pittsburgh Metro Airport	Hangar - Route 50, Cuddy, PA	1 CRV A6 LP 8 CRV A8 LP	1/1/90
51	State Police Hangar	Chess-Lamperton Airport Franklin, PA	4 CRV B10 Nat	4/1/90
51	Pittsburgh Institute of Aeronautics	Classroom - Allegheny Cty. Airport	3 CRV B8 Nat	7/1/90
51	Aviation Training Ctr.	Hangar - Beaver Cty. Airport Beaver, PA	2 CRV A6 Nat 2 CRV A8 Nat	8/1/90
51	Beaver County Airport	Hangar - Beaver Cty. Airport Beaver, PA	6 CRV A8 Nat	10/1/90
51	Springhill Aviation	Hangar - Springhill Rd. Sterling, PA	3 CRV B6 Lp	12/1/90
51	Butler Air Inc.	Hangar - Butler Airport - Butler, PA	3 CTH2 Nat	2/1/91
52	Capitol City Airport	Harrisburg, PA	60 RTH 75's	
	Berg Electronics	Harrisburg, PA	CRV	
52	Rite Aid	Harrisburg. PA	CRV	

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
PENNSYLVANIA (CONT'D)				
52	Allegheny Commuter Service	Harrisburg, PA	RTH	
52	Lebanon Airport	Lebanon, PA	RTH	
52	Indiana Co. Airport	Indiana, PA	CRV	
52	McCreary Tire Co.	Indiana, PA	CRV	
52	Heinz Co.	Allegheny Co. Airport	CRV	
52	Pittsburgh Nat'l Bank	Allegheny Co. Airport	24 CRV-B Classic	
52	National Intergroup	Allegheny Co. Airport	CRV	
52	PPG	Allegheny Co. Airport	CRV	
52	Corp. Jets	Allegheny Co. Airport	CRV	
52	Air Cargo Building	Greater Pittsburgh Airport	E's	
52	Salt Storage Area	Greater Pittsburgh Airport	CRV	
52	USX	Greater Pittsburgh Airport	RTH	
RHODE ISLAND				
38	Green Airport	Amica Insurance Co.-Warwic,RI	9 CRV	2/81
38	Norstar Aviation	Hangar, Warwick, RI	1 CRV A4 Nat 2 CRV A6	9/1/88
SOUTH DAKOTA				
37	Graham Field - Graham Flying	N. Sioux City, SD	16 CRV 4-40	
"	Businesss Aviation	Sioux Falls, SD	30 CRV 6-60	
"	Municipal Airport - Dean Hunt	Eagle Butte, SD 57625	6 CRV 4-40	
"	Star Aviation	Spearfish, SD	6 CRV 4-40	
37	Fischer Aviation	Watertown, SD	8 CRV 4-40	9/76
"	Rische Aviation	Mc Laughlin, SD	2 CRV A-6 LP	12/85
	Tea Airport Mueller Aviation	Tea Exit, Sioux Falls, SD 57064	4 CRV A-8 LP	1/85
37	Nauman Flying Service	RR 2 Box 29, Gettsburg, SD 57442 605/765-2336	3 CRV A-8	
37	Pierre Municipal Airport State Executive Aircraft Hangar	Pierre, SD 57501	3 CRV A-8 LP	5/83
2	DR Harlow Hangar	Aberdeen Airport Aberdeen, SD	2 CRV E 180 Nat	11/1/90
TENNESSEE				
69	Knoxville Airport - McGhee-Tyson	Air National Guard - Alcoa, YN	10 CRV A-8 N	6/84
69	Memphis Int'l Airport	PO Box 30168, TN 38130 901/345-7777 (Maint. bldg.)	7 CRV A-4 N 8 A-6 N 44 A-8 N	11/86
	Northwest Airlines Airplane	Northwest Airlines Baggage Handling Memphis Int'l Airport	91 CRV A-8	1987
	Northwest Airline	Hangar - Memphis Int'l Airport	5 E180	1987
	Memphis Int'l Airport	Fed. Express Gen. Bldg.	5 RTH 150	1988
TEXAS				
26	Municipal Airport Cargo Facility	El Paso, TX 79925 915/772-4271	6 CRV A6 N 5 CRV A8 N	11/86

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
TEXAS (CONT'D)				
34	Addison Airport	4505 Clair Chenault Dr. Addison, TX 75248 214/272-5491	4 RTH 150 N	9/86
34	Mooney Aircraft Corp.	Kerriville, TX	11 CRV A-6	11/82
34	Meachum Field - Richardson Aviation	Ft. Worth, TX	14 CRV A-8	3/81
	Meachum Field Texas Jet Inc. Hangar	Burlington-Northen Hangar(leasing) Ft. Worth, TX	4 RTH-150 N	10/84
	Army Nat'l Guard	Leased Hangar - Killeen, TX	9 CRV A-8	1/81
26	El Paso Int'l Airport	Maintenance & Whse Bldg.	5 CRV A-4 5 CRV A-6	1981
26	El Paso Int'l Airport	Aircraft Rescue & Fire Fighting Station	8 CRV A-6	1981
34	D/FW Airport - SMB Stage Lines Hangar	Texas	9 CRV A-8	2/84
34	Love Field - Citi-Jet	3 Hangars - dallas, TX 75209	72 CRV A-8	1/85
34	Midland Int'l Airport	Scharbauer Hangar	8 CRV B-12	Under Construction
UTAH				
26	Provo Airport - Hangar	Helicopter West - Provo, UT	4 CRV A8 N 4 CRV A8	4/84 5/85
"	K.C. Aviation - Hangar	PO Box 7145, Dallas, TX 75209	4 RTH-150 N	1/85
"	Municipal Airport	Provo, Ut	10 CRV 6-60	1979
"	Green River Airport	Green River, UT	2 CRV A-8	2/83
"	Haskins Helicopter	North Salt lake city, Ut	0 CRV A-8	1980
"	Debron Air Hangar	7365 South 3350 West West Jordan, UT	4 E-120	1/86
"	Marriot Kitchens Int'l Airport	Salt Lake City, UT	2 RTH 75A	9/85
"	Int'l Airport Hangar #4	2300 West 650 North Salt Lake City, UT	20 CRV A-8 N	1/86
"	Federal Express	Cargo Area, Salt Lake City Airport	12 B8 N 13 B12 N	10/86
"	Salt Lake City Airport	Maint. Facility	29 CRV A-8	12/85
"	Salt Lake City Airport	Maint. Facility	55 CRV A-8	1/87
"	Salt Lake City Airport	State of Utah - Hangar	8 CRV A-8	12/80
"	Salt Lake City Airport	State of Utah - Hangar	4 CRV A-8	1/85
"	Salt Lake City Airport	Mancini & Goesbeck - Hangar	4 CRV B-12	2/88
"	Salt Lake City Airport	Majestic Air - Hangar	18 CRV A-8	9/81
"	Salt Lake City Airport	Skywest Airlines - Hangar	5 CRV B-8	9/91
"	Salt Lake City Airport	McDonnell Douglas - Mfg. Plt.	72 CRV B-12	6/87
"	Salt Lake City Airport	Delta Airlines - Vehicle Service	5 CRV A-8	10/85
"	Salt Lake City Airport	Delta Airlines - Bagage Handling	15 CRV A-8	10/85
"	Salt Lake City Airport	Delta Airlines - Cabin Service Area	18 CRV B-4	10/88
"	Salt Lake City Airport	Delta Airlines - Hangar	52 CRV B-12	10/88
"	Salt Lake City Airport	Civil Air Patrol - Hangar	3 CRV A-8	4/88
"	Salt Lake City Airport	Huish Chemical - Hangar	4 CRV B-10	9/90

