WARM WAVES

Thawing Ice Rink Permafrost

APPLICATION OF FAR INFRARED TECHNOLOGY TO THAW ICE RINK PERMAFROST AND REMOVE MOISTURE

June 2019
www.digready.com
tjantsch@warmwaves.com

Problem Statement:

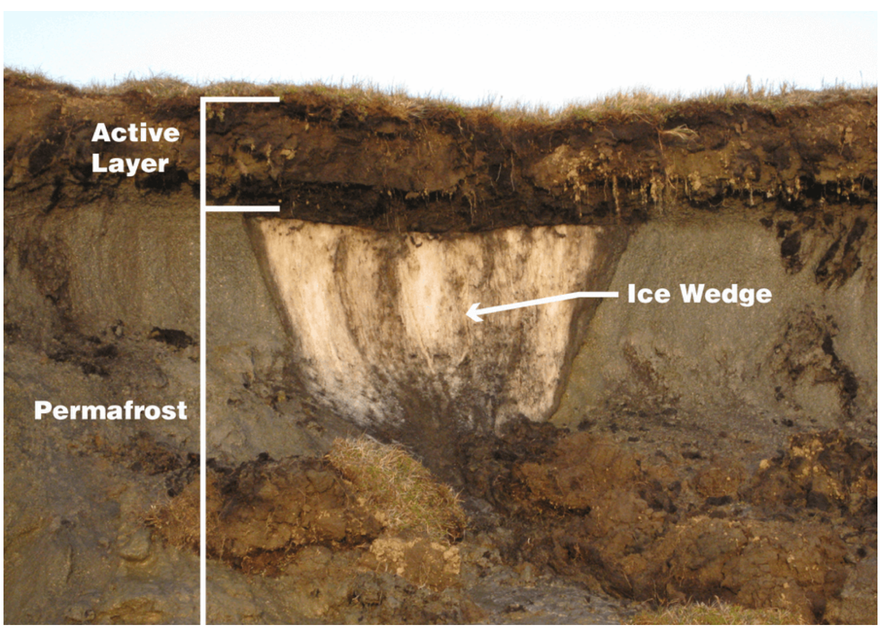
Ice Rink Frost Heave

(Source: Engineering Applications in Permafrost Areas: Solution to frost heave of ice arenas, C.E. Leonoff and R.C. Lo, http://pubs.aina.ucalgary.ca/cpc/CPC4-481.pdf)

Three basic elements are prerequisites for developing frost heave in ice rinks (Brown 1965); frost susceptible subsoils, subfreezing temperature, and available water. As water freezes, its volume expands by about one-tenth. This expansion accounts for only a small fraction of the overall heave. The bulk of heave is caused by the growth of a network of pure ice lenses in the subsoil. In frost-susceptible soils, which have significant amounts of fine-grained contents, (fraction less than 0.02 mm size) water in soil capillary pores does not freeze at 0°C due to freezing point depression by surface tension. Furthermore, a high suction pressure develops at the frost line and sucks in extraneous water from unfrozen areas, building up the ice lenses at the frost line. As the subfreezing temperature is sustained in the ground, a network of ice lenses will gradually grow with time as the frost line penetrates deeper into the subsoil. The surface heave is merely a manifestation of this growth of underground ice lens networks. While uniform heaving would have little effect on the use of ice surfaces, variations in soil profile, groundwater supply, and heating characteristics of buildings result in differential heaves, which, in the extreme, make the rink unplayable and unserviceable by modern ice-maintenance equipment.

Permafrost Definition: **(Source: Wikipedia,** https://en.wikipedia.org/wiki/Permafrost)

In geology, permafrost is ground, including rock or (cryotic) soil, at or below the freezing point of water 0 °C (32 °F) for two or more years.



Source: NASA, Climate Kids https://climatekids.nasa.gov/permafrost/

Current Permafrost Remediation Solutions:

1) Excavation and Wasting the full depth of frozen subsoil:

Excavating and wasting the full depth of the frozen subsoils containing ice lenses and replacing it with granular backfill rather than waiting for natural thawing, due to the extended time it would take to thaw and result in water-logged ground.

