Staple–Up™ With Onix

There seems to be a lot of misinformation regarding performance and efficiency of Staple-Up™ systems. Despite the fact that Watts Radiant has experience with tens-of-thousands of Staple-Up systems over the last 22 years in some of the coldest climates in the country, some insist that Staple-Up "doesn't work" or it has "limited heat capacity" or it is "much more expensive to operate."

The goal of this technical piece is to put these myths to rest and help explain the advantages of Staple-Up systems.

Question:

Is it true an Onix Staple-Up application costs less than PEX, even though the Onix tubing costs more?

Answer:

Yes, Onix Staple-Up applications do cost less than PEX Underfloor applications. There are two main reasons. The first has to do with labor. Onix installs 2-3 times faster than PEX. This is due in part to the increased flexibility of Onix over PEX, not to mention the additional time needed to install the special fasteners required for PEX, such as clips and/or heat transfer plates.

These additional fasteners also increase the cost of a PEX system. Even though Onix tubing may cost more than PEX tubing, the cost of Onix with staples is about 40% less than PEX with metal plates (see table).

Question:

Why can't PEX be stapled directly to the underside of the subfloor like Onix?

Answer:

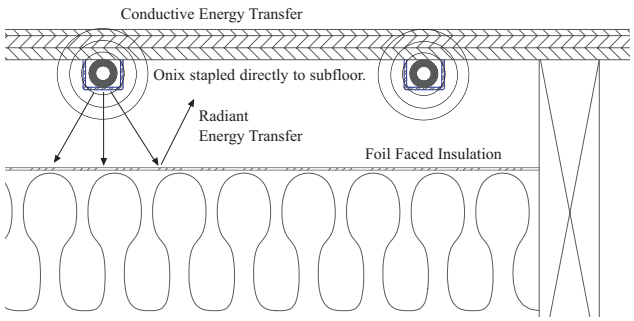
PEX will expand and contract as it is heated and cooled. How much it will move is directly proportional to the change in temperature. PEX tubing expands 1.1 inch for every 10 degree rise in temperature for every 100 feet of tubing. If a 200 ft. circuit of PEX is filled with 60°F water and heated to 160°F, the PEX expands approximately 22 inches.

This movement can cause noise and wear, either against the floor or against the staples themselves. A considerable amount of noise can be generated as the PEX expands and rubs against the metal plates or staples. This noise is transmitted into the house. Also, there is a question of heat transfer. As the PEX expands it has a tendency to pull away

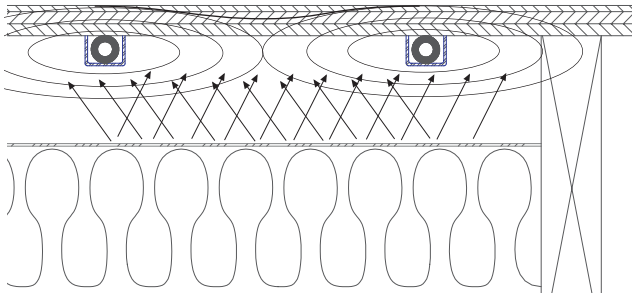
	Onix Staple-Up	PEX w/Plates	PEX Sandwich	PEX Thinslab
Tubing Cost	$2.55	$1.24	$1.24	$0.85
Staples/Screws	$0.02	$0.50	$0.08	
Metal Plates		$4.00		
SubRay			$4.65	
Light Crete				$4.00
Structural Modifications				$1.50
TOTALS	**$2.57/sf**	$5.74/sf	$5.97/sf	$6.35/sf

Values shown are based on a list price per square foot basis. Cost considerations are for tubing and attachment materials only. Labor costs are in addition to the totals listed above.

