Detroit Radiant Products Co.

Gas Fired Infrared Heating Equipment

Engineering & Application Guide

⚠ WARNING

Consult the Installation, Operation, and Maintenance Manual(s) for specific requirements regarding clearances to combustibles, minimum mounting heights, and system design guidelines.

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LIODEG-1M-12/15(CDS)
Replaces: LIODEG-2M-10/11(CDS)

Contents

INTRODUCTION

1.0 Introduction

Overview

This guide has been created to assist engineers, distributors, and contractors in applying the wide range of Re-Verber-Ray® products. It is the goal of this guide to offer practical assistance by outlining design criteria for a wide range of applications. Every type of application has specific concerns that need to be addressed when applying our many lines of Re-Verber-Ray® equipment. Through practical experience, we have compiled this information.

This guide begins with basic application steps to be followed, then an explanation of heat loss calculations, followed by sample installation and design criteria. In order to give you a place to start, the steps needed to properly apply infrared heaters are outlined below. The information is divided in such a way that if you know how to compute a heat loss you can proceed to the General Principles Guide and Application Examples. For your convenience, reference materials such as pipe sizing charts and spot heating charts are provided following the application examples. When using this guide, you will find it helpful to refer to the Installation, Operation, and Maintenance Manual for the Series of heaters you wish to apply for specific installation requirements.

The design criteria and application examples outlined represent general recommendations, based on experience, for that type of application. However, every application must be viewed on its own merit and address issues that are specific to that installation.

Your local Re-Verber-Ray® Representative is there to assist you should this information not fully address your application. Your local representative's contact information is located on the cover page of this guide.

Factory Representatives

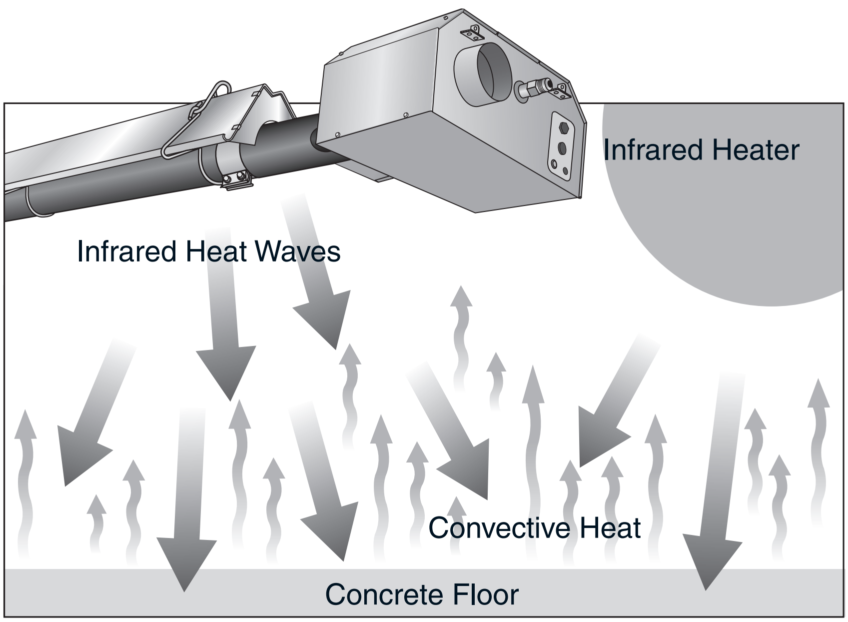
Although the installation may be fairly simple, system design and layout can be more difficult. It is critical that the equipment is designed and installed properly to assure a safe and effective heating system. Local representatives are available to review the requirements of your space and to assist you in selecting the proper equipment for your specific application.

Infrared Heat Energy

Infrared heaters offer an alternative, fuel efficient method of providing heat to spaces through a mixture of radiant and natural convection heat transfer.

Closely resembling everyday light, infrared heat energy is converted to heat rather than light. Both visible light and infrared are forms of radiation and their energy is carried from the source to an object through wave motion.

Without question, the sun is the best example of an infrared source. Similar to how the sun heats the earth, infrared heaters generate radiant energy that is converted into heat when absorbed by objects in its path. These objects in turn re-radiate this energy to heat the surrounding air. The floor and other objects in the space act like a reservoir; loosing very little heat during an air change of the space. Comfort levels in the space recover quickly as objects in the space transfer their stored energy to the space through convection.



"Similar to how the sun heats the earth, infrared heaters generate radiant energy that is converted into heat when absorbed by objects in its path. These objects in turn re-radiate this energy to heat the air."

Detroit Radiant Products' infrared heaters produce this infrared energy through gas combustion. Since combustion temperatures are in the medium range (1800°F for high intensity units, 1000°F for low intensity units), most of the heater's output is in the middle infrared band. In addition, this operating temperature also means a greater portion of the energy put into the heater is converted to infrared energy.

Higher efficiency is not the only advantage of producing "middle band" infrared energy. Because most common materials have a greater affinity for medium wave rather than short wave infrared, Detroit Radiant Products' gas-fired infrared heaters can heat, dry, and cure fast and economically. In the diverse conditions present in most commercial and industrial applications, radiant heaters direct heat more effectively to building occupants by efficiently delivering heat to the floor levels.

By emulating the true inexpensive efficiency of the sun, gas-fired infrared heaters are the perfect solution for hard to heat environments.

2.0 Safety

Applications

Infrared heaters are **not** explosion proof. No tube heater may be used in a Class 1 or Class 2 Explosive Environment. Consult your local fire marshal, insurance carrier, and other authorities for approval of the proposed installation.

Commercial / Industrial

Unless otherwise indicated, tube heaters are designed and certified for use in industrial and commercial buildings such as warehouses, manufacturing plants, aircraft hangars, and vehicle maintenance facilities. For maximum safety, the building must be evaluated for potential problems before installing the heater system. A critical safety factor to consider before installation is the clearance to combustibles.

Residential

Only select **LD3 and LS3 Series** heaters are certified for residential installation.

⚠ WARNING

Installation of a commercial tube heater system in residential indoor spaces may result in property damage, serious injury, or death.

Clearance to Combustibles

⚠ WARNING


Placement of explosive objects, flammable objects, liquids, and/or vapors close to the heater may result in explosion, fire, property damage, serious injury, or death. Do not store, or use, explosive objects, liquids, and/or vapor in the vicinity of the heater.

For maximum safety, the building must be evaluated for potential hazards before installing the heating system. Typical hazards include, but are not limited to:

- Combustible and explosive materials
- Gas and electrical lines
- Chemical storage areas
- Areas of high chemical fume concentrations
- Provisions for accessibility to the heater
- Storage areas with stacked materials
- Adequate clearances around air openings
- Combustion and ventilating air supply
- Lights and sprinkler heads
- Vehicle parking areas
- Areas with lifts, hoists or cranes
- Overhead doors and tracks
- Dirty, contaminated environment

When installing an infrared heater, minimum clearances to combustibles **must** be maintained. These distances are listed in the product manual and on the burner control box. If you are unsure of the potential hazards, consult your local fire marshal, fire insurance carrier, or other qualified authorities on the installation of gas fired heaters for approval of the proposed installation.

3.0 Equipment Selection

Basic Application Steps for Infrared Heaters

The following steps should be conducted prior to equipment selection and installation:

EQUIPMENT SELECTION

❶ **Conduct a Building Survey.** Conduct a building survey to determine the function of the building and what design limitations may exist.

Document the building's construction and utilities. Sketch the floor plan of the building with dimensions.

Map the location of all doors, windows, lights, sprinkler heads, electrical conduit, and gas lines. Record the location of the gas source (e.g.: gas meter or LP cylinder), the capacity (pipe size) of the gas supply, and available gas pressure. Determine current electrical capacity.

Indicate the location of interior obstructions such as machinery, overhead cranes and doors, lifts, storage areas, and parked vehicles. Indicate available mounting heights at potential heater locations. This information is critical in determining the BTU/h input of each individual heater and maintaining clearances to combustibles.

❷ **Discuss performance expectations.** Discuss with the end user what their expectations are for the heating system and control of the system.

❸ **Determine heat loss.** Place data collected during the building survey (e.g.: size, exposed walls and roofs, doors and windows, insulation type, and construction materials) into the Heat Loss Form (reference charts 6.7 - 6.10 in Appendix 6.0 to determine R value).

Record miscellaneous data such as open time for doors, cold mass, and windows. Also, if desired, record fuel cost data.

❹ **Determine heater type.** Review the various types of infrared heaters available to select the model(s) best suited for the application (see p. 12).

❺ **Review coverage.** Determine the number of heaters required to offset the calculated heat load and provide even heat distribution throughout the space. Heater BTU/h selection is generally based on available mounting heights and clearances where the heater will be located. It is practical to place burners in areas of greatest heat loss, opposite of each other and spaced equally. Compare your design against the sample applications provided in Section 5.

❻ **Finalize heater placement.** Maintain clearances to combustibles at all times and consider factory recommended mounting heights to ensure effective and comfortable heat patterns at the floor level.

❼ **Other.** Other related considerations include venting, controls, guards, shields, signs, and whether to utilize fresh air for combustion. Many accessories are offered for use in the application, configuration, and usage of the infrared heating system.

Sample Building Survey

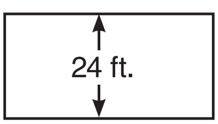
This information must be fully completed to compute an accurate building heat loss.

See p. 90 for a blank form.

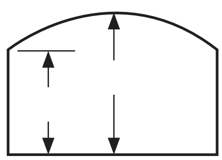
NOTE: Although not shown on the sample drawing, obstacles such as lights, sprinkler lines, and other overhead objects must be considered.

Floor Plan (Include dimensions and location of all doors and windows)

Elevation Details: (Note dimensions and interior obstructions)



[X] Flat



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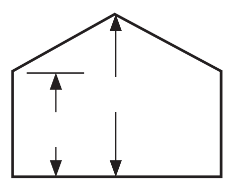


[ ] Pitched

Building Details:

Building Function:

- [ ] Manufacturing
- [ ] Car Wash
- [X] Warehouse
- [ ] Fire Station
- [ ] Other: ________

Doors:

- [ ] Roll up
- [X] Insulated
- [ ] Un-Insulated
- [X] Track
- [X] Activity: 2.25

Walls:

- [X] Materials: Metal
- [X] Insulation: 1 1/2”
- [X] R Value: 6.02

Roofs:

- [X] Materials: Metal
- [X] Insulation: 1 1/2”
- [X] R Value: 6.10

Type of Heating:

- [ ] Spot Heating
- [X] Whole Building Heat

Slab Edge:

- [X] Insulated
- [ ] Un-Insulated

Preferred Venting:

[ ] Sidewall [X] Roof

Desired Temp.:

65°F

Heat Loss

Calculating the building's heat loss is critical in designing an effective heating system. The heat loss calculation shown in Chart 3.1 is an example using the longhand heat loss method.

The sample building is located in Dayton, OH and could utilize any of the Detroit Radiant Products' infrared heaters. It is a warehouse constructed in the mid-1970's and is considered a normal building in terms of construction tightness, with average insulation. This data is necessary to accurately calculate the heat loss and to conduct an economic evaluation.

Use the data collected when doing the building survey to calculate the heat loss:

❶ Record the building size to calculate the volume.

❷ Insert the desired inside temperature and the outside design temperature to calculate the Delta T. Refer to Appendix 6.0, Chart 6.13 for outside design temperature (see pgs. 75-79).

❸ Record the type of building materials.

❹ Calculate square footage of the walls, roof, doors, windows and skylights.

❺ Record the U-factor (1/R-Value) for each part of the building. Refer to Appendix 6.0, Charts 6.7 - 6.10 for R-Values (see pgs. 69-71).

❻ Calculate perimeter footage of the slab edge.

❼ Determine the number of air changes per hour. Appendix 6.0, Chart 6.11 for typical number of air changes (see p. 72).

❽ Add in cold mass when it applies.

❾ If mechanical ventilation is present, determine if the natural or the mechanical ventilation has the greater heat loss.

❿ Calculate totals for each row.

⓫ Calculate the total heat loss by adding the subtotals, a+b+c+d.

Chart 3.1 • Sample Building Heat Loss

This information must be fully completed to compute an accurate heat loss of your building.
See p. 91 for a blank form.

Required Data

Building Size	Length	x	Width	x	Height	=	Volume
	300 Ft.		110 Ft.		24 Ft.		792,000

Temperature Differential	Inside Desired Temp	-	Outside Design Temp	=	Delta T
	65° F		0° F		65° F

Building Materials*		Size	x	U-factor (1/R)	x	Delta T	=	Heat Loss
**Wall 1	Metal 1.5 in.	14,400 Ft^2		0.166		65° F		155,376
**Wall 2		3,760 Ft^2		0.166		65° F		40,570
Wall 3		N/A		N/A		N/A		N/A
Roof	Metal 1.5 in.	33,000 Ft^2		0.130		65° F		278,850
**Doors	Ins. Metal	1,520 Ft^2		1.200		65° F		118,560
Windows		N/A		N/A		N/A		N/A
Skylights		N/A		N/A		N/A		N/A
Slab Edge	Poured Con.	820 LF		0.810		65° F		43,173
							(a)	636,529

* Grouping walls, doors and windows of a similar type as one is acceptable.
** Subtract door size from appropriate wall size as to not count Ft^2 twice.

Natural Ventilation	Air Changes	x	Building Volume	x	U-factor	x	Delta T	=	Heat Loss
	1.5		792,000		0.018		65° F	(b)	1,389,960

Special Considerations

Cold Mass	Weight (lbs.)	x	Specific Heat	x	Delta T	÷	Dwell Hours	=	Heat Loss
Trucks	80,000		0.12		65° F		8	(c)	78,000

Mechanical Ventilation (cfm)	Fan Size (cfm)	x	60 (min/hr)	x	Specific Heat	=	Delta T	=	Heat Loss
	N/A		N/A		N/A		N/A	(d)	N/A

Total Heat Loss

Sum of a,b,c,d **2,104,489**

EQUIPMENT SELECTION

Chart 3.2 • Sample Fuel Cost Estimate

Heating Factors	Description
Building Location	Dayton, OH
Heat Loss	2,104,489 BTU/h
*Average Winter Temperature	39.8° F
*Inside Design Temperature	65° F
Outside Design Temperature	0° F
*Heating Season	October 1st - May 1st (5,690 yearly degree days at 65° F. This is based on building location)
Fuel	Natural Gas: 1,040 BTU/ft^3 , Propane: 2,525 BTU/ft^3
Fuel Consumption (Use formula to calculate)	28,873.70 therms per year for natural gas at a cost of $0.85 per ccf. (1 therm is 100,000 BTU/h). 31,555.96 gallons per year for propane at a cost of $1.70 per gallon. (1 gallon is 91,500 BTU/h).
Seasonal Fuel Cost	28,873.70 therms x $0.85 per therm = $24,542.65 per season for using natural gas. (31,555.96 gallons x $1.70 per gallon = $53,645.13 per season for using propane.

***NOTE**: See pgs. 73-80 for Average Winter Temperature factors. Refer to chart 6.12 & 6.13 for annual degree days. Use the chart closest to the Inside Design Temperature wanting to be maintained.

Fuel Cost Estimate

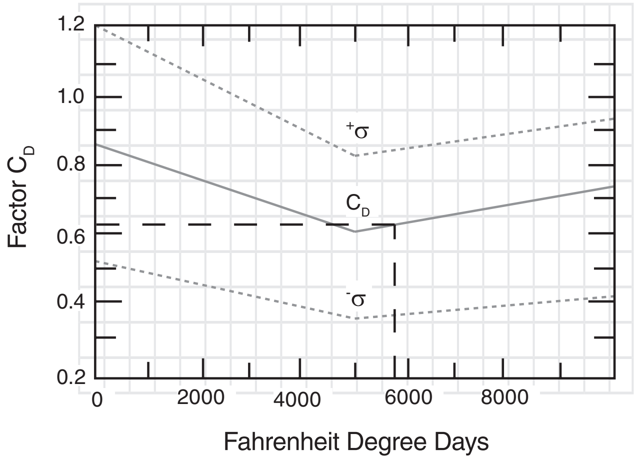
A total seasonal fuel cost estimation may be based upon average weather data gathered for many localities throughout the United States and Canada (refer to Chart 6.13: Winter Climatic Conditions).

The quantity of fuel consumed during heating season may be estimated from the calculated heat loss of the building. Use the following equation:

$$\text{Estimated Fuel Consumed} = \left[\frac{(H_L)\,(H_{IR})\,(DD)\,(T)}{(\text{Delta T})\,(K)\,(V)}\right](C_D)$$

H_L	Calculated total heat loss for the building in BTU/h.
H_{IR}	0.85 Infrared correction factor.
DD	Number of degree days for the estimated period. (For October 1st-May 1st heating season: Refer to chart 6.12 & 6.13 for annual degree days. Use the chart closest to the Inside Design Temperature wanting to be maintained.)
T	Hours in a day. Use 24.
Delta T	Design temperature rise in °F.
K	Steady state efficiency of the heater. (Using the following numbers as a guide for different equipment: 92%=infrared unvented heaters, 90%=condensing heaters, 82%=infrared vented tube heaters, 80%=new unit heaters, 76%=older unit heaters, 50%=old boilers.)
V	Heating value for fuel. (Use 100,000 for natural gas, use 91,500 for propane)
C_D	Correction factor for heating effect vs. degree days. Use the table below for this number.

Chart 3.3 • **Correction Factor Chart**



Sample Estimated Fuel Consumed for Natural Gas

$$\left[\frac{(2{,}104{,}489)\ (.85)\ (5690)\ (24)}{(65°\text{-}0°)\ (.82)\ (100{,}000)}\right](.63) = 28{,}873.70 \text{ Therms}$$

Sample Estimated Fuel Consumed for Propane

$$\left[\frac{(2{,}104{,}489)\ (.85)\ (5690)\ (24)}{(65°\text{-}0°)\ (.82)\ (91{,}500)}\right](.63) = 31{,}555.96 \text{ Gallons}$$

Utilities, Fuel & Electrical Requirements

Utilities

The survey must verify the availability of fuel and determine the type, capacity, heating value, specific gravity, pressure, and altitude of the area. The supply pressure and capacity must be adequate for the heating system to function properly. The possibility of using standby fuel for interruptible service should be investigated. Since a change in fuel can effect heater performance, the makeup of any standby fuel must be checked for compatibility. The location and size of existing gas supply piping should be noted for use in planning the installation. The electrical power requirement for infrared heaters varies. The availability of power, as well as the supply voltage and current, must be verified, since these may influence the selection of heater ignition controls.

Fuel

Different types of fuel require specific heater orifices and pressure regulators. Mixed and manufactured gases require different orifices than natural or propane gas. The manufacturer of an appliance should be consulted to determine the correct orifice in cases where these gases are employed.

Standby propane gas and air mixtures may be used in areas which have interruptible natural gas service. If the propane and air are mixed to provide 1,400 BTU/ft^3 with specific gravity of 1.29 (air = 1.0), no modification of natural gas appliances is necessary. For other propane-air mixtures, consult Detroit Radiant for necessary modifications.

Electrical Power

Electrical control of gas-fired infrared is common because mounted heaters are not readily accessible. 120-volt is required for low-intensity tube systems. 120-volt, 24-volt, or millivolt heater ignition controls are available for high intensity heaters. The choice of power supply is dictated by the models chosen, installation costs, and local codes. Care must be taken to ensure that the heater controls are matched to the power supply.

Note: The utilities available typically determine the fuel and electrical specifications of the heaters.

Types of Infrared Heaters

There are two types of infrared heaters: high intensity and low intensity. High intensity heaters are of a modular design and have been a popular choice since the 1950's. These types of heaters require high mounting heights due to an open flame blanketing a ceramic surface. A highly polished reflector helps to direct this highly concentrated heat where it is most needed. High intensity heaters are unvented and are typically installed in areas of high air filtration and work well for spot heating applications.

Low Intensity Infrared Heaters

Low intensity gas fired infrared heating systems entered the marketplace in the late 1970's, presenting the advantages of infrared heat to a multitude of new applications. Low intensity infrared tube heaters consist of three main components: a burner control box, highly emissive radiant emitter tubes, and a highly polished reflector hood. Infrared tube heaters do not rely on blowers for heat distribution offering a clean and quiet environment. They are typically installed in applications where total area heat is required or can be configured to conform to the expectations of the space, providing maximum flexibility in the placement of heaters. Typically controlled by a thermostat, tube heaters can be installed either vented or unvented and may bring in outside air for combustion if necessary.

Two Stage Technology

Traditional sizing of heater units has always been based on the maximum or high fire mode. The high fire mode is only required for 7% to 15% of the total heating hours. The high/low feature of a two stage heater can save a minimum of 12% in fuel cost over a single stage system (**NOTE:** statistics based on independent studies).

High Intensity Infrared Heaters

High intensity heaters consist of patio, portable, and ceramic space heaters and are best suited for buildings with high ceilings (e.g.: aircraft hangers, truck terminals, warehouses). High intensity heaters require a greater clearance to combustibles than low intensity heaters. Detroit Radiant high intensity heaters include the DR, DSC, PT, and BAH series. When choosing a high intensity heater you must factor in that it is unvented, requires adequate combustion air, and the thermostat amperage rating.

Vented Infrared Heaters

Venting is accomplished indirectly through the use of mechanical exhausters, gravity vents, or natural air flow. The ventilation requirement is 4.0 CFM per 1000 BTU/h of input for units operating on natural gas or propane. For example, the required ventilation for the installation of ten DR-60 heaters is 60 x 4.0 x 10 = 2,400 CFM.

IMPORTANT! Using mechanical exhausters is the only way to guarantee the proper amount of ventilation recommended in total building heat projects.

Ensuring adequate combustion air is essential to the proper operation of high intensity infrared heaters. If the building is under a negative pressure due to powered exhaust from the space, then combustion air must be supplied by air intake louvers. The sizing of these louvers is based on the required combustion air for the infrared heaters and is calculated at a ratio of 1 sq. in. of free air per 1000 BTU/h of input. For example, the square inches of free air required for 10) DR-60 natural gas heaters is 600.

IMPORTANT! If negative pressure exists in the building it must be corrected prior to the installation of the infrared heaters. The amount of intake combustion air required for the heaters is in addition to the solution implemented to correct the negative pressure condition.

Chart 3.4 • Heater Types

Application	Heater Series
Commercial & Industrial (low intensity)	HL3 (two-stage), DX3L, DET3 (two-stage), DES3
Agricultural (low intensity)	AG2 (two-stage), AG1, RVA2 (two-stage)
Residential (low intensity)	LD3 (two-stage), LS3
Vacuum (low intensity)	HLV (two-stage), SV
Harsh environment (low intensity)	SS (stainless steel, available in HL & DX series only)
High Intensity	DR, DSC
Portable (high intensity)	PT
Electric (high intensity)	BAH, SW, MW, DGS
Foreign (230 volt / 50 hz)	EHL (two-stage), EDX, RV/DR, GPH

NOTE: All Series are single stage unless noted.

Thermostats and Controls

Typically, one thermostat controls multiple heaters. The total amperage required for all the heaters must not exceed the thermostat amperage rating. For example, when using a 25-volt thermostat with 120-volt controlled heaters, you must use a step-down transformer. The VA draw of all the heaters on that transformer must not exceed the VA rating of the transformer. Refer to the wiring diagrams for the VA draw rating for each specific type of high intensity infrared heater control.

4.0 System Design

Design Considerations

Placement of infrared heaters is influenced by many factors. Aside from safety factors, considerations such as the number of vents or heater elbows that are allowed, maximum vent lengths, ducting of combustion air, and combining exhaust vents are a few examples. All installation manuals, along with national, state, provincial, and local codes, address these issues. It is critical that you read, understand, and follow all guidelines and instructions.

At this stage, the Building Survey (p. 90) should be completed and a layout should be developed for the correct placement of the burner control box, tubes, vents, and combustion air intake ducts. Inspect and evaluate the mounting conditions, vent locations, gas supply, and wiring.

In an area that receives little or no heat from its surroundings or in a small space located within the building, radiant heaters are sized and located so they will supply sufficient heat within the heated area to make the person feel comfortable. The feeling of warmth is completely independent of the actual air temperature in the heated area.

Additional heat per square foot is generally required to keep people comfortably warm in a “spot” or “small area” since the space is generally surrounded by cold walls, cold areas, or areas which quickly lose heat to the surrounding area (see p. 83).

There are three different types of areas: average, protected/insulated, or cold/drafty. The term “average” means an area which is within a normal building that is not subject to direct winds or drafts in excess of 2 mph. The walls are made of material other than steel or glass and the general surroundings within the building have neither an exceptionally high or low heat loss nor gain.

A “protected/insulated” spot or area is an area with little air circulation and is surrounded by low heat loss areas. It could be a small area closely surrounded by walls or by well-insulated walls at some distance from the area to be heated.

A “cold/drafty” location is an area subjected to direct or indirect cold drafts, or is surrounded by relatively high heat loss objects like metal or glass walls. Drafts in these locations should not exceed 5 mph without prior review by an experienced application engineer.

Mounting Heights

The first and most important steps to consider in system design are mounting height and clearance to combustibles. Both relate directly to the safe operation of the heating system and clearance to combustibles **must** always be maintained.

Factory recommended mounting heights (pages 81-83) are listed as a guideline. If infrared heaters are mounted too low or too high, they may result in heat discomfort or lack of heat. Detroit Radiant Products Company generally recommends observing the recommended mounting heights to optimize comfort conditions. However, certain applications such as spot heating, freeze protection, outdoor patio heating, or very high ceilings may result in the heaters being mounted outside of the factory recommended mounting heights. The effective infrared surface temperature of a person or object may be diminished with winds above 5 mph, therefore the use of adequate wind barrier(s) may be required.

Interior Obstructions
Obstructions inside the building can restrict the choice of heaters in nearby areas. In some cases, the limitation is physical. There may not be enough space to place the heater in the most desirable location.

In applications where a crane rail exists, the crane structure may not allow enough space on the walls to mount heaters. In this scenario, the only practical placement is above the crane beam. In areas where the crane could become parked beneath the heater, a reflective material, such as aluminum backed with fiberglass insulation, should be installed to protect the crane motor and wiring from possible damage.

The second form of interior obstruction is stored material in combustible containers which must be kept at a distance no less than the clearance to combustibles from any heater. Although the building itself may be high enough to call for a large heater, stored material rising near the heaters may require smaller units with a smaller clearance to combustibles.

System Layout

Heater Size and Quantity
After conducting the building survey and heater placement, now the size and quantity of the heater(s) need to be determined. The options for the heater size have already been established based on the available mounting height and clearance to combustibles.

For this example we will use a tube heater with a heater input of 100,000 BTU/h. To determine the quantity of heaters you will need to divide the total building heat loss (calculated on Heat Loss Form) by the heater size you have chosen. If the total heat loss is 300,000 BTU/h, three 100,000 BTU/h units (i.e. 300,000 ÷ 100,000 = 3) are needed to match the load.

Heat Distribution
A well designed heating system will result in even heat distribution throughout the space. Concerns regarding uneven heat distribution should be addressed by looking at alternative heaters. Recommended mounting heights for heaters do overlap and distribution concerns can sometimes be solved by using more heaters of a slightly smaller input (e.g.: using four 75,000 BTU/h units in place of three 100,000

BTU/h units to match the load of 300,000 BTU/h heat loss).

Heat distribution can also be controlled with the use of reflectors, side shields, guards, and ‘U’ or ‘L’ shape. Reflectors and reflector accessories direct infrared energy to the floor level. The reflector assembly depends on the heater configuration, proximity to combustibles, and space surrounding the heater.

Heater Location
In a total heating design for a building, the concern is to replace heat losses with heat input and to create the most uniform radiant pattern as possible. The arrangement of heaters influences the effectiveness of the heating system, but because of limitations imposed by building construction as well as other factors, it is not always possible to use the most efficient arrangement.

There are two basic heater layouts: perimeter mounting and ridge mounting. Under certain conditions combinations may be required.

Perimeter Mounting
In this arrangement, the infrared heaters required to satisfy the total heat loss are located along the outside walls of the building. Experience has proven this to be the most effective layout for gas-fired infrared heaters. This arrangement should be used whenever possible as it permits a 15% perimeter heat loss reduction.

NOTE: The following criteria must be met to allow the reduction.

The number of infrared heaters placed along each wall depends upon the amount of heat loss through the wall in proportion to the total conduction heat loss through all the walls. In most cases, this is also roughly proportional to the length of the particular wall.

Heaters Along Wall = Heat Loss of Wall / Total Wall Heat Loss x Total Number of Heaters

Areas where very high heat losses occur may require supplementary spot heating. Areas of very low heat loss, such as walls adjoining other heated areas, may be best heated by smaller units than are used throughout the rest of the building. Rotating the reflectors of units placed on outside walls allows the infrared to be directed into the surrounding work area. Observance of minimum mounting heights is critical to a proper installation.

Due to heat variations, the burner control box and first sections of radiant tube should be placed in the area(s) of highest heat loss (e.g.: overhead doors). Cooler sections of the tube should be located in areas that do not require as much heat. When placing the heater system along an exterior wall, pairs of heaters are usually installed opposing each other and then common vented together.

Ridge Mounting

In this arrangement, infrared heaters are mounted along the ridge line of the building, usually with adjacent heaters inclined in opposite directions for maximum coverage, although horizontal mounting may be used. This arrangement is the least desirable for infrared heaters. The heat input is concentrated at the farthest distance from walls where the conduction losses occur. A ridge mounting layout can provide the inside design temperature required, but increased fuel consumption should be anticipated.

Combination Layouts

Combinations of perimeter and ridge mounting arrangements are usually employed in large buildings where the closest opposite walls are more than 100 feet apart.

The basic perimeter layout is followed for greatest system efficiency. To counterbalance large heat losses through the roof in the center of the building, some of the infrared heaters are installed nearer the center instead of placing them all on the perimeter.

Locating a heat input of 10% to 20% of the total heat loss near the center area is usually sufficient. The 15% perimeter heat loss reduction may be taken if the heating in the center does not exceed 20% of the total input.

Optional Accessories

Low intensity infrared heaters can be placed in a straight, ‘L’, ‘U’, or extended ‘U’ configuration to allow maximum flexibility in the placement of the heater and control of heat distribution.

Specific localized needs have slight influence on the overall selection of heaters, but can dictate local deviations. Reflector extensions are often used to provide higher radiant intensity in these areas, although a total heating system ordinarily does not require the use of such extensions.

A maximum of two 90 degree elbows or one 180 degree ‘U’ fitting can be installed on a low intensity series heater. Placement of these accessories is determined by the high fire input of the specific model. Chart 4.1 shows the minimum distance from the burner control box that elbows or ‘U’ fittings **must** be placed for different model low intensity heaters.