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
UTAH (CONT'D)				
"	Salt Lake City Airport	S.L.C. Airport Authority Maint. Fac.		
"	Redtail Aviation	Hangar - Green Ruver, Utah	2 CRV A-8	2/83
"	Skywest Airlines	Hangar - St. George, Utah	4 CRV B-10	6/87
"	Skywest Airlines	Hangar - Palm Springs, CA	8 CRV B-12	11/89
"	Rocky Mt. Helicopters	Hangar - Provo, Utah	10 CRV A-8	3/79
"	Gallard Hangar	Provo, Utah	4 CRV A-8	5/82
"	Hosking Helicopters	Hangar - Woods Cross, Utah	9 CRV A-8	1/81
VIRGINIA				
7	Byrd Field - Harthorne Aviation	Richmond, VA	9 RTH 150	11/82
17	Federal Express Co. Airport Facility	1200 North henry Street Alexandria, VA 22314	6 RTH 75	7/85
17	West Ox Heliport	Helicopter Hangar - West Ox Rd. Fairfax, VA	1 CTH 125 Lp	7/1/88
7	Lynchburg Hangar #3	Lynchburg, VA	12 CRV E240 Nat.	12/1/88
7	Commonwealth Jet Services	Hangar - 400 Portugese Rd. Richmond, VA	4 CRV E240 Nat. 8 CRV E360 Nat. 2 RTH R5 Nat.	10/1/88
7	Flight Training Combat Ctr	Hangar - Dam Neck Bldg. 559 M/F MARESFAC - Virginia Beach, VA	7 CTH 80 LP 2 CTH 125 LP	10/1/88
7	Salem Aircraft Hangar	Roanoke, VA	4 CTH 125 LP	11/1/88
7	City of Lynchburg VA	Hangar- Lynchburg Airport Hangar #2	12 CRV E240 Nat	12/1/88
17	Janelle Aviation	Hangar - Leesburg Airpark Rt. 643	20 CRV E360 Nat.	7/1/89
7	Louisa County Airport	Hangar -	4 CTH 150 LP	5/1/90
17	Gannett Corp.	Corporate Hangar - Wash. Dulles Airport - Herndon, VA	24 CRV B8 Nat	12/1/90
17	Mobile Oil Hangar	Corporate Hangar - Dulles Airport Herndon, VA	30 CRV B10 Nat	1/1/91
7	Commonwealth Jet	Hangar - Richmond Int'l Airport Richmond, VA	2 EV 170 nat 2 EV 200 Nat	3/1/91
7	Winchester Reg. Airport	Hangar - Winchester, VA	2 CRV E120 Nat 2 CRV E180 Nat	4/1/91
7	Culpepper Airport		2 CTH 2-150	4/15/91
7	Commonwealth of Virginia	Richmond Int'l Airport Hangar	4 CTH 125 2 RTH RS	12/1/87
7	Reynolds Metals Co.	Hangar - Richmond Int'l Airport	10 CRV B12	6/15/85
7	Ethyl Corp.	Hangar - Richmond Int'l Airport	6 CRV A8	9/1/83
7	Petersburg-Dinwiddie Airport	Petersburg, VA	4 CRV A6	1/15/84
WASHINGTON				
27	Air Cargo Bldg.	Spokane, WA 509/624-3218 Spokane Int'l Airport	22 CRV 4-40 5 CRV 4-40	1970 1978
"	Spokane Int'l Airport	Crash/Fire/Rescue - Spokane, WA 509/624-3218	10 CRV 4-40	

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
WASHINGTON (CONT'D)				
"	Spokane Int'l Airport	Ticket & Baggage Expansion Spokane, WA 509/624-3219	22 CRV 5-40	1981
"	Seattle - Tacoma Airport	Weyerhaeuser Co. Hangar Seattle, WA	1 CRV A-8 6 CRV A-6 7 CRV A-4	
"	Delta Airlines Air Cargo	Sea-Tac Int'l Airport	20 CRV 6-60	
27	United Airlines Air Cargo Center	Sea-Tac Int'l Airport	52 CRV 6-60	
27	Clover Park Voc. Tech. School	Air Trades Bldg. 5214 Stellacoom Blvd. SW, Lakewood Ctr., WA 206/584-40	29 CRV 4-40	
27	Boeing Field SO. Foreign & Domestic Enterprises Inc.- Air Svc.	8201 Perimeter Rd, Seattle, WA 206/763-1460	4 CRV 5-40	3/81
"	Yakima Air Terminal	Snow Removl Equipment Bldg. West of terminal Bldg. - 1/2 mi. on Washington Way, Yakima, WA 98902 509/575-61149	6 CRV 4-50	10/83
"	Bowers Field - Midstate Aviation	Ellensburg, WA 98926	2 RTH-75	11/82
"	Deer Park Airport Thompson Air Motive - Hangar	Deer Park, WA 509/276-2892	8 CRV 5-40	1/81
27	Felts Field - Hangar	E 5829 Rutter, Spoke, WA 99212	4 RTH 75 1 CRVE-180 N 1 CRVE-360 N	7/79 10/88 10/88
"	Port of Seattle - Crash Fire & Rescue Station Airport Facility & Fire Station	170th & Perimeter Rd, Seattle, WA	9 CRV 4-40	
"	Snohomish Cty. Airport Warehouse	Bldg. 264, Smohomish, WA 98290 206/259-9488	1 RTH 75 LP	12/84
"	Port of Port Angeles - Maint. Hangar	338 W 1st Place, Port Angeles, WA 98362 206/851-6440	6 CRV 5-40 LP	4/85
27	Spokane Airways	Sporkane, WA 99219 509/838-3658	2 CRV E120	6/85
27	Nordstom Hangar #107	7999 Perimetr Rd, Boeing Field Seattle, WA 98108	4 CRV B6 N 8 CRV B8 N	8/86
"	Bellingham Airport Baggage Handling Zone	Bellingham, Washington 206/671-5674	1 CRV E180 2 RTH R50	2/88
"	Felts Fields Airplane	Hangar - E 5829 Rutter - Spokane, WA	2 CRV E180 Nat. 4 CRV E360 Nat.	10/1/88
"	Sequim Valley Airport	Hangar - 1246 Old Olympic Hwy.	2 CTH 125 LP	2/1/89
"	Geiger Field Hangar	Maint. Area - Spokane, WA	6 CRV E300 Nat	10/1/89
"	Bob's Aircraft Supply	Hangar - 17017 Meridian - Puyallup, WA	2 CTH2 150 LP	10/1/90
27	Contractors NW Hangar	Geiger Field - Spokane, WA	2 E-300 NAt	1/31/89
"	Discount Aircraft Salvage	Deer Park Airport - Spokane County Deer Park, WA 99006	1 E-120 Nat	3/21/89

