Engineered Vacuum Systems

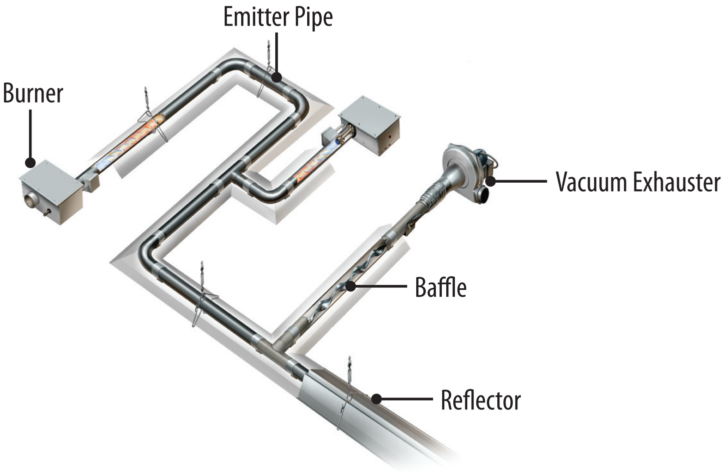
Engineered vacuum systems represent a small but important segment of the infrared market. More commonly found in larger applications, these systems offer potential operating benefits that are not easily obtainable with traditional infrared tube heaters.

While the benefits of choosing an engineered vacuum system are worth noting, so are the complexities. Therefore, careful consideration to the design, installation, operation and investment of an engineered vacuum system should be made.

Operating Theory

An engineered vacuum system emits low intensity infrared heat just like any other type of tubular heater. What makes these systems unique is the method in which they operate as well as their expanded operational boundaries.

An engineered vacuum system typically consists of the following components:



While each manufacturer will have their own design parameters, the theory behind vacuum system design is rather universal. The design goal of a vacuum system is to connect emitter tube extending from one or more burner assemblies to a vacuum pump. This is best achieved by applying the fundamentals of infrared design (see Chapter 3) with the required manufacturer's application design criteria (see page 7-6).

The operational objective of a vacuum system is to simply move hot gases from the burner(s) to the pump. This movement heats the emitter pipes, which in turn heat the building via infrared energy. This operation typically requires a higher capacity vacuum pump, capable of providing expanded system utility, as further described on the following pages.

Common Applications of Vacuum Systems


Aircraft Hangars


Distribution Facilities


Vehicle Storage


Fire Station Apparatus Bays

Burner Control Assembly

Some vacuum burners are limited in their BTU offering. Carefully choose inputs appropriate to your available mounting height and design needs.

Some vacuum burners utilize filters to avoid clogging of an internal ceramic burner. Changing burner filters is periodically required and can be a difficult and costly task. Outside combustion air in lieu of a filtered air intake design is recommended.

Vacuum Pump

Strategically locate the vacuum pump in an area where noise will not be of concern. Avoid the placement of pumps in contaminated, harsh or moisture laden environments.

Vacuum pumps are not created equally and often represent the most expensive and vital system component. Take time to learn the product, notably the horsepower, housing material, bearing type, shaft and impeller.

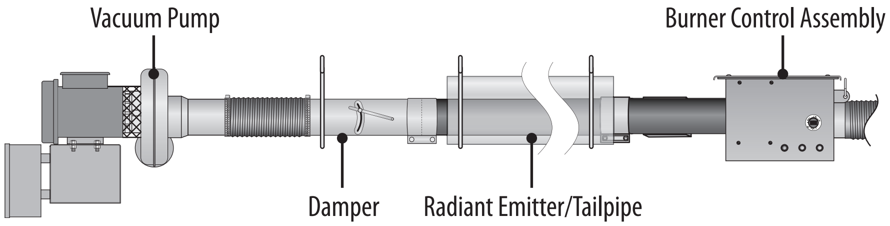
Emitter Pipe

The investment in a vacuum system warrants the use of quality tubes. Protect your investment by utilizing aluminized, titanium stabilized or stainless steel tubes and avoid less costly hot rolled or light gauge steel tubes.