RISKS:

- **Unknown cost of digging permafrost**
- **Disturbing 8 – 10+ feet of unknown subsoils (e.g. rock, land fill, hazardous waste, etc.)**
- **Cost of disposing of excavated subsoils**
- **Additional cost of granular backfill**
- **Health Hazard from exhaust fumes emitted by heavy excavation equipment**
- **Vibration to building and building footers due to excavation**
- **Potential for additional cost to support building footers during excavation**
- **Potential additional cost of shrouding the facility in plastic to protect the facility from a tremendous volume of dust and soot from heavy machinery**
- **Potential for additional cost to increase building access for heavy equipment**

2) Ground Thaw Plus Excavation and Wasting the full depth of frozen subsoil:

Thawing, excavating and wasting the full depth of the frozen subsoils containing ice lenses several times until the required depth is achieved and replacing it with granular backfill rather than waiting for natural thawing, due to the extended time it would take to thaw and result in water-logged ground.

RISKS:

- **Unknown cost of digging permafrost**
- **Multiple thaw/excavate cycles to achieve required excavation depth**
- **Disturbing 8 – 10+ feet of unknown subsoils (e.g. rock, land fill, hazardous waste, etc.)**
- **Cost of disposing of excavated subsoils**
- **Water-logged ground due to ground thaw**
- **Additional cost of granular backfill**
- **Health Hazard from exhaust fumes emitted by heavy excavation equipment**
- **Vibration to building and building footers due to excavation**
- **Potential for additional cost to support building footers during excavation**
- **Potential additional cost of shrouding the facility in plastic to protect the facility from a tremendous volume of dust and soot from heavy machinery**
- **Potential for additional cost to increase building access for heavy equipment**

3) Natural Thawing with the addition of Forced Hot Air:

When time permits, waiting for natural thawing with the addition of forced hot air to thaw permafrost to required depth.

RISKS:

- **Extended/Unknown time requirement for thawing permafrost to required depth**
- **Water-logged ground due to ground thaw**
- **Loss of revenue due to facility being out of service for an extended/unknown period of time**

Dig Ready Infrared Industrial Ground Thaw Technology

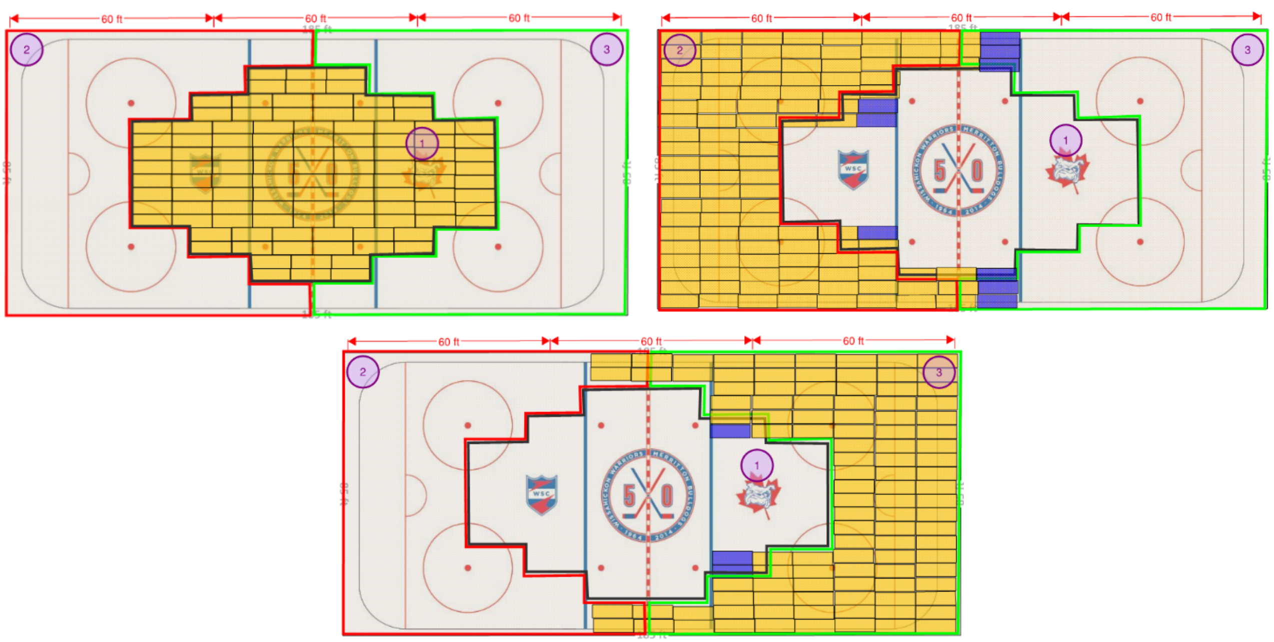
Dimensions Flat: 46″ x 132″
Dimensions Folded: 46″ x 46″
Weight: 22 lbs.
Heated Area: 33 square feet
Total Mat: 42 square feet
Product Description: WW2-500-15
Rated Voltage: 208 – 240 V
Rated Amp: 7.2 – 6.2 A per mat
Power Output: 1,750 Watts per mat at 240 VAC
Thermistor Overheat Sensor:185' F