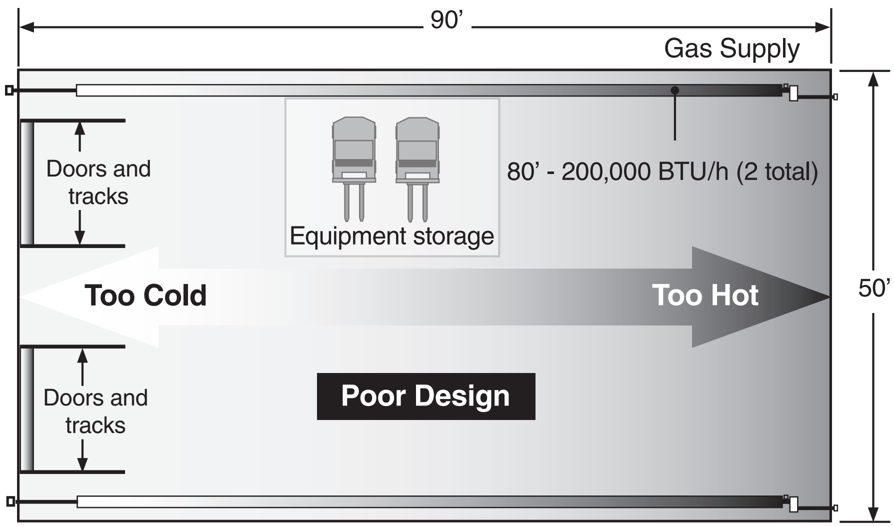
Chart 4.1 • Minimum Distance to an Elbow or 'U' Fitting (low intensity heaters)

Model (MBH)	Minimum Distance
40 - 100	10 ft.
110 - 125	15 ft.
130 - 175	20 ft.
200	25 ft.

Design Scenario:

The Figures 4.1 and 4.2 are basic examples of good and poor system designs. A tube heater system is being installed in a 90' (L) x 50' (W) x 14' (H) space. Two overhead doors are located at one end and an equipment storage area on one side. The calculated heat load is 380,843 BTU/h.

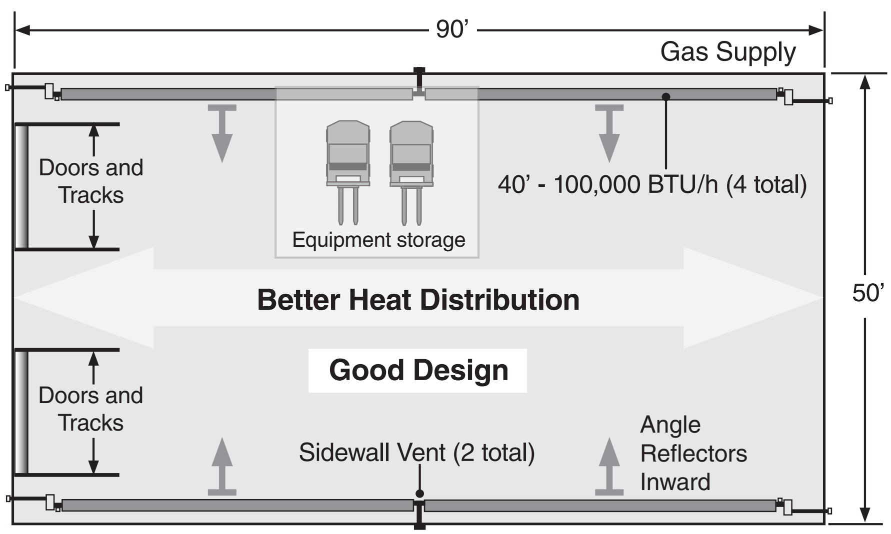
Figure 4.1 • Poor Design



- Two burners (200,000 BTU/h each) are placed at one end, opposite the area of highest demand.
- Recommended mounting heights are not observed.
- Produces an uneven heat distribution.

SYSTEM DESIGN

Figure 4.2 • Good Design



- Four burners (100,000 BTU/h each) are placed in each corner. Heat is directed to areas of highest demand.
- Recommended mounting heights have been observed.
- Produces even distribution of heat.

Special Considerations

Spot Heating

Spot heating should be utilized when only a portion of a building is to be heated.

Both high intensity infrared heaters and low intensity infrared tube heaters can be used in spot heating applications. Low intensity tube heaters are typically placed in a U-shaped configuration for spot heating. This allows for maximum flexibility in placement of the heaters. Refer to p. 83 for high intensity heater selection.

Corrosion and Freeze Considerations

In applications such as car washes or equipment rooms, protection against moisture, freezing, and corrosive acids may exist. Hydrocarbon compounds, which contain halogen elements such as hydrogen, chlorine, fluorine, bromine, and iodine, are generally non-corrosive. However, once these chemicals become burned through the combustion process, decomposition takes place, freeing halogen compounds. These compounds combined with moisture from combustion products form extremely corrosive acids and toxic fumes. Where these chemicals are present, atmospheric heaters should not be used (high intensity). When using low intensity tube heaters, outside air for combustion is required.

It is recommended that a system exposed to these elements be designed with options such as stainless steel, silicone sealed control box, outside air for combustion, waterproof thermostats, and electrical attachments. To protect against power failure and subsequent freezing millivolt controls (e.g.: DR30-NMV control system) are sometimes chosen for freeze protection.

Series Specific Considerations

No single device is the answer to every heating requirement. However, the Detroit Radiant Products line of gas infrared heaters can provide effective total building heat (or spot or area heat) in the majority of industrial and commercial structures. In addition, Detroit Radiant Products portable heaters can extend the benefits of infrared heating to construction sites and other temporary heat applications.

Detroit Radiant heaters can provide efficient heating with lower fuel costs in any of the following areas:

- Machine shops, assembly plants, service garages, parking enclosures, and other average height buildings.
- Vast manufacturing plants, aircraft hangars, warehouses, and other high-ceiling structures.
- Sports arenas, auditoriums, swimming pools, and other spectator used facilities.
- Buildings where fresh air for combustion is required such as welding shops, body shops, and car washes.
- Spot and area heating for construction, sports activities, preheating, drying, and many other applications where heat is needed at the spot.

The principal use of gas-fired infrared heaters is to efficiently heat commercial and industrial buildings or to spot heat the people within them.

Heating an overall area with gas infrared heaters is particularly suited for buildings with large air volumes or high rates of air movement where convection (air heating) methods are grossly ineffective. Infrared heats people, floors, walls, and other surfaces directly without heating the air first. The result is an instant warming effect, similar to the effect felt when the sun emerges from the clouds on a chilly day.

When infrared heating is used in an enclosed building, objects in the space absorb the emitted infrared energy. Once absorbed, the energy is converted into heat which in-turn warms the surrounding air. With convection space heating, the air must first be heated and then circulated in order to warm objects and people in the space. In buildings such as factories, foundries, aircraft hangars, and warehouses, the difficulties in convection heating become readily apparent. By contrast, a well designed system using gas fired infrared heaters creates a high degree of fuel utilization efficiency since it heats objects and people directly. Heating the total mass of air volume in the space is not necessary.

Low Intensity Heater

The following pages provide sample infrared design layouts and descriptions for low intensity heater Series: HL3, DX3L, DES3, DET3, and the HLV vacuum system.

General Design Considerations

Design considerations common to the low intensity heating systems include:

- Observance of factory recommended mounting heights is critical to a proper installation. This is especially true when installing long length heaters with inputs of 150,000 BTU/h and above.
- Do not combine the vents of two heaters into a straight-through tee. Part No. Y, RT or a staggered-tee fitting **must** be used with the common flue being 6-inches in diameter. Common vented units **must** share the same thermostat.
- A maximum of two 90° elbows (Part No. E6) or one 180° U-shaped fitting (Part No. TF1B) can be installed on a tube heater. Placement of these accessories is determined by the input of the applicable model.
- If heaters are installed in an area where chlorinated or fluorinated contaminants are present, outside non contaminated combustion air must be supplied.
- Do not exceed the maximum vent length of 20 ft. for exhausting the heater. Do not use more than two 90° elbows in the exhaust vent. Flue vent requirements do not change when elbows are installed.
- Do not exceed maximum air intake duct lengths (i.e., 20 ft. with a 4-inch duct).
- Do not draw intake air from an attic space. There is no guarantee that adequate air will be supplied.
- Units installed unvented must use a vent termination fitting with a flapper such as Part No. WVE-GALV.
- When available, upgrading to stainless steel add-ons and the use of outside air for combustion is recommended for applications in harsh environments.

  NOTE: In harsh environments, it is encouraged to silicone seal (SILSEAL) the burner control box on models that are not upgradable to stainless steel control boxes (SSCBAO).

Application of the HL3 Series

Sizing HL3 Series heaters is accomplished by selecting units based on the available mounting height in accordance with factory recommendations. Heater quantity is determined by matching the total BTU/h input indicated in the heat loss calculation to the accumulative input of the high fire mode of the selected unit(s).

The two stage feature of the HL3 Series affords the system the flexibility of handling the heat load as dictated by the design criteria. The two stage feature adjusts the BTU/h input to a lower setting for the majority of time when little heat is required.

Figure 4.3 • HL3 Series Application

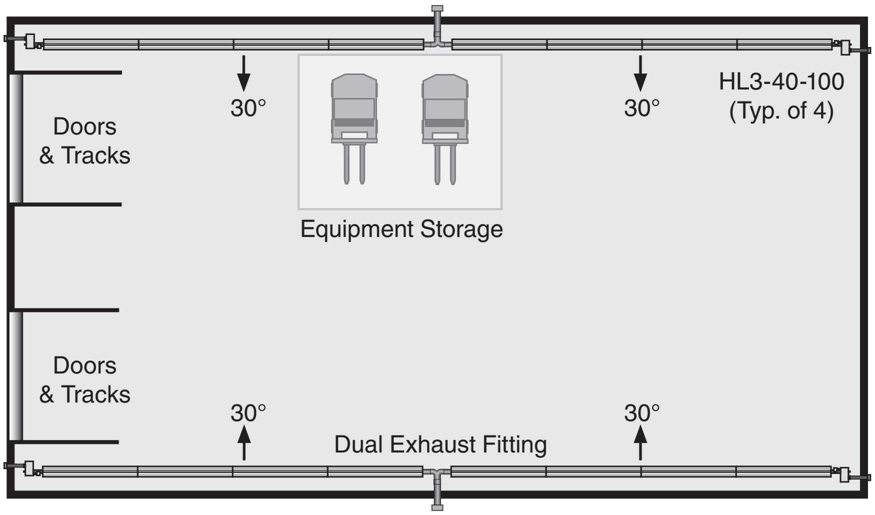


Figure 4.3 above illustrates two pairs of common sidewall-vented HL3 Series heaters. Outside combustion air is drawn from the sidewall for each unit. Note placement of burner control boxes are in opposing corners of the building. All tube heaters have a difference in surface temperatures and radiant output from beginning to end (the warmer burner control end of each unit is placed in areas of greatest heat loss). This is the best configuration for even heat distribution in applications with lower available mounting heights.

Considerations

Observance of factory recommended mounting heights is critical to proper installation. This is particularly true of heaters with inputs of 150,000 BTU/h and above.

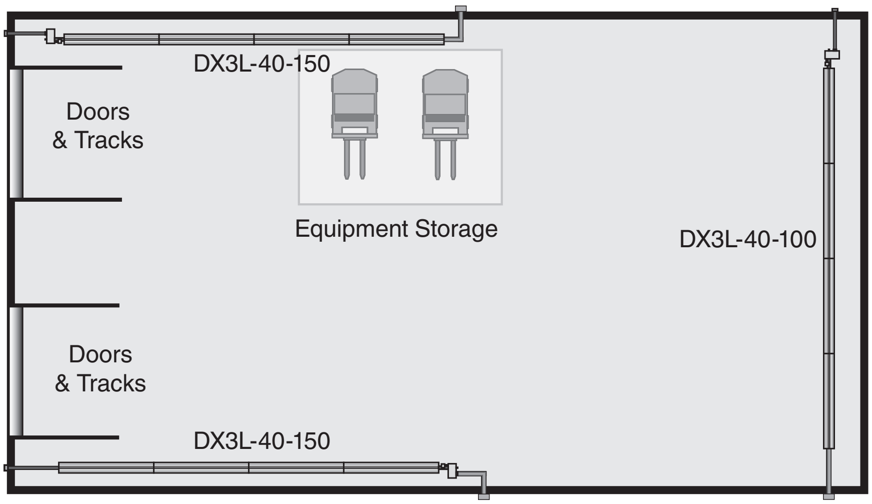
- HL3 Series units sharing a common thermostat must be equipped with a factory installed relay board (P/N: HLRP). Single units, connected to their own thermostat, do not require a relay. Care should be taken in planning projects to avoid using improperly equipped heaters (i.e., relays, transformers).
- Two stage models require the use of a 25V, two stage, heat-only thermostat. Common vented units must operate on the same thermostat.
- Stainless steel upgrades are recommended in harsh environments to protect the heater from corrosion.

SYSTEM DESIGN

Application of the DX3L Series

Tube heaters have a difference in surface temperature and radiant output from beginning to end of each unit. This operational condition is taken into consideration in this layout. By having the burner from one unit adjacent to the vent of the next unit, heating uniformity is assured.

Figure 4.4 • DX3L Series Application



Considerations

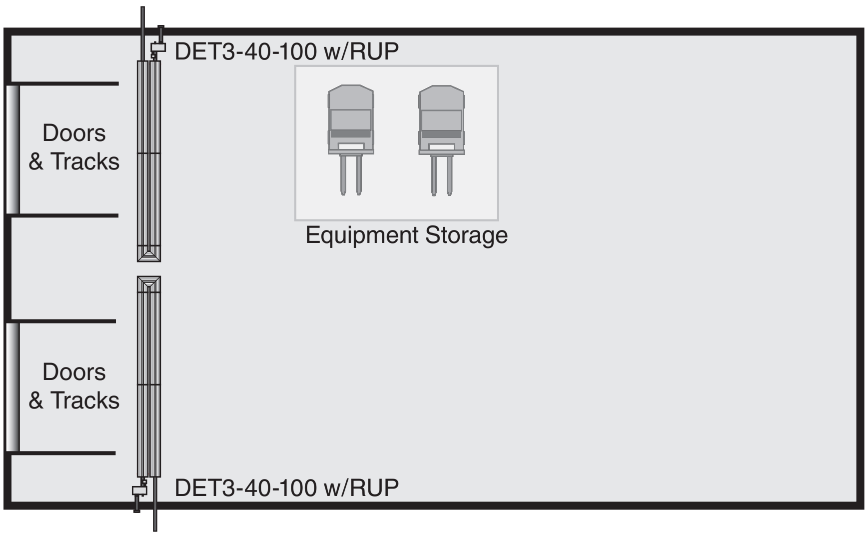
- Observance of factory recommended mounting heights is critical to proper installation. This is particularly true of heaters with inputs of 150,000 BTU/h and above.
- Stainless steel upgrades are recommended in harsh environments to protect the heater from corrosion.
- DX3L Series units sharing a common thermostat must utilize an external relay kit (P/N: ERK). Single units, connected to their own thermostat, do not require this kit. Care should be taken in planning projects to avoid using improperly equipped heaters (i.e., relays, transformers).
- Common vented units must operate on the same thermostat.

Application of the DES3 and DET3 Series

Tube heaters have a difference in surface temperature and radiant output from beginning to end of each unit. This operational condition is taken into consideration in this layout. Placing units into a U-shaped configuration creates uniformity with the differential. The heaters now act as spot heaters and are installed in the area of greatest heat loss.

Outside air for combustion should be supplied to the heaters when the building space is under a negative pressure or when the air inside of the space is diluted with chemicals or by-products of the work environment.

Figure 4.5 • DET3 Series Application



Considerations

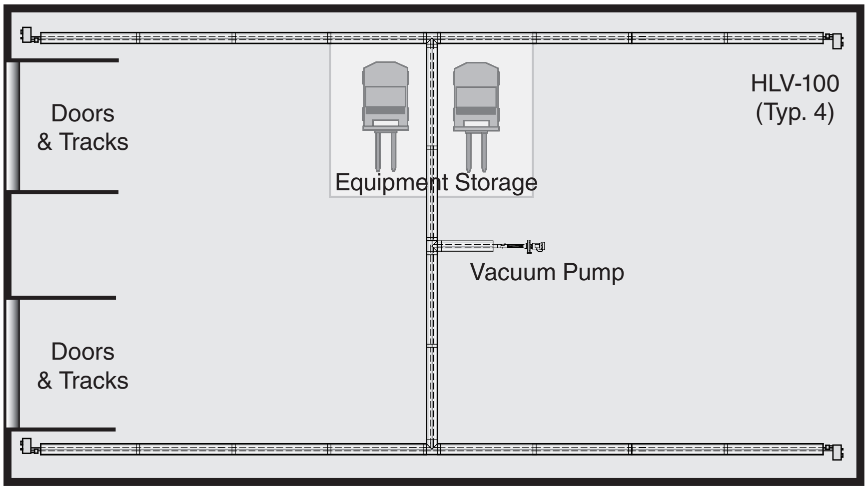
Observance of factory recommended mounting heights is critical to proper installation. This is particularly true of heaters with inputs of 150,000 BTU/h and above.

- Common vented units must operate on the same thermostat.
- Most S.S. upgrade options are not available with the DES3/DET3 Series. The use of silseal and aluminized steel tube upgrades is encouraged for use in harsh environments such as wash bays, etc.
- The DES3 Series is set up for 120V control. When 24V control is desired, an external transformer/ relay combination is required (R8285B). The DET3 Series comes standard set up for 24V control and would require an external transformer only (4000-01V).

Application of the HLV Series Vacuum System

The HLV Series is an engineered multiple burner vacuum system. Burner input, exchanger length, and pump size must be coordinated with specific system design criteria detailed in the design section of the HLV Series Manual.

Figure 4.6 • HLV Series Vacuum System Application



The sample layout above illustrates an "H" pattern where burner boxes are placed at the beginning of each run and the pump is centrally located. This provides even coverage throughout this facility and allows for only one exhaust penetration for this system.

System control is through the use of a thermostat which can be interlocked with a control panel allowing for standard single or two zone control and for monitoring system operational status. Hot-rolled (HRE) or coated aluminized (EA) tube and reflector packages are added to connect each burner box to the vacuum pump. Matching the appropriate quantity of tube and reflector packages, elbows, tees and other miscellaneous accessories allows the systems to be designed in a tailored fashion, specific to its application.

General Design Considerations:

Specific guidelines <u>must</u> be adhered to in order to ensure proper system design and operation.

- The length of each tube run from the burner box to the vacuum pump is determined by the gas input of the burner box serving that run.
- Vacuum pump selection is based on the overall BTU/h input of each system.
- A maximum of six burners, six dampers, three tees, and two elbows per branch are allowed per system (per pump).
- Proper tee usage is critical. Refer to the HLV Series accessory guide for available options.
- One titanium combustion chamber (TR-C) is required for each burner.
- The vacuum pump vent length must be from 2 ft. to 25 ft. The maximum number of elbows in the exhaust vent is two.
- A primary damper is provided with each system and must be placed before the vacuum pump. Due to variations in gas input and radiant tube lengths, it may be necessary to place secondary dampers at various points to balance the system's exhaust flow.

Consult the design section of the HLV Series Manual for additional system design guidelines.

SYSTEM DESIGN

High Intensity Heater

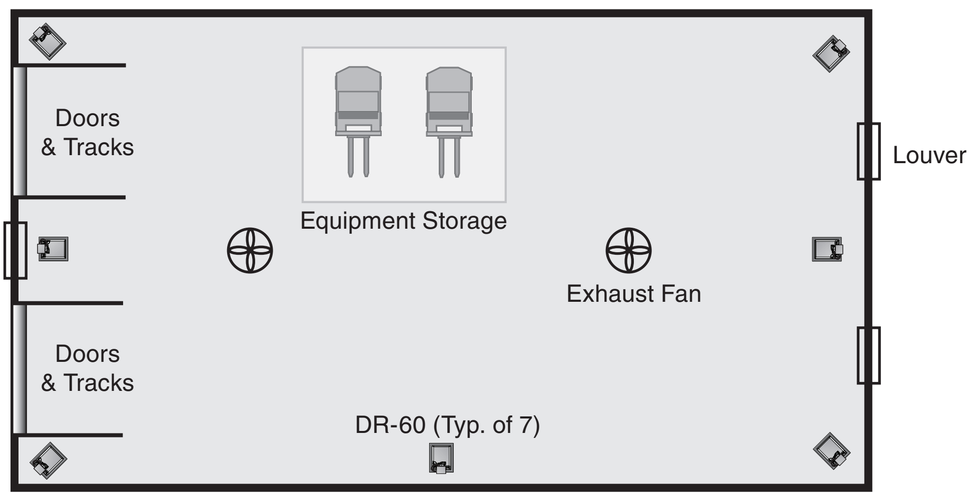
The following provides a sample infrared design layout and description for high intensity heater DR Series heaters.

General Design Considerations

Design considerations common to the high intensity heating systems include:

- Observance of minimum clearance to combustibles as listed on the unit's rating label is essential. Failure to adhere to these clearances can cause property damage, injury, and/or death.
- It is critical that proper mounting heights are maintained in order to eliminate potential hot spots and cold spots to ensure that proper heat distribution is achieved.
- Electrical wiring and gas piping should never be placed above the flue discharge area.
- The use of a factory approved warning plaque (Part No. PLQ) is recommended to be hung from the heater. This plaque reiterates the importance of adhering to the minimum clearance to combustibles and is highly visible. This may avoid future problems such as stacking boxes beneath the heaters.

Figure 4.7 • DR Series High Intensity Application



Application of the DR Series

Even temperatures throughout this building are achieved by perimeter mounting units within the space. Heaters are concentrated along exposed walls and thermostatic control is zoned. Zoning is determined by general proximity of groups of units to a specific heat loss, such as overhead doors. Space usage considerations can also dictate zoning of thermostats. Units are not explosion-proof and are not to be placed in combustible areas such as the equipment storage area.

DR Series heaters operate unvented. For proper ventilation, a positive air displacement of 4 cfm/1000 BTU/h of natural gas (4.5 cfm/1000 BTU/h for propane) consumed must be provided. Air displacement may be accomplished by means of a power exhaust, gravity vents or natural infiltration. Is is preferable to use several small exhausters as opposed to one large one. Exhausters should be placed at high points in the roof where stagnant air accumulates. Adequate combustion air is achieved by using intake vents sized to 1 square inch of net free area/1000 BTU/h.

5.0 Sample Applications

Applications

The following pages provide sample infrared design layouts and descriptions for low intensity heater Series: HL3, DX3L, DET3, and DES3.

Application • Fire Station Apparatus Bays

Equipment Selection
Unvented high intensity infrared heaters have few applications in apparatus bays. Even though many apparatus bays have ample ceiling height to accommodate high intensity heaters, maintaining clearance to combustibles from the vehicles, fire hoses, ceiling tiles, etc., makes the use of high intensity heaters prohibitive.

Low intensity tube heaters offer many advantages in apparatus bays. First, maintaining clearance to combustibles is much easier. Also the low profile of tube heaters makes it easier for them to be installed out of the way of other equipment. In most applications, the burner control boxes are placed near the overhead doors delivering more heat in the greatest heat loss area. Tube heaters are placed on the perimeter of the building and, quite often, in between individual overhead doors. This is usually true in applications where there are more than three overhead doors. As in all applications, available mounting height will dictate each heater's BTU/h input. However, in apparatus bays, consideration of the normal location of parked vehicles will greatly influence heater placement. It is not recommended to install radiant tubes above the roof or body of trucks and vehicles.

Tube heaters offer additional design advantages such as being able to directly vent heaters through a side wall or roof, the capability of common venting two units together, and the ability to bring outside combustion air to each heater eliminating the detrimental effect of vehicle exhaust on equipment longevity.

Apparatus bays are ideal applications for the use of the HL3 Series, two-stage infrared tube heaters. When calculating the heat loss of such facilities, consideration must be given for achieving heat recovery quickly when temperatures are extremely cold outside and/or doors are opened and closed to accommodate in-going and out-going vehicles. Such consideration greatly increases the heat loss of the building. However, such conditions exist for only a small portion of the heating season (less than 10%). Therefore, sizing of units to match the heat load requirement with the high fire input results in the units running in low fire for 90% of the season. This results in additional fuel cost savings and a greater degree of comfort in the space. See Figures 5.1 and 5.2 for example layouts.

Installation

Generally speaking, there are three types of fire station applications. They are:

❶ **Single story**: Overhead doors on one side of building only. The burner control boxes need to be placed near the overhead doors where the greatest heat loss will occur. Outside combustion air can be drawn from the sidewall. This type of building usually is rather shallow in depth (40-60'). Single runs of 30' to 50' tube heaters are common. If evenness of temperature throughout the space is desirable, installing units with burner boxes opposed to each other is recommended. In such a shallow space, the use of two opposed twenty or thirty-foot heaters common venting in the center would achieve the goal. This type of facility is more likely to have multiple overhead doors (more than 3) necessitating the installation of heaters in between individual doors in addition to the units on the outside walls.

❷ **Single story**: Overhead doors on two walls (usually a pull-through arrangement where vehicles enter from one side and exit from the opposite side.). This type of building is normally narrower and a lot deeper than the above buildings. This type of building almost always necessitates the use of opposing burner control boxes with two units being common vented in the center. Keep in mind that units common vented together must be controlled by the same thermostat. Being a single story building venting can be done through the roof or sidewall.

❸ **Multiple story**: Low ceiling (overhead doors on one wall). This type of building is typical of apparatus bays located in older inner city areas. This facility typically has living quarters for the firefighters above the first floor. This type of facility is difficult to heat with infrared heaters because of the normally low ceiling height, the necessity of venting all heaters through the sidewalls, and the lack of available space for mounting the equipment. Originally, this type of apparatus bay was heated by steam heat. Some cities, in an effort to avoid the high cost of boiler replacement have looked to alternative heating systems such as low intensity infrared heaters. Low intensity infrared heaters are an available alternative as long as the basic installation requirements can be met.

Pull - Through Apparatus Bay

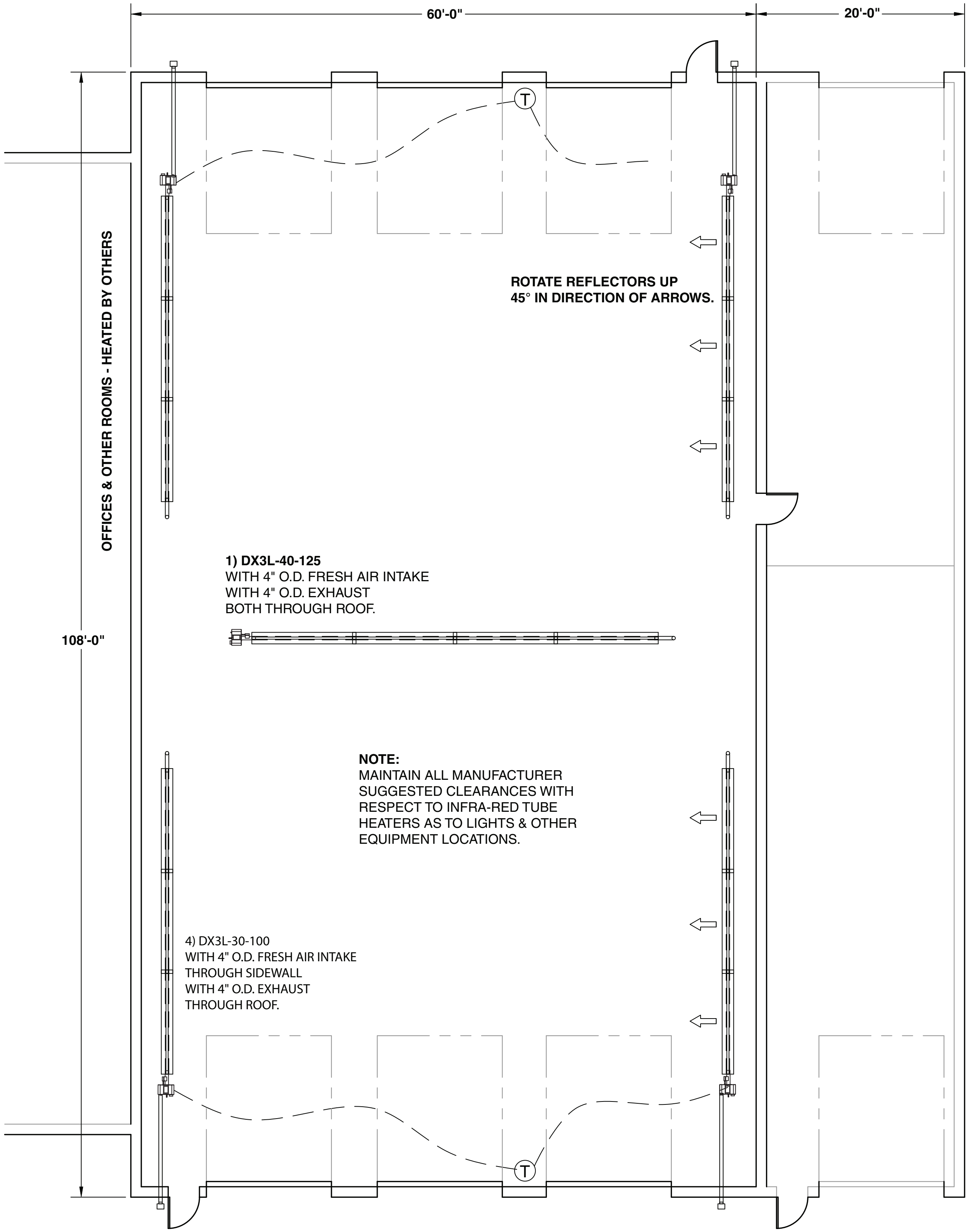
Placement of the burner boxes is near the overhead doors for the four perimeter heaters. This concentrates heat near the higher heat loss areas and makes the installation of outside combustion air ducts from the sidewalls easier. The perimeter heaters are out of the way of the vehicle traffic. Heaters used are short exchanger lengths – high BTU/h input (Ex. 30 ft. – 100,000 BTU/h) for high heat concentration at the doors. Evenness of heat distribution is assured by the addition of a 40 ft. – 125,000 BTU/h unit in the center of the bay. This is also a high activity area as firefighters perform maintenance on the trucks from this location.

Fire and Police Facility

Many municipalities combine their Fire and Police Departments into a single facility. This is an example of such a facility. Placement of low intensity tube heaters in the apparatus bay is similar to the previous example with heat being concentrated at the door areas. Due to the shorter length of this facility, the heaters in the apparatus bay are common vented through the roof. **NOTE:** the common vented units are on the same thermostat. This is required when two units are common vented together.