Unlike ceramic coated hot rolled steel, stainless steel tailpipe will not crack and offers superior longevity and protection.

A swaged tube design will ensure system integrity and avoid the possibility of a clamp acting as the heat exchanger or as an unwanted condensate catch.

Key System Components



Burner Control Assembly

The burner control assembly will house key combustion components including the gas valve, safety switches, igniter and the burner. Typically, burner inputs range from 40,000 to 200,000 BTU's and have a minimum and maximum emitter length.

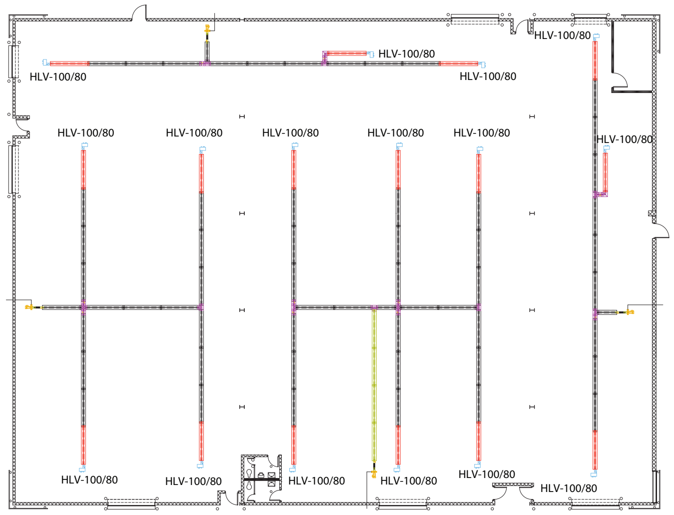
Vacuum Pump

The vacuum pump or exhauster is the device that transfers hot gases through the system by inducing a regulated suction onto the system. Typical vacuum pumps range from 0.5 to 1.0 HP and are selected according to total system BTU's and emitter lengths.

Emitter Pipe

Emitter or radiant pipe is the tubing that connects the burner assemblies to the pump. Typically 4 to 6 inches in diameter, this tubing is covered by a reflector and may be made of hot rolled, aluminized or titanium-stabilized steel. Condensing systems will utilize ceramic coated or stainless steel pipe (aka "tailpipe") designed to withstand the corrosive condensate that forms during normal operation.

Sample Vacuum System Application



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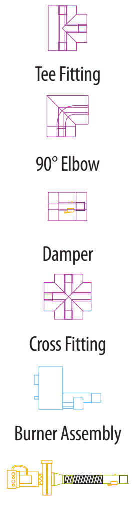


Color Legend:
Blue: Burner Box; **Red:** Combustion Tube; **Black:** Radiant Exchangers
Green: Stainless Steel Tailpipe; **Orange:** Vacuum Pump; **Purple:** Heater Accessories

Vacuum System Pros

- **Operating Efficiencies.** A vacuum system can be designed to achieve improved thermal efficiencies (see page 6-2). This is due to the fact that the system can be designed to condensate.
- **Reduced Vent Penetrations**. A vacuum system can tie multiple burners onto a single vacuum pump. Accordingly, the number of vent penetrations within the space may be reduced.
- **Extended Tube Lengths.** A vacuum system will best accommodate a design that employs extended runs of radiant emitter. This may be desirable in large applications or in applications where the vent penetration is a long distance from the pump.
- **Elevation Changes.** A vacuum system will allow for a design that requires an elevation change in the system itself. This may be necessary in unique, pitched or obstacle ridden applications.

Vacuum System Cons

- **Costly.** Vacuum systems are typically 30 – 50% more costly than a similar "push" tube design. A vacuum system requires a lot more components as well as a considerable installation and maintenance premium.
- **System Dependency.** A vacuum system is dependent upon a single pump. Should this pump fail, the entire system will be out of commission until a repair or replacement is completed.
- **Noise.** A vacuum pump typically generates noise that may be problematic in select applications. Considerations for this noise must be addressed in the design stages to avoid a future problem.
- **Complexities.** The design and installation complexities adherent to a vacuum system are many. Only a person knowledgeable of vacuum system designs should attempt to layout a system, conduct an installation and perform a system start-up.
- **Electrical Consumption.** Higher horsepower, higher amp, vacuum pump motors consume more electrical energy than a push tube system. This should be considered when selecting a system and when measuring overall operating efficiencies.