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
WASHINGTON (CONT'D)				
27	Everett Community College	Aviation School Bldg. Payne Field Payne Field Way, Everett, WA 98204 206/353-3800	5 CRV A-4 LP 10 CRV A-6 LP	6/85
"	Midstate Aviation	Bowers Field, Ellensburg, WA 98926	2 RTH-75	11/82
"	Turboplus Inc.	1520 26th Ave. NW, Gig Harbor, WA 98335	3 RTH 75A LP	10/87
WEST VIRGINIA				
51	Yeager Airport ANG Aerial Port Bldg.	Charleston, West Virginia 25311	2 CRV A-4 Nat.	8/87
	Consolidated N. Gas	Bridgeport, W. Virginia	CRV A's	
WISCONSIN				
49	City Airport - Airtronics	Clintonville, WI 54929		
"	Hayward Airport	Hayward, WI 54843		
"	Whittman Field -	Jack Marks Hangar, Oshkosh, WI	8 CRV A-8	12/80
49	General Aviation	Highway 51 S. Janesville, WI 53545		
"	Jim Sentry Hangar	La Crosse, WI 54601		
	Bongert Aviation Company	3278 Breezewood La. Neenah, WI 54956		
"	Enterprise Aviation	Silver Lake Dr., Portage, WI 53901		
49	Johnson Corporate Flight	3450 Mt. Pleasant St., Racine, WI 53404	3 CRVB-6 N 12 CRV-10 N	6/88 6/88
"	Sentry Hangar	Stevens Point, WI	6 CRV 6-60 2 CRV 4-40 12 CRV A-4	1978 " 1981
"	Outagamie Airport Hangar	Appleton, WI	20 CRV 6-60	1979
"	Aero Dyne Inc.	Milwaukee, WI	24 CRV 6-60	1979
49	Phillips Plastic Hangar	Box 168, Phillips, WI 54555 715/339-2161	4 CRV A-6 LP	4/84
"	Rhinelander Flight Service	Star Route 2, Box 501 Rhinelander, WI 54501 715/3679-3131	1 CRV E-180 N	2/86
"	Eagle River Airport	Trans North Hanger, Hwy. 45 N. Eagle River, WI 54501 715/479-6777	1 CRV E-180 N	11/86
"	Allen Bradley Hanger	5470 S. Howell Ave., Milwaukee, WI 414/382-2-3677	7 E-180 N	11/87
49	Menards Hangar	West melbey Rd.- Chippewa Falls, WI	3 CRV A8 LP	3/1/87
49	Eau Claire Airport	Maint. Div. Hangar - melbey Rd. Eau Claire, WI	1 CRV E120 Nat 2 CRV E180 Nat	1/1/88
49	Sky Port Services	Hangar - Hwy. D Box 355, Rochester WI	4 CTH 125 Lp	2/1/89

REP #	NAME	LOCATION INSTALLED	EQUIPMENT	DATE
WYOMING				
26	Cheyenne Municipal Airport	Aero Ventures, Cheyenne WY 307/635-9138	8 CRV A-8 N	3/84
“	Municipal Airport	Casper Air Service, Casper, WY	11 CRV 6-60	1976
26	Municipal Airport	Wyoming Central Airways, Casper WY	4 CRV 6-60	1976
“	Wind River Air Hangar	Riverton, WY	6 CRV A-8	5/82
“	Converse Company Airport	111 N 3rd, Douglas, WY 82633 307/358-4027	4 CRV B-10	9/83
“	University of Wyoming Campus	Atmospheric Science Hangar Addition Laramie, WY 82070	3 RTH 75	
37	Mondell Airport	Newcastle, WY	6 CRV 4-40	
“	Worland Airport	Worland, WY	7 CRV A-4	
37	Sky Aviation	Worland, WY	2 CRV A-8	1/84
37	Sheridan Cty. Airport	Big Horn Airways, WY	24 CRV 6-60	
	Sheridan Cty. Airport	Sheridan Air, Wy	8 CRV 4-40	
37	Sheridan Cty. Airport	Air US, Sheridan, WY	6 CRV 4-40	
			5 CRV A-8 N	7/81
“	Falcon Flight	Sheridan, WY	8 CRV 4-40	
“	Mumms Aviation	2325 Newton Ave. Cody WY 82414 307/587-5657	2 CRV A-8 N	12/84
	F.T.C. Hangar			
26	Wang Airport Hangar	PO Box 1586, Gillette, WY 82716	31 CRV A-6N	7/86
	Lenaway Cty. Airport Hangar		4 RTH	8/81 1/82
26	France Flying Service	Rawlins, WY	6 CRV A-6	

Aviation

Facilities Heating

<u>User List:</u>

Military Installations

All claims related to gas-fired, low-intensity heating are predicated on the equipment being designed, installed, maintained and serviced properly by a qualified professional.

Installation Code and Annual Inspections: All installation and service of ROBERTS GORDON® equipment must be performed by a contractor qualified in the installation and service of equipment sold and supplied by Roberts-Gordon LLC and conform to all requirements set forth in the ROBERTS GORDON® manuals and all applicable governmental authorities pertaining to the installation, service and operation of the equipment. To help facilitate optimum performance and safety, Roberts-Gordon LLC recommends that a qualified contractor conduct, at a minimum, annual inspections of your ROBERTS GORDON® equipment and perform service where necessary, using only replacement parts sold and supplied by Roberts-Gordon LLC.

Further Information: Applications, engineering and detailed guidance on systems design, installation and equipment performance is available through ROBERTS GORDON® representatives. Please contact us for any further information you may require, including the Installation, Operation and Service Manual.

