Heat Transfer in Activated Carbon in Relation to Carbon Bed Fires: Part I

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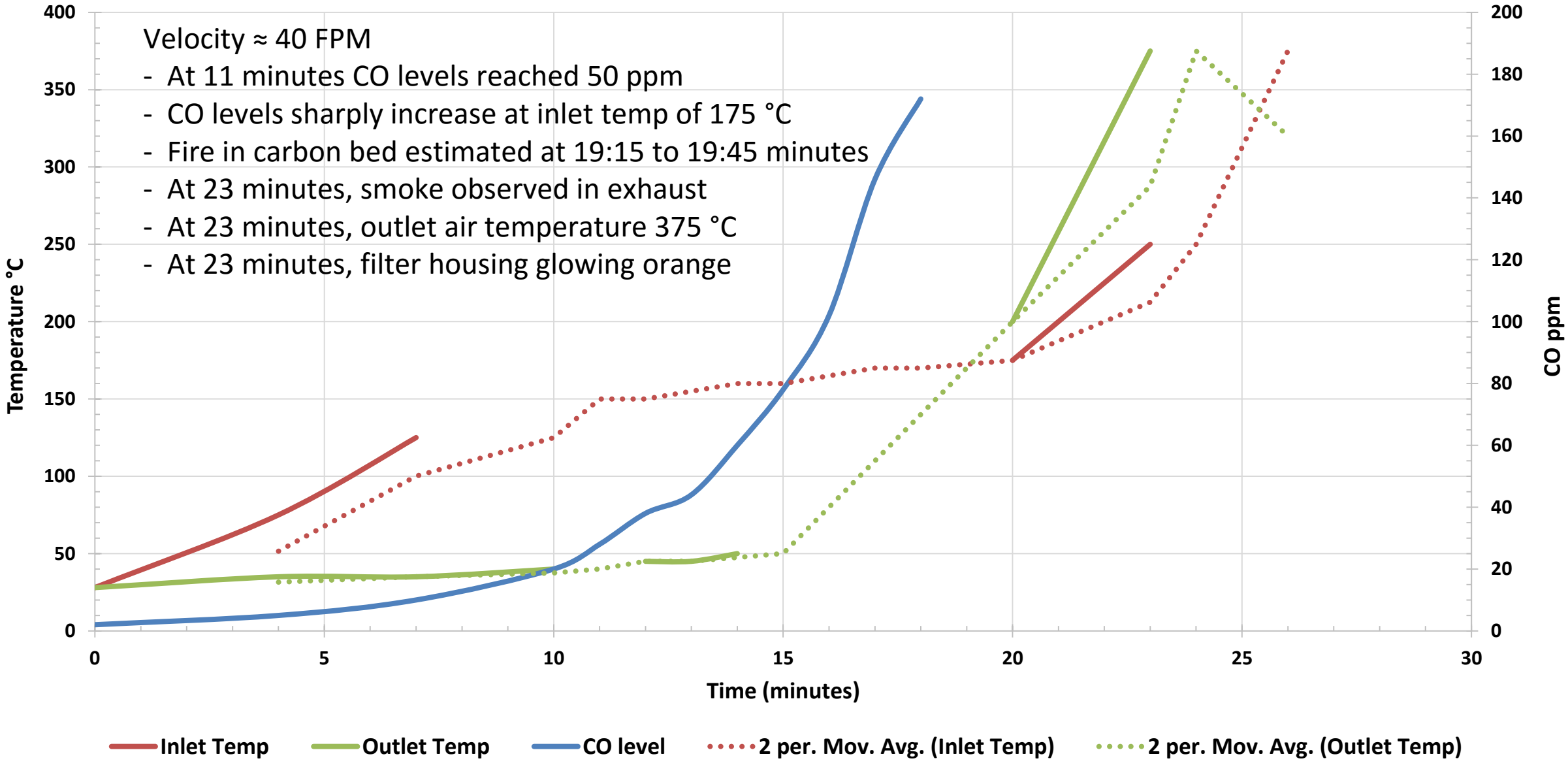
Alarms for Indication of Carbon Bed Fires

- Temperature, measured by thermocouple
  - High and High-High alarm levels
  - Dependent on location of thermocouple in relation to “thermal excursion”
  - May indicate only a fully developed fire
- Carbon monoxide levels
  - More sensitive, only one alarm “level” required
  - May be impacted by background CO levels

