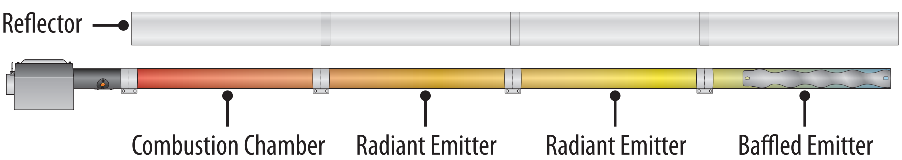
Construction Properties

Let's examine a low intensity tube heater.



An infrared tube heater is made up of a series of interconnected emitter tubes with a reflector(s) placed over the top. Collectively, these elements emit and direct heat for use in the intended space. Not all heaters are made alike and an understanding of the core components is important when selecting the product.

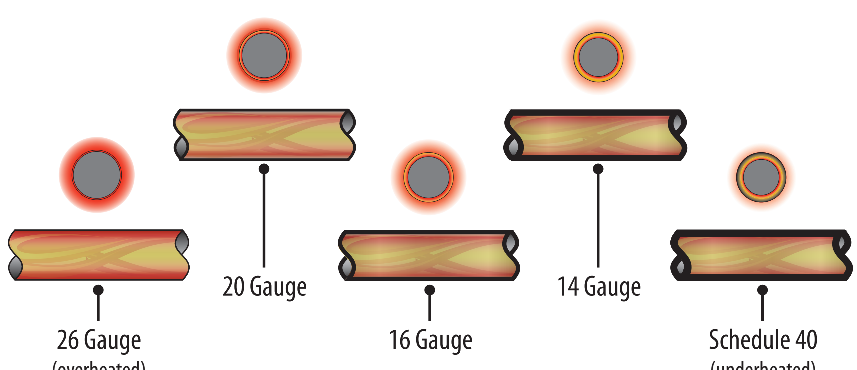
Radiant Heat Exchanger - What Matters

Tube exchanger material selection plays a vital role in the comfort, performance and longevity of a low intensity infrared heater. Let's examine the following product design considerations.

- **Thermal Conductivity:** The ability to transfer heat through a material, allowing for a greater transfer of heat energy. Different tube materials and thicknesses will have their own emissive characteristics.
- **Cost:** The material cost must be practical and economical, without sacrificing quality.
- **Corrosion Resistance:** There are at least four types of heat exchangers each having different corrosion and heat resistance properties.
- **Emissivity:** The ability of the heat exchanger to efficiently release heat in the form of radiant energy.

Exchanger Thickness Diagram

Let's review the various material utilized in the marketplace.



Sample exchanger surface temperatures after 10 minutes of operation.

Key Components

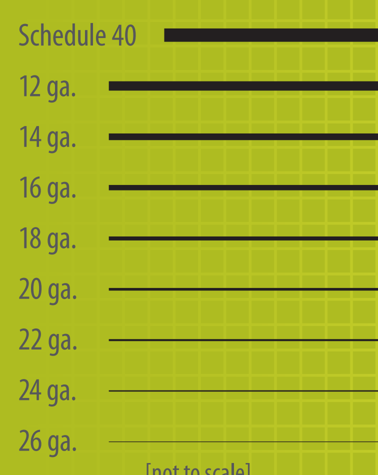
The tubes and reflectors utilized on an infrared tube heater constitute key system components and often govern most of the operational aspects of the heater itself.

Did You Know?

Thermal Saturation Rate: The rate of full energy transfer from the source to the emitter. This rate is impacted by burner design, tube material and tube wall thickness. When testing to satisfy ANSI Z83.20 the manufacturer must provide a minimum 15 minute saturation period before conducting performance testing.

The Norm: A *10-foot x 4-inch x 16-gauge* emitter tube is most commonly used within the infrared industry as it represents the best balance between performance, responsiveness, safety and price.

Gauge: A measurement of the wall thickness of an object (see chart below). Note that while the gauge of the emitter tube impacts performance and longevity so does the exchanger material, arguably to a greater degree than the gauge.



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Radiant tubes are constructed of stainless steel, titanium-stabilized steel, aluminized steel and hot rolled steel. Different tubes have different tolerances to heat and corrosion. Each material will also have its own emissive characteristics.

Unlike cold rolled steel, hot rolled steel is formed at a temperature above the recrystalization point of carbon to prevent work hardening.

Did you Know?

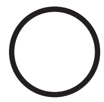
Stainless steel is broken down into three basic categories:

1. **Austenitic** (300 Series). Low iron. Non magnetic. Superior rust resistant properties.
2. **Ferritic** (Low 400 Series). Higher Iron. Magnetic. Able to be titanium stabilized.
3. **Martinstitic** (High 400 Series). Higher Iron. Magnetic. Able to be hardened.

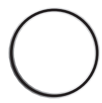
A Recipe for Steel

All steels share iron as their core common denominator. The modest addition of different alloys including carbon, magnesium, sulfur, copper, nickel, chromium, etc. will dictate the different grades and characteristics of the final product.