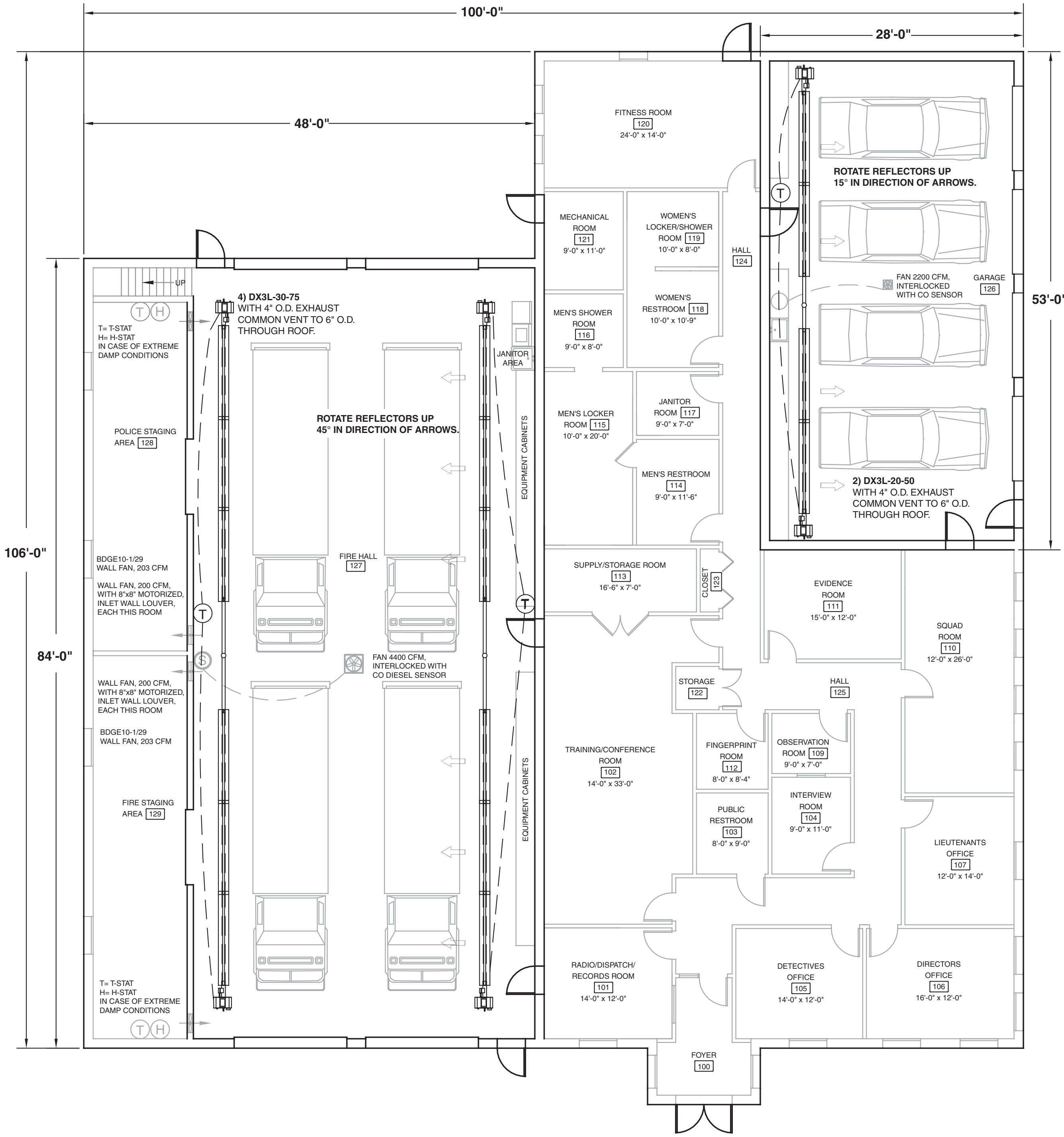
The police garage poses some unique problems in the application. Due to the small area in between overhead doors, heaters cannot be placed here. Therefore, heaters are placed at the rear of the garage with the reflectors angled at 15 degrees towards the center of the space. This provides comfort heat for the bench areas at the rear and to employees working on maintaining the vehicles. Again, the units are common vented and are therefore on the same thermostat.

Figure 5.1 • Pull - Through Apparatus Bay



SAMPLE APPLICATIONS

Figure 5.2 • Fire and Police Facility



Application • Aircraft Hangars

Equipment Selection
Due to high mounting heights in most aircraft hangars, most applications require the use of high BTU/h input high intensity infrared heaters or large BTU/h input low intensity tube heaters. When using high intensity infrared heaters, consideration of the higher clearance to combustibles and ventilation requirements must be kept in mind. High intensity heaters have significantly higher top and below clearances than an equivalent BTU/h rated low intensity tube heater. Ventilation requirements for high intensity heaters of 3.9 cfm for natural gas and 4.5 cfm for propane gas per 1000 BTU/h of input must be provided in the form of either mechanical exhaust or natural infiltration. When there is doubt as to the degree of natural infiltration in a particular hangar, provide mechanical exhaust fans to handle this ventilation. If necessary, air intake louvers must also be installed to provide combustion air to the heaters so a negative pressure is not created in the space when using mechanical exhausters.

Low intensity heaters provide advantages of being direct vented and having the capability of outside combustion air ducted directly to the heaters. Aircraft fuels and other chemicals used in the maintenance of aircraft necessitate the use of outside combustion air in most applications. Two-stage low intensity tube heaters offer additional fuel savings and increased comfort levels. A two-stage system offers the ability for quick heat recovery when overhead doors have been opened in high fire mode, and fuel savings and comfort when doors are closed with the heaters operating in low fire. See Figures 5.3 and 5.4 for example layouts.

Installation
As with all infrared heating applications, it is best to concentrate a higher percentage of the heating capacity near doors or other high heat loss areas. In aircraft hangars, this means concentrating heating capacity near the doors and placing internal heaters for even heat distribution. It is important to note that ANSI/NFPA 409 requires that both high and low intensity infrared heaters be installed at least 10 feet above the highest wing surface (normally the tail) of any aircraft stored in the facility.

Commercial Aircraft Hangar
Figure 5.3 on p. 30 is an example of a commercial airline maintenance hangar bay. This hangar has doors that open at both ends, creating a wind tunnel if both sets are open at the same time. To offset the higher heat load at the doors, ‘U’ shaped low intensity tube heaters are employed. Putting heaters into a ‘U’ configuration concentrates twice the number of BTU/h at the doors. A thermostat controls each pair of ‘U’ tubes allowing flexibility should the doors only be partially opened at a time. The interior straight low intensity tube heaters are spaced for evenness of heat distribution. **NOTE**: The burner control boxes are closest to the overhead doors for additional heat near those areas and opposing heaters are not common vented together. If common venting, the opposing heaters would need to be on the same thermostat. The customer wanted adjacent heaters tied together on the same thermostat. Though this resulted in more roof vent penetrations, it satisfied the customer’s system control desires.

Private Aircraft Hangar
Figure 5.4 on p. 31 is an example of two private aircraft hangars that house only one aircraft each. In this example, the heater is placed near the doors and away from the tallest section of the aircraft- namely the tail section. In both hangar examples, ample height is available to accommodate the heater and necessary clearances. This design allows for the installation of one unit instead of two. The chosen heater placement allows ample heat distribution near the door and heat coverage to the workbenches usually located at the sides of the hangar.

Figure 5.3 • Commercial Aircraft Hangar

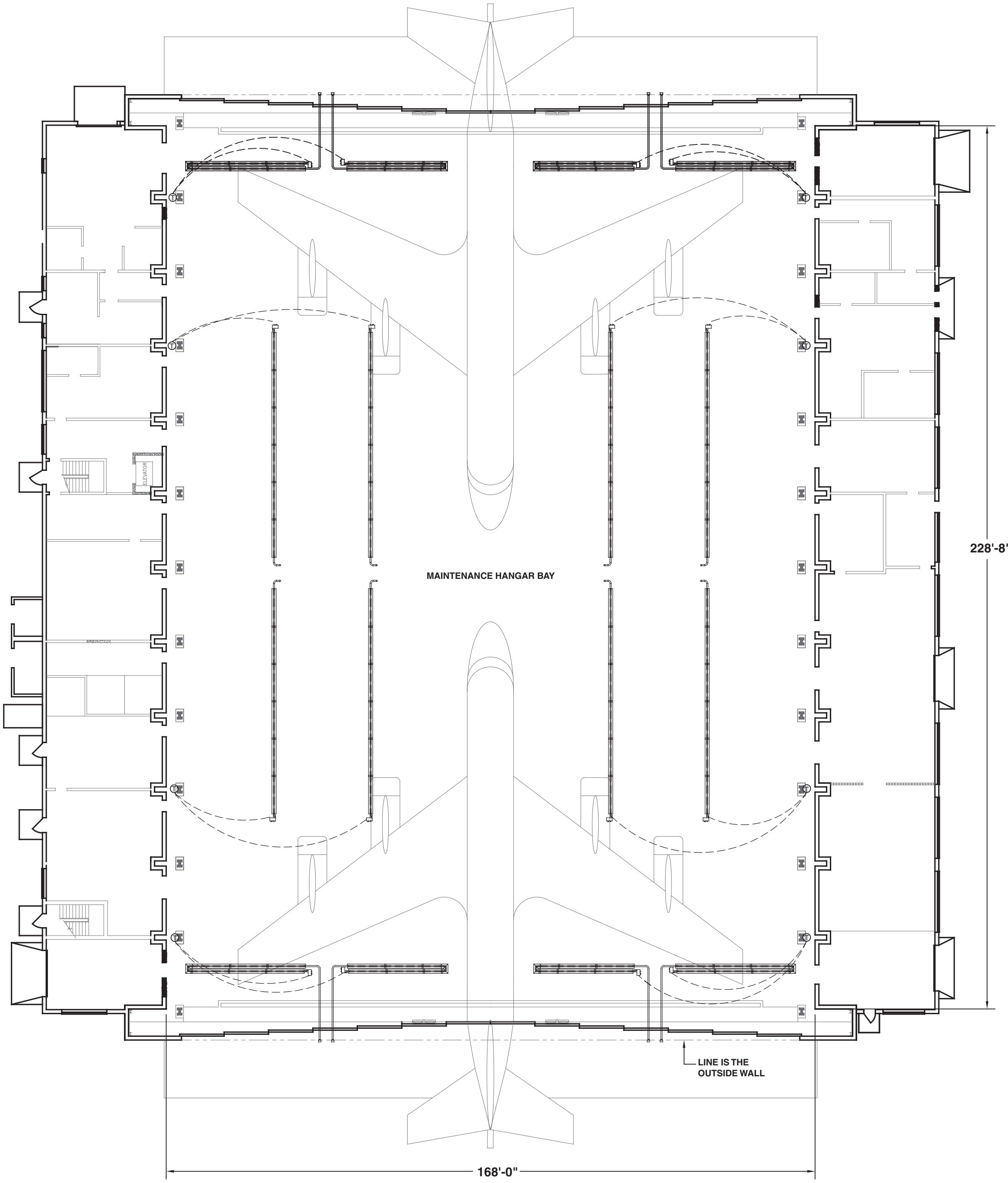
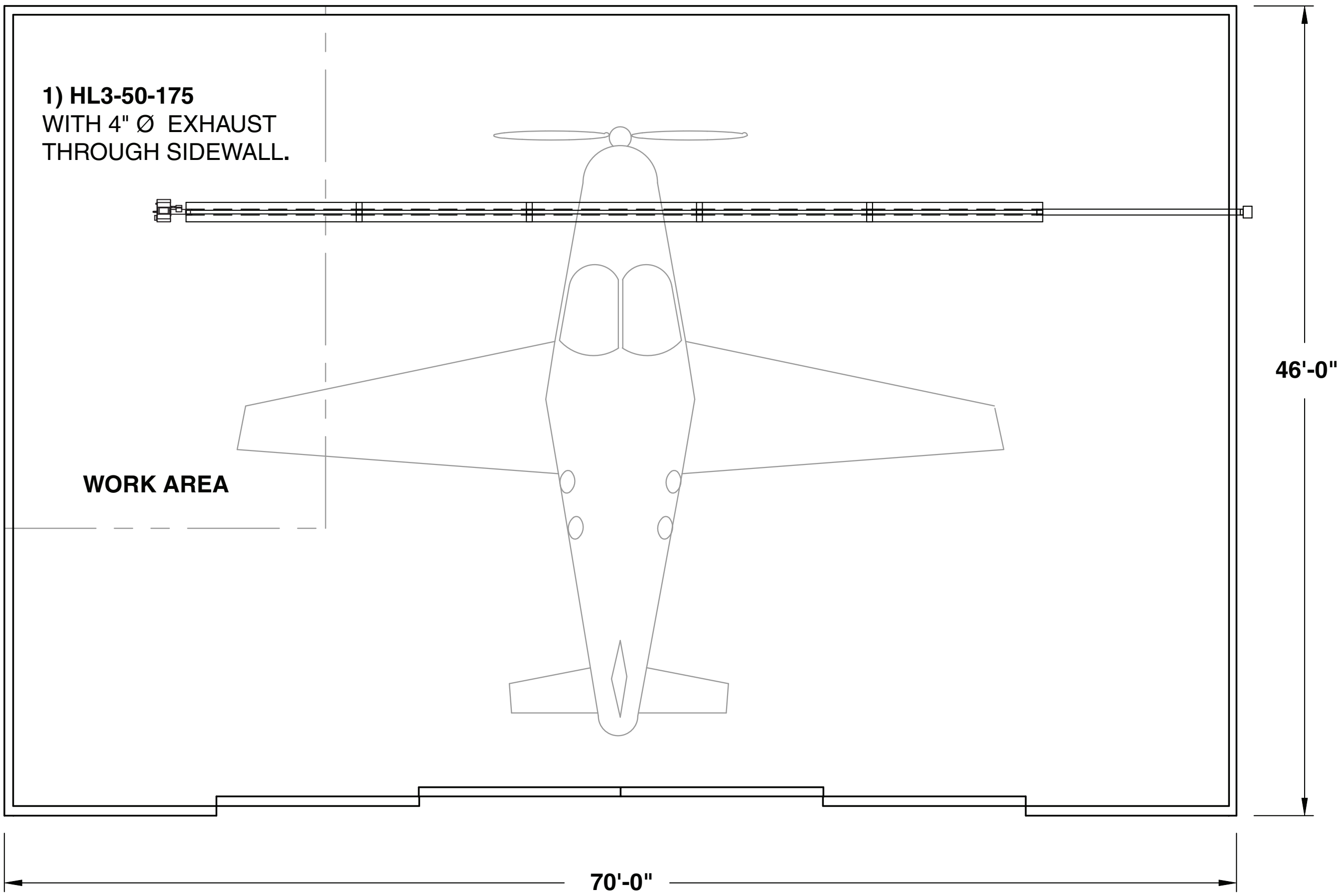


Figure 5.4 • Private Aircraft Hangar



Application • Car Wash

Equipment Selection

Car wash applications offer a variety of challenges. Most are designed for heat with the idea of freeze protection and spot heating of employees. Choose short length tube heaters with high BTU/h ratings. Small to midsize high intensity heaters are often placed at the ends of the tunnel for spot heating. Millivolt controls are sometimes chosen in equipment rooms (if shielded from the wind) for freeze protection during power outages. The options of stainless steel, silicone sealant, waterproof thermostats, and electrical attachments are recommended. Lastly, two-stage heaters will reduce fuel consumption when doors are closed, most often during the night. See Figures 5.5 thru 5.7 for sample layouts.

Installation

Most tunnel applications are designed with heaters on the cold wall and burners at both ends. Sometimes, tube heaters are on each on a wall opposite each other. Tunnel runs exceeding 50' typically require multiple heaters on a single wall, common vented in the center. Typical reflector mounting angle is between 15 and 30 degrees and side shields may be used if necessary. Observe all clearances to combustibles and shield car wash components where necessary. Heaters are typically vented through the sidewall and outside combustion air is required.

Car Wash - Automatic

Figure 5.5 on p. 33 is an example of many automatic car wash applications. Specifically, this layout represents many small automatic car washes such as the type utilized in gas station applications. In automatic washes, corrosive alkaline chemicals are typically utilized. In order to extend the life of the heaters in this type of application, stainless steel radiant tubes, stainless steel reflectors, and outside combustion air are recommended. **Note:** The burner boxes of the tube heaters in the tunnel area are installed at opposite ends from each other. Due to the inherent temperature differential along the length of each heater, placing of the burner boxes as shown ensures evenness of heat distribution throughout the tunnel area. The use of watertight thermostats are essential in wet environments.

A 30,000 BTU/h high intensity has been recommended for the equipment room, which is separate from the tunnel area. The NMV control system is a millivolt operated control that utilizes no external electrical power to operate. In the case of a power failure, the high intensity heater will provide freeze protection for the equipment.

Car Wash - Tunnel

Figure 5.6 on p. 34 is an example of an independent tunnel car wash in which pre-washing, washing, and drying areas are incorporated. Stainless steel tube heaters with outside combustion air are utilized, as should be the case in all car washes. The placement of the tube heaters is designed in this manner in order to optimize heat distribution in the tunnel area while keeping the tube temperature differential in mind.

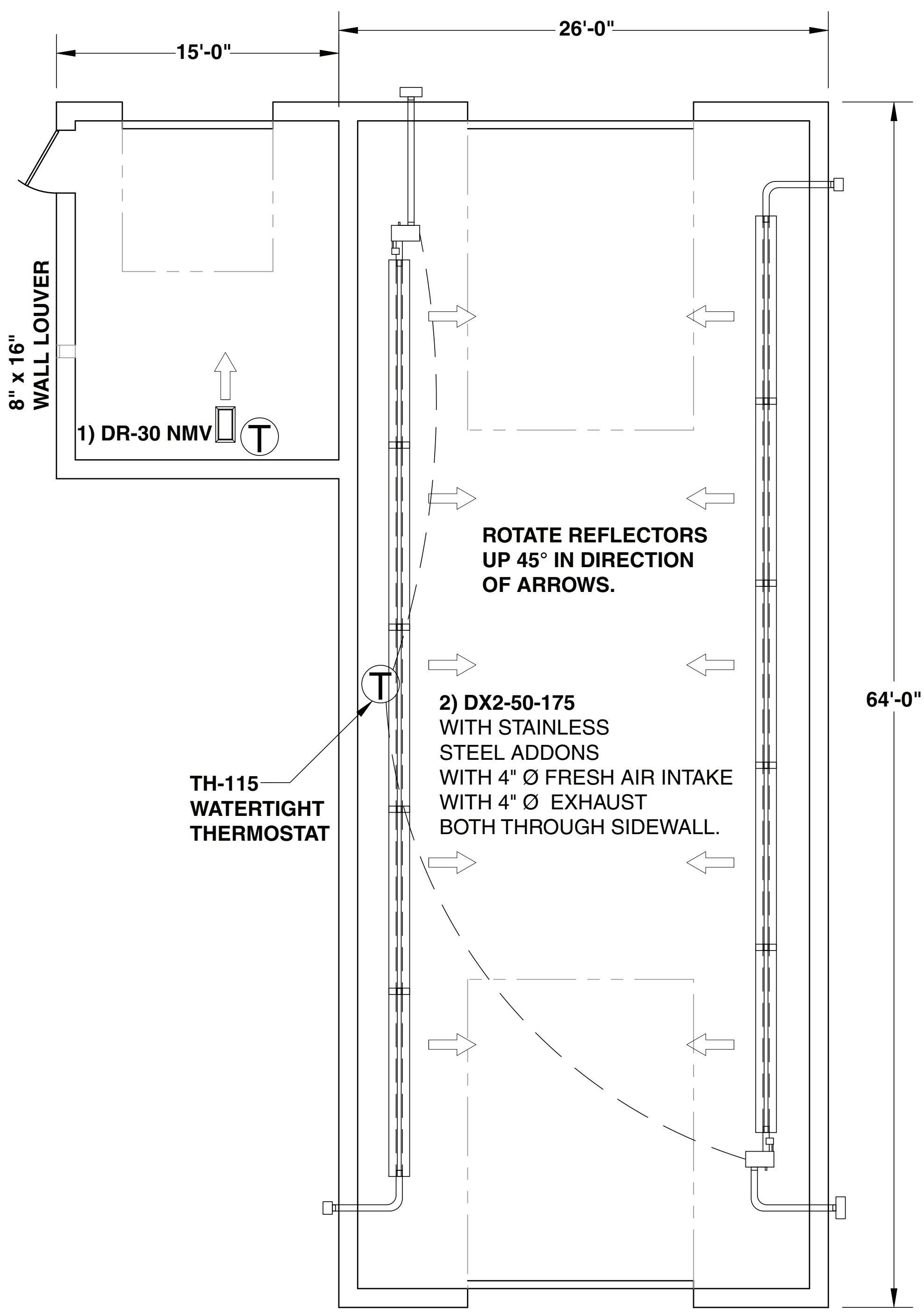
The entrance to the car wash, where pre-wash is performed by employees, has two 60,000 BTU/h heaters installed. These heaters are out of the direct spray area, but since they are housed in a high humidity area, direct spark ignition heaters with water-resistant solid state circuitry are incorporated. The intense heat from these heaters provides comforting spot heat for the employees while keeping ice from forming, thus eliminating the likelihood of slip and fall accidents.

Truck Wash

Figure 5.7 on p.35 is an example of a truck wash application. Truck washes typically use some very caustic chemicals, especially in applications in which livestock carriers are being washed. The use of outside combustion air and stainless steel options is even more important in this type of application. Also, due to the mass of the trucks and the cold mass heat loss they represent, a high concentration of heat is desirable.

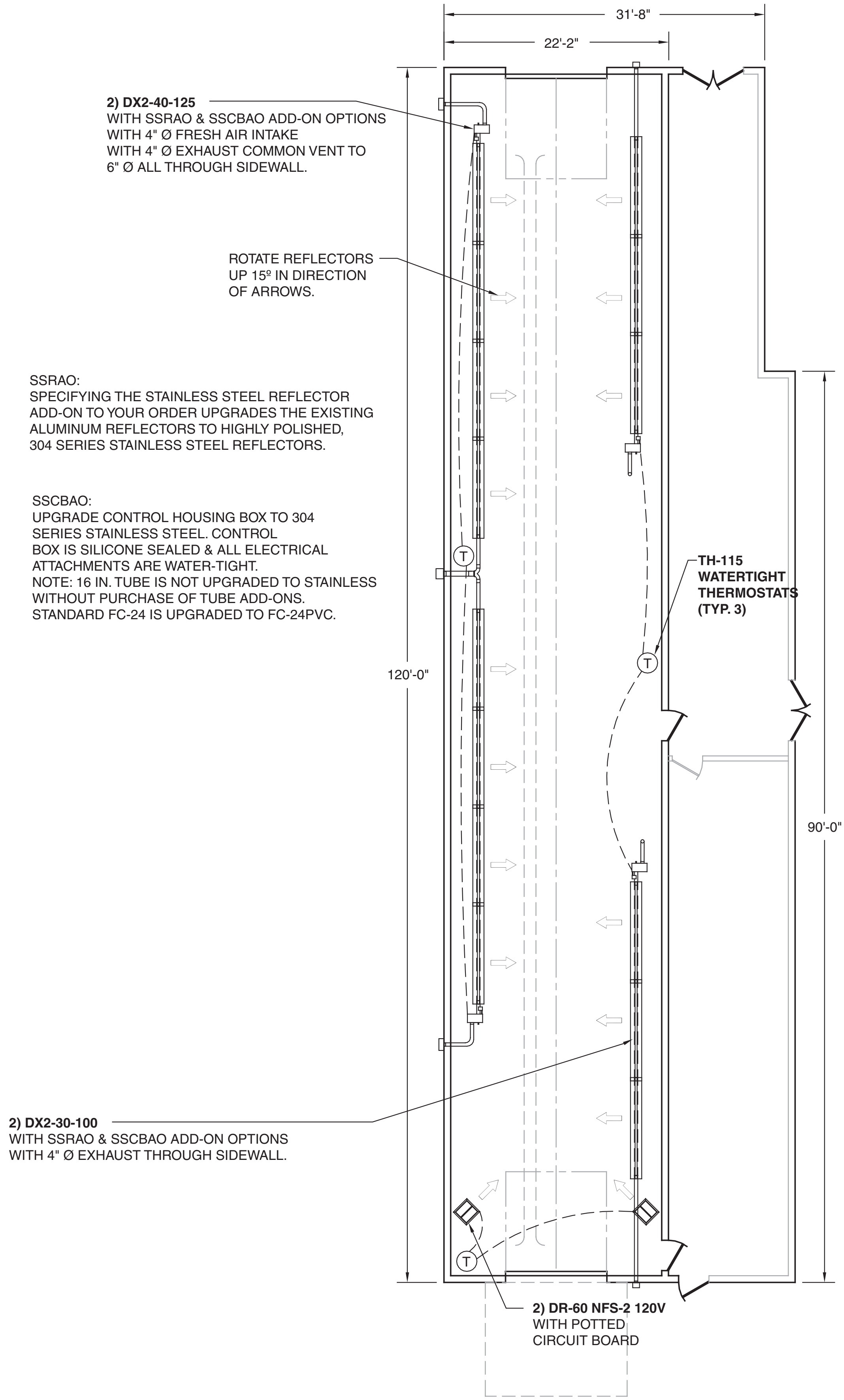
In this application, note the high BTU/h to square foot ratio, which is 150 BTU/h per square foot in the wash bay. Such a concentration of heat helps to offset the loss due to the trucks' presence and assists in keeping floors free from ice accumulation. A DR-30 millivolt heater is utilized in the equipment room for freeze protection in the event of a power failure.

Figure 5.5 • Car Wash



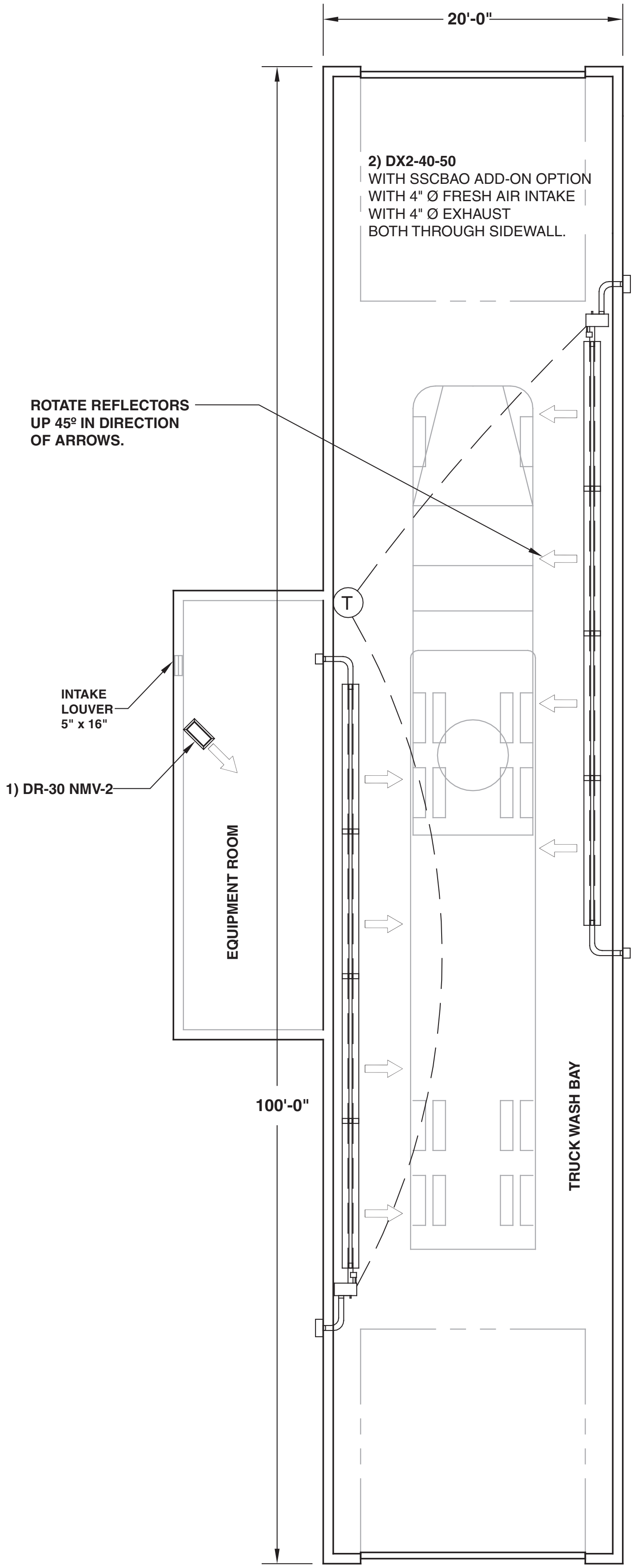
SAMPLE APPLICATIONS

Figure 5.6 • Car Wash



SAMPLE APPLICATIONS

Figure 5.7 • Truck Wash



Application • Body Shop

Equipment Selection

The use of infrared heaters in body shops provides several advantages over hot air systems such as unit heaters. Most shops are small in square footage with relation to the open door area. This results in large air changes when doors are opened and a need for quick heat recovery. Infrared heaters provide that quick recovery and, as a result, are far more fuel-efficient. They provide ample comfort without the large amount of air movement associated with unit heaters. Infrared heaters also provide directed heat to crucial areas while offsetting the heat loss of the building in general.

High intensity infrared heaters have been used in body shops but are often not the most effective equipment. High intensity heaters draw their combustion air from the surrounding space. Therefore, any air contaminants within the space (particle and/or chemical) will be drawn directly into the units. This can shorten their overall life expectancy and result in higher maintenance costs. High clearance to combustibles and factory recommended mounting heights may place limitations on model BTU/h selection to 90,000 BTU/h or less.

In most cases, low intensity tube heaters are the best option. Since they are direct vented, low intensity tube heaters do not exacerbate any air quality problem that may already exist. The use of outside combustion air is required and is one of the primary advantages of using low intensity heaters in body shops. The heaters draw their combustion air from outside the space so they are not affected by any airborne contaminants that may be present. Most body shops have relatively low ceilings of 15' or less. These mounting heights are more applicable to low intensity heaters in which units of 75,000 to 150,000 BTU/h rating are commonly used. Due to the need for quick heat recovery after overhead doors have been opened, HL3 Series two-stage infrared tube heaters are ideal for these applications. Recovery is quickly achieved by the heater's high fire mode; comfort and fuel savings are realized by low fire mode operation for those times when doors are closed or the shop is closed. See Figures 5.8 and 5.9 for example layouts.