Initial Tests

- Modified wind tunnel with adjustable plenum, fitted with a 24 inch x 24 inch, 4 inch deep carbon adsorber
- Carbon adsorber filled with standard co-impregnated carbon (KI and TEDA)
- Inlet air heated by an indirect fired natural gas furnace
- Inlet and outlet temperatures monitored 4 inches from filter inlet and outlet
- Carbon monoxide monitored 24 inches downstream of filter outlet
- Heat-up was carried out as quickly as possible

Deep Bed Carbon Ignition Test



Observations from Deep Bed Ignition Experiment

- Carbon monoxide level monitoring effectively indicates a thermal excursion prior to bed ignition
- Shutting down system (stopping air flow) effectively limits spread of fire even with natural convection currents present (not fully isolated from outside atmosphere)

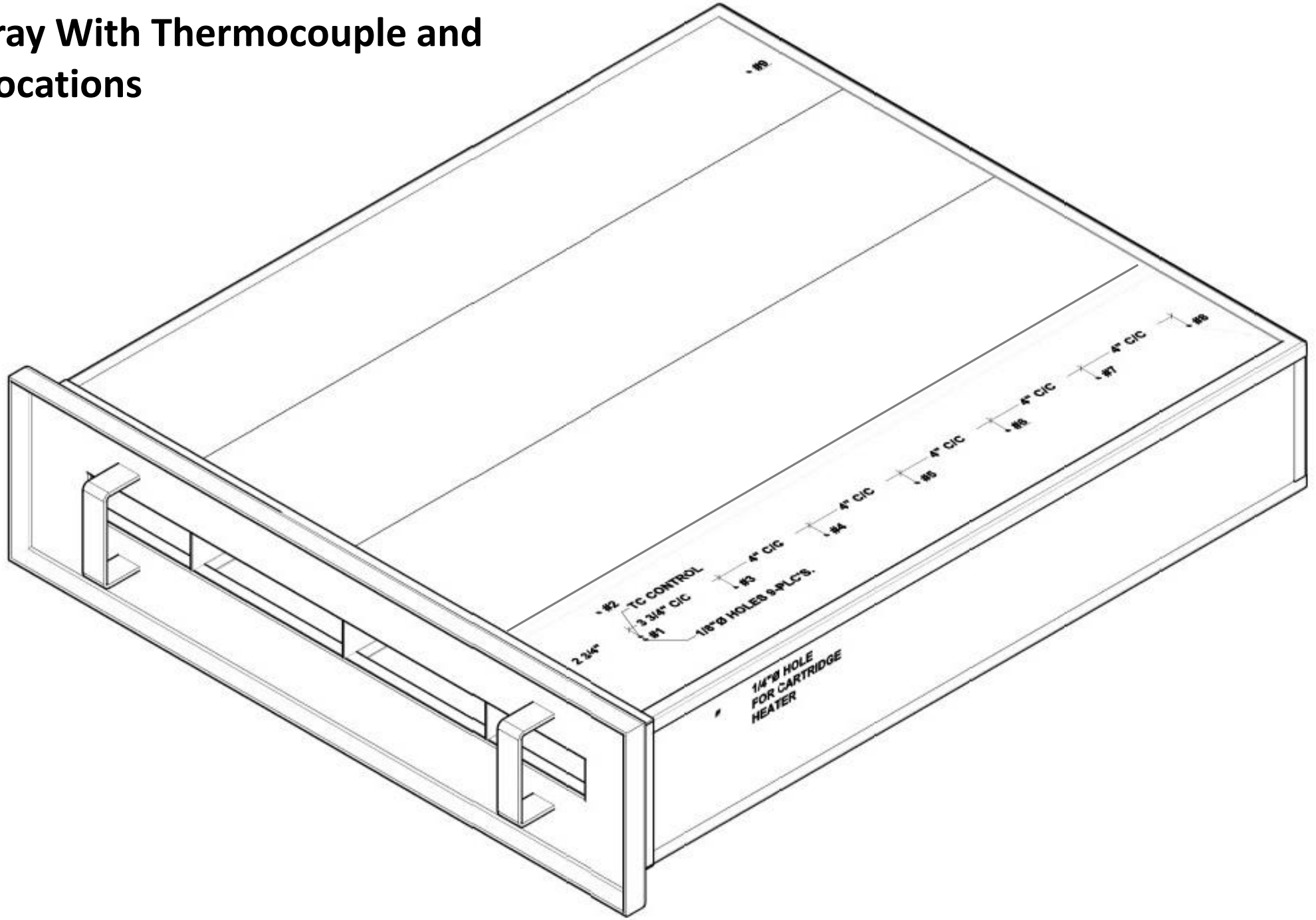
Type II Tray Carbon Bed Ignition Studies

