



EARTHLINKED  
TECHNOLOGIES

# THE SCIENCE OF REFRIGERANT-BASED GEOTHERMAL

Gregor Vialette – 02.25.16

# “Copper loops corrode and fail”

→ Alternatives: “*Ground eats the copper*”; “*Minerals in the ground will cause the copper to leak*”

## ❖ Copper

- ✓ Extracted from the ground itself
- ✓ Long history of use in HVAC
- ✓ A **noble** metal naturally resistant to corrosion
- ✓ Naturally compatible with > 90% of the land in North America

## ❖ Corrosion in Copper

- ✓ Patina: a natural **protective coating**

## ❖ Earth Loop Protection System (EPS)

- ✓ Impressed Current Cathodic Protection (ICCP)
  - Anode connected to a DC source
  - Optimized to provide enough current for protection of target structure
- ✓ **Permanent, uniform** and **automatic** protection
- ✓ Long life and reliability

# “Systems contain too much refrigerant”

→ Alternatives: “*The code requires an industrial type machinery room for these systems*”

## ❖ EarthLinked® Geothermal Systems

- ✓ ≈5 to 7 pounds of refrigerant per nominal ton of system capacity

## ❖ ASHRAE standards

- ✓ Standard 15-2013 and Standard 34-2013
- ✓ Complies with 2012 International Mechanical Code
- ✓ **Refrigerant Concentration Limit (RCL) = allowed concentration in **occupied space****
  - $RCL(R-410A) = \underline{26 \text{ lb/Mcf}} = 26 \text{ lb}/1000 \text{ ft}^3$

## ❖ Case study: extreme scenario

- ✓ 2000 ft<sup>2</sup> home → 4-ton job
- ✓ EarthLinked system: 28 lb of R-410A
- ✓ 7-foot ceilings → 14000 ft<sup>3</sup> of conditioned space → ≈ 9 Mcf of occupied space
- ✓ 410A Concentration =  $\frac{28}{9} = 3.11 \text{ lb/Mcf} \rightarrow \underline{8 \text{ times less than RCL}}$

## MYTH #3

# “They are not recognized by the Code”

→ Alternatives: “*These systems don’t comply to the Mechanical Code*”

### ❖ ASHRAE standards

- Standard and guidelines for the HVAC industry
- Complies with 2012 International Mechanical Code



### ❖ IgCC: DX is mentioned in the International Green Construction Code

### ❖ CSA

- C448 Series-16
  - “*Design and installation of earth energy systems*”
- Bi-national Standard for Design and Installation
- A reference for IGSHPA



### ❖ Testing standards



### ❖ Member of GEO



→ Alternatives: “*What if there is a leak?*”

❖ EarthLinked® Geothermal Systems

- ❖ Refrigerant-based
- ❖ No antifreeze
- ❖ Very limited risk
- ❖ Seal tested at factory
- ❖ Seal test in the field (400 PSIG nitrogen for a minimum of 8 hours)

❖ R-410A refrigerant

- ❖ Boiling point: **-60.5°F**
- ❖ Would immediately **vaporize** and seek the atmosphere
- ❖ MSDS available

❖ POE oil

- ❖ Insoluble in water → would not contaminate aquifers
- ❖ MSDS available

# “Loops in DX are too short”

→ Alternatives: “The ground cannot keep up”, “The ground will heave or dry out”,  
“Copper is too conductive for the ground”

## ❖ Fourier’s law (1807)

$$Q = -k \cdot A \cdot \frac{dT}{dx}$$

## ❖ Compact loop system

- ✓ Higher **thermal conductivity** of Copper
- ✓ Greater **temperature range** of operation for R-410A
- ✓ **The combination of Copper + R-410A allows for a larger temperature gradient ( $\Delta T$ )** than HDPE and an antifreeze solution would

## ❖ Proper design

- ✓ Design the system to meet Q (House load)
  - Heating and Cooling loads -> Manual J
  - Geographic location of the site
  - Selection of Earth Loop configuration depending on space, performance and installation cost
- ✓ Otherwise: performance issues
- ✓ **True for all geothermal systems**

# MYTH #5

# “Loops in DX are too short”

Case of a multilayered cylinder:

$$Q = \frac{2\pi * L * (T_4 - T_1)}{\frac{\ln\left(\frac{r_2}{r_1}\right)}{k_{copper}} + \frac{\ln\left(\frac{r_3}{r_2}\right)}{k_{cement}} + \frac{\ln\left(\frac{r_4}{r_3}\right)}{k_{ground}}}$$