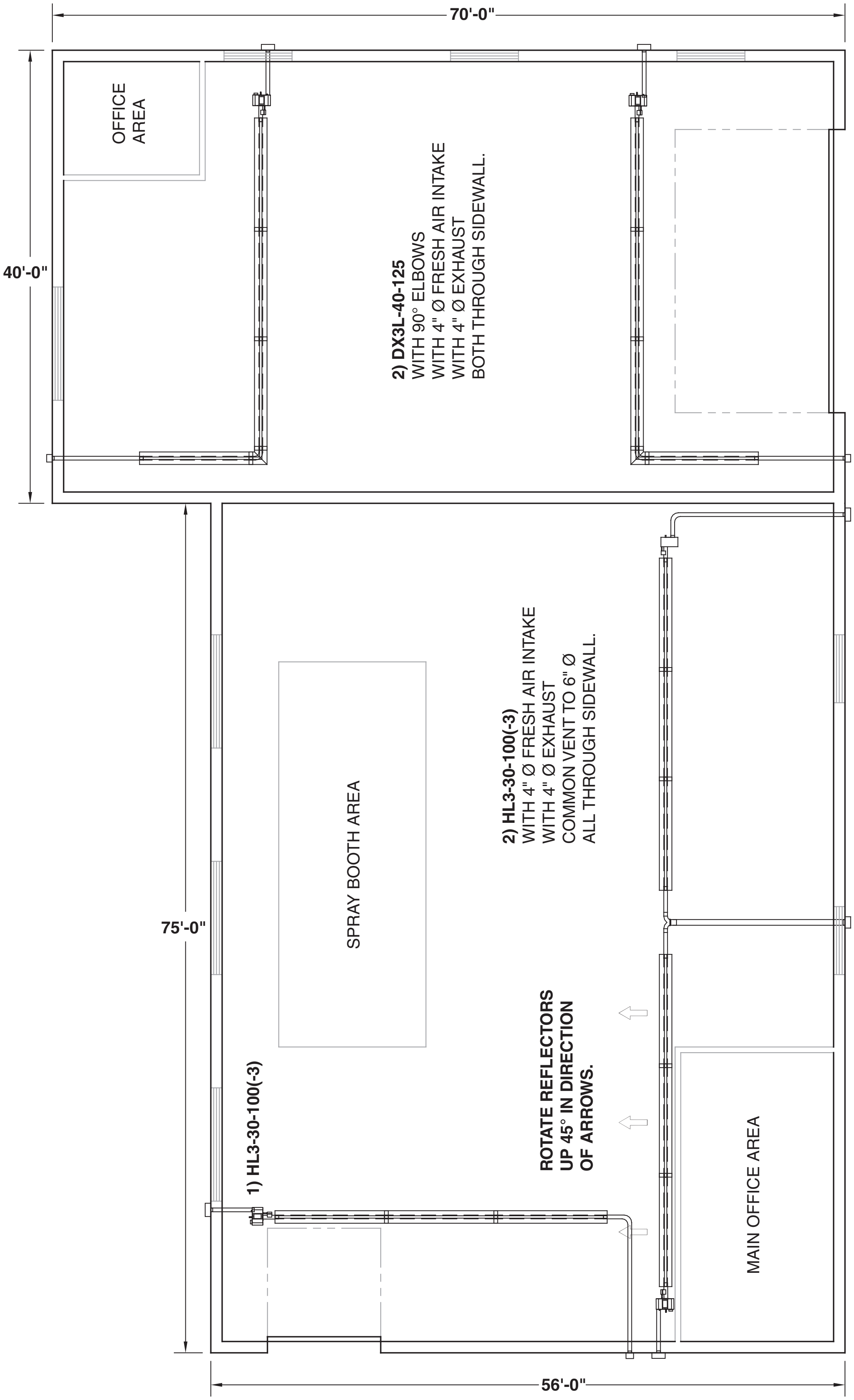
Body Shop

Figure 5.8 on p. 37 is an example of a body shop layout. This layout follows the basic principle of placing the heaters around the perimeter with particular attention to door areas where the greatest heat loss occurs. Outside combustion air is utilized and outside air and venting is accomplished through the sidewall. In no case should a heater ever be placed in a paint booth. Low intensity tube heaters are not explosion proof and are not safe to use within the paint booth itself.

Body Shop – Retrofit

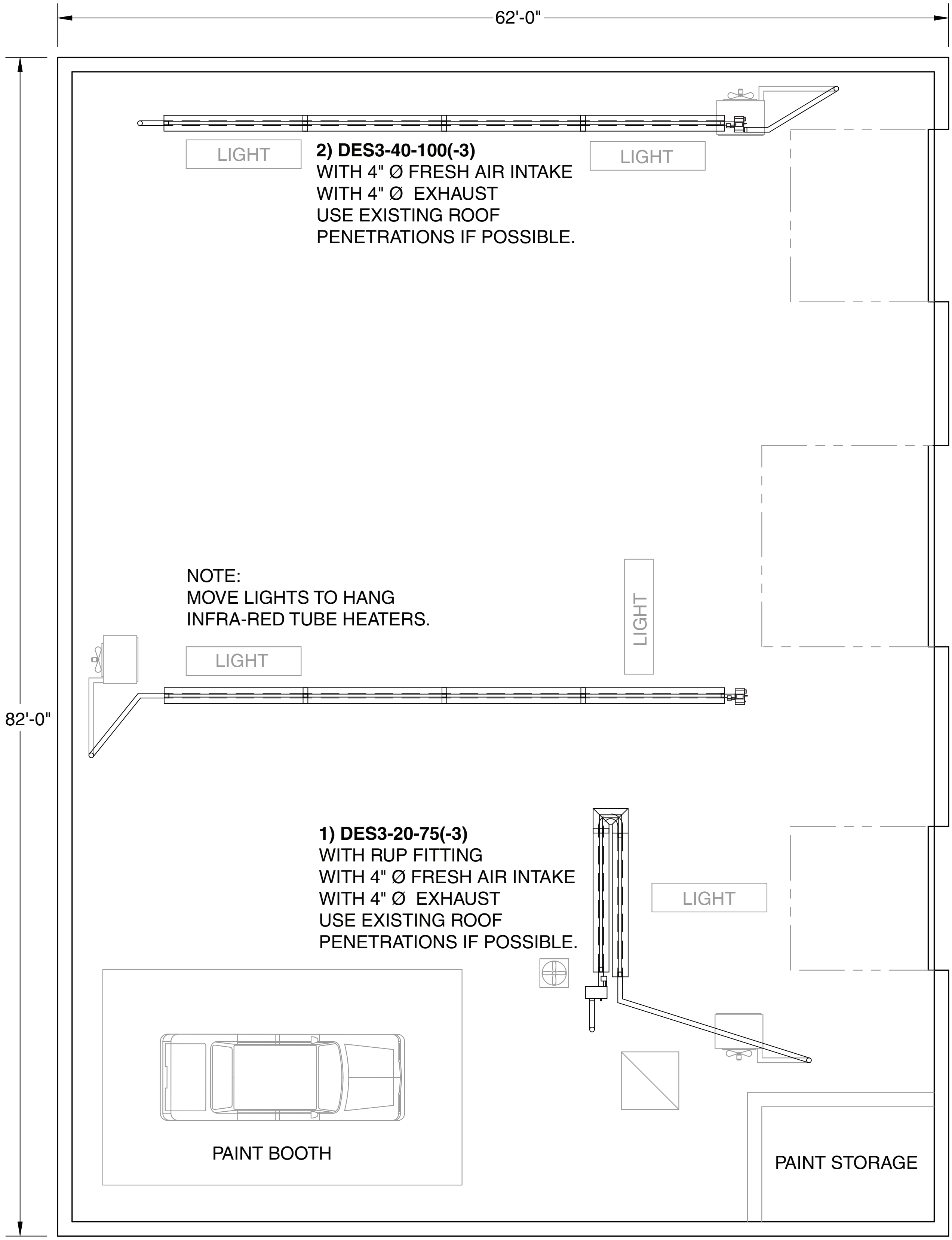
Figure 5.9 on p. 38 is an example of a retrofit layout in which older unit heaters are being replaced with low intensity tube heaters. In order to simplify the installation and utilize existing roof penetrations, the existing vents from the unit heaters are being reused to vent and bring combustion air to the tube heaters.

Figure 5.8 • Body Shop



SAMPLE APPLICATIONS

Figure 5.9 • Body Shop - Retrofit



Application • Vehicle Maintenance Facility

Equipment Selection
With a large percentage of door area to square footage of space and the introduction of large amounts of cold mass (vehicles, trucks, etc.) into the space on a continuous basis, heat demand varies greatly from one part of the day to another. By directly heating the floor and objects in the space, infrared heaters create a heat sink in the floor and objects which greatly assists heat recovery, keeps the space comfortable for employees, and provides a fuel efficient heating system.

High intensity infrared heaters are used in vehicle maintenance facilities that have the ceiling height to accommodate them and where clearance to combustibles can be maintained. Units of 100,000 BTU/h or less are normally utilized. Placement of heaters is most often between overhead doors. The heaters are angle mounted to direct the infrared rays to the interior of the space.

The preferred low intensity tube heater system is HL3 Series, two stage infrared tube heaters. Two stage heaters are sized so that the high fire mode will match the heat loss. When overhead doors have been opened and/or trucks and vehicles pulled into the space, the high fire mode has been sized to quickly recover. For long periods of time when the facility is closed or doors have been closed, the low fire mode will economically keep the space comfortable.

The choice of heater type depends on the physical size of the building and available space for suspending the heaters. Shallow facilities will have heaters placed opposite from the overhead doors with the reflectors angled to the interior. Deeper facilities will have heaters placed in between overhead doors with burner control boxes placed nearest the doors. In drive through facilities, pairs of heaters will be placed opposing each other and are common vented in the center of the space through the sidewall or roof. The use of outside combustion air is usually recommended. Such facilities utilize chemicals for parts washers and engine cleaners that can be detrimental to the heaters if those chemical vapors are drawn into the heater. Also, keep in mind that salt trucks, even though they may be empty, often come into the facility wet with salt water which can be corrosive. See Figures 5.10 thru 5.12 for example layouts.

Vehicle Maintenance Facility
Figure 5.10 on p. 40 is a sample vehicle maintenance facility layout. In this example, there are two facilities. One is 100’ deep and is a drive through facility and the other is a narrow 43’ facility with doors on one of the 126’ walls. In the drive through facility, units are evenly spaced for heat distribution and two common vented units are used for each run. Such a layout offers evenness of heat distribution and concentrates the burner control boxes near the overhead doors. Each pair of heaters is controlled by its own thermostat and outside combustion air is utilized.

In the narrow facility, the heaters are placed along the 126’ wall opposite of the doors. The reflectors are angled inward. The 50’, 150,000 BTU/h units will deliver heat across the width of the narrow facility. Outside combustion air is recommended.

Drive-Through Vehicle Maintenance Facility
Figure 5.11 on p. 41 is an example of a drive though facility of medium width (approximately 60’). Due to customer preference, the burner control boxes have been located along the top wall only. Employees and workbenches are located nearer this top wall and the doors opposite are used strictly for exiting vehicles. Each heater is controlled individually allowing optimum control flexibility. If a bay is not in use, the heater can be turned off. Note that in the second to last bay from the right, stainless steel constructed heaters and watertight thermostats have been recommended. Since this bay is used for washing vehicles, it was recommended that the customer utilize these upgrades to the standard equipment.

Bus Garage

Figure 5.12 on p.42 is an example of a bus garage layout. The municipality that owns this bus garage wished to reuse the existing unit heater vents when replacing worn out unit heaters with HL3 Series two stage infrared tube heaters. The units are placed into a 'L' configuration with the addition of an E6 – 90° elbow installed after the first 30 feet of radiant pipe. This makes utilization of the unit heater vents easier and provides heat for the workbenches located at the rear of the facility. There are only two brief periods each work day in which buses are brought into or taken from the facility. The decision was made to use HL3 Series two stage infrared tube heaters to take advantage of the quick recovery in high fire and the fuel savings of long periods of low fire operation.

Figure 5.10 • Vehicle Maintenance Facility

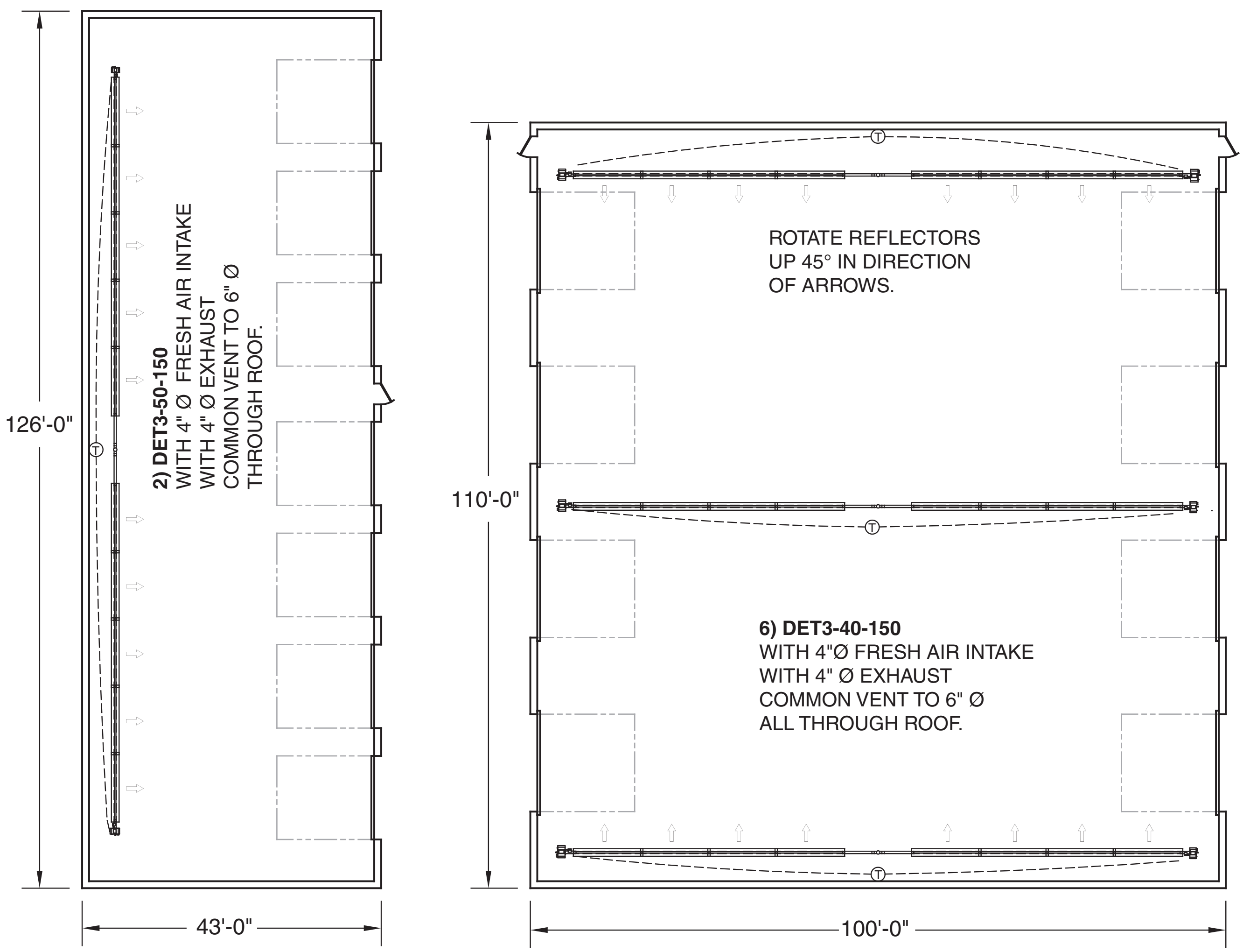
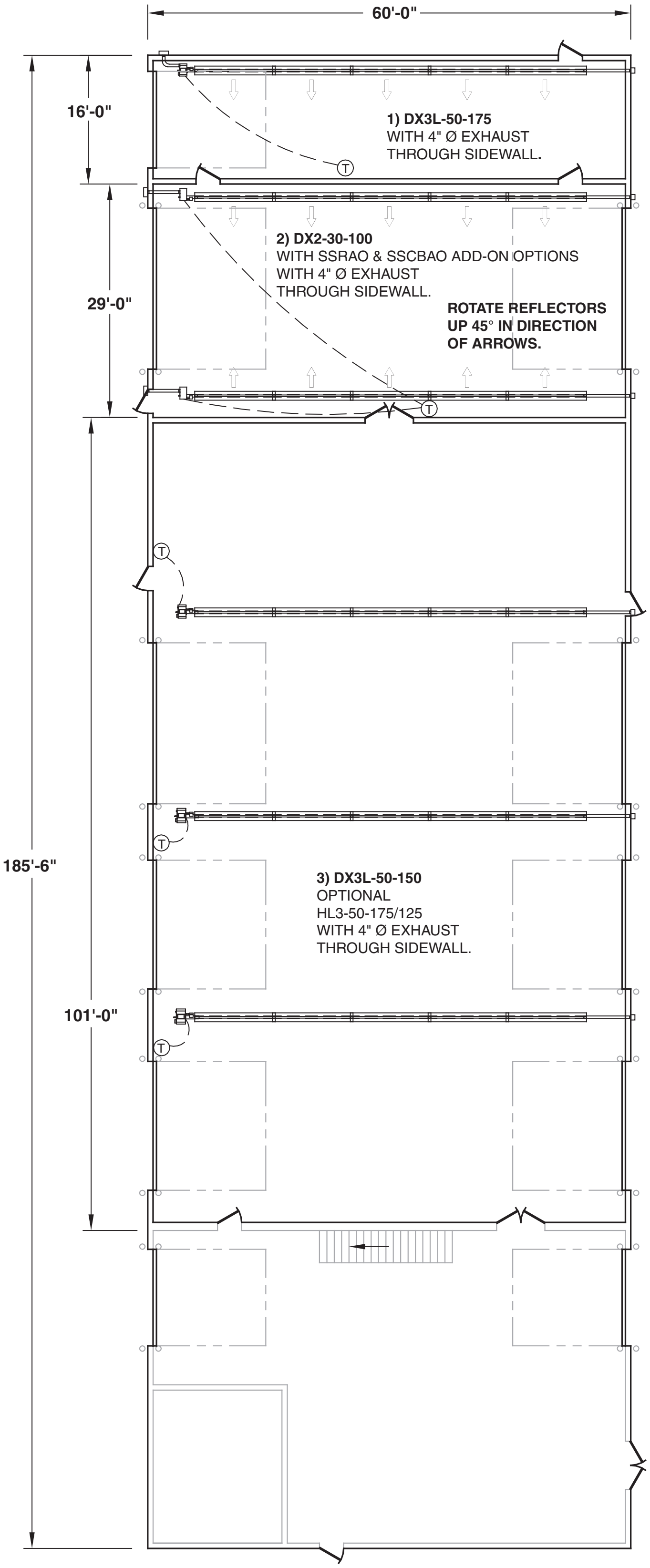


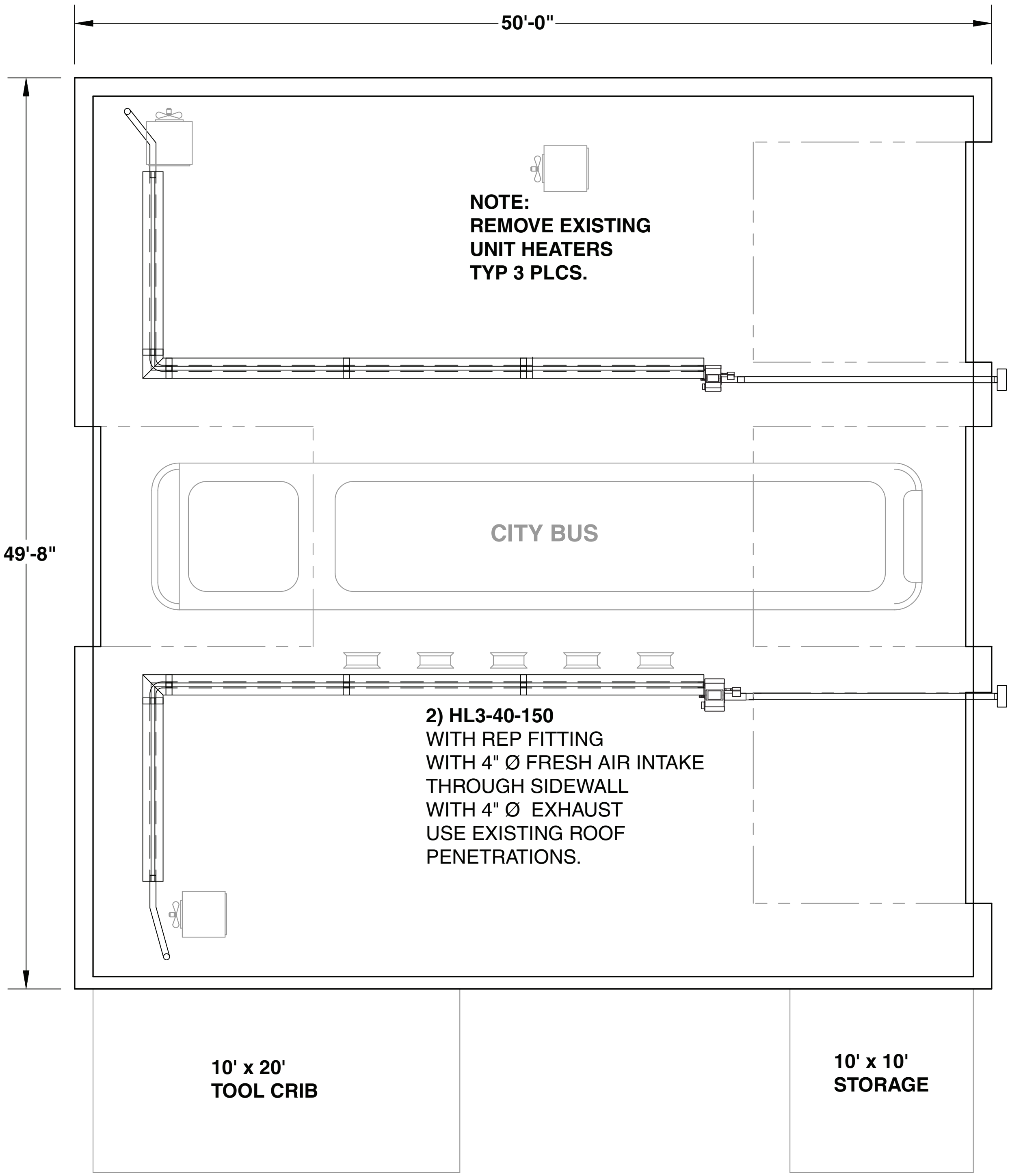
Figure 5.11 • Drive - Through Vehicle Maintenance Facility



SSRAO:
SPECIFYING THE STAINLESS STEEL REFLECTOR ADD-ON TO YOUR ORDER UPGRADES THE EXISTING ALUMINUM REFLECTORS TO HIGHLY POLISHED, 304 SERIES STAINLESS STEEL REFLECTORS.

SSCBAO:
UPGRADE CONTROL HOUSING BOX TO 304 SERIES STAINLESS STEEL. CONTROL BOX IS SILICONE SEALED & ALL ELECTRICAL ATTACHMENTS ARE WATER-TIGHT.
NOTE: 16 IN. TUBE IS NOT UPGRADED TO STAINLESS WITHOUT PURCHASE OF TUBE ADD-ONS.
STANDARD FC-24 IS UPGRADED TO FC-24PVC.

Figure 5.12 • Bus Garage



Application • Auto Service Garages

Equipment Selection

Most auto service garages are similar to vehicle maintenance facilities in that they have a large percentage of open door area in relation to overall square footage and a large number of cold vehicles being brought into the space. Therefore, many of the same recommendations for equipment selection and placement apply to an auto service garage.

However, some auto service garages are set up differently than other types of maintenance garages. An example is an auto dealership garage. A large number of auto dealership garages have a single, shared entrance and exit door while others have one entrance door and one exit door. The ratio of open door to square footage of floor space is less which, in most cases, results in a lower heat loss and a need for fewer BTU/h per sq. ft. in comparison.

Most auto service garages have vehicle lifts that must be taken into consideration as vehicles raised on the lifts may be damaged by infrared heaters placed in close proximity. It is important to maintain minimum clearance to combustibles from any vehicle on the floor or on a lift. Also, care must be taken to maintain clearances from hose reels, exhaust collection systems, etc.

The preferred layout in these facilities is a perimeter style. High intensity heaters are angled inward at a 20° to 35° angle. Low intensity infrared tube heaters mounted on the perimeter will often have their reflectors angled up at a 45° angle inward. The presence of vehicle lifts sometimes forces the placement of heaters down center aisles with reflectors angled toward the bay area.

Since most auto service garages employ the use of degreasers, parts washers, rust-proofing, etc., the use of low intensity infrared tube heaters with outside combustion air supplied to each heater is recommended. Chemical contaminants need to be ventilated from the space mechanically even if tube heaters with outside air are utilized. Such fumes striking the surface of the hot radiant tube or heated at floor level can cause a chemical reaction resulting in offensive odors being present in the space. Most chemical fumes of this type are heavier than air and ventilation of the lower level of the building is recommended. See Figures 5.13 thru 5.16 for example layouts.

Small Auto Service Garage

Figure 5.13 on p. 45 is representative of many small auto service garage applications. The overhead doors and vehicle lifts prevent the placement of heaters near the overhead doors. The location of the lube reels prevents the placement of a heater in between the overhead doors. A solution to this lack of space is to place one heater over the workbench area at the rear of the shop, angled up to 45° inward. A second heater is placed along either of the sidewalls with the heater angled inward. The placement of a heater along the unobstructed sidewall is preferable to along the wall with the stairs to the pit area. The customer prefers the heaters to be controlled individually so if one bay is not in use, that heater can be turned off.

Auto Dealership Garage

Figure 5.14 on p. 45 is an example of a large auto dealership service garage layout. Note that there is one shared entrance/exit door. This layout is also a perfect example of the theoretical application of infrared heaters since there are no obstructions in the space (vehicle lifts, etc.). The majority of the heaters (14 of 17 total units) are placed along the perimeter of the building. Since there was no customer concern regarding the number of roof penetrations, the perimeter heaters run with alternating burner box locations. This creates a more even heat pattern but does result in more roof penetration since each unit is individually roof vented.

Retail Tire Facility

Figure 5.15 on p. 47 is an example of many retail tire facility applications. Tire storage racks and overhead doors force the placement of heaters in the center of the space. Though this is not the ideal way of heating such a facility, the angling of the heaters ensures that the racks are protected from the heat yet the employees are kept warm. The heaters are placed in a "U" configuration to concentrate the heat pattern. This particular store has ample mounting height available to accommodate the 200,000 BTU/h units.

Multiple Door Service Center

Figure 5.16 on p. 48 is an example of a service facility with multiple doors. This forces the placement of the heaters away from the perimeter. Since the doors are on opposite walls, the heaters must be mounted in the center of the space angled toward the exterior. The single heater, single thermostat arrangement of the two heaters on the left side and the two right side heaters are placed on one thermostat. This was a customer preference as the bays on the right hand side are almost in constant use while the bays on the left are seldom used. The wash bay area uses a single 'U' shaped tube heater to concentrate heat. The use of stainless steel upgrade options on heaters in the wash bay areas is highly recommended but was not specified on this particular project. The narrower building with doors on one side makes it possible to place heaters opposite the doors and angle them toward the interior. Because there is a wall in between the two heater locations, each heater is controlled by its own thermostat.