These products are not for residential use.

This document is intended to assist licensed professionals in the exercise of their professional judgment.

MILITARY INSTALATIONS

STATE	BASE OF FORT	NUMBER OF BURNERS	MODEL	DATE INSTALLED	BUILDING	CONTACT	PHONE NUMBER	COMMENTS
ALABAMA	BATES FIELD	2	RTH-75	12/84	MAIN SHOP		205/694-6175	
	U.S. COAST GUARD AVIATION TRAINING CENTER	1	RTH-W50					
ALABAMA	MAXWELL AFB	10	CRV A-6	6/84	COMMISSARY			
ALABAMA	DANNELLY FIELD ANG	4	CRV A-6	1/84	WEAPONS SHOP LTC CALIBRATION DONLEY SHOP - BLDG. # 1403		205/284-7302	WORKING GOOD
ALASKA	HOPE, ALASKA	1	RTH-75		N.G. ARMONY			
ALASKA	KULIS ANG BASE	3	CRV A-4	1/84	WHSE.	MR. DAVE HENRY	907/226-1258	HAS PERFORMED WITHOUT FAIL
ALASKA	ELMENDORF AFB	6	RTH 150A		WHSE.			
ARIZONA	LUKE AF BASE	19	CRV A-6	1/87	BLDG 945	BOB CHRIST	602/935-2694	
	LUKE AF BASE	32	CRV 1-6	1/87	BLDGS 983 & 985	BOB CHRIST	602/935-2694	
ARIZONA	AIR NAT'L GUARD	5	CRV 1-6	8/86	TUCSON INT'L AIRPORT	CAPT. PAWLICK	602/573-2251	
ARIZONA	DAVIS-MONTHAN AFB	4	CRV A-6	5/89	HELICOPTER HANGAR			
		3	CRV A-8					
ARKANSAS	LITTLE ROCK AFB	22	CRV A-6	9/84	BASE SUPPLY BLDG. 450			
		29	CRV A-8					
	"	5	RTH 75A	12/80			501/988-6732	
	"	8	CRV A-6	8/82	CARPENTER BASE		"	
	"	4	CRV A-6	1984	C.E. SHOP			
	"	7	CRV-B10	10/88	BLDG. # 257			
	"	2	CRV-B8	7/90	BLDG. 3 259			
	"	5	CRV-B10	"	"			
	"	12	CRV-B12	7/10/90	BLDG # 256	PAUL KINDER	501/988-6434	
	"	2	CRV B2	8/21/90	BLDG. #550			
	"	5	CRV B6	"	"			
	"	11	CRV B8	"	"			
ARKANSAS	FT. SMITH ANG BASE	10	CRV A-6	9/83	WHSE.	LTC PHILLIP	501/646-1601	
		2	CRV A-6	9/83	AGE SHOP			

MILITARY INSTALATIONS - PAGE 2

STATE	BASE OF FORT	NUMBER OF BURNERS	MODEL	DATE INSTALLED	BUILDING	CONTACT	PHONE NUMBER	COMMENTS
ARKANSAS	N. LITTLE ROCK				MACHINE			
	ANG				SHOP VEH.			
					REPAIR			
ARKANSAS	ELMENDORF AFB	8	CRV B-10	6/87	AIR FREIGHT			
		6	RTH 150A	12/86	TERMINAL WHSE.			
CALIFORNIA	FRESNO	5	CRV 5-40	3/12	SHOP	LTC	209/454-5316	
	ANG BASE					HOLLISTER	EXT. 135	
		12	CRV B-8	4/85	HELIPCOPTER			
		6	CRV A-2	6/85	REPAIR AREA			
					ARMONY			
CALIFORNIA	MOFFITT	1	RTH 75A	6/83	SHOP	MAJ.	415/966-4851	
	FIELD					FRED		
	ANG					FRANCISCO		
CALIFORNIA	MATHER AFB	2	RTH-75	6/84	ARENA AREA			
	“	2	RTH-75A	7/83			916/364-4303	
	“	31	CRV 5-40	12/82	HANGAR 7063			
CALIFORNIA	SHARPE ARMY	12	CRV A-8	8/83	VEHICLE MAINT.		209/982-2641	
	DEPOT	5	CRV A-6	“	BLDG # 179			
	DEPOT	1	CRV A-8	1/84	BLDG#179 ADDITON			
		5	CRV A-6	7/86	VEHICLE MAINT. BLDG.			
		13	CRV A-8	7/86	VEHICLE MAINT. BLDG.			
CALIFORNIA	CALIFORNIA ANG	12	CRV B-8	3/85	HELICOPTER REPAIR		209/268-1776	
	ANCHRAD &				AREA			
	AUCRAD FAC.							
CALIFORNIA	CAMP ROBERTS	1	RTH 75	3/86			805/239-1015	
CALIFORNIA	TRAVIS AFB	6	CRV A-6	4/85	BLDG.# 16		415/229-0113	
	“	40	CRV B-6	8/1/90	BLDG 839,841,843		707/424-2984	
	“	18	CRV A-8					
CALIFORNIA	SACRAMENTO	27	CRV B-8	1/86	WAREHOUSE #257		916/388-2701	
	ARMY DEPORT	4	CRV 5-40	7/86	AUTO HOBBY SHOP			
CALIFORNIA	McCLENNAN AFB	25	CRV5-180	7/85	AREA #2			
		3	RTH R50	5/86	WAREHOUSE		916/677-1038	
	“	7	CRV 5-40	11/86	COM/ELECTRON FACILITY		916/925-9205	
	“	6	RTH-75A	9/86	BLDG 783k			
	“	12	CRV E120	1/1/90	WAREHOUSE			
	“	10	CRV B6	9/1/90	BLDG. # 783k	TOM VIC		
	“	1	CTH100	1/1/91		SGT. GARDNER		
	“	2	CTH125	“		“		
CALIFORNIA	U.S. NAVAL POST	2	CTH125Nat	3/88	BLDG. 216			
	GRADUATE							
	SCHOOL							
	MONTERREY, CTY.							