- **Permafrost and moisture removed with FAR Infrared Energy at an average of 1(+/-) foot per day (varies depending on surface condition and subsoil composition)**
- **Removes moisture as it thaws leaving a dry workspace**
- **Predictable ground thaw/moisture removal timelines**
- **Reduces risk of building vibration due to heavy excavation equipment**
- **Reduces risk/cost of additional support for building footers**
- **Reduces risk of exposing unknown subsoils**
- **Reduces cost of disposing of subsoils and the addition of granular backfill**

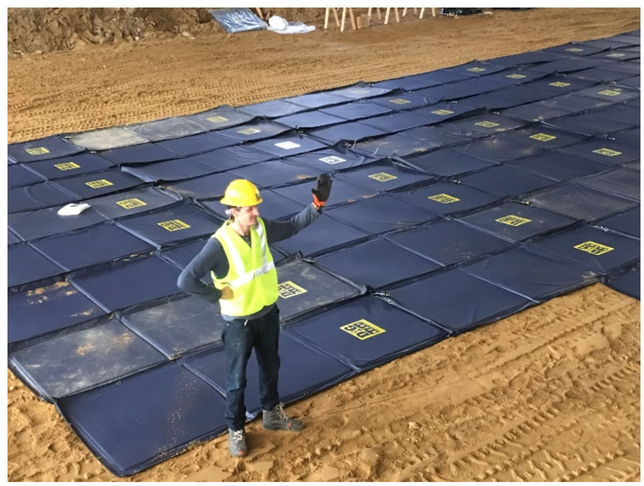
Dig Ready Industrial Ground Thaw Process:

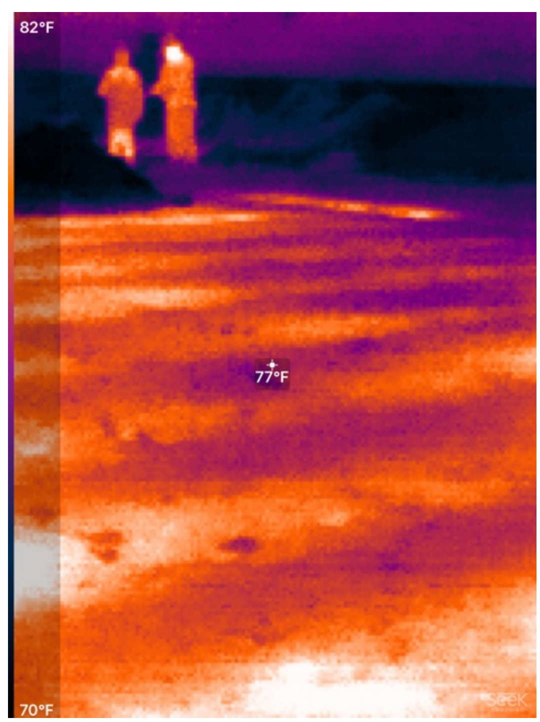
1) Analysis of depth and locations of permafrost – Core drill soil samples