Figure 5.13 • Small Auto Service Garage

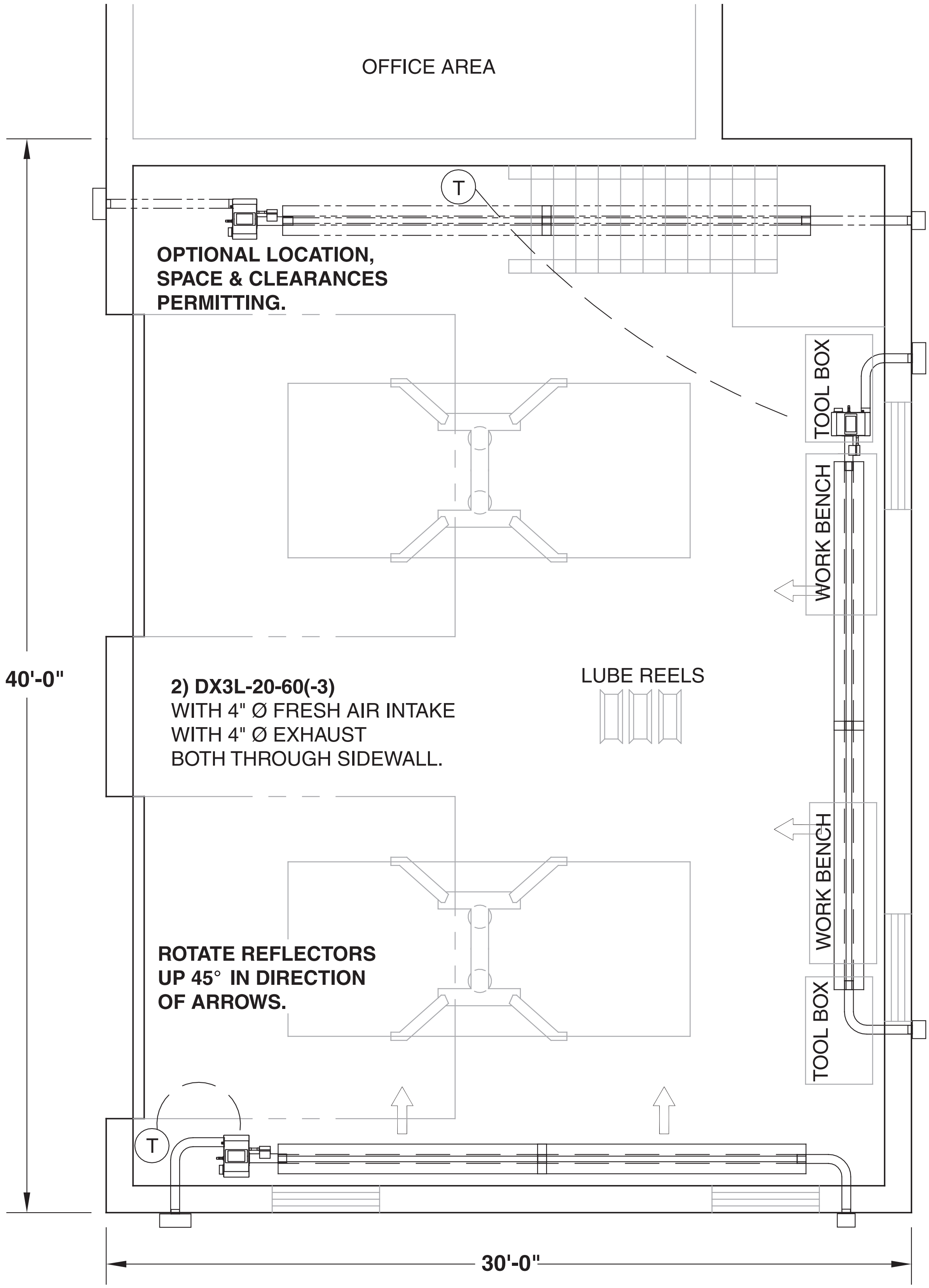


Figure 5.14 • Auto Dealership Garage

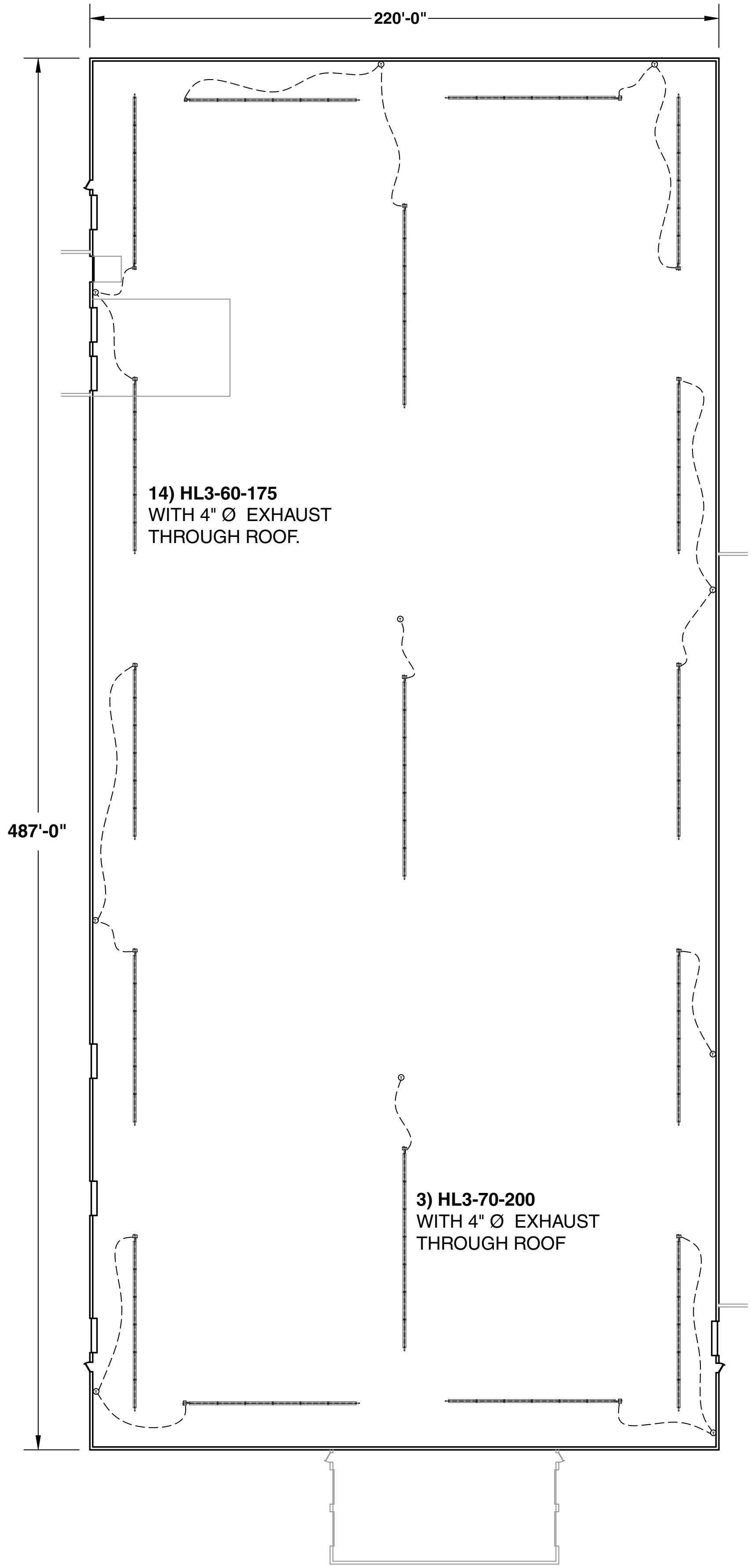


Figure 5.15 • Retail Tire Facility

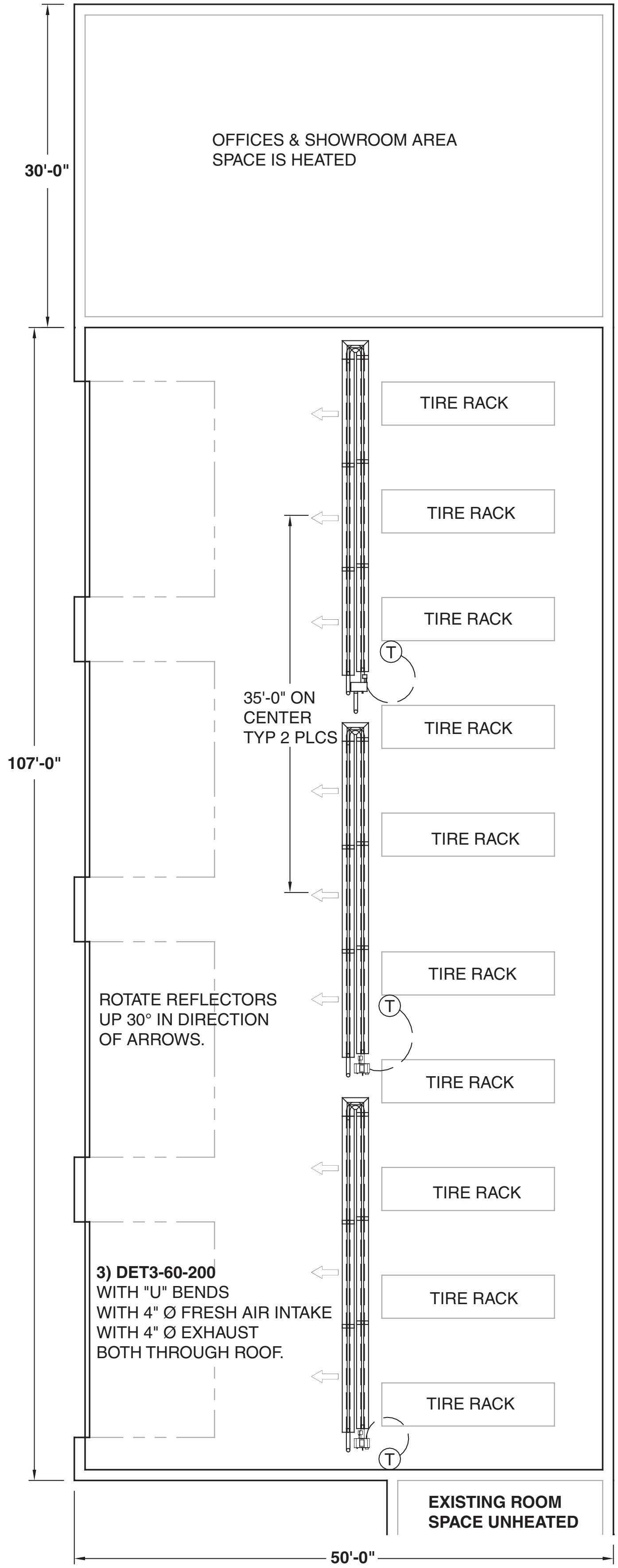
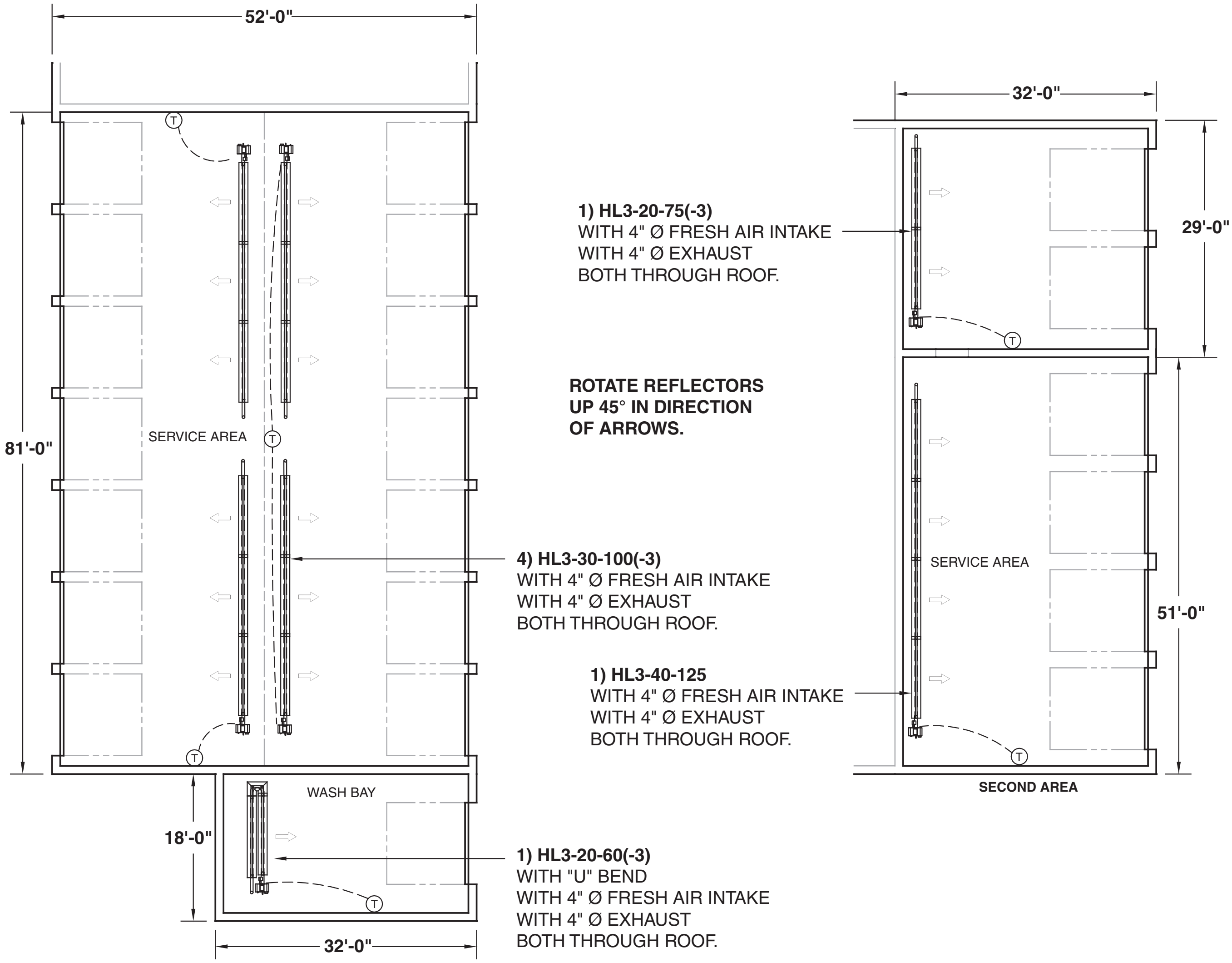


Figure 5.16 • Multiple Door Service Center



SAMPLE APPLICATIONS

Application • Pole Barns

Equipment Selection

Infrared heaters are very well suited for use in a pole barn application. Most customers desire a system that will quickly heat up their workshop without having to heat the building all of the time. Besides quick start up, most customers only wish to heat the facility to a semi-comfortable temperature (50° to 60°) while concentrating the heat in the areas they usually occupy, such as work bench areas. Infrared heaters easily accomplish these goals.

High intensity infrared heaters are limited in their use in this type of application due to the usually low ceiling height. Typically, these buildings have 12 to 14 foot ceilings. Even though smaller high intensity heaters are applicable (30 to 45,000 BTU/h), they do not deliver enough heat resulting in the use of additional heaters. Ventilation is also a concern as most customers are hesitant to invest in the added cost of exhausters in the installation.

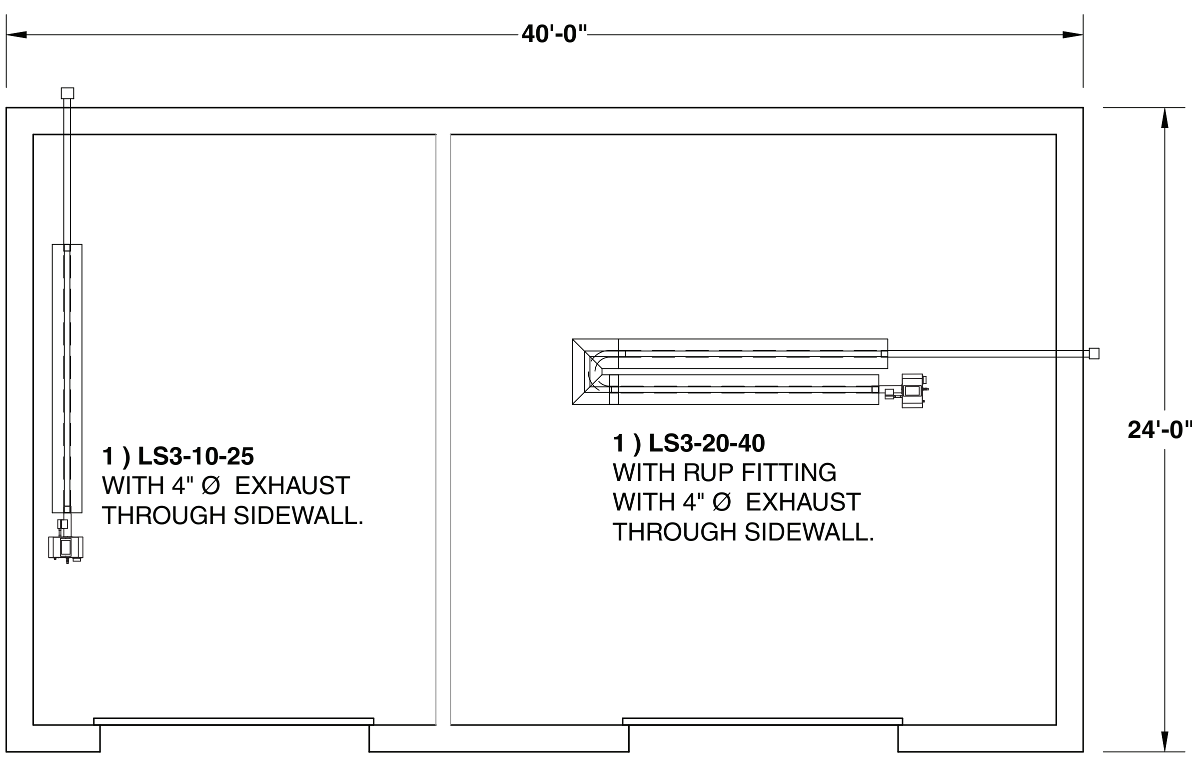
Most commonly, low intensity infrared tube heaters are utilized in pole barn applications. Ceiling height and building size are the determining factors for sizing units. Due to their relatively small size and low ceiling heights, inputs of 75,000 BTU/h or lower are most common in these types of layouts. Outside combustion air is a good recommendation in cases where the use of the building is mainly for the maintenance of vehicles and farm equipment. See Figure 5.17 for an example layout.

Pole Barn

Figure 5.17 on p. 49 is an example of a pole barn application. This pole barn has two functions and is, therefore, divided into two areas. The smaller area on the left is where vehicles and farm equipment are maintained. Due to the height of some of this machinery, the heater is installed on the outside wall. An LS3-10-25N model is used due to the size of this room and the low ceiling height. The larger room to the right is a workshop where vehicles are not commonly located. The customer performs most of his work in this room near the center and wished the heater placed there. A 40,000 BTU/h unit is installed in this room in a “U” configuration since the size of the room does not easily accommodate a 20 foot long heater.

SAMPLE APPLICATIONS

Figure 5.17 • Pole Barn



Application • Dog Kennels

Equipment Selection

Infrared heaters are used in dog kennels primarily for three reasons. First, infrared heaters offer the best in fuel economy. These heaters are minimally 25% more fuel efficient than hot air heaters. Second, unlike hot air heaters infrared heaters do not create drafts which can be a health concern for dogs. Last, and arguably most important, infrared heaters keep the floors dry. Because infrared heaters heat the floor directly, the higher floor temperature quickly evaporates any moisture. While occupied, the kennels are kept dry, lowering bacteria levels and improving the dogs' environment. When the kennels are emptied and washed down, the floors are quickly dried. Dogs can be returned to the area more quickly and the potential for slip and fall accidents is reduced.

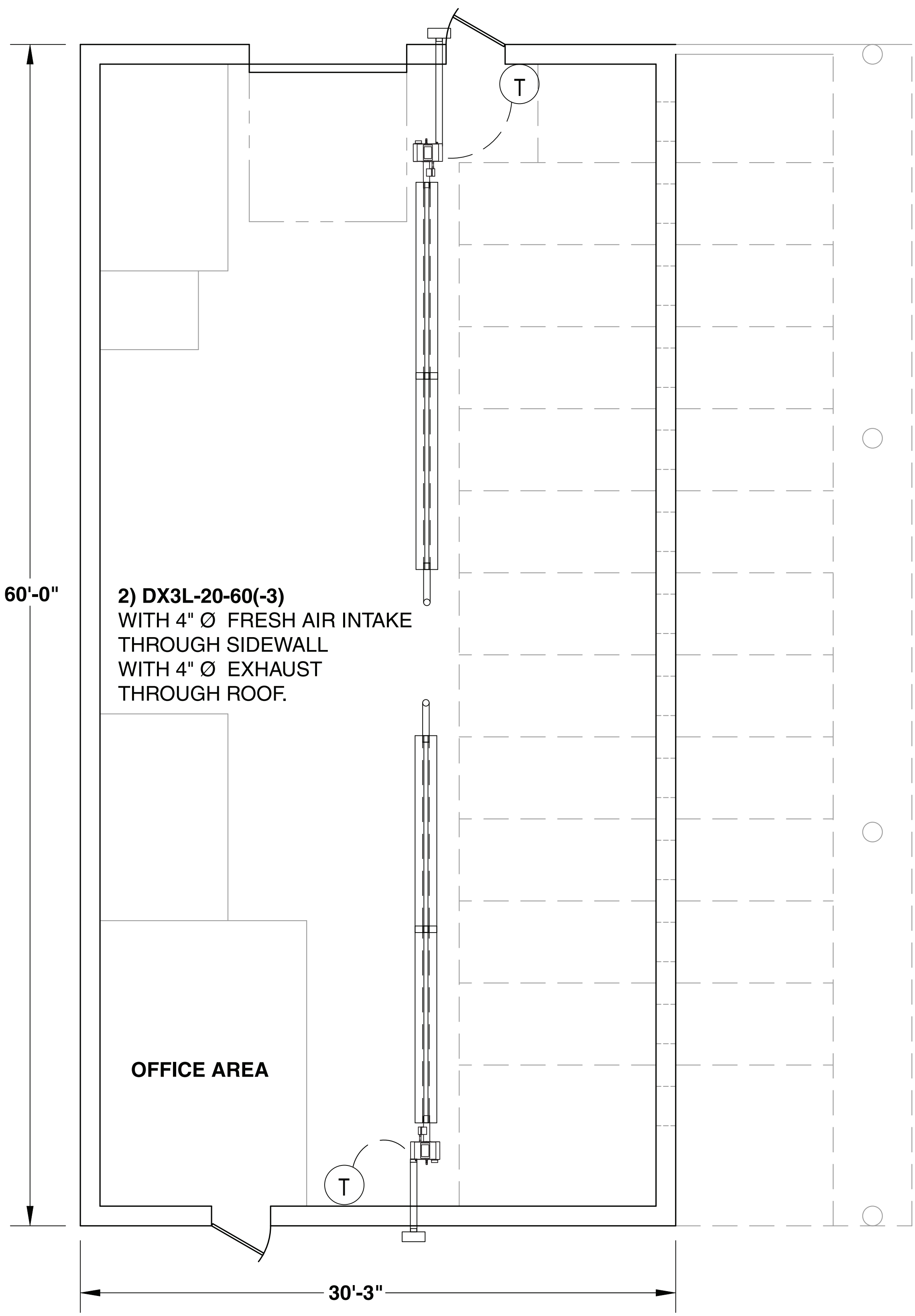
Low intensity infrared heaters are used almost exclusively in this type of application. Ceiling heights are usually low and heat distribution is more easily obtained with low intensity infrared tube heaters. The use of tube heaters also makes wash downs easier as water spray will not harm the equipment. Another reason for using tube heaters is that the use of outside combustion air is a necessity in this application. Ammonia fumes drawn into heating equipment can greatly shorten the equipment's longevity. Using outside combustion air eliminates this concern.

HL3 Series two stage infrared tube heaters are recommended in dog kennel applications. Not only are they more fuel efficient, but depending on the building's location, two-stage heaters will operate in the low fire mode for over 90% of the time. In this mode, there will be less cycling of the heaters (at least 35% less). Heaters will operate in low fire mode for long cycles creating a blanket comfort zone for the animals. See Figure 5.18 for an example layout.

Commercial Dog Kennel

Figure 5.18 on p. 51 is an example of a dog kennel application. This particular kennel has both interior and exterior kennel areas. The animals are allowed to freely pass from the interior to the outside via small exit doors. The use of two short 20' heaters is preferable to one 30 or 40 ft. heater. The two heaters will create a more even heat distribution. Placement of the heaters near the front of the kennel has two advantages. First, the animals will sleep near the front of the kennel because the intensity of heat is greater there. This also makes it easier for the caregivers to check on the animals. Second, dunging will take place towards the rear of the interior kennel or outdoors, as dogs typically will not soil their sleeping area. This provides for a cleaner environment for the dogs and makes wash downs easier.

Figure 5.18 • **Commercial Dog Kennel**



Application • Residential Garage/Woodworking Shops

Equipment Selection
The use of infrared heating in residential garages is a relatively new application. The LS3 and LD3 Series are CSA Design Certified for use in residential garages that are attached to the home. Only equipment with such a certification can be installed in this type of application. Heaters installed in a residential garage must be vented out of the roof or sidewall.

Since many people use their garage for purposes in addition to storing their automobiles, the need to heat garages has dramatically increased. One of the more popular uses for a residential garage is woodworking. This popular hobby lends itself well to the use of infrared tube heaters. First, wood dust may pose a problem for any type of heating equipment that draws its combustion air from the interior space. Blowers and heat exchangers can become clogged in woodworking applications. The LS3 and LD3 Series heaters can be installed with combustion air ducted from the outside. This seals the heating system from wood dust contamination. Additionally, using outside combustion air also protects the heating system from the affects of lacquer, shellac, paint, and glue fumes. Woodworkers prefer infrared tube heaters because there are no blowers creating air movement that can damage finishes.

For ease of installation, most garage heater applications place the heater nearest the gas supply. This is usually along the wall commonly shared with the house. Heaters are also placed in this location to maintain clearances to combustibles from the vehicles parked in the space. Reflectors can be angled to direct heat into the center of the garage.

For woodshop applications, a heater or heaters are normally placed over the area where the woodworker is performing most tasks, often over a workbench or machinery. Outside combustion air is required and is normally ducted from the sidewall, which also helps to eliminate the possibility of roof leaks. See Figures 5.19 and 5.20 for example layouts.

Residential Garage
Figure 5.19 on p. 53 is an example of a residential garage application in which the heater is placed for ease of gas connection and far enough in the space to avoid vehicles being parked below it. Venting is accomplished through the sidewall.

Residential Garage
Figure 5.20 on p. 54 is also an example of a residential garage application in which the placement of the heater is designed for ease of gas connection from the house supply. The warmer section of the heater (the burner box and first radiant tube section) are placed closest to the side door for greater heat coverage. The heater reflectors are angled inward but the heaters are not placed over the vehicle parking area. Venting is accomplished through the sidewall.

Figure 5.19 • Residential Garage

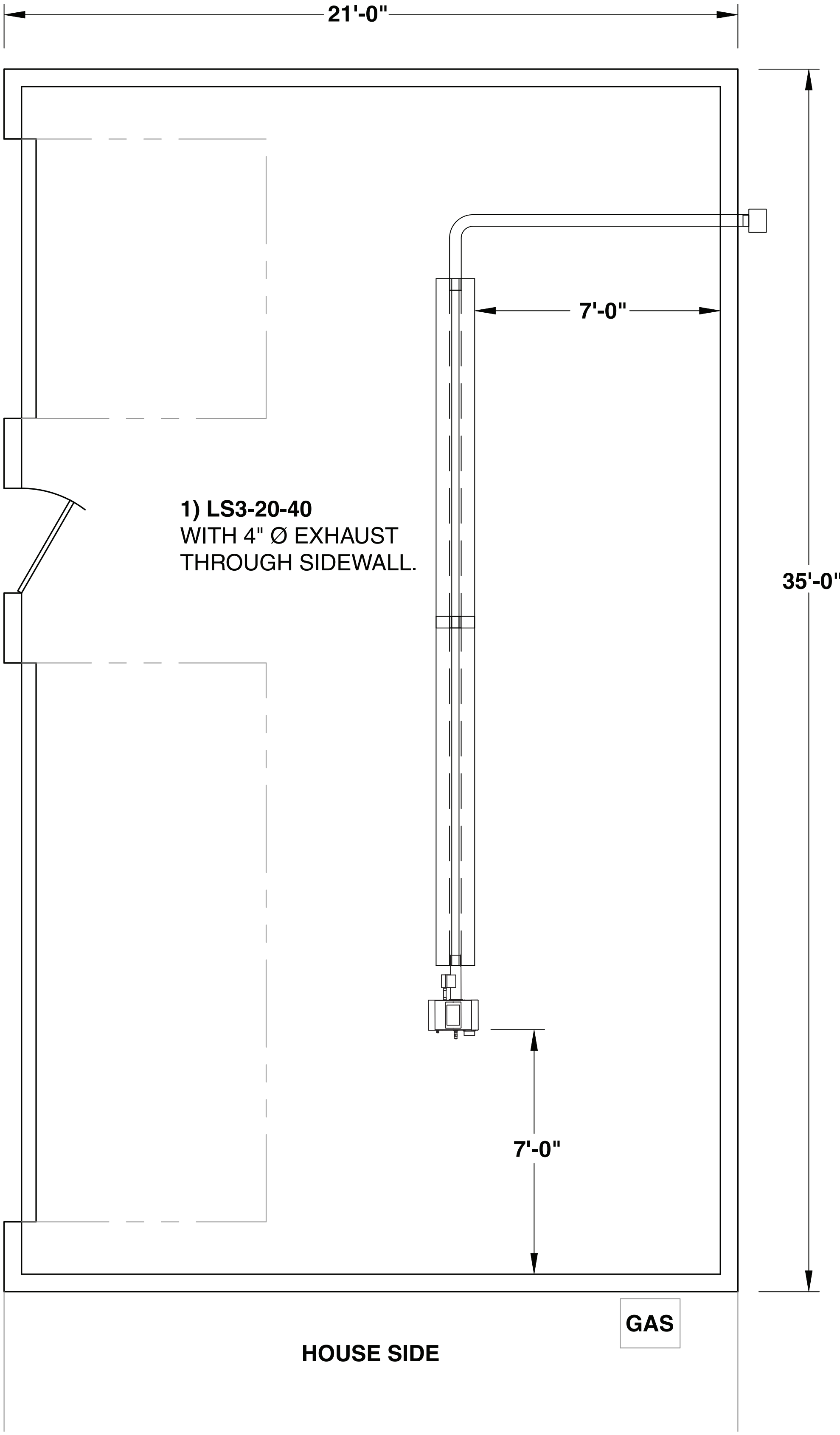
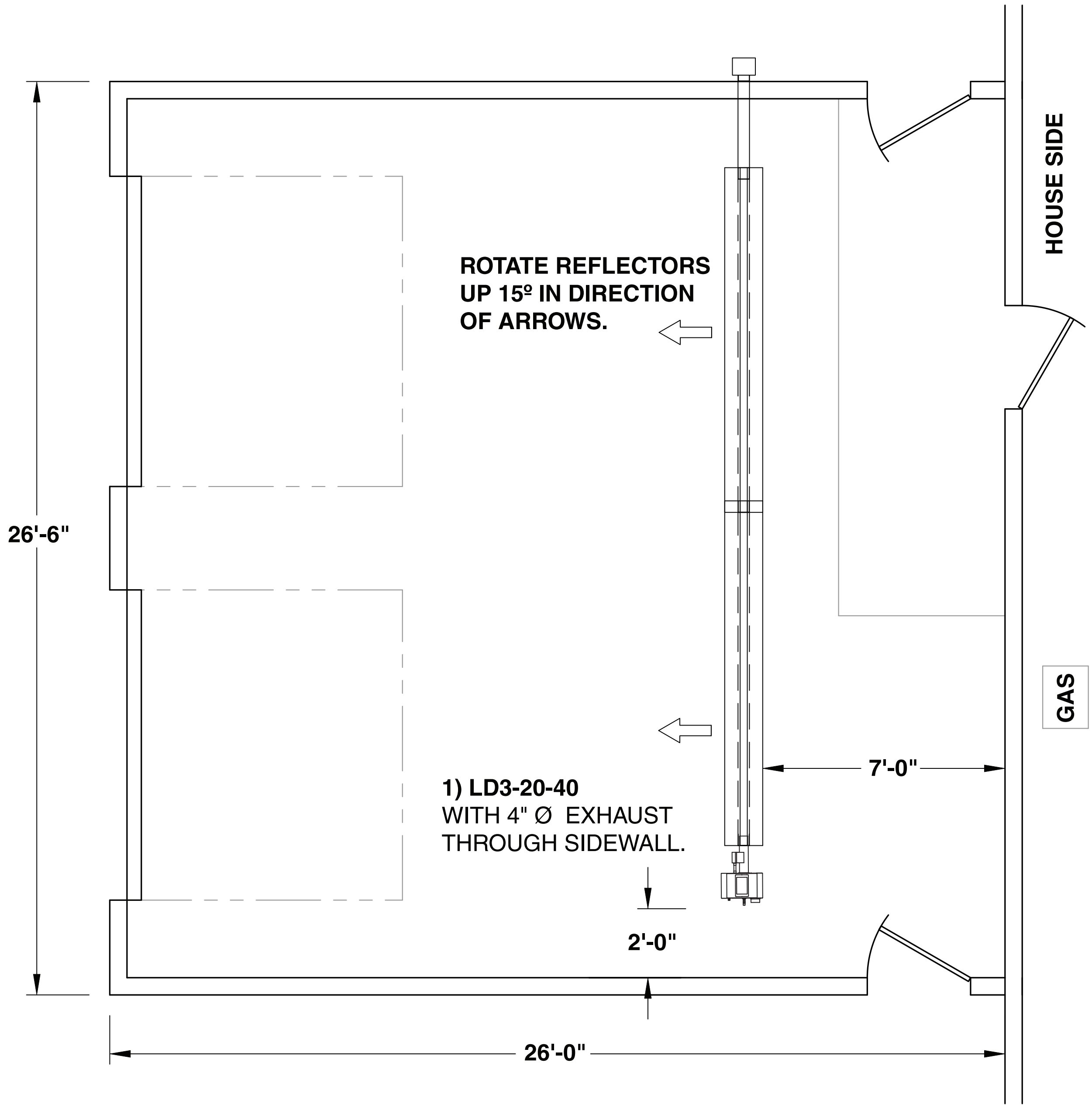


Figure 5.20 • Residential Garage



Application • Golf Ranges

Equipment Selection

The use of infrared heaters to heat covered golf tees has become quite popular in recent years. Even though these applications are mostly outdoors, the fact that infrared heaters create infrared energy that does not convert to heat until it strikes an object is the secret to their success. The key to heating golf tees is to create enough heat intensity in the tee area to offset the effect of the ambient air temperature on the golfer. Areas of concern when applying infrared heaters to covered golf tees include:

- **Available mounting heights** – The covering over the tee area is commonly quite low (12 to 14 ft.). The coverings are many times made of wood or other combustible material. Minimum clearance to combustibles **must** be maintained. Even though heaters can be mounted slightly lower in this application than they would normally be inside of a building, below minimum clearance to combustibles must still be maintained. Also, keep in mind there may be a person 6 ft. or taller standing in the box area.

- **Hazards** – Heaters must be placed outside the potential club swing area. You do not want a 6'-4" golfer winding up his club and crashing into the heater reflector on his back swing. Keep in mind that there are left-handed golfers too. Heaters placed in the tee box must be at a height to avoid club swings. Heaters can be placed near the rear of the covered area and the reflectors angled inward if height is restricting placement in the tee box.

- **Heater control** – Some owners wish to control the heaters in each individual tee box and owners sometimes wish to have the heaters coin operated. In such cases, it is then up to the customer whether he wants heat and is willing to pay for it. This makes the system very flexible but limits equipment options Some tee boxes are too small to accommodate even the smallest low intensity tube heater. These applications can often utilize high intensity heaters, which are small but have high top and below clearances. The low ceilings also restrict high intensity heaters to inputs below 60,000 BTU/h.

