Improving Temperatures for Subway Surface Decontamination

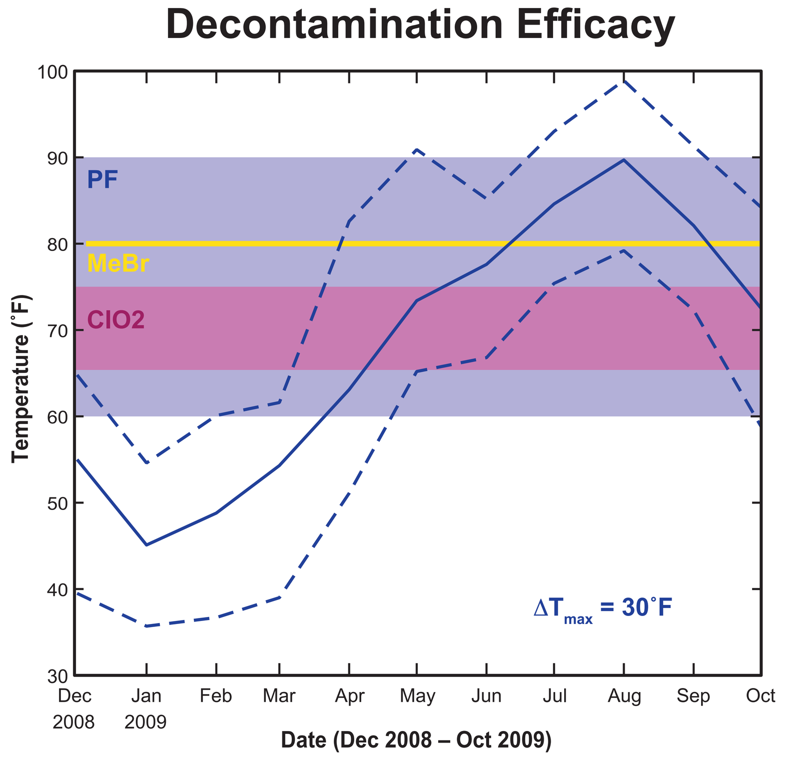
Objective: **Evaluate the feasibility and practicality of heating subway surfaces to improve biological threat decontamination efficacy.**

Motivation

Identification of Need

- **Common biological decontaminants for biological threat agents work best at moderate to high temperatures**
- **Subway systems are frequently at suboptimal temperatures**

Decontamination Efficacy



Power consumption per unit area must be weighed against cost of multiple applications

Subway Surface Temperatures

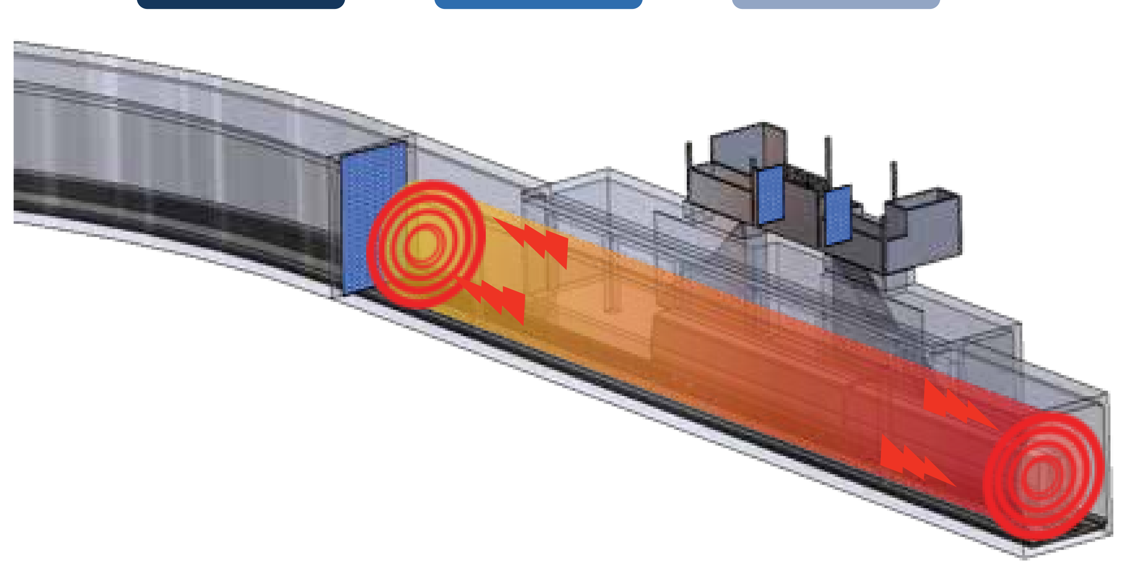
Month-Y	Temperature (°F)		
	Mean	Min	Max
December-08	55.0	39.5	64.8
January-09	45.1	35.7	54.6
February-09	48.8	36.7	60.1
March-09	54.3	39.0	61.6
April-09	63.1	51.1	82.6
May-09	73.4	65.2	90.
June-09	77.6	66.8	85.2
July-09	84.6	75.4	93.0
August-09	89.7	79.2	98.9
September-09	82.1	72.3	91.3
October-09	72.5	58.8	84.2