- Carried out in a wind tunnel built for performing mechanical leak testing of individual Type II filters
- Airflow consistent with typical air cleaning system operational conditions (≈ 333 SCFM, ≈ 40 FPM)

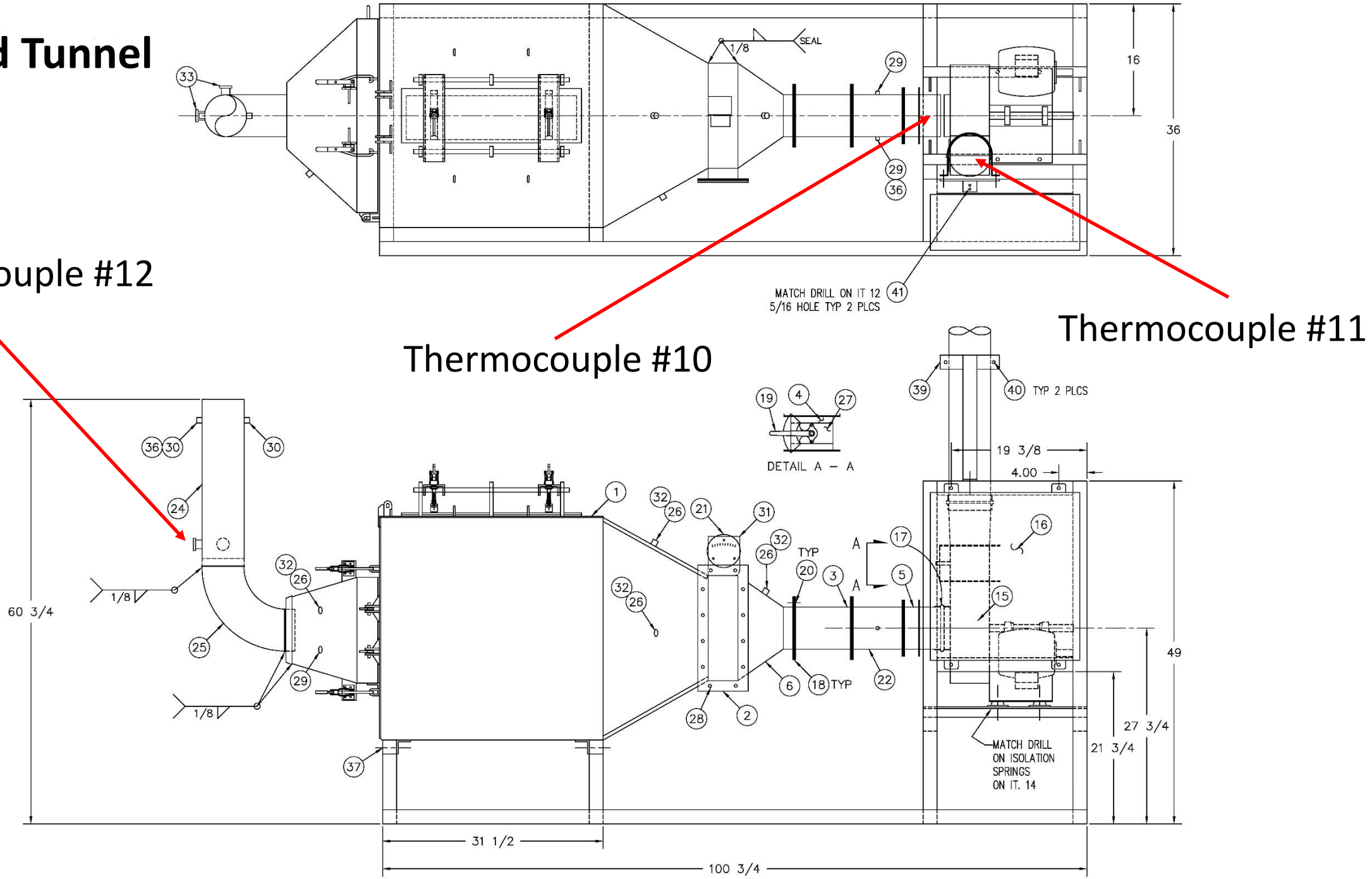
Differences Between Deep Bed and Type II Tray Experiments

- Filter type
- Thermocouple locations
  - Inlet and outlet air temperatures measured in both experiments
  - Additional measurement points within the adsorber used in the Type II tray experiment
- Ignition source
  - Deep bed experiment – hot air
  - Type II Tray experiment – cartridge heater, “hot spot” ignition point