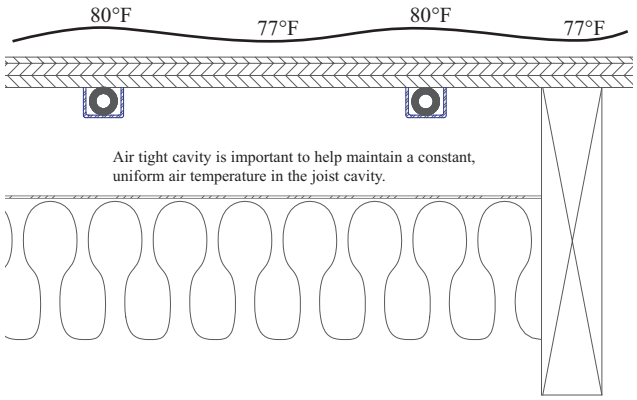
Phase 1: Initial Start-up Conditions



Phase 2: Mid-Point Conditions



Phase 3: Steady-State Conditions



from the subfloor. This separation decreases the tubing's ability to transfer energy to the subfloor, and reduces its overall heating ability.

Question:

Why doesn't Onix have these problems?

Answer:

Onix is comprised of a cross-linked EPDM compound that does not expand with temperature changes. Onix is the same diameter and length at 200°F as it is at 50°F.

No expansion means no wear on the tubing, no noise and no reduced heat transfer due to tubing moving away from the floor.

Question:

I've heard Staple-Up applications cause thermal striping. Is this true?

Answer:

No. Onix Staple-Up does not cause thermal striping (objectable temperature differences). All radiant floor applications will experience some thermal variances in floor surface temperature on start up. This is due to the instantaneous load on the floor at that time. As the floor reaches steady-state conditions, this variance evens out, resulting in a very even floor temperature.

The surface temperature for an Onix Staple-Up system will be nearly identical to that of a PEX underfloor system with plates.

Most ThinSlab applications will experience a greater sense of thermal striping on start up than a Staple-Up application. This is because the increased conductivity of the thin concrete above the tubing sends the heat to the surface faster than the mid-point between the circuits. This results in a greater initial striping.

Tube spacing has a direct impact on how much temperature difference a floor can experience. The wider the tube spacing the greater the potential for striping. Staple-Up applications are 8" on center while Thin Slab applications are usually 12" on center.

The two images on to the left show a the temperature of a floor in a standard forced air heated home. The image to the right shows a radiant tile floor.

Notice the color of the radiant floor and the person's hand. Both are about the same color, indicating both are about the same temperature. The person in this room is losing very little energy to the floor and is much more comfortable as a result.

Once all properly installed radiant systems reach steady-state conditions, temperature differences are insignificant, resulting in a very even floor temperature.

Question:

I've been told heat transfer plates are required to spread the heat out across the floor. Why doesn't Onix need heat transfer plates?

Answer:

Onix does not need heat transfer plates for two reasons. First, Onix is in direct contact with the subfloor, resulting in direct conductive, efficient heat transfer.

Second, Watts Radiant recommends all Onix Staple-Up installations use foil-faced insulation. The foil on the insulation "reflects" the downward energy back up into the subfloor. This reflected energy is spread out over the bottom of the subfloor, creating an even temperature.

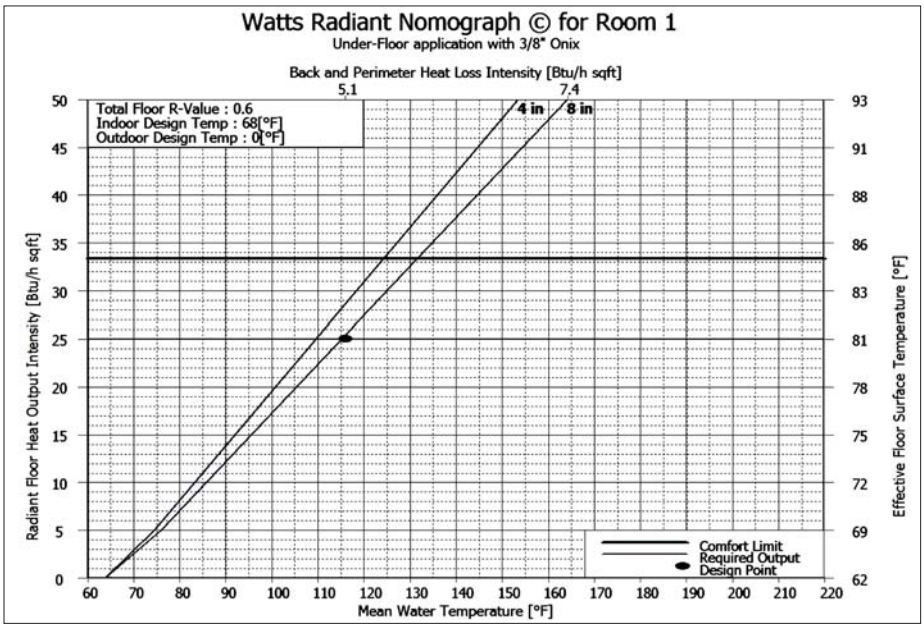
Question:

Does Onix Staple-Up take longer to respond than other frame floor applications?