MILITARY INSTALATIONS - PAGE 3

STATE	BASE OF FORT	NUMBER OF BURNERS	MODEL	DATE INSTALLED	BUILDING	CONTACT	PHONE NUMBER	COMMENTS
CALIFORNIA	NAVAL AIR STATION NORTH ISLAND, SAN DIEGO	10	RTH150Nat	3/88	PWC 825-BAY 6			
CALIFORNIA	MARCH AFB	3	CRV A-4	9/88	BLDG# 2274			
		1	CRV A-6	9/88				
CALIFORNIA	CAMP PENLENTON	4	CRV A-4	3/89	BLDG 2219			
CALIFORNIA	CAMPTON NG	4	CRV 5-40	4/1/90	WAREHOUSE			
COLORADO	AF ACADEMY	2	RTH R50	12/85	WEST END OF MAIN EXCHANGE			
		5	RTH 150		HANGAR			
COLORADO	PETERSON AFB	10	CRV B-10	--	C-130 MAINT. HANGAR			
CONNECTICUT	CONN. NG WINSOR, CT	10	CRV 5-40	--	SUPPLY DEPOT			
DELAWARE	DOVER AFB	2	CRV A-6	1/31/88	BLSG. 630 RECEIVING UNIT		912/788-7252	
GEORGIA	WESTPOINT PEPPERELL DALTON, GA	1	RTH 150	2/84				
IDAHO	GOWEN FIELD	18	CRV A-2	1987	BASE SUPPLY & EQUIP. WHSE.	LTC ANDERSON	208/389-5247	
		4	CRV A-4					
		1	CRV R-50					
IDAHO	IDAHO N.G	7	CRV A-6	10/84	ASSY HALL & SHOP AREA			
ILLINOIS	GREAT LAKES NAVAL BASE	4	CRV A-8	5/82	MASONRY SHOP BLDG. 1517		312/688-4802	
ILLINOIS	ARMY RESERVE CORP.	5	RTH 75A	3/82			815/963-5423	
ILLINOIS	ARMY RESERVE CTR.	9	RTH 75A	2/83	AUTO SERVICE		309/691-3411	
	“	9	RTH 75A	7/82	AUTO MAINT.		312/522-1020	
	“	5	RTH 75A	9/82	AMSA 45 AUTO MAINT.		312/349-2991	
	“	8	RTH 75A	9/82	AMSA 45 MAIN BLDG.		“	
			RTH 150A	“	“			
	“	6	RTH 75A	9/82	AMSA 45 WHSE. STORAGE			
ILLINOIS	ARMY RESERVE CTR O’HARE FIELD	9	RTH 75A	8/82	AUTO SERVICE SHOP		312/694-3031	
ILLINOIS	CHICAGO O’HARE ANG BASE	8	CRV A-8	3/86	VEHICLE MAINT. BLDG.	LIC. THOMAS SALAMAN	312/694-6930 EXT. 31	WORKING BEAUTI-FULLY, NO COMPLAINTS

STATE	BASE OF FORT	NUMBER OF BURNERS	MODEL	DATE INSTALLED	BUILDING	CONTACT	PHONE NUMBER	COMMENTS
ILLINOIS	SCOTT AFB	20	CRV A-8		BENVILLE, IL			
		21	CRV A-6					
		6	RTH 100					
INDIANA	US ARMY RESERVE	5	RTH 75A	8/82	VEHICLE SRVC		219/949-1265	
OIWA	NAT'L GUARD BOONE AIRPORT	12	CRV B10	9/89				
IOWA	CAMP DODGE	13	CRV A8	8/1/89	MAINT. SHOP (COL. ROGERS)			
		2	CRV A8	8/1/89	#1 WARM UP BAY			
		4	CRV A6	6/1/90	N.G. SHOP			
IOWA	IOWA ARMY NG	1	CRV E120	12/1/89	FIRING RANGE			
IOWA	MASON CITY N.G.	4	CRV A6	7/1/89				
		3	CRV A8					
IOWA	N.G. ARMONY	14	CTH2-80	10/1/90	ARMORY			
IOWA OMS#4	IOWA N.G. RED OAK, IA	2	CRV A8	12/1/90	SHOP			
IOWA OMS#11A	IOWA N.G. SORTM LAKE, IA	2	CRV B8	11/1/90	MAINT. BLDG.			
KANSAS	McCONNELL AF BASE ANG	20LP	CRV A-8	7/83	HANGAR 50	CAPT.	316/687-7801	
		16LP	CRV A-6	9/83	FUEL CELL	JAMES		
					MAINT. 51	MILLER		
		8 LP	CRV	4/83	AUTO MAINT.			
KANSAS	FORT RILEY	17	CRV A-6	10/81	VEHICLE MAINT.			
	"	5	CRV 5-40	2/83	AUTO CRAFT CTR.			
		10	CRV A-6					
	"	3	CRV E-300	8/1/89	BLDG# 352	JIM NOLAN	913/239-3397	
	"	5	CRV A-8	8/1/88	WHSE. BLDG 213	"	913/239-3397	
KANSAS	FORBES FIELD ANG	16	CRV A-6	4/84	HANGAR #1	LT ROBERT	913/862-1234	
		20	CRV A-8	5/84	HANGAR #2	BURK		
		9	CRV A-2	7/86	MTR VEH BLDG	KENNETH SIMPSON		
KENTUCKY	STANDIFORD FIELD A.N.G.	4	EV 200	3/1/91	HANGAR			
MARYLAND	US COST GUARD	8	CRV B-10	11/83	BLDG. #32			
	"	6	CRV A-8	11/83	BLDG. 85-D		301/389-1600 EXT. 206	
MASSACHUSETTS	OTIS ANG BASE	27	CRV A-8	3/83	HANGAR	CMS FRED LEAVITT	617/698-5016	
MICHIGAN	SELFRIDGE ANG BASE	1	RTH150A	1/83	SHEET METAL SHOP BLDG.	MAJOR LUCAS OR D. WALSH	313/466-5009	
		3	RTH 75A					