(Max, Min, **or** Mean) > T_{decon} (Max, Min, **and** Mean) > T_{decon}

(Max, Min, **and** Mean) < T_{decon}

Operational Concept and Objectives

Isolate → Control Environment → Apply Decon



- **Analyze and model power requirements to heat subway surfaces**
- **Empirically evaluate effectiveness and practicality through small-scale testing**
- **Perform operational-scale demonstrations of required capability**

Investigation and Testing

Initial Heating Estimates

Radiant Heating

- **Computational fluid dynamics model using ANSYS**
- **Initial temperature: 40°F, target temperature: 70°F**

1 kW/m² radiant heat flux on 1 m slice of 12' tunnel cross-section can be heated in 2.5 min

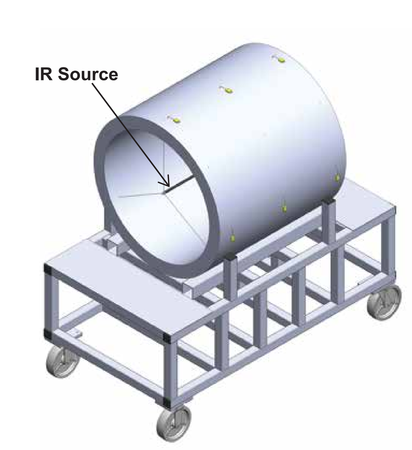
Convective Heating

- **Simplified steady-state model**
- **Initial temperature: 40°F, air temperature: 40°F, target temperature: 70°F**

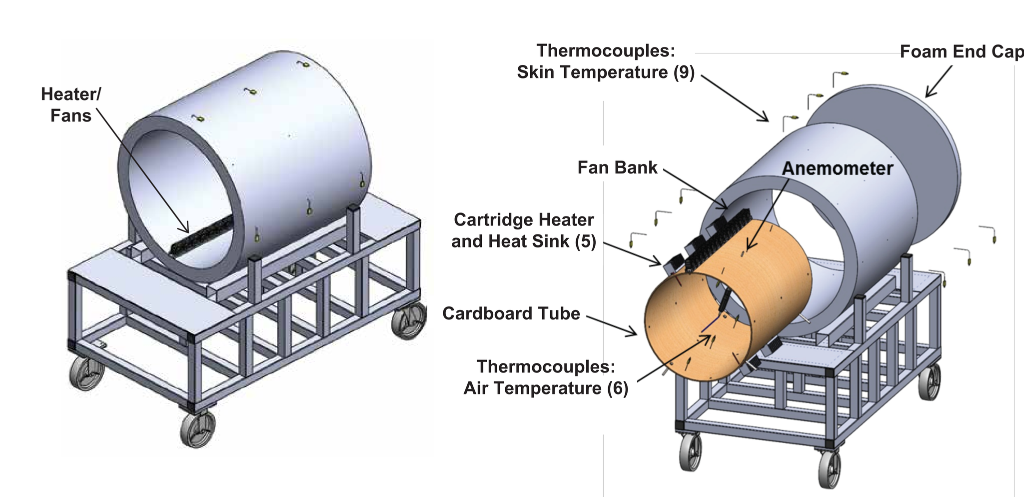
12" thick concrete, 12' diameter tunnel, 0.1 mile length can be heated in 40 min with 40 kW