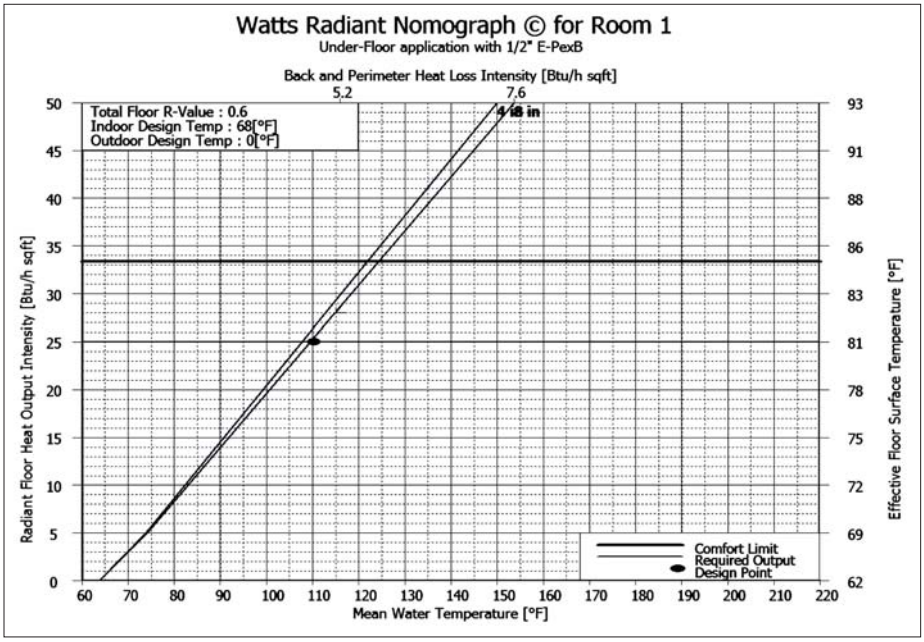
Answer:

No. Response times are dictated by the thermal mass of the construction material, not the radiant tubing. All construction materials have a Specific Heat Value; this is the amount of energy required to raise the temperature of one pound of material one degree Fahrenheit.

The tables reflect the requirements for a 1,000 sf. room with a floor temperature change from 50°F to 80°F with a 50,000 Btu/hr output boiler. These numbers only reflect the time and load required to change the floor mass temperature, and do not take into account the additional load required to raise the room temperature, or to sustain the room's heat load.



Onix Staple-Up Nomograph showing a supply temperature of 125° with a BTU load of 25 BTU/sqft and floor surface temperature of 81°F.



PEX with Plates Nomograph showing a supply temperature of 120° with a BTU load of 25 BTU/sqft and floor surface temperature of 81°F.

Question:

Why don't hanging PEX applications work as well as Onix Staple-Up?

Answer:

Hanging PEX applications suspend the tubing in the joist cavity with a series of plastic clips spaced every 24 - 32" on center. This is done to eliminate the noise as the PEX tubing expands and contracts with temperature changes. This creates an air gap between the PEX tubing and the subfloor, eliminating conductive heat transfer from the tubing. A major result of this lack of contact is a reduction in the total BTUs produced. Most hanging PEX applications are limited to a maximum of 20 BTU/hr per square foot, often requiring the installation of supplemental heat.