MILITARY INSTALATIONS - PAGE 5

STATE	BASE OF FORT	NUMBER OF BURNERS	MODEL	DATE INSTALLED	BUILDING	CONTACT	PHONE NUMBER	COMMENTS
MICHIGAN	K. SAWYER TAC & SAC	1	RTH 75A LP		MEETING BLDG.			B52 BOMBERS
MINNESOTA	CAMP RILEY	1	CRV B10	12/1/89	WHSE.			
MINNESOTA	DULUTH ARPT. ANG	6	CRV B10	7/1/88	WHSE.	STG. BOB DAY		
MINNESOTA	CONTINENTAL MFG	3	CRV E300	12/1/89	WELDING BLDG. #3	SCOTT DUNE	612/852-7500	
MINNESOTA	CAMP RIPLEY	2	CRV B4	7/1/90	ARMORY	HAROLD HAWKS		
MINNESOTA	HOLMAN FIELD	12	CRV B10	11/1/90	HANGAR	TOM BONG		
MISSISSIPPI	U.S. ARMY NAT'L GUARD GULFPORT, MS	39	CRV B-10	7/87				
MISSOURI	FT. LEONARD WOOD	6	CRV A-6	8/83	MOTOR REPAIR SHOP		314/368-8922	
	"	6	CRV A-6	--	BLDG. #999			
	"	6	CRV A-6	1/85	BLDG. #991			
	"	6	CRV A-6	1/85	BLDG. #998			
	"	6	CRV A-6	1/85	BLDG. #990			
MISSOURI	WHITEMAN AFB	4	CTH2 125	1/1/91	WHSE.			
MONTANA	GREAT FALLS ANG BASE	6	CRV A-6 & A-8'S	5/84	FUEL CELL REPAIR HANGAR	CAPT. GARY SHICK	402/727-4650	
MONTANA	FORT HARRISON	6	CRV A-6	4/84	WAREHOUSE		406/449-2015	
NEBRASKA	OFFUTT AFB	2	CRV A-8	4/85	AIRCRAFT MAINT. FACILITY			
NEBRASKA	GOVERNMENT TRAINIG CTR.	21	CRV A-4	1982	STATE BLDG. REGION #4			
NEVADA	RENO ANG BASE	20	CRV A-8	4/82	HANAGAR #9	CAPT. WILLIAM STRANDELL	702/788-4557	EXCELLENT PRODUCT. VERY COST EFFECTIVE
NEVADA	NELLIS AFB	49	CRV B-8	7/85	BLDG. #201			
		100	CRV B-10					
NEW MEXICO	N. MEXICO ANG BASE	30	CRV A-8	12/84	1 LG. HANGAR	LTC. CECIL LYNN	505/844-9765	IN THE WINTER WHEN WE OPEN AND CLOSE
		24	CRV A-8		SM. HANGARS			
NEW MEXICO	KIRTLAND	5	CRV A-6	2/82	BLDG. 986, AREA IV			
	KIRTLAND	20	CRV A-2	10/83	BLDG. 481		505/242-2811	
		36	CRV A-8	"				

MILITARY INSTALATIONS - PAGE 6

STATE	BASE OF FORT	NUMBER OF BURNERS	MODEL	DATE INSTALLED	BUILDING	CONTACT	PHONE NUMBER	COMMENTS
NEW MEXICO	KIRTLAND AFB	1	RTH 75A	7/82	LIVE FIRE RANGE			
	SANDIA NAT'L LABS				SERVICE BLDG.			
	KIRTLAND AFB	4	CRV A-6	2/82	BLDG. 875 ADDITION			
	SANDIA NAT'L LABS				TO MOTOR POOL			
	KIRTLAND AFB	8	CRV A-8	2/82	RAW STOCK MACHINE SHOP			
	SANDIA NAT'L LABS							
NEW MEXICO	KIRTLAND AFB	24	CRV A-8	3/85	BLDG. # 1030		505/844-2611	
	N.M. ANG							
	KIRTLAND AFB	30	CRV A-8	3/85	BLDG. #1043		505/844-0240	
	N.M. ANG							
	KIRTLAND AFB	5	CRV		HANGAR			
	N.M. ANG							
NEW MEXICO	HOLLOMAN AFB	7	CRV 6-60	2/79	BLDG. #825			
	"	6	CRV A-8	3/82	PAINT SPRAY BLDG.			
	"	5	CRV 4-40	5/79	REPAIR SHOP FOR			
	"	1	CRV 6-60	"	FOR JET ENGINE			
NEW MEXICO	LOS ALAMOS	9	CRV A-6	5/82	BLDG. SM-39			
	NAT'L LABS	6	CRV A-8					
	"	3	CRV A-6	11/81	BLDG. SM-282			
					RADIO REPAIR SHOP			
	"	14	CRV A-8	?	HARNESS FACILITY			
	"	11	CRV A-8	11/80	CLINTON R. ANDERSON CRANE BLDG.			
	"	6	CRV A-8	?	BLDG. SM-170			
	"	33	BURNES	?	TEST FABRICATION FAC.			
					11 STORY BLDG.			
	"	10	CRV A-8	3/J82	TARGET BLDG. ADDITION			
NEW MEXICO	CANNON AFB	2	CRV-A	1981	HOBBY SHOP			
NEW MEXICO	HOLLOMAN AFB	24	CRV-B10	1985	AIRCRAFT MAINT. BLDG.			
NEW YORK	NIAGARA FALLS	3	CRV 4-40	11/71	BLDG. #903	MAJ.	716/236-2400	
	ANG BASE	3	CRV A-40	12/85		WILLIAM		
NEW YORK	CULVER ROAD	16	CRV E9	3/1/89	ARMORY			
	ARMORY							
NEW YORK	MASSENA	4	CRV A4	4/1/89				
	U.S.A.R.C							
NEW YORK	STEWARD AIR	2	CRV A-6	4/1/90	HANGAR "G"			
	BASE							
	ANG-NEWBURGH	16	CRV A-8					
NORTH DAKOTA	FARGO ANG	6	CRVA-8	7/85	AGE SHOP	LTC DON CASWELL	701/241-7211	GOOD SYSTEM

STATE	BASE OF FORT	NUMBER OF BURNERS	MODEL	DATE INSTALLED	BUILDING	CONTACT	PHONE NUMBER	COMMENTS
NORTH DAKOTA	ARMY NAT'L GUARD	9	CRV A4	12/81	VEHICLE STRG.			
	ARMY NAT'L GUARD	8	CRV A8	4/83	HANGAR MAINT. SHOP			
OHIO	MIAMISBURGH, OH	8	CRV4-40	--	MOUND LAB INCINERATOR			
OHIO	MANSFIELD - LAHM ANG BASE	12	CRV A-4	9/84	VEHICLE MAINT.	LTC LARRY LEE	419/522-9355	VERY WELL SATISFIED
OHIO	"	5	RTH W-50	12/85	SHREVE, OH		216/453-6775	
OHIO	"	4	RTH 75	2/86	2825 W. GRANVILLE RD. WORTHINGTON, OH		614/889-7017	
OHIO	OHIO STATE ARMY NAT'L GUARD	20	CRV A-8	6/86	AKRON-CANTON AIRPORT GREENSBURG, RD.		216/896-1932	
OHIO	OHIO ARMY N.G.	10	CTH 80	2/1/89	ARMORY 2002 S. MAIN			
OHIO	OHIO N.G.	3	CRV A6	3/1/88	OLD ARMORY RD.			
OHIO	O.N.G. ARMORY	4	CTH 100	3/1/89	ARMORY 240 S. STATE ST.	AGOM QM PC ANN WEATER	614/889-7102	
OHIO	NAT'L GUARD	4	CTH 125	1/1/89	ARMORY 1924 NASA AVE.			
OKLAHOMA	FT. SILL	6	CRV A-4	10/86	PHYSICAL FITNESS CTR. LAWTON, OK		405/427-8371	SGT. GARY GEORGE IS CONTACT FOR
OKLAHOMA	ALTUS AF BASE	4	RTH R50	10/86	VEHICLE MAINT. FAC.			OK. MILITARY DEPT
OKALHOMA	THINKER AF BASE	5	CRV A-2	3/87	INTEGRATED SUPPORT FAC.			
		3	CRV A-4	3/87	VEHICLE MAINT. AREA			
		1	CTH 80	3/89	BLDG. 101			
OKLAHOMA	OMS FACILITY	4	CRV A-8	5/85	STILLWATER, OK			
OKLAHOMA	C.S.M.S	23	B-SERIES	9/85	NORMAN, OK			
OKLAHOMA	A.A.S.F.	22	CRV B-10	9/85	LEXINGTON, OK			
OKLAHOMA	A.A.S.F.	8	CRV B-8	6/88	TULSA, OK			
		4	CRV B-10					
OKLAHOMA	OMS FACILITY	3	CRV B-4	8/86	LEXINGTON, OK			
OKLAHOMA	CAMP GRUBER	6	CRV B-10	10/86				