Considerations

Engineering: Most manufacturers offer an extensive vacuum system design guide that is necessary to follow carefully when designing an engineered vacuum system. A working knowledge of the manufacturer's guidelines is highly suggested when applying a vacuum system.

Environmental: By design, an infrared system offers energy saving benefits; most notably a reduction in fuel consumption. A condensing vacuum system offers the ability to achieve higher thermal efficiencies. However, consideration must be made for the disposal of the condensate, if generated.

Comfort: A properly designed infrared system (see Chapter 3) will result in optimal comfort levels. Considerations should be made when determining the location of the burner boxes, the condensate piping, and the vacuum pump. Location of these critical items impact the total comfort in the space.

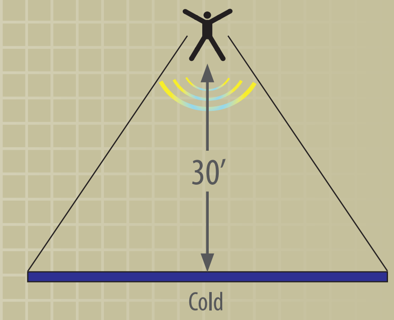
Installation: The installation of a vacuum system is more complex than typical "push tube" systems. Notable differences may include starting the installation at the pump and building backwards, slope consideration, elevation changes, damper locations, tees, elbows and many other peripheral items.

Start-Up: A vacuum system requires a thorough and proper start-up by a professional. The start-up includes system balancing, establishing proper box pressures and control programming.

Consider This...

A vacuum system operating at maximum lengths will likely condensate and requires the use of condensate pipe or "tailpipe". Tailpipe is often one of the most expensive portions of a vacuum system, yet it yields minimal radiant output.

Our normal body temperature is 98.7°F. Tailpipe will operate at a similar temperature if the system is condensing. Commonly mounted 30-feet in the air, one must ask how effective the radiant output is for this portion of the system.



Economic Example

Assumptions:

- Cost p/ Therm - (100 MBH) @ $1.00
- Degree Days - 2270 (Detroit @ 45°F)
- No Night Setback
- 100% Building Occupancy

System A (Dry):

Acquisition Cost:	$20,000
Thermal Eff.:	82%
BTU Input:	400,000
BTU Output:	328,000
Operating Cost:	$11,073 p/annum

System B (Wet):

Acquisition Cost:	$32,000
Thermal Eff.:	90%
BTU Input:	400,000
BTU Output:	360,000
Operating Cost:	$10,089 p/annum

Payback:

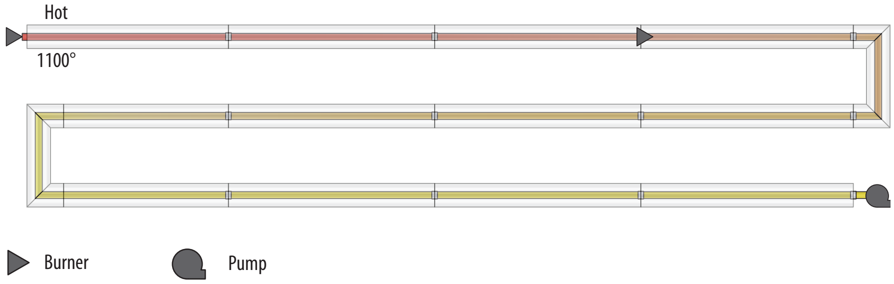
Difference A vs. B:	$12,000
Annual Savings A vs. B:	$984
Payback in Years:	12.20

Dry Systems

A dry system would be defined as a system that maintains operating stack temperatures above the point of condensation. The following characteristics are typical to a dry system:

- Shorter burner to pump lengths.
- System completely covered by reflectors.
- A more even radiant heat emittance from the system.
- Lower thermal efficiencies.