Keeping the above concerns in mind, high intensity heaters need to be installed maintaining clearance to combustibles, sized properly for the mounting height, protected from the wind and elements as much as possible, and out of the club swing area.

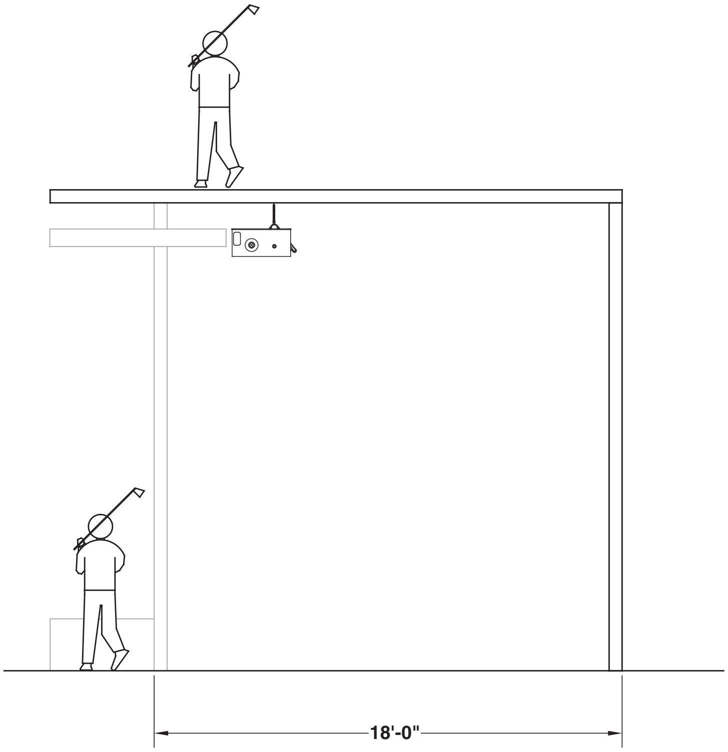
Many times, the high intensity heaters will need to be installed at the rear of the covered area facing the tee box. If the distance to the tee box is great, the use of parabolic reflectors will aid in directing as much heat as possible into the tee box area. It is also recommended that high intensity heaters be fitted with heater screens to protect the ceramic tiles from balls, etc.

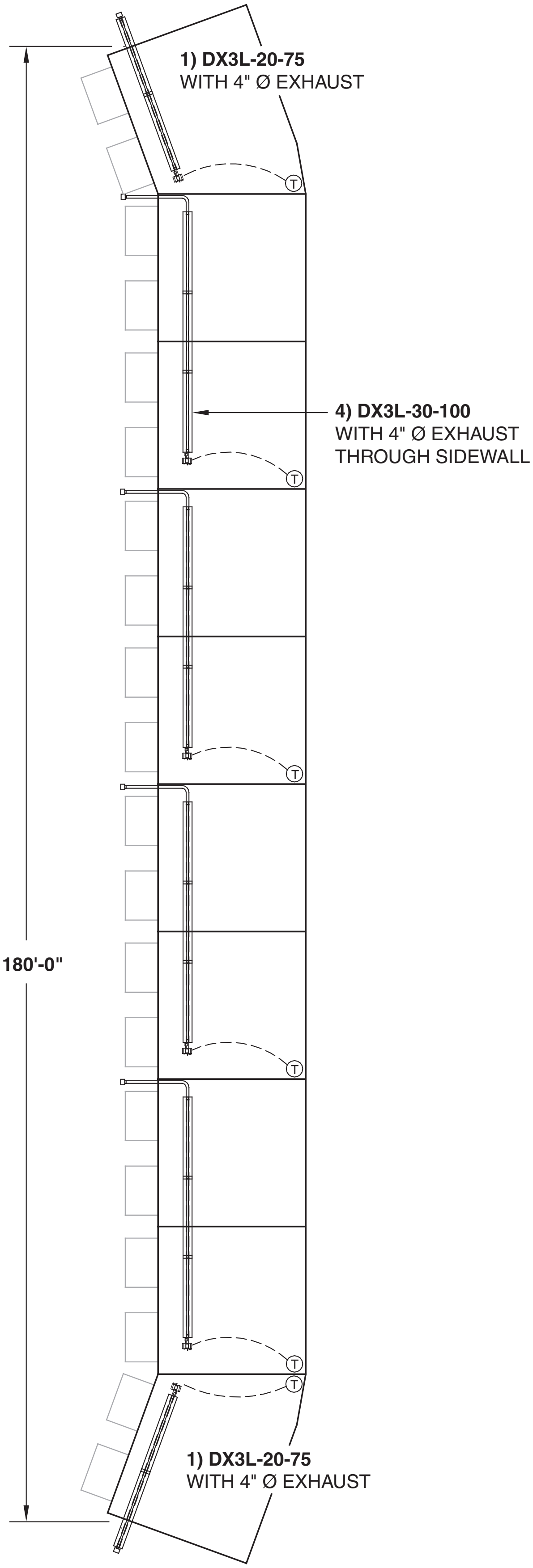
Low intensity infrared tube heaters are used more often for a couple of reasons. Tube heaters are not affected by wind and elements as much as high intensity heaters. The top minimum clearance to combustibles for tube heaters is dramatically less than high intensity heaters. Therefore, they can be easily mounted closer to a combustible cover. When the goal is to place one heater per tee box, it is sometimes accomplished by putting the tube heaters into a "U" configuration. Otherwise, tube heaters can be placed crossing multiple tee boxes. By doing so, individual tee box control is lost, but overall equipment cost is less because fewer heaters will need to be installed. See Figure 5.21 for an example layout.

Commercial Driving Range

Figure 5.21 on p. 56 is an example of a commercial diriving range application. This layout specifies the use of low intensity infrared tube heaters covering more than one tee. With the exception of the end tee boxes, a 30 ft. tube heater covers the width of two tee boxes so a total of 6 heaters cover this 180 ft. driving range. Even heat distribution over the tee boxes is accomplished by utilizing a short heat exchanger for high input units.

Figure 5.21 • Commercial Driving Range





SAMPLE APPLICATIONS

Application • Lease Property

Equipment Selection

Most industrial lease properties suited for the use of infrared heating are those applications where multiple tenant spaces are contained in one building and a heating system needs to be supplied for each tenant. The modular design of infrared heaters makes them a natural option for this type of facility. In the past, unit heaters had primarily heated this type of application. Even though infrared heaters represent a larger equipment dollar investment, the small differential in pricing is easily outweighed by the fuel cost savings obtained. Owners are placing infrared heaters in these facilities as an enticement for prospective renters. Tenants will usually have control over their own heating system, so sizing of individual heaters cannot rely on the common walls being heated. Some tenants may choose not to use their heating system or the settings may be extremely low. Therefore, it is best not to assume that the common walls are heated and to treat each unit as its own entity.

High intensity infrared heaters are used in these applications where ample ceiling height exists and minimum clearance to combustibles can be maintained. Due to their lower per unit cost, high intensity infrared heaters are attractive to most lease property managers. The inherent problem in installing high intensity heaters is that over time tenants leave or current tenants change their storage patterns. This can pose safety issues should the tenant be unaware of the hazards of placing combustible materials near the heaters. One solution is to hang chains from the heaters at a length equal to the minimum clearance to combustibles. Detroit Radiant Products Company offers a Clearance to Combustible Warning Plaque (Part No. PLQ) which is mounted from the heater or adjacent walls to indicate where the minimum clearance to combustible distance is.

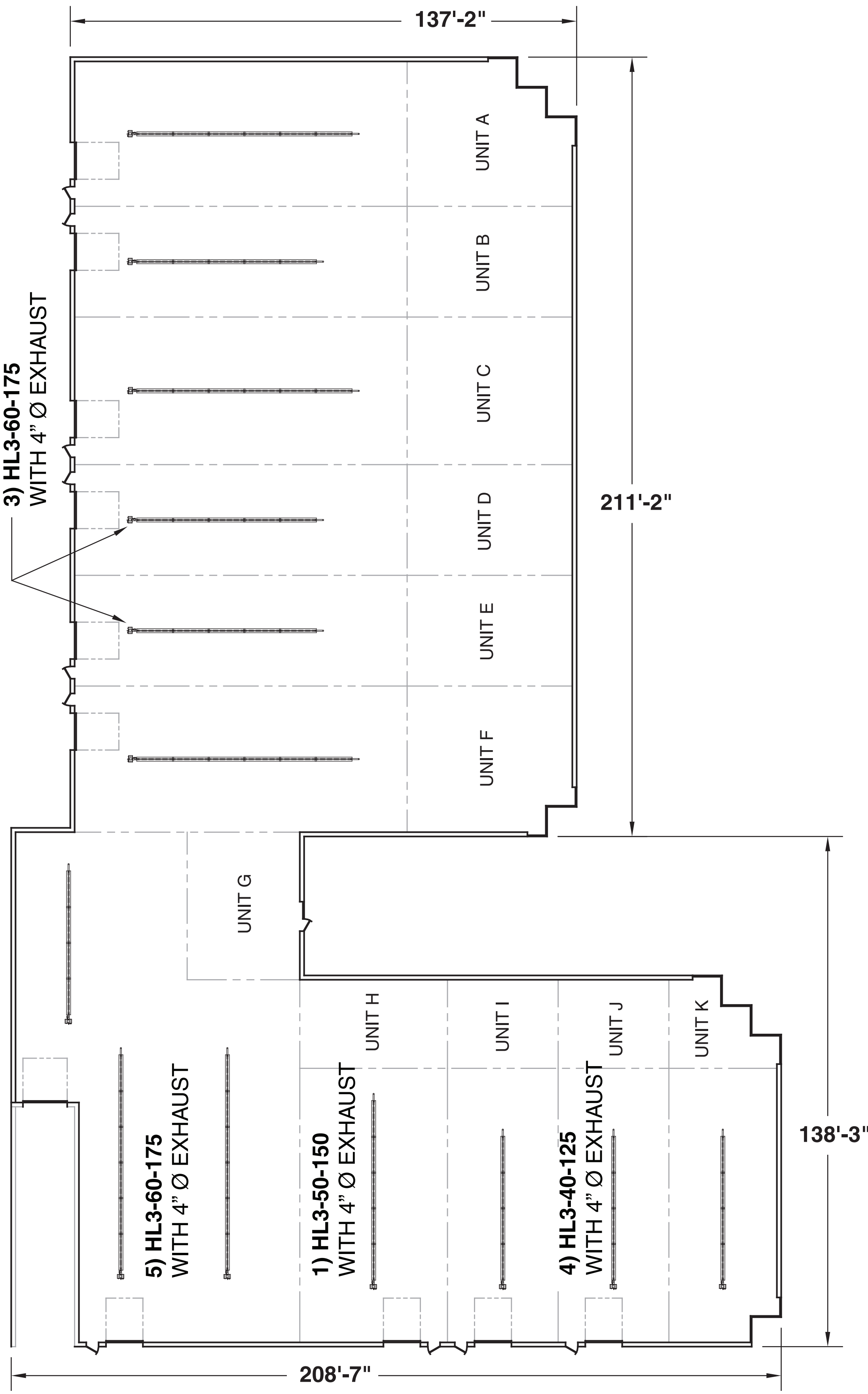
Additionally, the operations of tenants vary greatly. The current tenant's operation may be suitable for high intensity heaters, however, the next tenant may not be as well suited. For example, a current tenant may use the facility as a warehouse for finished products. As long as clearances are maintained, this would be a suitable application. However, the next tenant may have a welding shop operation. Low intensity heaters with outside air for combustion would be better suited in such an application where oil, mist, and smoke are present.

Low intensity heaters are far more flexible to various tenant operations, but represent a significantly higher per unit cost. This can be minimized in most installations as larger BTU/h rated tube heaters can be installed at the same mounting height as planned for the high intensity heaters with lower clearance to combustibles. The goal of the heating system is to provide some heat rather than trying to meet a heat load calculation. One or two units per tenant unit are most often seen. The use of outside combustion air is highly recommended to protect the longevity of the heaters in a variety of operations. See Figure 5.22 for an example layout.

Multiple Unit Lease Property

Figure 5.22 on p. 58 is an example of a multiple unit lease property application. This particular example represents an eleven-unit lease property heated with low intensity infrared tube heaters. The length and BTU/h input of each heater is based on the size of the unit. The largest unit, Unit G, employs three heaters because of its size. The other units use one heater that is 40, 50 or 60 ft. in length and BTU/h ratings of 125,000, 150,000 or 175,000. In all cases the burner control box and first section of radiant pipe are placed near overhead doors to help offset the heat loss in those greater loss areas.

Figure 5.22 • Multiple Unit Lease Property



Application • Manufacturing Facilities

Equipment Selection
Most manufacturing facilities have several unique characteristics that affect the application of infrared heaters. Manufacturing buildings are more likely to be poorly insulated, loosely constructed, and have high ratios of heat loss per square foot. Added to this, many older manufacturing buildings have been added on to numerous times over the years, resulting in many interior rooms and interconnected buildings. Total building heat is not the usual approach for such facilities as there are large areas of storage not requiring heat and smaller areas, where employees work, requiring ample heat. Finally, such facilities are much more likely to have air quality problems from the manufacturing process within the space requiring the most heat.

Traditionally, high intensity heaters have been applied in these facilities. They have the advantage of delivering high amounts of heat to relatively small areas. High intensity heaters are often easier to install and less costly for spot heating type applications. These facilities are more likely to have ceiling heights conducive to high intensity heaters. Overhead cranes are common in manufacturing buildings and high intensity heaters need to be placed below the crane rails with the motors of the crane shielded so as to prevent damage in the event the crane motor stops near an individual heater. However, buildings with poor air quality should not use high intensity heaters as the contaminants in the air will shorten the life of the heaters.

Low intensity tube heaters have become much more popular in manufacturing facilities for several reasons. First, ducting of outside combustion air is an advantage that few other heating systems can offer. Low intensity heaters will have a longer life expectancy in such a facility when ducted with outside combustion air. Second, many applications include heating of assembly lines. Even heat distribution is more easily and economically accomplished using low intensity tube heaters. Assembly lines are usually long narrow areas to be heated. Employers are usually interested in keeping employees at their tasks, so they will request ample heat over the assembly area and less or no heat over adjacent areas. Long narrow areas are often best heated with heater inputs sized for the mounting height but with the shortest exchanger length available in that input. Heaters should be placed end to end, alternating burner control boxes instead of trying to duel vent units with the heaters burner control boxes opposing each other. Finally, it is economically beneficial to heat mezzanine and low ceiling areas with low intensity heaters because fewer tube heaters of higher input can be used instead of several small high intensity heaters. See Figures 5.23 through 5.26 for example layouts.

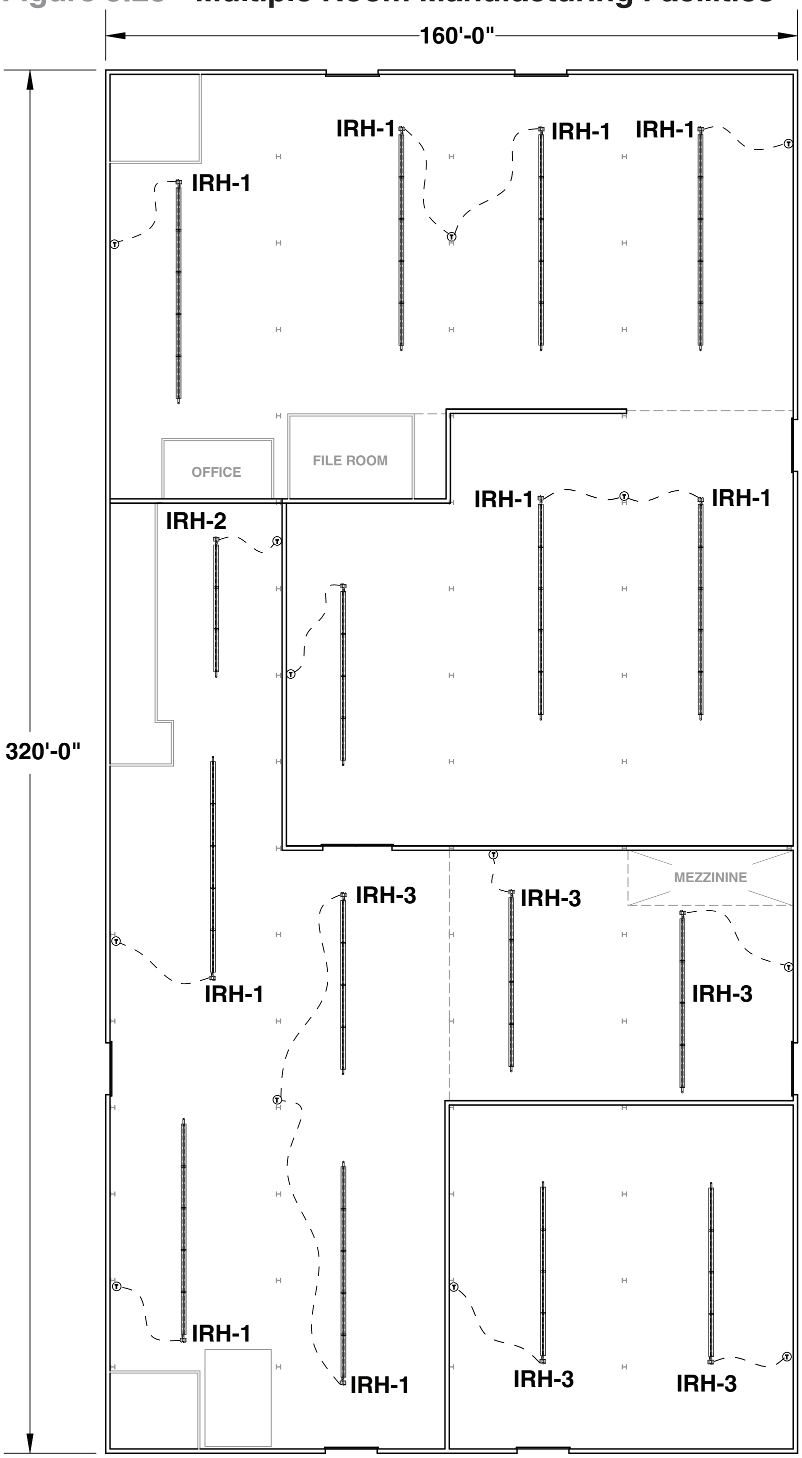
Multiple Room Manufacturing Facilities
Figures 5.23 and 5.24 on pgs. 60 and 61 are examples of multiple room manufacturing facility applications. In these layouts, each room is treated separately. Heaters are placed for the most direct infrared effect instead of specifically offsetting a heat loss calculation. Heaters are thermostatically controlled in a way to heat individual areas within the space. If a given area is not being utilized, the heaters in that area can be turned off or down. Heaters are placed so the control boxes and first radiant tube are in the highest heat demand area or the most critical to the heat needed in that area.

Manufacturing Facility with Overhead Cranes
Figure 5.25 on p. 62 is an example of a manufacturing facility application with overhead cranes. In the area to the right, heaters are installed below the crane with the reflectors tilted up to a 45° angle inward. In the center and left areas, the heaters are installed above the crane high in the trusses. The crane motor needs to be shielded in these areas. Two stage heaters are offered as an option. Due to the small door area to overall square footage ratio, two stage heaters will run in low most of the time with high fire operation mostly restricted to the coldest days. The system will provide comfort heat at the lower input, but have the ability to react to a period of extreme outside temperatures.

Open Span Manufacturing Facility – Total Building Heat

Figure 5.26 on p. 63 is an example of a total building heat application. The two halves of the building are being treated separately in order to provide even heat distribution. For the most part, heaters are placed in an end to end configuration with burner control boxes and first radiant tubes alternating rather than opposing each other. This will help to enhance the evenness of heat distribution. Finally, the placement of heaters under the mezzanine area is designed to reduce the number of heaters required. To heat this mezzanine area with high intensity heaters would have involved the use of four or more units instead of the two tube heaters shown here. The spacing of the heaters in this mezzanine area is designed to accommodate the way material is stored here.

Figure 5.23 • Multiple Room Manufacturing Facilities



INFRA-RED HEATER SCHEDULE			
KEY	MODEL	BTUH	LENGTH
IRH-1	DES3-50-150	150,000	50'
IRH-2	DES3-30-100	100,000	30'
IRH-3	DES3-40-150	150,000	40'

Figure 5.24 • Multiple Room Manufacturing Facilities

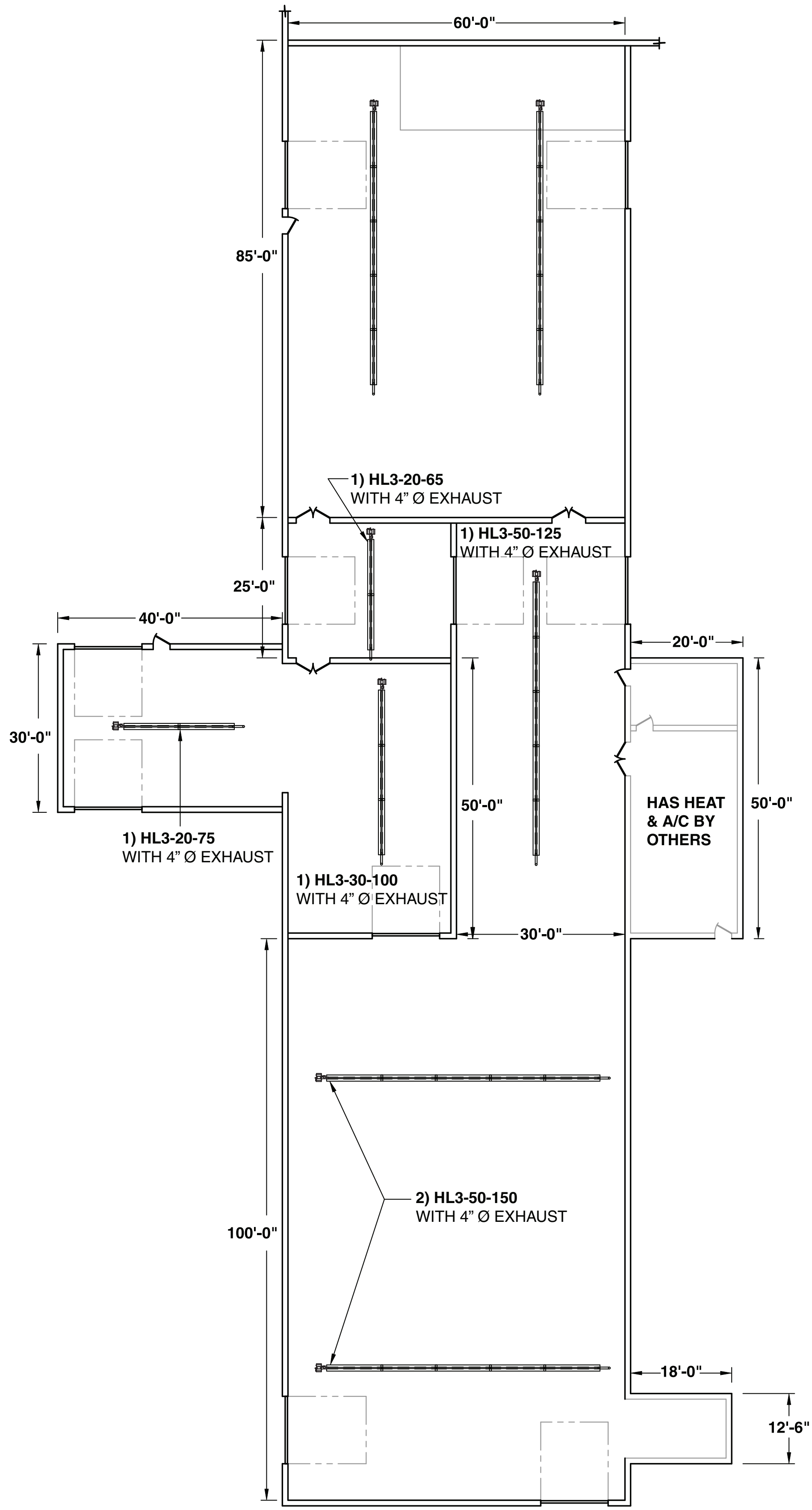
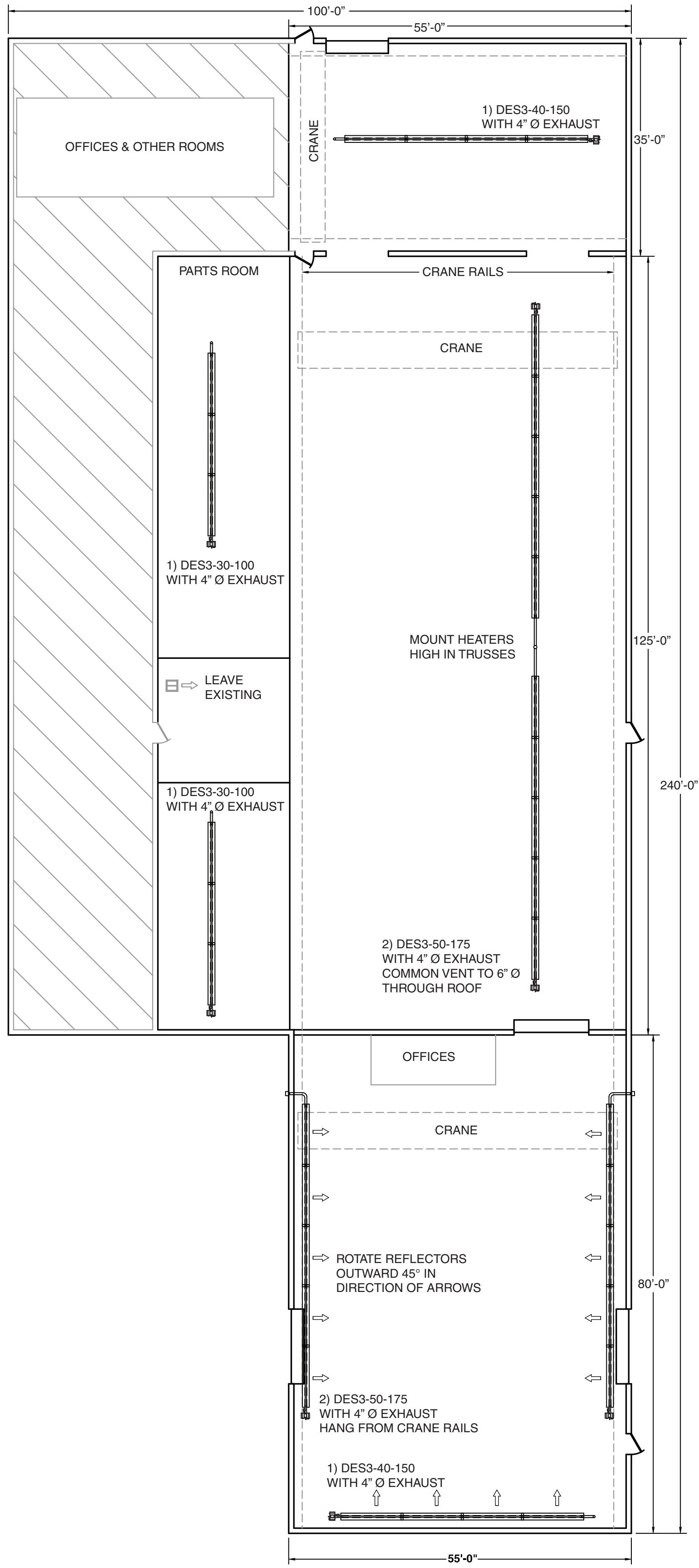
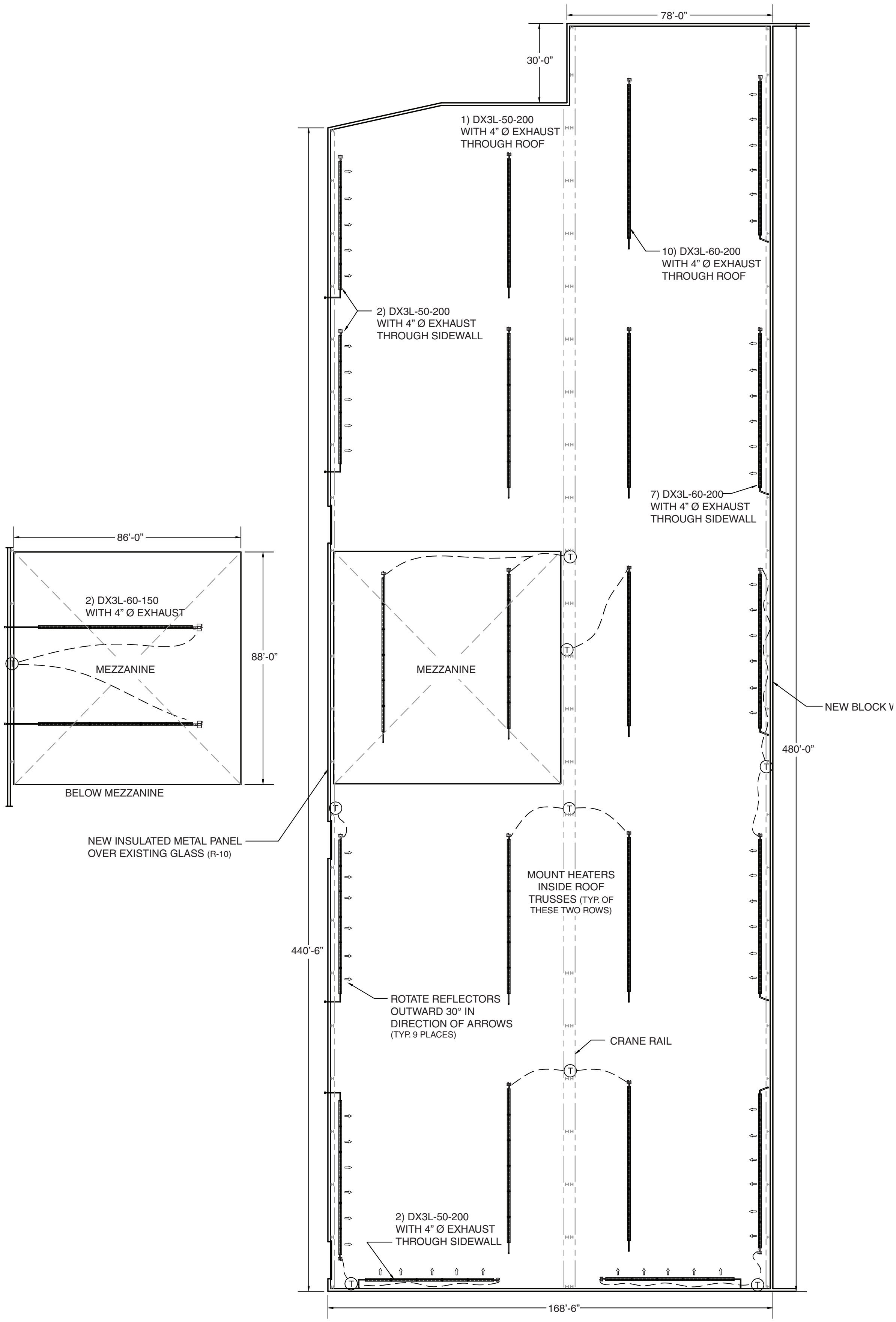


Figure 5.25 • Manufacturing Facility with Overhead Cranes



SAMPLE APPLICATIONS

Figure 5.26 • Open Span Manufacturing Facility – Total Building Heat



SAMPLE APPLICATIONS

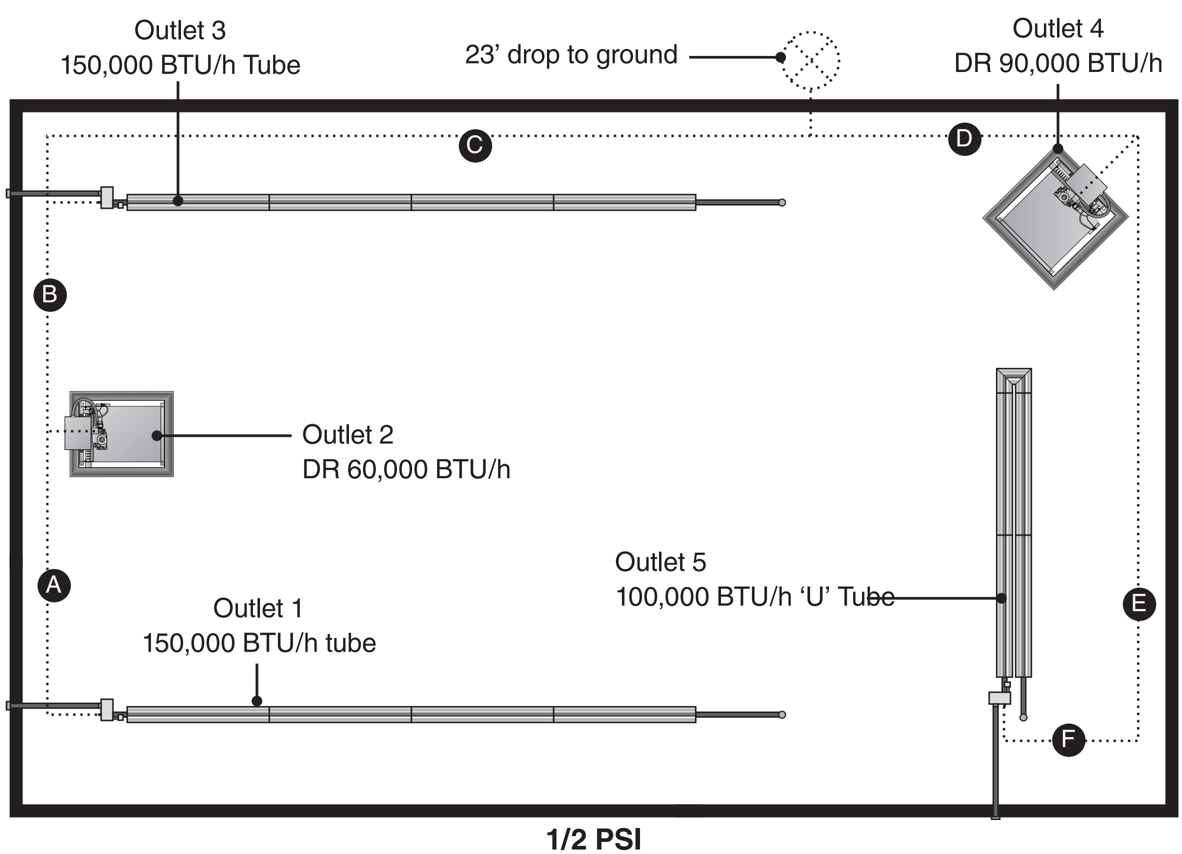
6.0 Appendixes

Gas Piping System Design

IMPORTANT! Evaluate the capacity of the gas supply to the burner control box.