Material Types



Hot Rolled Steel: A common commercial grade ferritic steel that is heated to high temperatures then formed through a rolling die. This material is naturally dark in color, producing moderate emissive values. Characteristics of hot-rolled steel include low cost, limited corrosion resistance and lower heat tolerances.



Aluminized Steel: A common hot rolled steel that is coated with an aluminum-silicon alloy by the utilization of the hot-dip process. This alloy material is naturally silver in color, thereby reducing the emissive capacity of the finished product. This in turn, warrants a special treatment for increased heat output (see page 5-3). Characteristics of aluminized steel include a higher cost, greater corrosion resistance and an increased heat tolerance.

Titanium-Stabilized Aluminized Steel: An enriched version of aluminized steel. The base metal, or substrate, is treated with a small amount of titanium to afford superior strength and heat tolerance. The aluminum-silicon coating is the same as the standard aluminized steel. Characteristics of this material include a superior ability to withstand vigorous cyclic service of higher temperatures, a greater corrosion resistance and a notable cost premium due to materials and availability.

Stainless Steel: A higher end commercial grade steel containing substantive amounts of chromium and nickel. The higher cost of stainless steel limits its use to primarily harsh or humid environments where it exhibits superior corrosion resistance. 304 Series stainless is commonly utilized due to its superior corrosion resistance, however it is susceptible to warping at high temperatures due to reduced heat transfer properties. A titanium-stabilized 409 Series stainless steel has a higher heat tolerance than the 304 Series, but can exhibit surface rust. Left without a highly emissive surface coating, both materials demonstrate lower output values.

Material Characteristics

Steel Type	Max. Temp	Est. ε Value	Cost	Pros	Cons
409 Stainless	1450°F	.64 to .68	$$$$	Titanium-stabilized High heat tolerance	Can show surface rust High cost & low emissivity
304 Stainless		.62 to .66	$$$$$	Corrosion resistant High heat tolerance	May distort under high heat High cost & low emissivity
Titanium Stabilized		.72 to .74	$$$	Enhanced heat tolerance Corrosion resistant	Availability Higher cost & low emissivity
Aluminized		.72 to .74	$$	Medium heat tolerance Corrosion resistant	Not suitable for high heat Higher cost & low emissivity
Hot Rolled	850°F	.80 to .82	$	Low cost Highly emissive	Susceptible to corrosion Low heat tolerance

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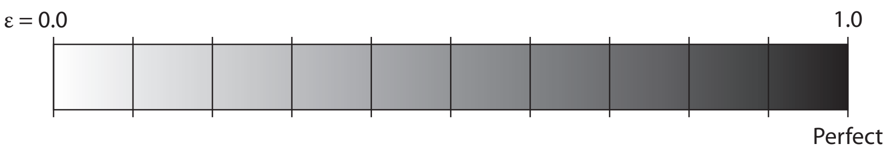
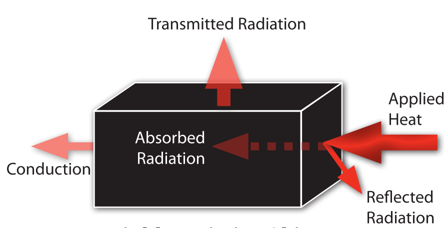
Exploring Emissivity

Emissivity is a measure of the ability of a material to radiate energy. It is quantified by the ratio of the radiating ability of a given material to that of a black body.

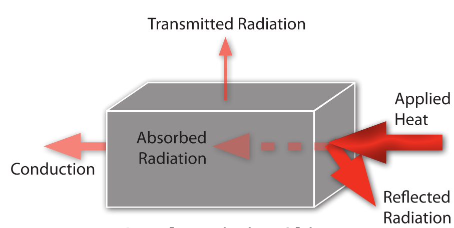


Heat transfer through radiation takes place in the form of electromagnetic waves mainly in the infrared region.

Some objects in nature have almost completely perfect abilities to absorb and emit radiation - these objects are called black bodies. A black body is a hypothetical object that is able to completely absorb all wavelengths of thermal radiation that falls on its surface. A true black body would have an ε = 1.0 while real objects will yield values less than perfect.



Highly Emissive Object

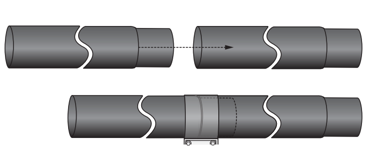


Poorly Emissive Object

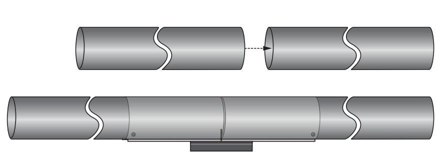
In general, good emitters of radiation are also good absorbers of radiation at specific wavelength bands. Likewise, weak emitters of radiation are also weak absorbers of radiation at specific wavelength bands.

Swaged Design

A swaged interlocking tube design provides a tube-on-tube overlap that helps to ensure structural integrity, ensures a tight seal, and is easier to install. The clamp is designed to merely hold the secured tubes in place.