System A: Non-Condensing System

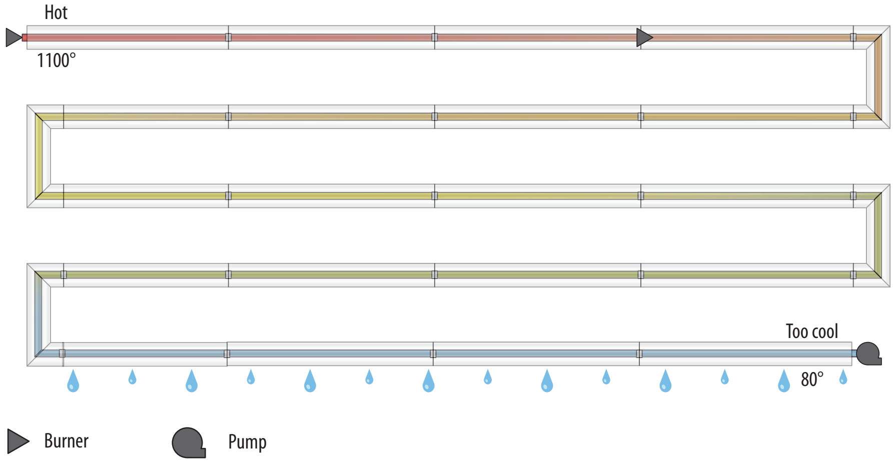


Condensing Systems

A wet system would be defined as a system that maintains operating stack temperatures below the point of condensation. The following characteristics are typical to a wet system:

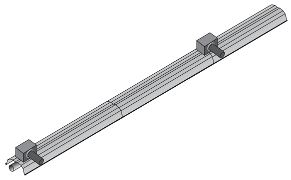
- Longer burner to pump lengths.
- Uncovered condensate or tailpipe.
- A sloped system with a condensate trap.
- A less even radiant heat emittance from the system.
- Higher thermal efficiencies.

System B: Condensing System

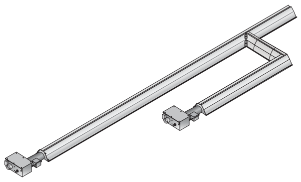


In-Series vs. Tandem Burner Design

“In-series” burners describe a system footprint where the burners are physically located inline with the emitter pipe. Tandem burners emulate an in-series design, but are purposely located directly adjacent to the emitter pipe for operating purposes.



In-Series Design



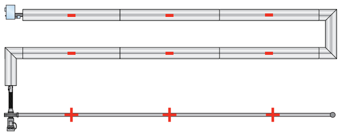
Tandem Design

Features

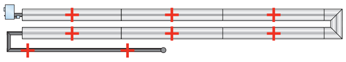
	In-Series	Tandem
Design Parameters	Flexible per Design Guide	Flexible per Design Guide
Burner Filters	Pending Burner Design	Typically Not Required
Upstream Gases	Will Impact Upstream Burner	Will Bypass Upstream Burner
BTU's	Typically Small to Mid Range	Typically Small to Large Range

Positive vs. Negative Pressure Operation

Infrared tube heaters employ both negative and positive pressure to move their products of combustion. Both methods will yield similar operating results and operating efficiencies. When choosing one method over the other one should carefully consider the overall design objectives and choose the system type best able to complete the intended purpose.



Negative System



Positive System

Features

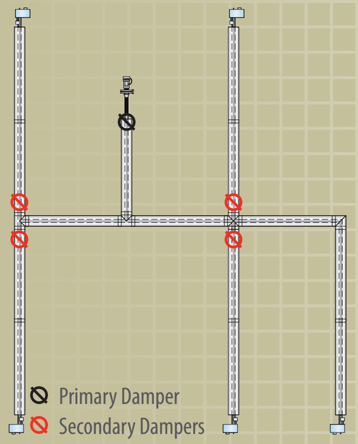
	Negative	Positive
Condensing Option	Optional with Tailpipe	Not Available
Elevation Changes	Optional	Not Typical
Fixture Efficiency	70% Min. to 92% Max.	70% Min. to Typ. 86% Max.
Safety	Certified to ANSI Z83.20	Certified to ANSI Z83.20
Unvented Use	Optional	Optional
Venting Lengths	Longest Length	Shorter Lengths
Venting Pipe	Under Positive Pressure	Under Positive Pressure

Other Considerations

Dampers:

A ***primary damper*** is used in every system and is placed before the vacuum pump.