2) Define permafrost thawing strategy – Location and Number of ground thaw phases based on available (208v – 240v) power

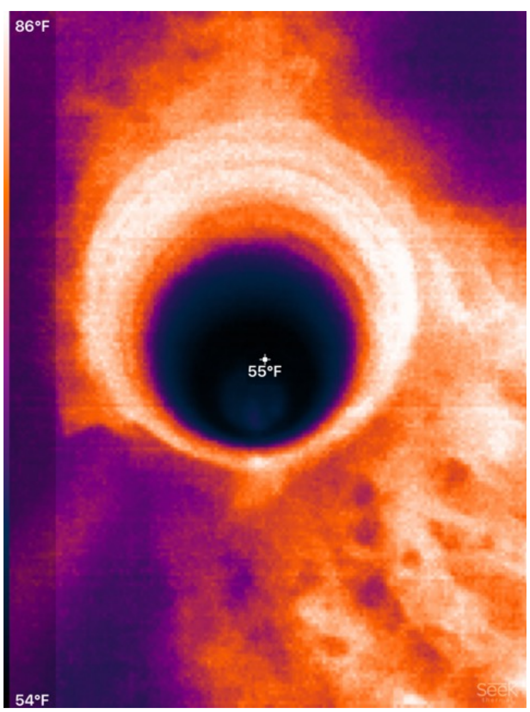


3) Infrared Technology Mobilization





4) Dig test holes to assess permafrost and moisture



5) De-Mobilization

VIDEO: DIG Ready Thaws Permafrost Under Ice Rink

DIG Ready Infrared Industrial Ground Thaw is being used to thaw permafrost that has formed over 60+ years under an indoor ice-skating rink. With minimal excavation, the permafrost is being removed to make way for a new ice rink.

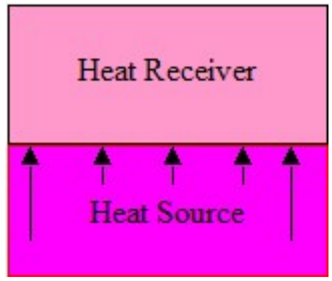
https://www.youtube.com/watch?v=uT3G76mNpoU

APPENDIX- A:

The Principles of Heat Transfer:

Materials or spaces can be heated in any of three familiar methods:

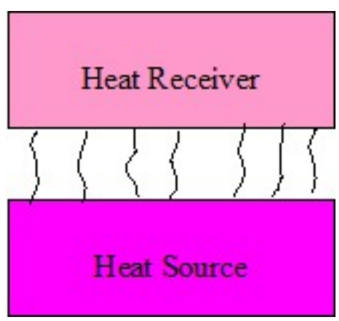
- **Conduction:** By contact with a heat source.



Conduction

Conductive heating is achieved by placing an article into touch contact with a heat source. The rate of heat transfer is determined by several factors, not just the thermal properties and difference in temperature of the two bodies. The surface conditions over the contact area, the pressure of contact and the nature of any gas, liquid or solid films at the interface all play a part in the conductive process.

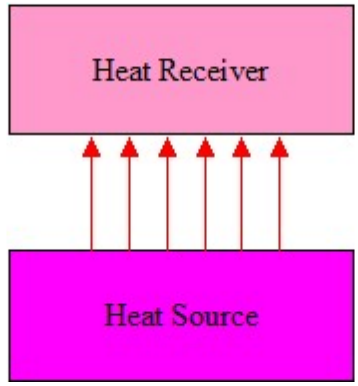
- **Convection:** By the movement of a hot fluid or gas, such as air, over the material.