Small-Scale Testing Setup

Radiant



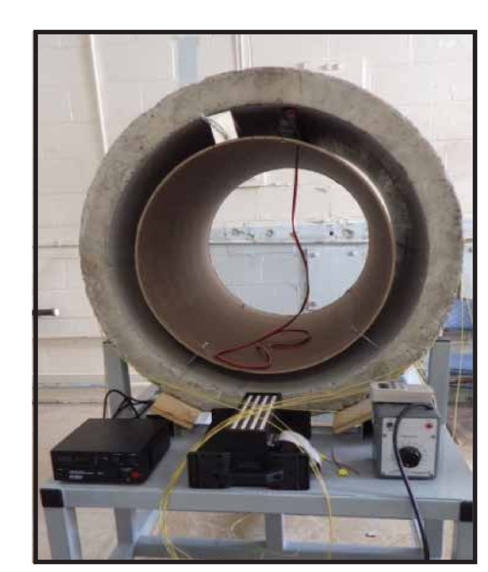
Convective



Parameters	Radiant	Convection
Concrete tube and end caps	36" outer diameter ×3" thickness ×35" length end caps used are the same material for both.	
Thermocouple count:	32	40
Heating system	(1) 1500W suspended quartz element	(5) 250W heat sinks with two airflow scenarios
Average test length	300 minutes with combined transient and steady state phases	