- Check that the gas piping and service has the capacity to handle the load of all heaters being installed, as well as any other gas appliances being connected to the supply line.
- Check that the main gas supply line is of proper diameter to supply the required fuel pressures.
- If utilizing used pipe, verify that its condition is clean and comparable to a new pipe. Test all gas supply lines in accordance with local codes.
- Test and confirm that inlet pressures are correct. Refer to the rating plate for required minimum and maximum pressures. The gas supply pipe must be of sufficient size to provide the required capacity and inlet pressure to the heater (if necessary, consult the local gas company).

Figure 6.1 • **Pipe System Design**



Example:
Determine the required pipe size of each section of the piping system (shown in Figure 6.1) with a designated pressure drop of 0.50 inch water column. Gas to be used has 0.65 specific gravity and a heating value of 1,000 BTU/h per cubic foot.

Solution

NOTE: The example below applies to natural gas piping.

❶ Calculate the maximum gas demand for each outlet by dividing the BTU/h rating listed in the example by 1,000 BTU per cubic foot. This will give you the cubic feet of gas per hour (CFH) of each unit.

❷ Calculate the distance from the main gas line to the most remote outlet. This is the only distance used. In this example, that would be the distance to Outlet 1, a total of 148 feet.

For the remainder of this exercise, refer to Chart 6.1 on p. 66. Since the longest distance to any outlet is 148 feet, we will use the next to last column from the right (titled 150) for all of these calculations. Beginning with Outlet 1, and working back toward the main gas line, begin figuring how many cubic feet of gas per hour (CFH) each span of pipe will need to deliver in order to meet the requirements of the listed device.

❸ **Outlet 1:** The 25 foot span of pipe, labeled Section Ⓐ, needs to supply 150 CFH. Using the column labeled 150 feet (equivalent pipe length), as defined by step 3 of this exercise, you'll see that in order to supply 150 CFH, a pipe with a diameter of 1" is required.

NOTE: The pipe diameter must be able to supply at least as much cubic feet of gas per hour (CFH) as required by each unit. If the necessary CFH is close, round up to the next pipe size.

❹ **Outlet 2:** The pipe for Section Ⓑ must be large enough to deliver CFH of gas capable of meeting the requirements for both Outlet 1 and Outlet 2, or 210 CFH. Using this number, the chart calls for a pipe diameter of 1 1/4".

Outlet 3: The pipe leading from the Main Gas Line to Outlet 3, Section Ⓒ, must also carry enough cubic feet of gas per hour (CFH) for Outlet 1 and Outlet 2, or 360 CFH. The chart shows a pipe diameter of 1 1/2".

❺ **Outlet 4:** Section Ⓓ must supply Outlets 4 and 5, or 190 CFH; therefore, a pipe diameter of 1-1/4" is necessary.

❻ **Outlet 5:** This outlet is supplied by Sections Ⓔ and Ⓕ. Because both sections supply Outlet 5 the same amount of pressure, the same size pipe can be used for both. A 1" diameter pipe will be adequate for the 100 CFH.

Chart 6.1 • Maximum Capacity of Pipe in Cubic Feet of Gas per Hour for Gas Pressures of 0.5 psi or Less and a Pressure Drop of 0.5 inch Water Column. (Natural Gas)

Nominal Iron Pipe

Pipe Size (Inches)	Length of Pipe (Feet)						
	20	40	60	80	100	150	200
1/2	120	82	66	57	50	40	35
3/4	250	170	138	118	103	84	72
1	465	320	260	220	195	160	135
1 1/4	950	660	530	460	400	325	280
1 1/2	1,460	990	810	690	620	500	430
2	2,750	1,900	1,520	1,300	1,150	950	800
2 1/2	4,350	3,000	2,400	2,050	1,850	1,500	1,280
3	7,700	5,300	4,300	3,700	3,250	2,650	2,280
4	15,800	10,900	8,800	7,500	6,700	5,500	4,600

(Based on a 0.60 Specific Gravity Gas)

Chart 6.2 • Pipe Sizing Table for 2 psi Pressure Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour for an Initial Pressure of 2.0 psi with a 1.0 psi Pressure Drop. (Natural Gas)

Schedule 40 Standard Pipe

Pipe Size (Inches)	Length of Pipe (Feet)						
	20	40	60	80	100	150	200
1/2	1,065	753	615	532	462	372	318
3/4	2,150	1,521	1,241	1,075	934	751	642
1	3,932	2,781	2,270	1,966	1,708	1,373	1,174
1 1/4	8,072	5,708	4,660	4,036	3,508	2,817	2,413
1 1/2	12,096	8,553	6,983	6,048	5,257	4,222	3,613
2	23,295	16,472	13,449	11,647	10,125	8,130	6,959
2 1/2	37,127	26,253	21,435	18,563	16,138	12,960	11,093
3	65,633	46,410	37,893	32,817	28,530	22,911	19,608
4	133,873	94,663	77,292	66,937	58,194	46,732	39,997

(Based on a 0.60 Specific Gravity Gas)

Chart 6.3 • Pipe Sizing Table for 5 psi Pressure Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour for an Initial Pressure of 5.0 psi with a 3.5 psi Pressure Drop. (Natural Gas)

Schedule 40 Standard Pipe

Pipe Size (Inches)	Length of Pipe (Feet)						
	20	40	60	80	100	150	200
1/2	2,252	1,593	1,301	1,153	979	786	673
3/4	4,550	3,217	2,627	2,330	1,978	1,589	1,360
1	8,320	5,883	4,804	4,260	3,617	2,905	2,487
1 1/4	17,084	12,080	9,864	8,542	7,427	5,964	5,104
1 1/2	25,602	18,103	14,781	12,801	11,128	8,937	7,649
2	49,305	34,864	28,466	24,652	21,433	17,211	14,729
2 1/2	78,583	55,566	45,370	39,291	34,159	27,431	23,478
3	138,924	98,234	80,208	69,462	60,387	48,494	41,504
4	283,361	200,366	163,598	141,680	123,173	98,911	84,656

(Based on a 0.60 Specific Gravity Gas)

Chart 6.4 • Pipe Sizing Table for 2 Pounds Pressure Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour for an Initial Pressure of 2.0 psi with a 10 Percent Pressure Drop. (Natural Gas)

Schedule 40 Standard Pipe

Pipe Size (Inches)	Length of Pipe (Feet)							
	50	100	150	200	300	400	500	1000
1	1,112	764	614	525	422	361	320	220
1 1/4	2,283	1,569	1,260	1,079	866	741	657	452
1 1/2	3,421	2,351	1,888	1,616	1,298	1,111	984	677
2	6,589	4,528	3,636	3,112	2,499	2,139	1,896	1,303
2 1/2	10,501	7,217	5,796	4,961	3,983	3,409	3,022	2,077
3	18,564	12,759	10,246	8,769	7,042	6,027	5,342	3,671
3 1/2	27,181	18,681	15,002	12,840	10,311	8,825	7,821	5,373
4	37,865	26,025	20,899	17,887	14,364	12,293	10,895	7,488
5	68,504	47,082	37,809	32,359	25,986	22,240	19,711	13,547
6	110,924	76,237	61,221	52,397	42,077	36,012	31,917	21,936

(Based on a 0.60 Specific Gravity Gas)

Chart 6.5 • Pipe Sizing Table for 5 Pounds Pressure Capacity of Pipes of Different Diameters and Lengths in Cubic Feet per Hour for an Initial Pressure of 5.0 psi with a 10 percent Pressure Drop. (Natural Gas)

Schedule 40 Standard Pipe

Pipe Size (Inches)	Length of Pipe (Feet)							
	50	100	150	200	300	400	500	1000
1	1,989	1,367	1,098	940	755	646	572	393
1 1/4	4,084	2,807	2,254	1,929	1,549	1,326	1,75	808
1 1/2	6,120	4,206	3,378	2,891	2,321	1,987	1,761	1,210
2	11,786	8,101	6,505	5,567	4,471	3,827	3,391	2,331
2 1/2	18,785	12,911	10,368	8,874	7,126	6,099	5,405	3,715
3	33,209	22,824	18,329	15,687	12,597	10,782	9,556	6,568
3 1/2	48,623	33,418	26,836	22,968	18,444	15,786	13,991	9,616
4	67,736	46,555	37,385	31,997	25,694	21,991	19,490	13,396
5	122,544	84,224	67,635	57,887	46,485	39,785	35,261	24,235
6	198,427	136,378	109,516	93,732	75,270	64,421	57,095	39,241

(Based on a 0.60 Specific Gravity Gas)

Chart 6.6 • Maximum Undiluted Propane Capacities Listed are Based on 11 Inch Water Column Setting and a 0.5 Inch Water Column Pressure Drop. (Propane Gas)

Schedule 40 Standard Pipe

Pipe Size (Inches)	Length of Pipe (Feet)							
	10	20	30	40	50	60	80	100
1/2	291	200	161	137	122	110	94	84
3/4	608	418	336	287	255	231	198	175
1	1,146	488	632	541	480	435	372	330
1 1/4	2,353	1,617	1,299	1,111	985	892	764	677
1 1/2	3,525	2,423	1,946	1,665	1,476	1,337	1,144	1,014
2	6,789	4,666	3,747	3,207	2,842	2,575	2,204	1,954

(Capacities in 1,000 BTU/h)

U-Factors for Common Materials

Chart 6.7 • Typical U-Factor for Roofs (U-Factor = 1/R-Value)

Material	Type of Insulation	Thickness of Insulation							
		0”	1”	2”	3”	4”	6”	8”	12”
Metal	Batt (R= 3.1/in.)	.9	-	-	.096	.074	.051	.039	.024
	Rigid (R= 4-5/in.)	.9	.179	.099	.068	-	-	-	-
1/2” Wood	Batt (R= 3.1/in.)	.62	-	-	.092	.071	.049	.038	.026
	Rigid (R= 4-5/in.)	.62	.164	.094	.066	-	-	-	-

Material	Type	Thickness of Insulation		
		0”	1”	1.5”
Concrete Deck	Lightweight (2”)	.30	.16	.13
	Lightweight (3”)	.23	.14	.12
	Lightweight (4”)	.18	.12	.10

Chart 6.8 • Typical U-Factor for Walls (U-Factor = 1/R - Value)

Material	Type of Insulation	Thickness of Insulation					
		0"	1"	2"	3"	4"	6"
Metal	Batt (R= 3.1/in.)	1.2			.099	.076	.051
	Rigid (R= 4-5/in.)	1.2	.188	.102	.070		
1/2" Wood	Batt (R= 3.1/in.)	.62			.092	.071	.049
	Rigid (R= 4-5/in.)	.62	.164	.094	.066		

Material	Type	Thickness of Material			
		4"	6"	8"	12"
Brick	Face and Common	.80	.68	.48	.35
Block	Hollow	.51		.39	.37
	Solid			.39	.36
Poured Concrete	140#/ft^3	.86	.75	.67	.55
	80#/ft^3	.42	.31	.25	.18

Chart 6.9 • Typical U-Factor for Doors, Windows and Slab Edge

<table>
<tr><th colspan="2">Doors</th><th colspan="3">Windows</th><th colspan="2">Slab Edge</th></tr>
<tr><th>Material</th><th>U-Factor</th><th>Material</th><th>Type</th><th>U-Factor</th><th>Material</th><th>U-Factor</th></tr>
<tr><td>Uninsulated Steel</td><td>1.2</td><td rowspan="2">Glass</td><td>Single Pane</td><td>1.22</td><td>Uninsulated Edge</td><td>.81</td></tr>
<tr><td>Insulated Steel</td><td>.69</td><td>Double Pane</td><td>.70</td><td>Insulated Edge</td><td>.55</td></tr>
<tr><td>Wood (1” Thick)</td><td>.64</td><td colspan="2">Fiberglass Panels</td><td>1.09</td><td></td><td></td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">Sky Lights</td><td>Single Wall</td><td>1.15</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Double Wall</td><td>.70</td></tr>
</table>

Chart 6.10 • Cold Mass Specific Gravity

Material	Specific Gravity
Steel	.12
Aluminum	.23
Copper	.09
Cast Iron	.11
Cement	.19
Concrete (140#/ft^3)	.16
Sand and Stone	.19
Glass	.16
Rubber	.48
Wood	.50

Chart 6.11 • Air Change

Air Changes by Natural Infiltration (per hour)					
				Typical No. of A/C	
Type Of Facility	**Construction**	**Square Feet**	**Height**	**Min.**	**Max.**
Warehouse	Good	10,000-30,000	18	0.75	1.50
		30,000+	24	0.50	1.25
	Average	10,000-30,000	16	1.00	2.00
		30,000+	24	0.75	1.50
	Poor	10,000-30,000	18	1.50	3.00
		30,000+	24+	1.00	2.50
Auto, Truck Implement Service	Good	5,000-7,500	18	1.50	3.00
	Poor	5,000-7,500	16	4.00	6.00
Light Mfg. Machine Shops	Good	10,000-25,000	24	0.75	2.00
	Average	8,000-15,000	16	1.00	2.50
Aircraft Hangar	Good	5,000-15,000	24+	1.50	3.00
	Average	15,000+	40+	1.50	2.50
Vehicle Storage	Average	5,000	16	1.00	2.00
Indoor Tennis Courts/Gymnasiums	Good	30,000	30	1.00	2.00

Chart 6.12 • Annual Degree Days - 45°F Base and 55°F Base

State	City	Degree Days 45°F Base	Degree Days 55°F Base
AL	Birmingham	430	1293
	Mobile	135	601
	Montgomery	227	888
AZ	Phoenix	10	174
	Yuma	8	197
AR	Fort Smith	698	1778
	Little Rock	551	1512
CA	Eureka	167	1352
	Fresno	119	853
	Independence	584	1750
	Los Angeles	0	88
	Red Bluff	157	981
	Sacramento	120	892
	San Diego	0	167
	San Francisco	31	824
	San Luis Obispo	24	463
CO	Denver	1907	3701
	Grand Junction	1741	3322
	Pueblo	1671	3320
CT	Meridan	0	734
	New Haven	1769	3237
DC	Washington	0	127
FL	Pensacola	101	501
GA	Atlanta	416	1289
	Augusta	286	1059
	Macon	220	898
	Savannah	135	643
ID	Boise	1589	3370
	Lewiston	1136	2819
	Pocatello	2422	4462
IL	Cairo	1091	2300
	Chicago	2368	4151
	Springfield	1930	3500
IN	Evansville	1302	2676
	Indianapolis	1816	3389
IA	Charles City	3176	4977
	Davenport	2296	4142
	Des Moines	2502	4206
	Dubuque	2969	4837

State	City	Degree Days 45°F Base	Degree Days 55°F Base
IA	Keokuk	2137	3689
	Sioux City	2806	4596
KS	Concordia	1851	3412
	Dodge City	1517	2998
	Topeka	1683	3175
	Wichita	1394	2797
KY	Lexington	1318	2720
	Louisville	1141	2451
LA	New Orleans	87	465
	Shreveport	280	963
ME	Eastport	2622	4761
	Portland	2589	4637
MD	Baltimore	1184	2578
MA	Boston	1595	3299
	Nantucket	1453	3244
MI	Alpena	3280	5444
	Detroit	2270	4074
	Escanaba	3606	5781
	Grand Haven	2359	4242
	Grand Rapids	2546	4437
	Houghton	3953	6203
	Lansing	2670	4592
	Marquette	3320	5467
	Port Huron	2539	4424
	Saginaw	2689	4611
	Sault Ste. Marie	3976	6262
MN	Duluth	4538	6816
	Minneapolis	3492	5424
	Moorhead	4796	6572
	St. Paul	3368	5217
MS	Vicksburg	253	837
MO	Columbia	1647	3131
	Hannibal	2051	3554
	Kansas City	1766	3271
	St. Louis	1450	2830
	Springfield	1279	2645
MT	Havre	3491	5560
	Helena	3039	5185
	Kalispell	2922	5205

APPENDIXES

Chart 6.12 • **Annual Degree Days - 45°F Base and 55°F Base**

State	City	Degree Days 45°F Base	Degree Days 55°F Base
NE	Lincoln	2326	3926
	North Platte	2495	4361
	Omaha	2393	4087
	Valentine	2878	4798
NV	Winnemucca	1764	3107
NH	Concord	2834	4858
NJ	Atlantic City	1334	2900
NM	Sante Fe	1752	3593
NY	Albany	2490	4384
	Binghamton	2706	4666
	Buffalo	2367	4242
	Ithaca	2653	4603
	New York	1190	2709
	Oswego	2394	4267
	Rochester	2383	4620
NC	Charlotte	516	1527
	Hatteras	290	994
	Raleigh	508	1420
	Wilmington	275	1014
ND	Bismark	4061	6157
	Williston	4173	6275
OH	Cincinatti	1405	2822
	Cleveland	2029	3766
	Columbus	1756	3356
	Dayton	1874	3491
	Sandusky	2100	376
	Toledo	2307	4097
OK	Oklahoma City	823	1945
OR	Baker	2307	4359
	Portland	502	1940
	Roseburg	464	1726
PA	Erie	2157	3982
	Harrisburg	1517	3122
	Philadelphia	1228	2687
	Scranton	1938	3755
	Pittsburg	1872	3545
RI	Block Island	1307	2960
SC	Charleston	173	750
SC	Columbia	318	1127
	Greenville	505	1534
SD	Huron	3413	5360
	Pierre	3086	4882
	Rapid City	2728	4679
	Yankton	3016	4798
TN	Chattanooga	607	1681
	Knoxville	731	1884
	Memphis	568	1499
	Nashville	798	1914
TX	Abilene	431	1238
	Amarillo	1048	2367
	El Paso	250	1068
	Fort Worth	342	1069
	Galveston	34	272
	Houston	111	532
	Palestine	235	785
	San Antonio	123	556
UT	Modena	1884	3719
	Salt Lake City	1594	3299
VT	Burlington	3094	5091
	Northfield	3652	7121
VA	Lynchburg	975	2303
	Norfolk	558	1608
	Richmond	815	2021
WA	North Head	184	2064
	Seattle	510	2112
	Spokane	2081	4127
	Tacoma	548	2011
	Walla Walla	1188	2620
WV	Elkins	1882	3629
	Parkersburg	1491	2974
WI	Green Bay	3348	5381
	La Crosse	3131	4992
	Madison	3051	4993
	Milwaukee	2660	4590
WY	Cheyenne	2500	4583
	Lander	3091	5171

Chart 6.13 • Winter Climatic Conditions

State	City	Elevation (ft.)	Outside Design Dry-Bulb Temp. (°F)d	Yearly Degree Days (Base 65°F)	Average Winter Temp. (°F)d
AL	Birmingham	610	19	2823	54.2
	Huntsville	619	13	3262	51.3
	Mobile	119	28	1681	59.9
	Montgomery	195	22	2194	55.4
AK	Anchorage	90	-25	10470	23.0
	Fairbanks	436	-53	13980	6.7
	Juneau	17	-7	8574	32.1
	Nome	13	-32	13801	13.1
AZ	Flagstaff	6973	0	6999	35.6
	Phoenix	1117	31	1027	58.8
	Tucson	2584	29	1578	58.1
	Winslow	4880	9	4692	43.0
	Yuma	199	37	782	64.2
AR	Fort Smith	449	15	3437	50.3
	Little Rock	257	19	3084	50.5
	Texarkana	361	22	2533	54.2
CA	Bakersfield	495	31	2120	55.4
	Bubank	699	36	1646	58.6
	Eureka	217	32	4430	49.9
	Fresno	326	28	2447	53.3
	Long Beach	34	36	1211	57.8
	Los Angeles	312	42	1274	60.3
	Oakland	3	35	2870	53.5
	Sacramento	17	30	2666	54.4
	San Francisco	52	42	2862	55.1
	Santa Maria	238	32	2783	54.3
CO	Colorado Springs	6173	-1	6480	37.3
	Denver	5283	-2	6128	40.8
	Grand Junction	4849	8	5700	39.3
	Pueblo	4639	-5	5598	40.4
CT	Bridgeport	7	4	5466	39.9
	Hartford	15	1	6104	37.3
	New Haven	6	5	5897	39.0
DE	Wilmington	78	12	4888	42.5
DC	Washington	14	16	4925	45.7
FL	Jacksonville	24	29	1354	61.9
	Key West	6	55	62	73.1
	Miami	7	44	149	71.1

Chart 6.13 • Winter Climatic Conditions (continued)

State	City	Elevation (ft.)	Outside Design Dry-Bulb Temp. (°F)d	Yearly Degree Days (Base 65°F)	Average Winter Temp. (°F)d
FL	Pensacola	13	29	1498	60.4
	Tampa	19	36	591	66.4
GA	Atlanta	1005	18	2827	51.7
	Augusta	143	20	2525	54.5
	Macon	356	23	2364	56.2
	Savannah	52	24	1799	57.8
HI	Honolulu	7	60	0	74.2
	Hilo	31	59	0	71.9
ID	Boise	2,842	4	5727	39.7
	Lewiston	1413	6	5220	41.0
	Pocatello	4444	-8	7109	34.8
IL	Chicago	594	-3	6498	38.9
	Moline	582	-7	6415	36.4
	Peoria	652	-2	6097	38.1
	Rockford	724	-7	6933	34.8
	Springfield	587	-1	5596	40.6
IN	Evansville	381	6	4617	45.0
	Fort Wayne	791	0	6205	37.3
	Indianapolis	793	0	5521	39.6
	South Bend	773	-2	6294	36.6
IA	Des Moines	948	-7	6436	35.5
	Dubuque	1065	-11	7270	32.7
	Sioux City	1095	-10	6900	34.0
	Waterloo	868	-12	7348	32.6
KS	Dodge City	2594	3	5037	42.5
	Topeka	877	3	5225	41.7
	Wichita	1321	5	4765	44.2
KY	Lexington	979	6	4713	43.8
	Louisville	474	8	4352	44.0
LA	New Orleans	3	32	1417	61.0
	Shreveport	252	22	2251	56.2
ME	Caribou	624	-18	9560	24.4
	Portland	61	-5	7318	33.0
MD	Baltimore	14	16	4720	46.2
	Frederich	294	7	5087	42.0
MA	Boston	15	6	5630	40.0
	Worchester	986	-3	6831	34.7

Chart 6.13 • Winter Climatic Conditions (continued)

State	City	Elevation (ft.)	Outside Design Dry-Bulb Temp. (°F)d	Yearly Degree Days (Base 65°F)	Average Winter Temp. (°F)d
MI	Alpena	689	-5	8274	29.7
	Detroit	633	4	6422	37.2
	Escanaba	594	-7	8481	29.6
	Grand Rapids	681	2	6896	34.9
	Lansing	852	2	7098	34.8
	Marquette	677	-8	9712	30.2
	Sault Ste. Marie	721	-12	9224	27.7
MN	Duluth	1426	-19	9724	23.4
	Minneapolis-St. Paul	822	-14	7876	28.3
	Rochester	1297	-17	8308	28.8
MS	Meridian	294	20	2352	55.4
	Vicksburg	234	23	2041	56.9
MO	Columbia	778	2	5177	42.3
	Kansas City	742	4	5249	43.9
	St. Louis	465	7	4758	44.8
	Springfield	1265	5	4602	44.5
MT	Billings	3567	-10	7006	34.5
	Butte	5526	-24	8996	31.2
	Great Falls	3664	-20	7828	32.8
	Havre	2488	-22	8250	29.8
	Helena	3893	-17	7975	31.1
	Miles City	2629	-19	7723	31.2
NE	Lincoln	1150	-5	6242	38.8
	North Platte	2779	-6	6766	35.5
	Omaha	978	-5	6153	35.6
	Scottsbluff	3950	-8	6742	35.9
NV	Elko	5075	-13	7181	34.0
	Las Vegas	2162	23	2239	53.5
	Reno	4490	12	5600	39.3
	Winnemucca	4299	1	6271	36.7
NH	Concord	339	-11	7478	33.0
NJ	Atlantic City	11	14	5113	43.2
	Newark	11	11	4843	42.8
	Trenton	144	12	4980	42.4
NM	Albuquerque	5310	14	4281	45.0
	Roswell	3643	16	3332	47.5
NY	Albany	19	1	6860	37.2
	Binghamton	858	-2	7237	36.6

Chart 6.13 • Winter Climatic Conditions (continued)

State	City	Elevation (ft.)	Outside Design Dry-Bulb Temp. (°F)d	Yearly Degree Days (Base 65°F)	Average Winter Temp. (°F)d
NY	Buffalo	705	3	6692	34.5
	New York	132	11	4947	42.8
	Rochester	543	2	6728	35.4
	Schenectady	217	-5	6650	35.4
	Syracuse	424	-2	6803	35.2
NC	Asheville	2170	13	4326	46.7
	Charlotte	735	18	3162	50.4
	Greensboro	897	14	3848	47.5
	Raleigh	433	16	3465	49.4
	Wilmington	30	23	2429	54.6
ND	Bismark	1647	-24	8802	26.6
	Devils Lake	1471	-23	9901	22.4
	Fargo	900	-22	9092	24.8
	Williston	1877	-21	9044	25.2
OH	Akron	1210	1	6154	38.1
	Cincinatti	761	8	4410	45.1
	Cleveland	777	2	6121	37.2
	Columbus	812	2	5492	41.5
	Dayton	997	0	5690	39.8
	Mansfield	1297	1	6364	36.9
	Sandusky	606	4	5796	39.1
	Toledo	676	1	6460	36.4
	Youngstown	1178	1	6451	36.8
OK	Oklahoma City	1280	11	3663	48.3
	Tulsa	650	12	3642	47.7
OR	Eugene	364	22	4786	45.6
	Medford	1298	21	4539	43.2
	Portland	21	21	4400	47.4
	Rosenburg	505	25	4491	46.3
PA	Erie	732	7	6243	36.8
	Harrisburg	335	9	5201	41.2
	Philadelphia	7	11	4759	44.5
	Pittsburgh	749	7	5829	42.2
	Reading	226	6	4945	42.4
	Scranton	940	2	6254	37.2
RI	Providence	55	6	5754	38.8

Chart 6.13 • Winter Climatic Conditions (continued)

State	City	Elevation (ft.)	Outside Design Dry-Bulb Temp. (°F)d	Yearly Degree Days (Base 65°F)	Average Winter Temp. (°F)d
SC	Charleston	9	26	2005	59.9
	Columbia	217	20	2594	54.0
	Greenville-Spartanburg	816	18	3272	51.6
SD	Huron	1282	-16	7834	28.8
	Rapid City	3165	-9	7211	33.4
	Sioux Falls	1420	-14	7812	30.6
TN	Chattanooga	670	15	3427	50.3
	Knoxville	980	13	3690	49.2
	Memphis	263	17	3041	50.5
	Nashville	577	12	3677	48.9
TX	Abilene	1759	17	2659	53.9
	Amarillo	3607	8	4318	47.0
	Austin	597	25	1648	59.1
	Brownsville	16	36	644	67.7
	Corpus Christi	43	32	950	64.6
	Dallas-Fort Worth	481	19	2370	55.3
	El Paso	3918	21	2543	52.9
	Galveston	5	32	1008	62.2
	Houston	158	29	1525	62.0
	Port Arthur	16	29	1447	60.5
	San Antonio	792	25	1573	60.1
	Waco	500	21	2164	57.2
UT	Salt Lake City	4220	5	5631	38.4
VT	Burlington	331	-12	7665	29.4
VA	Lynchburg	947	15	4354	46.0
	Norfolk	26	20	3368	49.2
	Richmond	162	14	3919	47.3
	Roanoke	1174	15	4284	46.1
WA	Seattle-Tacoma	386	20	4797	44.2
	Seattle	14	28	4615	46.9
	Spokane	2357	-2	6820	36.5
	Walla Walla	1185	12	4882	43.8
	Yakima	1061	6	6104	39.1
WV	Charleston	939	9	4644	44.8
	Elkins	1970	1	6036	40.1
	Huntington	565	10	4583	45.0
	Parkersburg	615	8	4754	43.5

Chart 6.13 • Winter Climatic Conditions (continued)

State	City	Elevation (ft.)	Outside Design Dry-Bulb Temp. (°F)d	Yearly Degree Days (Base 65°F)	Average Winter Temp. (°F)d
WI	Green Bay	683	-12	7963	30.3
	La Crosse	652	-12	7340	31.5
	Madison	858	-9	7493	30.9
	Milwaukee	672	-6	7087	32.6
WY	Cheyenne	6126	-6	7388	34.2
	Lander	5593	-16	7790	31.4
	Sheridan	3942	-12	7721	32.5

NOTES:

A. Abstracted from Table 1 - Climatic Conditions for the United States and Canada, Chapter 22, ASHRAE Handbook of Fundamentals, 1967.