Time Required to Heat Floor

4" Concrete	5.88 Hours
1.5" Thin Slab	1.93 Hours
0.75" Subfloor	0.66 Hours

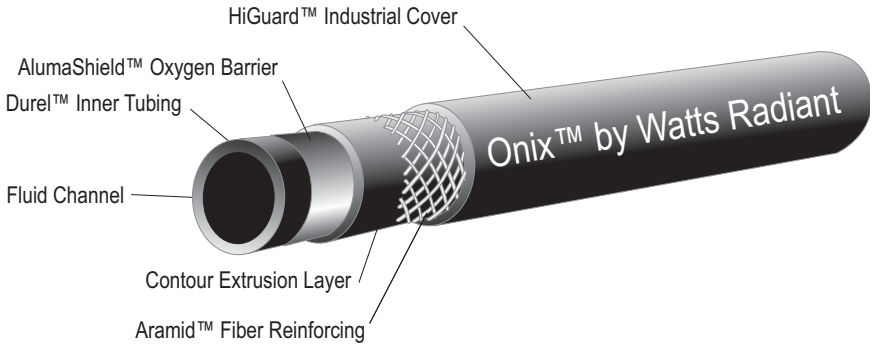
Heat Capacities

4" Concrete	9.80 BTU/ft³°F
1.5" Thin Slab	3.22 BTU/ft³°F
0.75" Subfloor (Staple-Up)	1.10 BTU/ft³°F

BTU's Required

4" Concrete	294 MBH
1.5" Thin Slab	96.6 MBH
0.75" Subfloor (Staple-Up)	33.0 MBH

Onix Staple-Up applications can produce up to 45 BTU/hr/sq. ft. of useable heat. This is a result of the Onix having direct contact with the subfloor.



Question:

Why does Onix require a higher supply water temperature than PEX when both are installed the same way?

Answer:

Onix requires a slightly higher water temperature because of the physical properties of the material. Onix is composed of EPDM rubber with a thicker wall profile (added resistance to jobsite abuse) than a PEX tubing.

Due to the thicker wall, a slightly higher water temperature is required to achieve the same outside tubing temperature as would be seen with PEX. Since both pipe outer surface temperatures are the same, then they both have the same BTU delivery to the floor and same overall system response.

On the average, when compared to PEX, Onix will only see around a 5-8°F variance on supply fluid temperatures.

Question:

Doesn't a higher supply temperature mean higher operating costs?

Answer:

No. Operating costs are determined solely by the amount of energy consumed (BTUs), not by the supply water temperature.

One easy way to monitor energy usage is to measure flow rate (gpm) and system temperature drop (supply water temp - return water temp). At a flow rate of one gallon of pure water per minute, a temperature drop of 20°F will "deliver" 10,000 BTU/hr. Whether the

The average supply fluid temperature difference between Onix and PEX is approximately 8°F.

tw = supply fluid temperature
td = outside tube surface temperature

Fluid Temperature Variances

Tubing Material	Temperature Drop (tw - td) °F
1/2" EPDM Rubber	13.098
1/2" PEX-AL-PEX	4.418
1/2" PEX	4.848
1/2" L Copper	practically 0°F

Various Piping Thermal Properties

Tubing Material	Inside Diameter (inch)	Outside Diameter (inch)	Thermal Conductance (Btu/hr.*ft.*°F)	Thermal Resistance (hr.*ft.*°F/Btu)
1/2" EPDM	0.5	0.875	0.17	0.5239
1/2" PEX-AL-PEX	0.472	0.63	0.26	0.1767
1/2" PEX	0.472	0.63	0.237	0.1939
1/2" L Copper	0.545	0.625	223	0.9775×10^{-4}

temperature drop is from 150°F to 130°F or 110°F to 90°F, one gpm will always "deliver" 10,000 BTU/hr.

Btu/hr = GPM x 500 x DT

GPM = system flow rate in gallons per minute
DT = Supply water temperature - return water temperature

Most radiant systems operate with a non-condensing boiler, meaning the boiler needs to operate at 140°F to 160°F (supply) or above. So, whether a radiant system operates at 150°F or 110°F, the boiler water is "mixed down" to supply the radiant system. This means the flue and stack losses from the boiler will be the same for both radiant supply temperatures.

Remembering that the energy consumed (BTU/hr.) is determined by flow rate and temperature DROP (not supply temperature), a radiant system that requires 150°F supply will not use more energy that a system that requires 110°F.

The only time a lower water temperature translates to better efficiency is if a condensing boiler is used. These boilers are designed to operate at very low return temperatures, such as a snowmelting application.