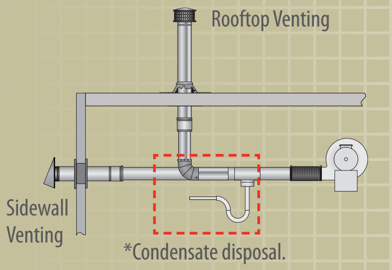
Secondary dampers are required when there are variances in burner gas input and/or radiant tube runs. These are necessary to balance the system’s exhaust flow.



Venting & Air Intake:

Vacuum systems allow for a reduced number of roof penetrations.

Provide fresh air for combustion when negative building pressure or chemicals are present in the space.



*Condensate Traps:

Condensate traps are required on wet systems that are vented through the roof. They are not required when venting through the sidewall unless specified by the local body having jurisdiction.

Design Definitions

Calculated Maximum Run:
The longest allowable 'Calculated Run' from any burner to the vacuum pump, including condensing pipe.

Calculated Minimum Run:
The shortest allowable 'Calculated Run' from any burner to the vacuum pump, including condensing pipe.

Calculated Run:
Calculated run is determined by adding the total 'Single Flow' plus one-half of the 'Common Flow' of tubing or pipe.

Calculated Starting Point of Condensing:
The point in the 'Calculated Run' where condensing pipe must begin.

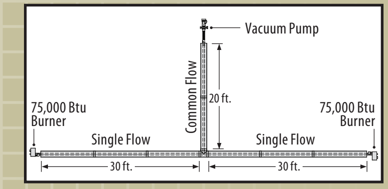
Minimum Distance to Fitting:
The minimum allowable distance from a burner to the first elbow or intersection.

Run:
The total actual length of tube or pipe from an individual burner to the vacuum pump.

Single Flow:
The tube or pipe in a run from the burner to the first intersection.

Common Flow:
The tube or pipe in a run between the first intersection and the vacuum pump. 'Common Flow' begins at the point where two or more burners share common tube or pipe.

Single and Common Flow Diagram



Design for Non-Condensing Systems

System tube lengths are determined by the gas input (BTU/h) of each burner. The chart below illustrates sample system design parameters for each burner model used in each system. When calculating tube lengths, do not add in elbow and tee fittings as they have been accounted for.

Designing a non-condensing system can be fairly straightforward given the following steps are properly applied. In addition to these steps, an understanding of the design definitions is critical.

1. Begin by designing a tentative layout without regard to design parameters. Use this approach to place each burner and the vacuum pump where most desired.

2. Once a tentative layout has been established, confirm that each run in the system meets the criteria for 'Calculated Minimum Run'. 'Calculated Minimum Run' is determined by adding the total 'Single Flow' plus one-half of the 'Common Flow'.

   - If the system does not meet the 'Calculated Minimum Run', length must be added to the run until all burners meet the design parameters.
   - If the run exceeds the 'Calculated Maximum Run', it will be necessary to either make the system a condensing system or shorten the runs which exceed this criteria.

3. Confirm the following applies (non-condensing systems only):

   a) A maximum of two elbows per run are allowed.
   b) A maximum of three intersections (tees or crosses) are allowed per system.
   c) All elbows and intersections less than 20 feet from a burner require a reflector.

Sample Design Parameters

Burner MBH Input	Minimum Distance to Elbow or Intersection	Calculated Minimum Run	Calculated Starting Point of Condensing	Calculated Maximum Run
40-60	10 ft.	30	45	85
75-80	10 ft.	35	50	95
90-100	10 ft.	40	55	105
110-125	10 ft.	45	60	110
140-150	15 ft.	50	65	120
170-180	15 ft.	55	70	130
200	20 ft.	60	75	140

For complete design information, refer to the HLV Series Design Manual (F/N: LIOHLV).