B. The values for outside design dry-bulb temperatures listed here are those established by ASHRAE Handbook of Fundamentals, 1967, as the temperature which equaled or exceeded 99% of the total hours in December, January, and February for a normal winter. These are the values in most common use for most industrial and commercial buildings, however; the complete ASHRAE values are included in the ASHRAE Handbook of Fundamentals, 1967, and should be consulted under the following conditions:

- If the structure has a low heat capacity, is not insulated, has more than normal glass area, or is occupied during the coldest part of the day, the Median of Extremes should probably be selected as the outdoor design temperature. A moderate heat capacity, some internal load, and daytime occupancy would indicate the 99% value as a reasonable choice. Massive institutional buildings with little glass can usually be designed from the 97.5% value.
- Before reaching a final decision on the outdoor design temperature, the designer must keep in mind that if the outdoor design temperature difference is exceeded, the indoor temperature may fall. This is dependent upon the thermal mass of the structure, its contents, and upon whether or not the internal load was taken into account in the calculations.
- Finally, there is a factor, perhaps intangible, that should not be ignored. It is the performance expected by the owner from the system. In order to judge whether or not expected performance can be assured, the designer needs a full understanding of the basis on which the capacities of all the system components are derived or determined, the limits of accuracy of published performance data, and the accelerating capability of certain types of equipment. There is no substitute for experienced engineering judgment in problems of this type.

C. Abstracted from Table 2, Chapter 40, ASHRAE Guide and Data Book, 1970.

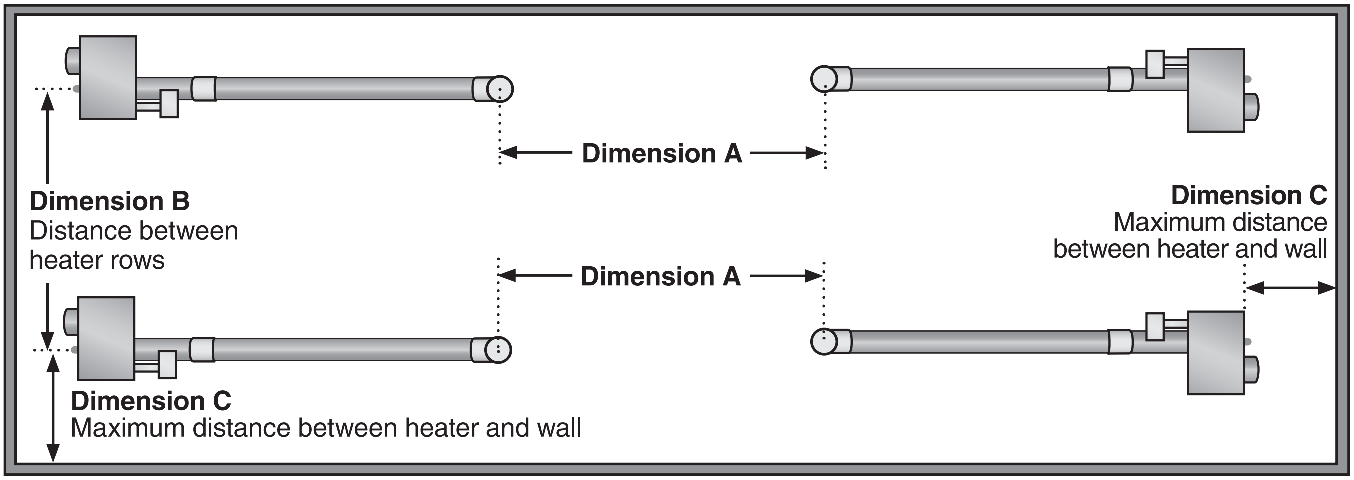
D. For Period from October to April, inclusive.

Chart 6.14 • Recommended Mounting Heights and Coverages - Low Intensity Heater

NOTE: This chart is provided as a guideline. Actual conditions may dictate variation for this data.

Model	BTU Range	Recommended Mounting Height (ft.)	Coverage Straight Config. (LxW)	Coverage U-Tube Config. (LxW)	Distance Between Heaters (ft.) Dimension A	Distance Between Heater Rows (ft.) Dimension B	Maximum Distance Between Heaters and Wall (ft.) Dimension C
10 ft	25-40 MBH	8' - 11'	10' x 10'	N/A	10' - 20'	20' - 40'	15'
20 ft.	50-65 MBH	10' - 16'	20' x 12'	12' x 12'	10' - 20'	20' - 40'	16'
	75-100 MBH	12' - 20'	22' x 15'	N/A	20' - 30'	30' - 50'	18'
30 ft.	50-65 MBH	10' - 16'	30' x 14'	17' x 13'	10' - 20'	20' - 40'	17'
	75 -100 MBH	12' - 20'	33' x 18'	18' x 15'	20' - 30'	30' - 50'	20'
	125 MBH	13' - 20'	33' x 18'	18' x 15'	20' - 30'	30' - 50'	20'
40 ft.	50-65 MBH	10' - 16'	40' x 16'	22' x 14'	10' - 20'	20' - 40'	20'
	75-125 MBH	12' - 20'	44' x 21'	23' x 17'	20' - 30'	30' - 50'	20'
	150-175 MBH	16' - 30'	45' x 26'	24' x 20'	30' - 40'	40' - 60'	25'
50 ft.	100-125 MBH	15' - 25'	55' x 24'	28' x 19'	20' - 30'	30' - 50'	25'
	150-200 MBH	16' - 30'	56' x 30'	29' x 23'	30' - 40'	40' - 60'	25'
60 ft.	125 MBH	16' - 25'	66' x 27'	33' x 21'	20' - 30'	30' - 50'	25'
	150-200 MBH	17' - 40'	67' x 34'	34' x 26'	30' - 40'	40' - 60'	25'
70 ft.	175-200 MBH	17' - 40'	78' x 38'	39' x 29'	30' - 40'	40' - 60'	30'
80 ft.	200 MBH	18' - 45'	89' x 42'	44' x 32'	30' - 40'	40' - 60'	30'

Figure 6.2 • **Mounting Height Dimensions** (see Chart 6.14 for measurements)

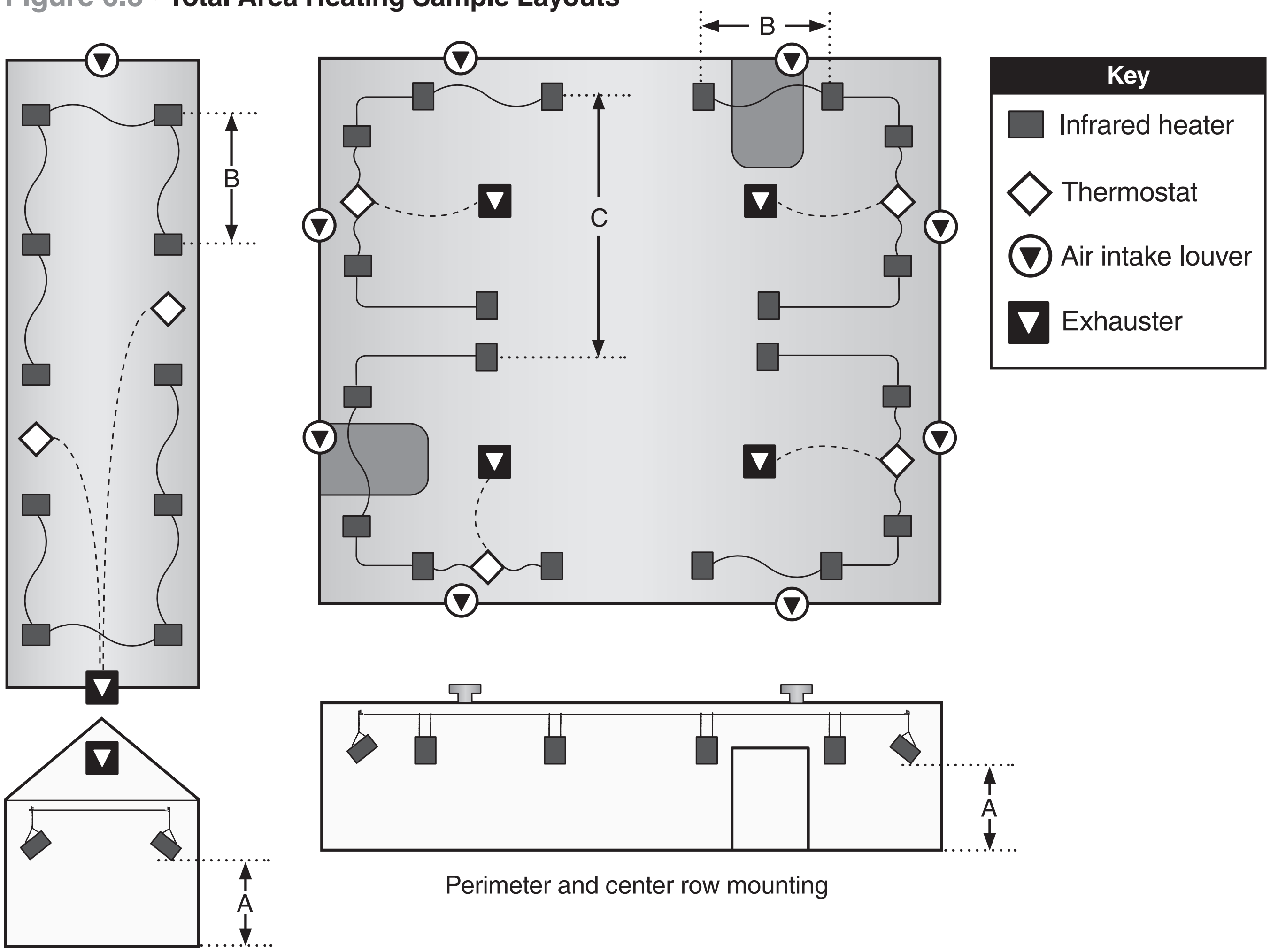


APPENDIXES

Chart 6.15 • Recommended Mounting Heights - High Intensity Heater

Model No.	Mounting Heights Dim. A: 30º Angle Standard Reflector (ft.)	Mounting Heights Dim. A: 30º Angle Parabolic Reflector (ft.)	Distance Between Heaters Dim. B (ft.)	Distance Between Heater Rows Dim. C (ft.)	Distance Between Heater and Wall (ft.)
DR 30(S)	12-14	12-15	8-24	15-40	4-8
DR 45	12-14	16-19	12-36	15-55	6-12
DR 50	12-14	17-20	12-36	15-55	6-12
DR 55	13-15	18-21	12-36	15-55	6-12
DR 60	14-16	18-21	12-36	15-55	6-12
DR 75	15-17	19-22	16-48	20-70	6-12
DR 80	15-17	19-22	16-48	20-70	6-12
DR 85	16-18	21-25	16-48	20-70	6-12
DR 90	16-18	21-25	16-48	20-70	6-12
DR 95	17-20	21-25	16-48	20-70	6-12
DR 100	17-20	23-27	16-48	20-70	6-12
DR 130	21-24	26-32	20-60	25-85	8-14
DR 160	24-28	29-35	24-65	30-100	8-14

Figure 6.3 • Total Area Heating Sample Layouts



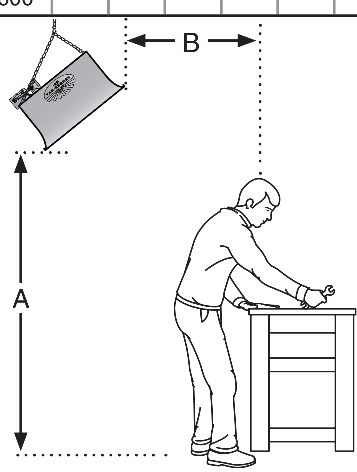
Perimeter and center row mounting

Perimeter mounting

Chart 6.16 • Recommended Mounting Heights - Spot Heater (High Intensity)

Model & Input	Type of Area (Surroundings)	Approx. Area Covered	Approx. Coverage (sq. ft.)	Recommended Mounting Height (Dim. A)											Distance Behind Person or Work Station (Dim. B)	Centers for Full Coverage (Spot & Area) Htg. Only
				10’	12’	14’	16’	18’	20’	22’	24’	26’	28’	30’		
DR-30	Cold/Drafty	10’ x 10’	100	9’											4’	10’
30,000	Average	12’ x 12’	144	10’	12’										5’	12’
BTU/h	Protected/Insul.	14’ x 14’	196		12’	14’									6’	14’
DR-45	Cold/Drafty	12’ x 12’	144	10’	12’										5’	12’
45,000	Average	14’ x 14’	196		12’	14’									6’	14’
BTU/h	Protected/Insul.	16’ x 16’	256			14’	16’								7’	16’
DR-60	Cold/Drafty	16’ x 16’	256		12’	14’									6’	16’
60,000	Average	18’ x 18’	324			14’	16’								7’	18’
BTU/h	Protected/Insul.	20’ x 20’	400				16’	18’							8’	20’
DR-75	Cold/Drafty	18’ x 18’	324			14’	16’								7’	18’
75,000	Average	22’ x 22’	484				16’	18’							8’	22’
BTU/h	Protected/Insul.	26’ x 26’	676					18’	20’						9’	24’
DR-90	Cold/Drafty	20’ x 20’	400				16’	18’							9’	20’
90,000	Average	24’ x 24’	576					18’	20’						10’	24’
BTU/h	Protected/Insul.	28’ x 28’	784						20’						11’	26’
DR-95	Cold/Drafty	24’ x 24’	576					18’							10’	24’
95,000	Average	28‘ x 28’	784					18’	20’						11’	26’
BTU/h	Protected/Insul.	32’ x 32’	1024						20’						12’	26’
DR-100	Cold/Drafty	24’ x 24’	576					18’							10’	24’
100,000	Average	28‘ x 28’	784					18’	20’						11’	26’
BTU/h	Protected/Insul.	32’ x 32’	1024						20’						12’	30’
DR-130	Cold/Drafty	26’ x 26’	676					18’							11’	26’
130,000	Average	30’ x 30’	900					18’	20’						12’	28’
BTU/h	Protected/Insul.	35’ x 35’	1225						20’	22’					13’	32’
DR-160	Cold/Drafty	28’ x 28’	784						20’	22’					12’	28’
160,000	Average	35’ x 35’	1225								24’	26’			16’	32’
BTU/h	Protected/Insul.	40’ x 40’	1600										28’	30’	20’	35’

Figure 6.4 • **Spot Heater Heights**



APPENDIXES

7.0 Field Terminology

Absorptivity: An inherent property of a material evaluated by the ratio of the radiant energy absorbed to that falling upon it. It is equal to the emissivity for radiation of the same wave length.

Air Change: 1. Introduction of new, cleansed or recirculated air to a space. 2. A method of expressing the amount of air movement into or out of a building or room in terms of the number of building volumes or room volumes exchanged in unit time.

Air Inlet Collar (AIC): An adjustable device for varying the size of the primary air inlet(s).

Aluminized Steel: Steel having resistance to oxidation due to formation of an aluminum/aluminum alloy coating by hot dipping, hot spraying or diffusion processes. Emissivity typical 0.45-0.55 (untreated), 0.7-0.8 (heat treated).

Ambient Air: The surrounding air (usually outdoor air or the air in an enclosure under study).

Annual Fuel Utilization Efficiency (AFUE): The ratio of annual output energy to annual input energy which includes any non-heating season pilot input loss.

Atmospheric Burner: A device for the final conveyance of the gas, or a mixture of gas and air at atmospheric pressure, to the combustion zone.

Blackbody: 1. A body that absorbs all the radiant energy falling upon it. 2. A body that has the maximum theoretical radiant energy emittance at a given absolute temperature.

British Thermal Unit (BTU) (An I-p Unit): The heat energy in a BTU was defined by the Fifth International Conference on the Properties of Steam (1956) as exactly 1 055.055 852 62 J. It was related through specific heat to the IT calorie so that 1 cal/kg·K = 1 BTU/lb·F for 1 lb = 453.592 37 g. The mechanical equivalent energy of a BTU is approximately 778.169 262 ft lb. The heat energy of a BTU is approximately that required to raise the temperature of a pound of water from 59°F to 60°F.

Burner Control Assembly: An assembly of various valves, burner head, ignition system, filter, etc. necessary to operate and control the burner.

Calculated Maximum Run: The longest allowable ‘Calculated Run’ from the burner to the exhauster including the condensing pipe.

Calculated Minimum Run: The minimum allowable ‘Calculated Run’.

Calculated Run: Calculated run is determined by adding the total ‘Single Flow’ plus one half of the ‘Common Flow’ of pipe.

Calculated Starting Point Of Condensing Run: The point in the ‘Calculated Run’ where condensing pipe must begin.

Calorized Steel: Steel having resistance to oxidation due to heating in an aluminum powder at 1472 to 1832°F. Emissivity typically 0.6.

Chimney: One or more passageways, vertical or nearly so, for conveying flue gases to the outside atmosphere.

Chimney Effect: The rising of air or gas in a duct or other vertical passage, as in buildings, induced when the density of air in the chimney is lower than that of surrounding air or gas.

CLO: A non-SI unit of clothing insulation defined as the thermal insulation necessary to keep a sitting person comfortable in a normally ventilated room at 70°F (21°C) and 50% relative humidity. In physical terms, the thermal resistance of one CLO = 0.88 F·ft2·h/BTU (0.155 K·m2/w).

Combustion Air: The air required for complete combustion of fuel, and usually consisting of primary air, secondary air and excess air.

Combustion Chamber: Portion of radiant tubing where combustion is occurring. A flame is found in this portion of tubing. Combustion chamber may be titanium or aluminized tubing, pending surface temperatures.

Comfort Chart: A chart showing dry-bulb temperatures, relative humidities and air motion so the effects of the various conditions on human comfort may be compared.

Comfort Zone: A condition in an environment or enclosure whereby a suitable operative temperature is maintained. The required range of operative temperature for human comfort is defined by the comfort chart (refer to ANSI 55-1981).

Common Flow: The radiant pipe in a run between the first intersection (Tee or Cross) and the exhauster. 'Common Flow' begins at the point where two (2) or more burners share a common exchanger. A section carrying the flow of combustion gases of more than one radiant branch.

Condensate: Liquid formed by condensation of a vapor. In combustion of hydrocarbon fuels, water condensed from flue products (this is typically slightly acidic). NOTE: Combustion of natural gas produces 11.2 gallons of condensate for each 1x106 BTU burned. Combustion of propane gas produces 8.9 gallons of condensate for each 1x106 BTU burned. Condensation begins at/below the dew point.

Condensation: The change of state of a vapor into a liquid by extracting heat from the vapor.

Conduction (Heat Conduction): Process of heat transfer through a solid.

Control, Single Stage: A control that cycles a burner from the maximum heat input rate and off.

Convection: 1. Transfer of heat by a fluid moving by natural variations in density. 2. Transfer of heat by the movement of a fluid.

Forced Thermal Convection: Heat transmission by mechanically induced movement of fluid.

Free Thermal Convection (Natural Convection): Heat transmission by movement of a fluid caused by density difference.

Coupling: A device used to connect sections of tubing.

Coupling, Damper: A coupling with a damper. This is installed where needed to adjust the vacuum in a system.

Decorative Grille: A 1/2" square honeycomb aluminum grille installed below the radiant tube. This is for decorative purposes only. A one foot wide model installs directly on the reflector. A two foot wide model installs in a suspended ceiling.

Degree Day: A unit of accumulated temperature departure, based on temperature difference and time. Used in estimating fuel consumption and specifying nominal heating load of a building in winter. For any one day, the number of degree days of temperature difference between a given base temperature usually 65°F (18.30°C) (18.00°C in Canada) and the mean outside temperature over 24 hours.

Dew Point: Temperature at which water vapor is saturated (100% relative humidity). **NOTE**: It is improper to refer to the dew point as the temperature at which condensation starts to occur, because condensation at the dew point requires removal of latent heat from the vapor to induce condensation, and this can occur only if the vapor is cooled below the dew point. Conversely, if condensation has occurred, it will not evaporate until the latent heat has been returned to the liquid phase.

Direct Exhaust System: A mechanical venting system supplied or recommended by the manufacturer through which the products of combustion pass directly from the furnace, heater, or boiler to the outside and which does not employ a means of draft relief.

Direct Vent System: A system consisting of (1) a central furnace, heater or boiler for indoor installation, (2) combustion air connections between the furnace, heater or boiler, and the outdoor atmosphere, (3) flue gas connections between the furnace, heater or boiler and the vent cap, (4) vent cap for installation outdoors, supplied by the manufacturer and constructed so all air for combustion is obtained from the outdoor atmosphere and all flue gases are discharged to the outdoor atmosphere.

Draft Hood: A device installed on gas-fired appliances designed to protect the appliance from chimney draft disturbances.

Dry-bulb Temperature: The temperature of air indicated by an ordinary thermometer.

Dual Fuel Burner: A burner design with two separate orifices and gas trains for both pilot gas flow and main gas flow. This permits a fuel conversion to be made by selective energizing of the gas trains (i.e. and without physical change of orifices).

Efficiency: The ratio of the energy output to the energy input of a process or a machine.

Efficiency, Thermal: The ratio of the useful/available energy at the point of use to the thermal energy input over a designated time.

Efficiency, Radiant: The measure of the percentage of gross BTU input that is realized/available as direct radiant BTU output.

Emissivity (E) : The ratio of the radiant energy emitted by a surface to that emitted by a blackbody at the same temperature. (Perfect blackbody emissivity (e) = 1, perfect reflector (e)=0).

Excess Air: In combustion, the percent of air greater than that required to completely oxidize the fuel.

Flow Unit: The amount of fuel-air mixture required for firing at the rate of 10,000 BTU/h. This would equal 1.83 SCFM. Flow units are used as a measure of flow rate for both combustion air and the air entering through the end vent.

Flue: The general term for the passages and conduits through which flue gases pass from the combustion chamber to the outer air.

Flue Gases: Products of combustion and excess air.

Flue Losses: The sensible heat and latent heat above room temperature of flue gases leaving the appliance.

Forced Draft: Combustion air supplied under pressure to the fuel burning equipment.

Gas Connector Assembly: A semi-rigid or flexible connection between the gas line and the burner control assembly. This includes a shut off valve with 1/2" female pipe connection.

Halogenated Hydrocarbon Compounds: Hydrocarbon compounds which contain halogen elements such as hydrogen, chlorine, fluorine, bromine, and iodine. These are generally non-corrosive until after being heated at several hundred degrees (as during a combustion process). At this point, a decomposition takes place, freeing halogen compounds. When these compounds are combined with moisture from combustion products, extremely corrosive acids are formed.

Heat: A form of energy that is exchanged between a system and its environment or between parts of the system induced by temperature difference existing between them.

Heat Gain: The quantity of heat absorbed by an enclosed space or system.

Heat, Latent: Heat given off or absorbed in a process other than a change of temperature.

Heat Reservoir: An ideal system that can absorb or reject an indefinitely large amount of heat.

Heating Value, Higher (HHV): The heat produced per unit of fuel when complete combustion takes place at constant pressure and the products of combustion are cooled to the initial temperature of the fuel and air and when the vapor formed during combustion is condensed.

Heating Value, Lower (LHV): The gross heating value minus the latent heat of vaporization of the water vapor formed by the combustion of the hydrogen in the fuel.

Induced Draft: Drawing air from the combustion chamber by mechanical means.

Inductive Load: An alternating current load in which current lags voltage.

Infiltration: The uncontrolled inward air leakage through cracks and crevices in any building element and around windows and doors of a building, caused by the pressure effects of wind or the effect of differences in the indoor and outdoor air density.

Liquefied Petroleum Gases: The terms "Liquefied Petroleum Gases", "LPG" and "LP-Gas" include any material which is composed predominantly of any of the following hydrocarbons, or mixtures of them; propane, propylene, butanes (normal butane or isobutane), and butylenes. This high heating value gas is stored under high pressure in liquid form.

Make-up Air: Air brought into a building from the outside to replace that exhausted.

Mean Radiant Temperature (MRT): The single temperature of all enclosing surfaces which would result in the same heat emission as the same surfaces with various different temperatures.

Minimum Distance to Elbow or Intersection: The minimum allowable distance from the burner box to the first intersection.

Orifice: The opening in an orifice cap, orifice spud or other device whereby the flow of gas is limited and through which the gas is discharged.

Orsat Apparatus: A gas analyzer based on absorption of CO_2, O_2, etc. by separate chemicals that have a selective affinity for each of those gases.

Power Burner: A burner in which either gas, air, or both, are supplied at pressures exceeding the line pressure for gas and atmospheric pressure for air. This added pressure is applied at the burner.

Primary Air: The air introduced into a burner which mixes with the gas before it reaches the port(s).

Pyranometer: An instrument that measures the combined direct and indirect radiation by means of a calibrated sensing element.

Radiant Branch: A section of radiant pipe with one or more burners firing.

Radiation: The transfer of energy in wave form from a hot substance to another independent substance cooler in temperature with no material means of heat transfer.

Radiant Tube: The section(s) of tubing, following the combustion chamber, downstream from the burner. This section of tubing is typically aluminized steel or hot rolled steel.

Reflector: A device configured to direct radiant energy to the point of use in the space while absorbing minimal energy.

Reflector Center Support: A device that orients and maintains the reflector.

Residential Application: Providing comfort heating for a building that is attached to living quarters.

Resistive Load: 1. An electric load without capacitance or induction or one in which inductive portions cancel capacitive portions at the operating frequency. 2. An electric load with all energy input converted to heat.

Run: The total actual length of radiant pipe from the individual burner box to the exhauster.

Single Flow: The radiant pipe in a run from the burner box to the first intersection (Tee or Cross). A section carrying the flow of combustion gases of only one radiant branch.

Single Fuel Burner: This is the standard burner in which the pilot and main orifices can be changed to fire with either natural gas or propane. No change is required in the regulator settings.

Stack: A structure that contains a flue, or flues, for the discharge of gases.

Stack Effect: The impulse of a heated gas to rise in a vertical passage such as in a chimney, small enclosure or building due to density differences.

Stack Gases: The mixture of flue gases and air that enters at the draft diverter, draft hood, integral draft diverter or stack.

Stainless Steel: Any of several steels containing 12 to 30% chromium as the principle alloying element; they usually exhibit passivity in aqueous environments; providing corrosion resistance. Typical emissivity (e)=0.45.

Stoichiometric Combustion (Perfect Combustion): Fuel burning completely; all combustible is consumed with no excess air. Only the theoretical amount of oxygen is used (chemically correct ratio of fuel to air).

Stratification: Division into a series of graded layers, as with thermal gradients across a stream.

Tail Pipe: The section of tubing connecting the last section of radiant tubing in a series of burners to the vacuum pump.

Therm: A quantity of heat equal to 100,000 BTU's or 100 cubic feet.

Thermal Expansion: Increase in one or more of the dimensions of a body, caused by a temperature rise.

U-Factor: 1. Fuel use factor per 1000 BTU/h calculated heat loss. 2. The time rate of heat flow per unit area under steady conditions from the fluid on the warm side of a barrier to the fluid on the cold side, per unit temperature difference between the two fluids. It is evaluated by first evaluating the R-value and then computing its reciprocal.

Vacuum System: A complete combustion system consisting of one vacuum pump, a number of burners, 1 control panel, a number of thermostats and 4 inch O.D. steel tubing for heat exchanger surface in the form of radiant pipe plus assorted reflectors and other hardware. The number of such system required is based primarily on the heat loss of the building.

Vent/Air Intake Terminal: A device which is located on the outside of a building and is connected to a furnace, boiler or heater by a system of conduits. It is composed of an air intake terminal through which air for combustion is taken from the outside atmosphere, and an exhaust terminal from which flue gases are discharged.

Vent Pipe: Passages and conduits in a direct vent system through which gases pass from the combustion chamber to the outdoor air.

Zone (Control Zone): A space or group of spaces within a building with heating or cooling requirements where comfort conditions can be maintained by a single controlling device.

Building Survey Form

This information must be fully completed to compute an accurate building heat loss. Duplicate this sheet as necessary

Local Representative or Distributor:

Client Data

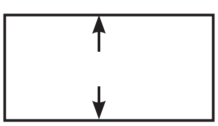
Name: ______________________ **Street**: ______________________

Phone: ______________________ **City**: ______________________

E-mail: ______________________ **State**: ______________________

Floor Plan (Include dimensions, location of all doors and windows)

Elevation Details: (Note dimensions and interior obstructions)



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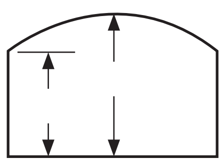

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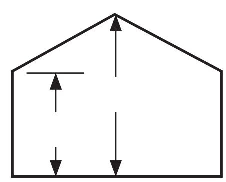

☐ Pitched

Building Details:

Building Function:

- ☐ Manufacturing
- ☐ Car Wash
- ☐ Warehouse
- ☐ Fire Station
- ☐ Other: ________

Doors:

- ☐ Roll up
- ☐ Insulated
- ☐ Un-Insulated
- ☐ Track
- ☐ Activity: _______

Walls:

- ☐ Materials: _______
- ☐ Insulation: _______
- ☐ R Value: _______

Roofs:

- ☐ Materials: _______
- ☐ Insulation: _______
- ☐ R Value: _______

Type of Heating:

- ☐ Spot Heating
- ☐ Whole Building Heat

Slab Edge:

- ☐ Insulated
- ☐ Un-Insulated

Preferred Venting:

☐ Sidewall ☐ Roof

Desired Temp.:

____°

FORMS

Building Heat Loss Form

This information must be fully completed to compute an accurate building heat loss.

Required Data

Building Size	Length	x	Width	x	Height	=	Volume

Temperature Differential	Inside Desired Temp	-	Outside Design Temp	=	Delta T

Building Materials*	Size	x	U-factor (1/R)	x	Delta T	=	Heat Loss
Wall 1							
Wall 2							
Wall 3							
Roof							
Doors							
Windows							
Skylights							
Slab Edge							

* Grouping walls, doors and windows of a similar type as one is acceptable.

Natural Ventilation	Air Changes	x	Building Volume	x	U-factor	x	Delta T	=	Heat Loss

Special Considerations

Cold Mass	Weight (lbs.)	x	Specific Heat	x	Delta T	÷	Dwell Hours	=	Heat Loss

Mechanical Ventilation (cfm)	Fan Size (cfm)	x	60 (min/hr)	x	Specific Heat	=	Delta T	=	Heat Loss

Total Heat Loss

FORMS

NOTES:

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