Question:

What material is Onix made from? How is it different from other rubbers like automotive radiator hose or other radiant hose materials?

Onix (EPDM) Properties

Tensile Strength	1000 psi
Percent Elongation	300 %
Low Temp Flexibility	10 times ID @ -40 Deg F
Ozone resistance	100 pphm, 50% extension, no cracks
Electrical resistance	Greater than 10 mega ohms
Burst pressures	
at ambient	800 psi at 73 Deg F
at 180 Deg F	600 psi at 180 Deg F
Thermal conductivity	0.17 Btu/hr-ft-Deg F

Answer:

Onix is a multi-layer composite product, with EPDM, aramid reinforcing and a ductile aluminum oxygen barrier. EPDM stands for Ethylene Propylene Diene Monomer, which is a cross-linked synthetic rubber. The peroxide-cured carbon-carbon bonds that form the cross-linking in the Onix tubing are extremely stable and give Onix the ability to resist sunlight, oxidative aging, and and long term effects of high temperature operation.

Question:

What testing has taken place to ensure Onix will last?

Answer:

Watts Radiant continuously tests Onix in multiple phases of production. Each batch of tubing produced is tested to a min. 100 psig pressure to ensure burst resistance. A Rheometer test is also performed on each batch, which tests the cross-linking. During production other material properties are tested, such as tensile strength, elongation, specific gravity, and viscosity levels.

Besides being operated for over 60,000 continuous hours of testing at 180°F, Watts Radiant sends samples of Onix to independent labs for further testing. These labs test the components used in the construction of Onix tubing.

These tests determine the physical and chemical changes the compenents undergo. Based on the variances from beginning to end, an estimated life span is determined.

Question:

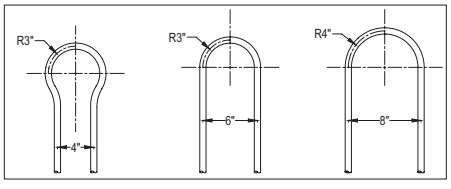
How does Onix compare to PEX?

Answer:

Onix outperforms PEX on several levels.

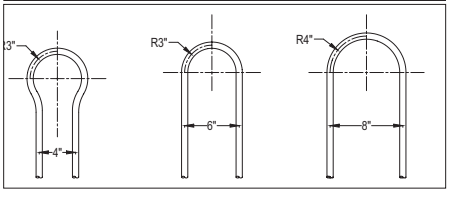
1. Onix has a tighter bend radius than an equivalent PEX size, making installation easier. Onix can be installed in tighter areas, allowing for more effective coverage.

Onix Bend Radius



I.D. Size	Onix Bend Radius	PEX Bend Radius
3/8"	3"	4
1/2"	4"	5"
5/8"	5"	6"
3/4"	6"	7"
1"	8"	10"

PEX Bend Radius



2. Onix cannot be permanently kinked, eliminating wasted jobsite time spent repairing kinks in PEX tubing.
3. Onix is UV resistant for a minimum of 5 years, so it can be left in the sun on the jobsite without damaging the tubing or the oxygen barrier.
4. Onix remains flexible to sub-zero temperatures, making it easy to install in frigid environments.
5. Onix has a burst rating of 600 psig at 180°F, while PEX has a burst rating of 325psig at 180°F, meaning it will hold up to extreme "runaway" boiler conditions.
6. Onix does not require special tools to make the connection at the manifold, saving hundreds of dollars in tool costs.
7. Onix's oxygen barrier is inside the tubing, protecting it from job site abuse.
8. Onix's outer cover is extremely durable, protecting the inner tubing and oxygen barrier from job site abuse.
9. Onix is crush-resistant, recovering its shape after being compressed by vehicles.

Onix allows for a faster, easier, cleaner installation.

The Bottom Line

Onix Staple-Up is a very straightforward, simple-to-install system that is easily understood by the installer and the owner. The system doesn't require special fasteners, metal plates, proprietary tools, heavy concrete, or a special mechanical room design. It's a system that works without all the complications.

Onix Staple-Up works, and it works well. Try it on your next project. Design the system with our Radiant Works software and you'll have the experience of 22 years of successful radiant system design guaranteeing it will work like a champ!