Swaged Tube



Non-Swaged Tube

On the other hand, a non swaged tube design means that the clamp will act in part as the heat exchanger. The use of a large stainless steel clamp is often utilized to mask the fundamental problems that exist with this lesser securing method.

Pyromark 1200 Paint®

Pyromark® Series 1200 flat black paint, manufactured by Tempil Division, is highly absorptive and emissive. It achieves uniform emissivity for maximum heat diffusion and can withstand temperatures up to 1200°F.

NASA's space program applies the Pyromark 2500® Series paint to the shroud of the Space Shuttle to reject high temperatures seen during re-entry.

Different materials are subject to different tolerances to heat and corrosion. However, when tube exchangers are coated with a highly emissive black tube coating, infrared heat output is enhanced - achieving an emissive value of .95.

Did you Know?

That an untreated "silver" 40-foot 150,000 BTU tube heater will exhibit stack temperatures 150°F to 200°F hotter than a duplicate model with treated 'black' tubes. This difference directly correlates to increased emissivity and radiant outputs.

Upon each start of a heating cycle, water vapor condenses momentarily until the unit heats up to operating temperatures. Swaged tubes retain any condensation, allowing it to quickly evaporate from the full cycle of the heater.

A heater featuring a swaged tube design will typically reduce the installation time by 1-2 hours (when compared to non-swaged tubes).

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When Infrared Energy Strikes an Object:

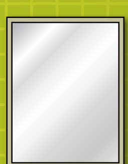
1. It is absorbed as heat, such as when the sun shines on our skin.
2. It is reflected, such as when light reflects off of a piece of glass.
3. It is transferred, such as the sun shining through a window and warming up a room.

The following formula may be used to quantify the process defined above:

$$\alpha + \tau + \rho = 1$$

α = fraction of radiant energy absorbed.
τ = fraction of radiant energy transmitted. (τ=0 when dealing with solid materials)
ρ = fraction of radiant energy reflected.

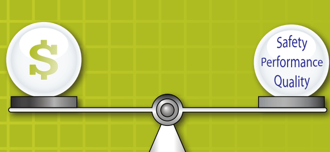
The "Perfect" Reflector



Because infrared waves share the same physical properties as visible light on the electromagnetic spectrum, it is best to compare how well light is reflected from a highly polished surface versus a dull surface. Theoretically, the perfect reflector exhibits mirror like properties capable of a 100% reflective value.

In Summary

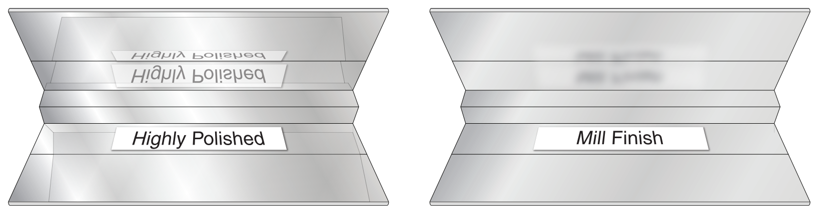
Properly choosing a quality infrared heater requires an understanding of the different tube and reflector types.



Too often these key construction features are overlooked and a lesser quality product is selected on price alone. In nearly every situation the upgrade to higher quality materials is a minimal incremental investment to the entire job itself.

Exploring Reflectivity

Core reflector material is an important variable when evaluating reflector design. When radiant energy strikes a surface, it is either absorbed, reflected or transmitted through the material.

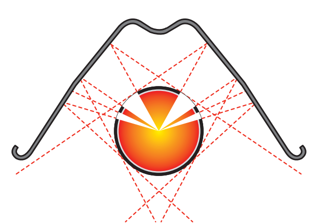


Reflector Material	% Reflectivity	*Absorption Value
Stainless Steel (Polished)	60% to 90%	0.10 to 0.40
Aluminum (Polished)	60% to 90%	0.10 to 0.40
Aluminum (Dull or Mill Finish)	35% to 60%	0.40 to 0.65

*Absorptance for solar radiation taken at 1000°F.
Source: Table 3; Section 3.8. 1993 ASHRAE Fundamentals Handbook.

Highly polished, mirror-finished aluminum reflector material is most effective in delivering infrared heat energy to the floor levels. Polished aluminum has a very low absorption value; therefore, it has a very high reflective value.

Reflector Design Theory



The shaded areas represent the sections of tube that emit infrared which reaches the space below. The sum of the angles of these sections is 315°. Dividing this number by 360° gives a percentage of the infrared which reaches the space below. This percentage is 87.5.

Note that the energy not reaching the space below (white) is absorbed by the tube and re-radiated.

Reflector design refers to the geometric shape of the top shield. This shape is mathematically engineered to allow for optimal focus of the infrared waves, similar to how light is focused from ballasts. The design is directly correlated to the heat pattern of the appliance.

Another important function of the reflector is to capture a significant amount of the appliance's convective heat output. This heat energy is absorbed by the appliance and then re-radiated in the form of infrared energy.

While reflector design is an important consideration in the design process of an infrared heater, it is typically secondary to the considerations placed on material type which have a greater impact on reflectivity.

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