**Q** : Conductive heat transfer (BTUH)

***k<sub>copper</sub> / k<sub>cement</sub> / k<sub>ground</sub>*** : Thermal conductivity (BTU/ (h.°F.ft<sup>2</sup>))

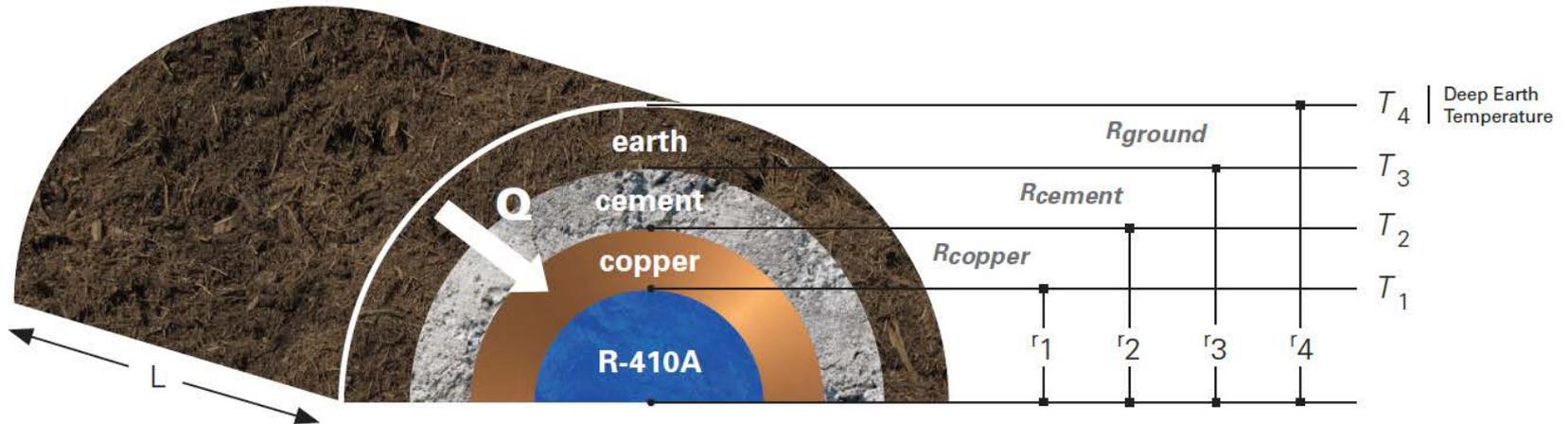
**A** : Surface area (ft<sup>2</sup>)

$\frac{dT}{dx}$  : Temperature gradient (°F/ft)

**T<sub>1</sub> / T<sub>2</sub> / T<sub>3</sub> / T<sub>4</sub>** : Temperatures at the surface of the layer (°F)

**r<sub>1</sub> / r<sub>2</sub> / r<sub>3</sub> / r<sub>4</sub>** : Radius of the layer

**R<sub>copper</sub> / R<sub>cement</sub> / R<sub>ground</sub>** : R-value or Thermal resistance of the layer ((ft<sup>2</sup>.°F.hr)/BTU)



→ Alternatives: “*DX is harder to install than water-source*”

## ❖ Simple

- ✔ NO anti-freezing agents, system flushing, circulating pump, water well drilling or plumbing
- ✔ Earth loops are pre-engineered and factory-assembled
- ✔ Less maintenance
  - No need to top off water and glycol levels

## ❖ Compact

- ✔ Smaller **footprint** (see Myth #5)
  - Reduced installation cost (drilling and excavating)
  - Smaller borehole diameters
  - Smaller drill rigs
- ✔ No deeper than 100'