Convection

Convective heating relies on the movement of hot fluid or gas, such as air, which acts as a carrier of heat from one body to another. In industry, forced convection is commonly used, that is, the gas or liquid is directed towards the article by a fan or pump. Natural convection occurs because gas or liquid at different temperatures have different densities. An ordinary central heating radiator emits heat mainly through "natural convection".

- **Radiant Energy:** Using infrared.



Radiant Energy

The use of FAR Infrared radiant energy provides certain advantages over conductive and convective heat transfer:

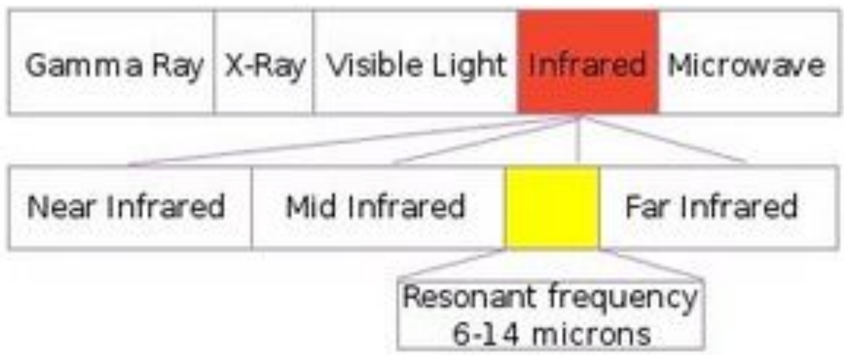
- No contact is necessary with the material to be heated
- High heating power densities can be used (if required by the process)
- Much shorter heating times
- Infrared systems usually have a fast response

With radiant techniques, it is energy that is transferred, not heat. The material converts the radiated energy to heat by absorption. It is therefore imperative that there is no contamination in the air between the heat source and the product being heated, otherwise the radiated energy will be absorbed by this contamination. Moisture vapor is a potential problem (if the process is evaporating moisture it is essential that this is extracted so that it doesn't cause a barrier between the energy source and the product).

APPENDIX- B:

What is FAR Infrared?

Far infrared (FIR) is a region in the infrared spectrum of electromagnetic radiation. Far infrared is often defined as any radiation with a wavelength of 15 micrometers (µm) to 1 mm (corresponding to a range of about 20 THz to 300 GHz), which places far infrared radiation within the CIE IR-B and IR-C bands. The best example of FAR infrared heat is the Sun.



INFRARED IS DIVIDED INTO 3 WAVEBANDS:

- **Near-infrared** - region of the electromagnetic spectrum (from 780 nm to 2500 nm)
- **Middle Infrared** – wavelength between 8 µm and 14 µm.
- **Far Infrared** – wavelength of 15 micrometers (µm) to 1 mm

How Far Infrared Works:

Far infrared heats surfaces with radiant energy released on contact and provides a strong drying/remediation process.

Radiant energy is not absorbed by air and does not actually become heat until an object absorbs it. While radiant energy does generally show up as heat, this is because it vibrates and rotates the atoms in the absorbing object, which results in a rise in the temperature of that object. Radiant energy may also show up as a chemical change in the absorbing object (polymerization) or evaporation of water or solvents (drying).

References:

Engineering Applications in Permafrost Areas: Solution to frost heave of ice arenas, C.E. Leonoff and R.C. Lo, http://pubs.aina.ucalgary.ca/cpc/CPC4-481.pdf

Wikipedia, https://en.wikipedia.org/wiki/Permafrost)

The Principles of Infrared, N.C. Rothwell, September 2007, http://www.drc.co.uk/DRC/TECH-DOCS/infraRed.aspx

Wikipedia, https://en.wikipedia.org/wiki/Far_infrared