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STATE	BASE OF FORT	NUMBER OF BURNERS	MODEL	DATE INSTALLED	BUILDING	CONTACT	PHONE NUMBER	COMMENTS
OKLAHOMA	ARMONY	2	CRV B-6	6/88	TULSA			
		2	CRV B-8		100 PERSON ARMONY			
		2	RTH R-5					
OKLAHOMA	TULSA ANG	2	CRV E-180	9/88	WAREHOUSE			
OKLAHOMA	CAMP GRUBER	4	CRV B-8	10/89	OMS #3			
OKLAHOMA	HUGO	2	CRV B-6	6/90	ARMORY			
		2	CRV B-8					
OREGON	AIR NAT'L GUARD	16	CRV 6-60	1975	AVIATION FACILITY			
					1921 TURNER RD. SE			
					SALEM, OR			
OREGON	AIR NAT'L GUARD	1	CTH1-125	2/91	MACHINE SHOP			
OREGON	AIR NAT'L GUARD	1	CRV E-180	5/86	BASE SUPPLY WHSE			
		1	CRV E-120					
OREGON	US ARMY	1	RTH 75A	1979	SUPPORT FACILITY			
	AVIATION				1921 TURNER RD. SE			
					SALEM, OR			
OREGON	RILEA N.G.	2	RTH 75A	1982	TRUCK & REPAIR SHOP		503/861-3835	
					WARRENTON, OR			
OREGON	WHITHYCOMBE	3	CRV 5-40	6/83	ARMAMENT MUSEUM			
					CLACKAMAS, OR			
OREGON	WHITHYCOMBE	3	CRV 4-40	1970	CLACKAMAS, OR			
	NAT'L GUARD							
OREGON	OREGON ANG	2	CRV E-180	6/1/88	BASE SUPPLY &			
		1	CRV E-120		ADMIN. WHSE.			
		4	RTH-W5					
PENNSYLVANIA	U.S. ARMY	1	CRV E-120	10/1/88				
	RESERVE	4	CRV E-360	"				
	NEW CASTLE							
PENNSYLVANIA	HARRISBURGH	9	CRV A-8	JULY 84	MOTOR	LTC	717/948-2206	EXCELLENTT
	ANG BASE				SERVICE	JOHN	ALSO MSG	WORKS WHEN
					SHOP	GRIFFITH	J. GERSTNER	OTHER HTG.
								SYSTEM WON'T
PENNSYLVANIA	PITTSBURGH	53	CRV A-6	NOV. 85	HANGAR #	CAPT.	412/269-8388	EXCELLENT
			& A-8					SYSTEM
	ANG BASE	54	CRV A-6		HANGAR #	DOUG		
			& A-8			REYNOLDS		
PENNSYLVANIA	ARMY CORPS	1	CRV A-8	11/81	NEW BETHLEHEM		814/257-8811	
	OF ENGINEERS							

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STATE	BASE OF FORT	NUMBER OF BURNERS	MODEL	DATE INSTALLED	BUILDING	CONTACT	PHONE NUMBER	COMMENTS
PENNSYLVANIA	911TH TACTICAL AIRFIFT	6 2	CRV A-6 CRV A-8	12/83 “	PITTS. INT'L AIRPORT			
PENNSYLVANIA	PHILADELPHIA NAVY YARD	93	CRV A-8	1/85	MOTOR VEHICLE BLDG. 587			
PENNSYLVANIA	U.S. ARMY RESERVE WILKES BARRE	3 3 2	CRV A4 CRV A6 CRV A8	11/1/89	ARMY RESERVE MAINT. CENTER MAN			
PENNSYLVANIA	USAF 911 TAG PITTSBURGH	3 2	CRV A8 CTH 125	7/1/89	GREATER PITTSBURGH AIRPORT			
SOUTH DAKOTA	NAT'L GUARD	5	CRV A-8	8/82	STURGIS, SD			
SOUTH DAKOTA	SD ARMY NAT'L GUARD	24	CRV A (VARIOUS)		ARMORY			
SOUTH DAKOTA	ELLSWORTH AF BASE	12	CRV E 180'S	3/87	3 MUNITIONS BLDGS.			
SOUTH DAKOTA	S.D. ARMY N.G. RAPID CITY, SD	3 2	CRV B-10LP CRV B-12LP	11/5/86	HELICOPTER SHOP			
SOUTH DAKOTA	S.D. NAT'L GUARD	1 3	CRV B6 CRV B8	2/1/90	N.G.OMS SHOP #11			
TENNESSEE	TN. ARMY N.G.(DRESDEN)	1	RTH 75A	8/1/89	ARMORY			
TENNESSEE	TN. NAT'L GUARD (ENGIENEERS)	15 15 4	RTH 75A RTH 75A RTH 75	7/82	ARMORIES			
TENNESSEE	US CORPS ENGRS MEMPHIS DIST.	3	RTH 75A	--	1726 MITCHELL RD MEMPHIS, TN			
TENNESSEE	SMYRNA NAT'L GUARD	4	RTH 75A		SMYRNA,TN			
TENNESSEE	AIR NAT'L GUARD	10	CRV A8	6/84	KNOXVILLE AIRPORT, ALCOA, TN			
TEXAS	ELLINGTON ANG ELLINGTON FIRE STATION	18 4 10	CRV A10 CRV A10 CRV A10	11/85 9/1/90	HANGAR & SHOP FIRE STATION	LTC AL STEPCHINSKI MAJ. HOOTEN	713/481-1400 EXT. 2781	GREAT SYSTEM
TEXAS	TEXAS NAT'L GUARD ARMORY	1	RTH-R75	9/87	ARMORY			