Radiant

Convective



Results and Future Work

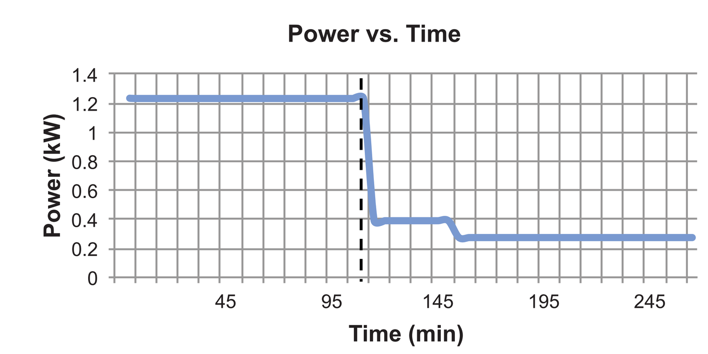
Initial Results

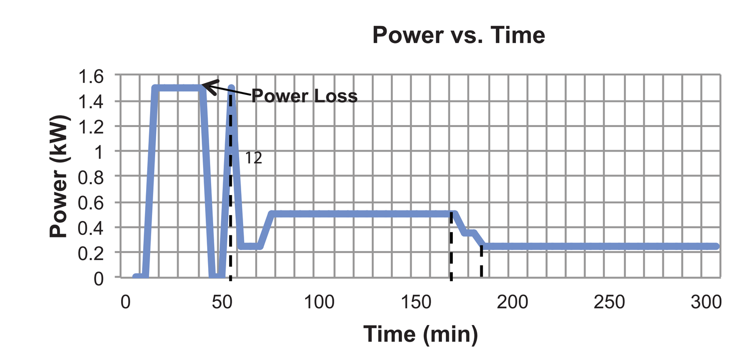
Small-Scale Convective Heating

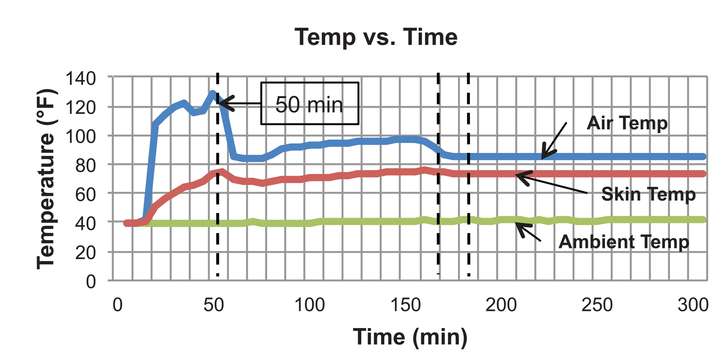
Measurement	Units	Transient	Steady State
Ambient temp	°F	68.5	72.6
Heat Input	kW	1.2	0.3
Air velocity	miles/hr.	24.0	24.0
Air temp	°F	135.0	99.6
Skin temp, start	°F	67.0	99.0

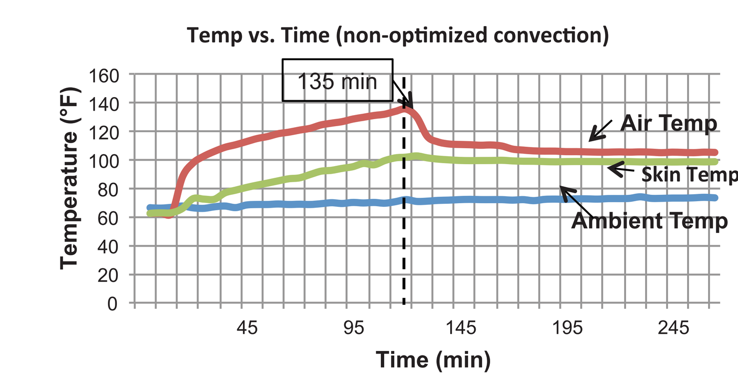
Small-Scale Radiant Heating

Measurement	Units	Transient	Steady State
Ambient temp	°F	39	41
Heat Input	kW	1.50	.250
Air temp	°F	128	85
Skin temp, start	°F	40	73





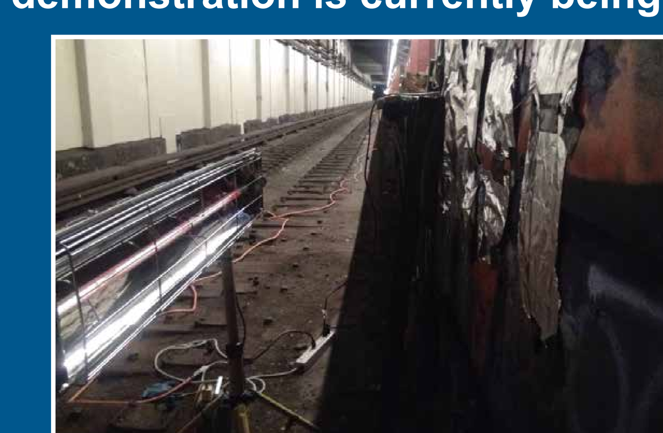


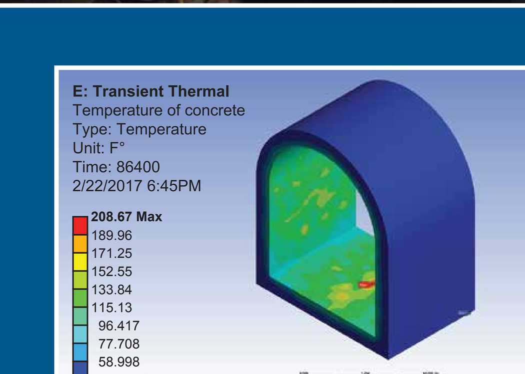


In comparison to convective heating, radiant heating achieves decontamination temperatures faster, with less power input, and without air movement

Operational-Scale Demonstration

- **Radiant and convective heating recently tested in New York City subway**
- **Analysis of results showed radient heating most effective. Operational demonstration is currently being planned.**





Simulation results show operation-scale heating can be achieved with similar hardware and extended heating times

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