## ❖ Efficient

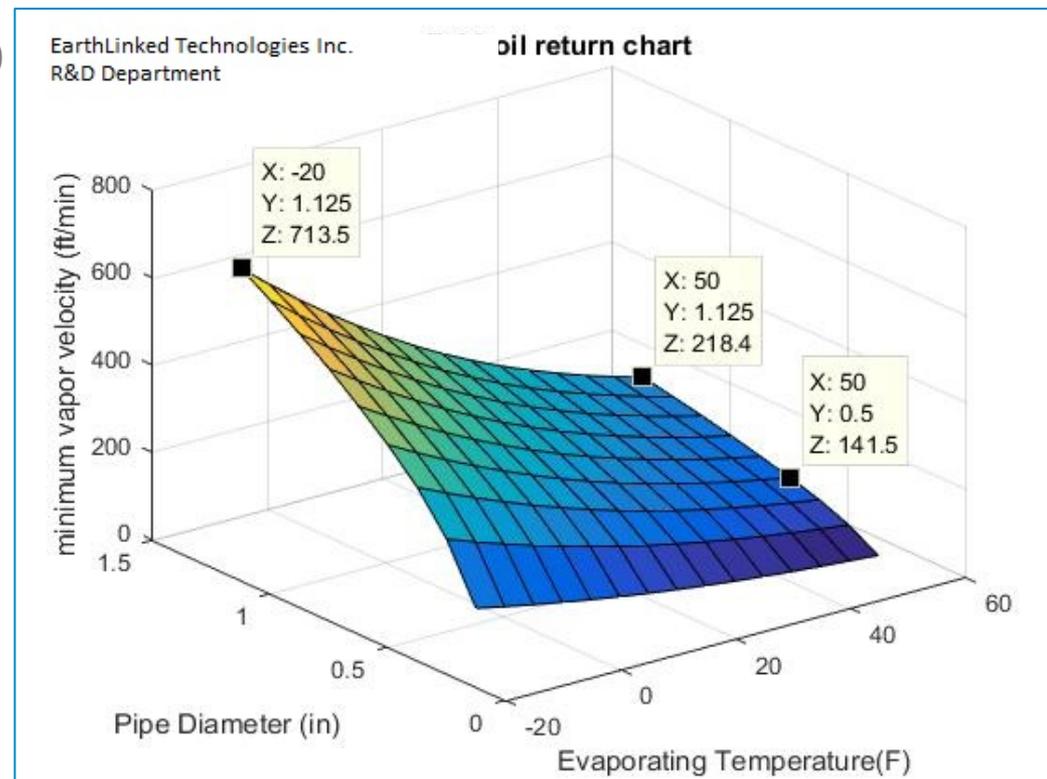
- ✔ One-step heat exchange process
  - More efficient
- ✔ Lower installation cost
- ✔ Quicker to install

## MYTH #7

# “Bad oil return burns compressors”

→ Alternatives: “Bad oil return could cause a compressor failure”; “Oil returns are an issue”

- ❖ R-410A and POE oil: **perfectly soluble**
- ❖ Patented oil return mechanism: boils the refrigerant out of the ACC
- ❖ No compressor failure since 2010
- ❖ Proper sizing
  - 🌿 Adequate refrigerant velocity



→ Alternatives: “*Without the circulator pump the workload of the compressor is increased*”

## ❖ Run time

- ❖ Our compressors do not run any longer
- ❖ Operated within recommended operating conditions
  - Proper designing
- ❖ Many differences between water-based and refrigerant-based

## ❖ Compression ratio

- ❖ Apples to apples comparison
- ❖ CASE STUDY

- $Compression\ ratio = \frac{\text{absolute discharge pressure (psia)}}{\text{absolute suction pressure (psia)}}$



→ Alternatives: “Most *DX* manufacturers don’t hold their product line long”

❖ Direct Geoexchange

- ❖ Oldest type of geothermal heat pump technology
- ❖ Robert C. Webber (1940s)

❖ EarthLinked Technologies

- ❖ Established in 1980 by Robert Cochran, PE
- ❖ Older than most water-source companies
- ❖ Thousands of units sold worldwide
  - > 100,000,000 hours of service
  - 18 countries and 48 US states
- ❖ Reputable and excellent track-record
- ❖ Tested by the EPA: 75% energy savings

❖ Time-tested

- ❖ Our oldest systems (1980s) still performing as designed today
- ❖ Technology: mature and innovative

→ Alternatives: “*Direct Exchange geothermal is a fraction of the geothermal market*”

## ❖ HVAC market

- Geothermal heat pumps as a whole are only ≈2% of the HVAC industry

## ❖ Geothermal market

- Growing quickly
- Will triple by 2020
- Predicted Compound Annual Growth Rate ≈14% (between 2015 and 2020)

## ❖ Current market barriers: why EarthLinked has key advantages

- US Department of Energy
- Technological challenges
  - Loops are complex and expensive
  - Installation-specific design and engineering of the ground loop
- Market challenges
  - Initial upfront cost and Payback
  - Space constraints
  - Outdated Regulatory Policies
  - Low market awareness