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STATE	BASE OF FORT	NUMBER OF BURNERS	MODEL	DATE INSTALLED	BUILDING	CONTACT	PHONE NUMBER	COMMENTS
TEXAS	ARMY AIR FORCE EXCHANGE SERVICE WACO, TX	5 1 5 14	CRV B4 CRV B6 CRV B8 CRV B10	10/87	WAREHOUSE			
TEXAS	DYESS AF BASE ABILENE, TX	25	CRV B4	10/87	BLDG. 4003		915/673-2556	
TEXAS	KELLY AFB	4	CRV B6	8/1/90	BLDG. 920 TANG	MAJ. VON BOSHAY		
TEXAS	ANG MUELLER FIELD AUSTIN, TX	10	CRV B6	1987	HELICOPTER HANGAR			
UTAH	DEFENSE DEPOT OGDEN	22	CRV A-2	11/86	BLDG 116 OGDEN, UT			
UTAH	SALT LAKE CITY ANG	9	CRV A8	9/83	FIRE STATION	LTC FRANK JOHNSON	801/595-2200 801/595-2431	VERY ENERGY EFFICIENT - NO MAINT. PROBLEMS
VIRGINIA	ARLINGTON NAT'L CENETARY	1	RTH-R75	10/87	WHSE BLDG. # 107			
VIRGINIA	FED. EMERGENCY MGMT. AGENCY BERRYVILLE	5 3 1	CRV A2 CRV A4	12/1/88	WHSE. BLDG. #444			
WASHINGTON	SPOKANE ARMY COMPLEX	13 22	CRV 5-40 RTH 150A	10/83 11/86	MOTOR POOL HELICOPTER STORAGE	MAJ. AL VERNON	509/247-5501	
WASHINGTON	FT. LEWIS	20	CRV 5-40	9/83	BLDG. 5102 MOTOR POOL		206/967-6621	
WASHINGTON	FT. LEWIS	6	RTH 75A	1/85	BLDGS. 2062, 2063, 2066, 22070, 2072			
WASHINGTON	FT. LEWIS	162	CRV 5-40	1/85	BUILDINGS			
WASHINGTON	FT. LEWIS ATTACK HELICOPTER BATTALION	40 12	CRV 5-40 CRV 5-40	6/84 1/87	HANAGAR - TACTICAL EQUIP SHOP		206/764-3515	
WASHINGTON	FT. LEWIS	12	CRV B-10	12/1/88	BLDG. #9660	LEON WITTNER	206/976-5423	
WASHINGTON	WASH. A.N.G. TACOMA	4	CRV E360	10/4/88	EQUIP. STORAGE			

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STATE	BASE OF FORT	NUMBER OF BURNERS	MODEL	DATE INSTALLED	BUILDING	CONTACT	PHONE NUMBER	COMMENTS
WASHINGTON	NAVAL AIR	25	CRV 5-40	5/84	HANGAR #9 MAINT		206/226-3522	HJHJHJHJHJHJ
	STATION	14	CRV B-88	5/88	HANGAR #8	LT. WITHOIT		
	WHIDBEY ISLAND							
		12	CTH 125	10/88	AIRCRAFT			
					MAINT.			
WASHINGTON	US ARMY	4	CRV 5-40	1981	REPAIR SHOP		206/753-6004	
	VANCOUVER							
	BARRACKS							
	“	25	CRV 5-40	12/83	BLDGS. A,B,C, & D			
WASHINGTON	US NAVY	14	CRV B4	3/1/90	SUPPLY DEPT.			
	TRIDENT	6	CRV B6		U-21 BLDG.			
	SUB BASE	1	CTHS 80		#1038			
WASHINGTON	CAMP MURRAY	1	CRV E-360	10/88	EQUIPMENT			
	TACOMA				STRG. BLDG.			
WEST VIRGINIA	SHEPERD	11	CRV A-6	9/86	AERIAL	MAJOR	304/263-0801	
	FIELD		& A-8		PORT	WILLIAM		
	ANG				FACILITY	BURKART		
WEST VIRGINIA	WV ANG BASE	13	CRV 4-40	6/76				
	KANAWHA FIELD							
	CHARLESTON							
		22	CRV A-2	--				
		2	CRV A-4					
		3	CRV A-6					
		42	CRV A-8					
WEST VIRGINIA	WV ANG BASE	4	CRV A-6	11/81	MOBILE			
	KANAWHA FIELD	7	CRV A-4		STORAGE			
	CHARLESTON				A’CFT ENGINE			
					REPAIR			
WEST VIRGINIA	W.V. NAT’L	3	RTH 75A	11/86				
	GUARD	2	RTH A50A					
WEST VIRGINIA	W.V. NAT’L	6	CRV A6	4/1/89				
	GUARD	2	CRV A8					
WISCONSIL	DEPT. OF	--	--	--	3020 WRIGHT			
	MILITARY				MADISON, WI			
	AFFAIRS							
WISCONSIL	TRUAX FIELD				AIR FORCE			
					HANGAR			
WISCINSIN	CAMP WILLIAMS	--	--	--	CAMP DOUGLAS			
					WISCONSIN			
WISCONSIN	COAST GUARD	3	CRV A2	5J/1/87	BOAT STRG.			
	KENOSHA	3	CRV A4					

STATE	BASE OF FORT	NUMBER OF BURNERS	MODEL	DATE INSTALLED	BUILDING	CONTACT	PHONE NUMBER	COMMENTS
WISCONSIN	COAST GUARD	3	CRV A2	5J/1/87	BOAT STRG.			
	KENOSHA	3	CRV A4					
WYOMING	THERMOPOLIS	5	CRV A-8	12/84	THERMOPOLIS, WY			
	NAT'L GUARD							
WYOMING	NEWCASTLE	11	CRV A-4,	12/80	ARMORY			
	NAT'L GUARD		6 & 8					
WYOMING	GURNSEY	4	CRV A-6	12/83	ARMORY	307/772-6240		
	NAT'L GUARD							
	"	7	CRV A-4	7/84	DRILL HALL			
		2	CRV A-6		7 CLASSROOMS			
	"	3	RTH-75A	12/84	CSMS			
		10	CRV A-6	"	"			
		7	CRV A-8	"				
	"	2	CRV E-90	8/85	FLIGHT SERVICES			
		1	CRV E-12					
	"	1	CRV A-4	4/86	FOOD STRG. BLDG.			
WYOMING	EVANSTON N.G.	4	CRV A-4	12/83	DRILL HALL			
		2	CRV A-6	1//84				
WYOMING	CHEYENNE N.G.	4	CRV A-6	9/84	STORAGE BLDG			
WYOMING	CHEYENNE ANG	31	CRV A-6	7/86	C 130 HANGAR			