Type II Tray With Thermocouple and Heater Locations



Test Wind Tunnel



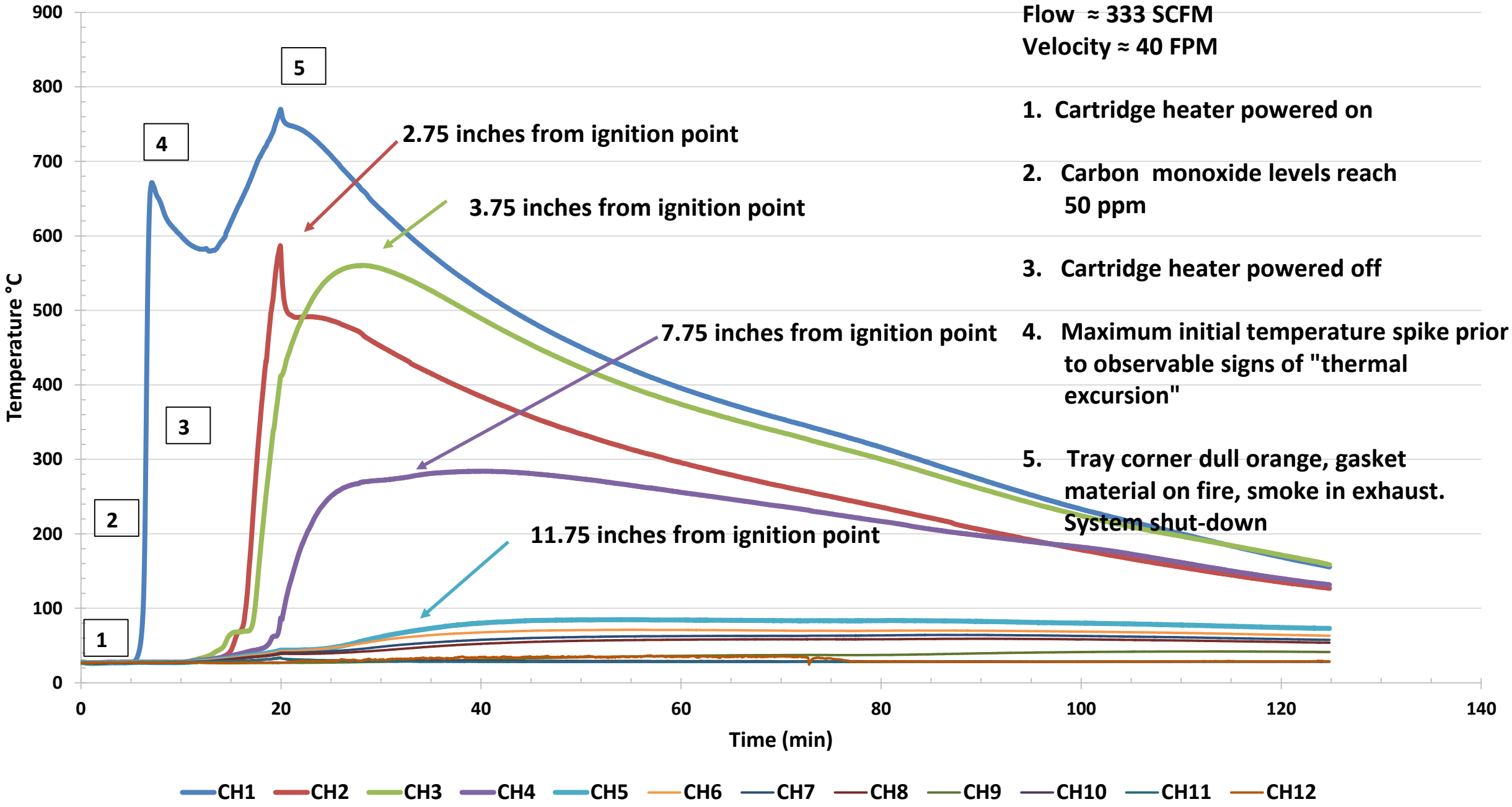
Experimental

- Type II tray, with thermocouples and cartridge heater in place secured in wind tunnel
- System operated for approximately 3 to 5 minutes to determine initial temperature and CO levels
- Cartridge heater powered on
- Cartridge heater powered off after reaching ignition point
- System allowed to run until “obvious” signs of thermal excursion observed
- System shut down and monitored until safe

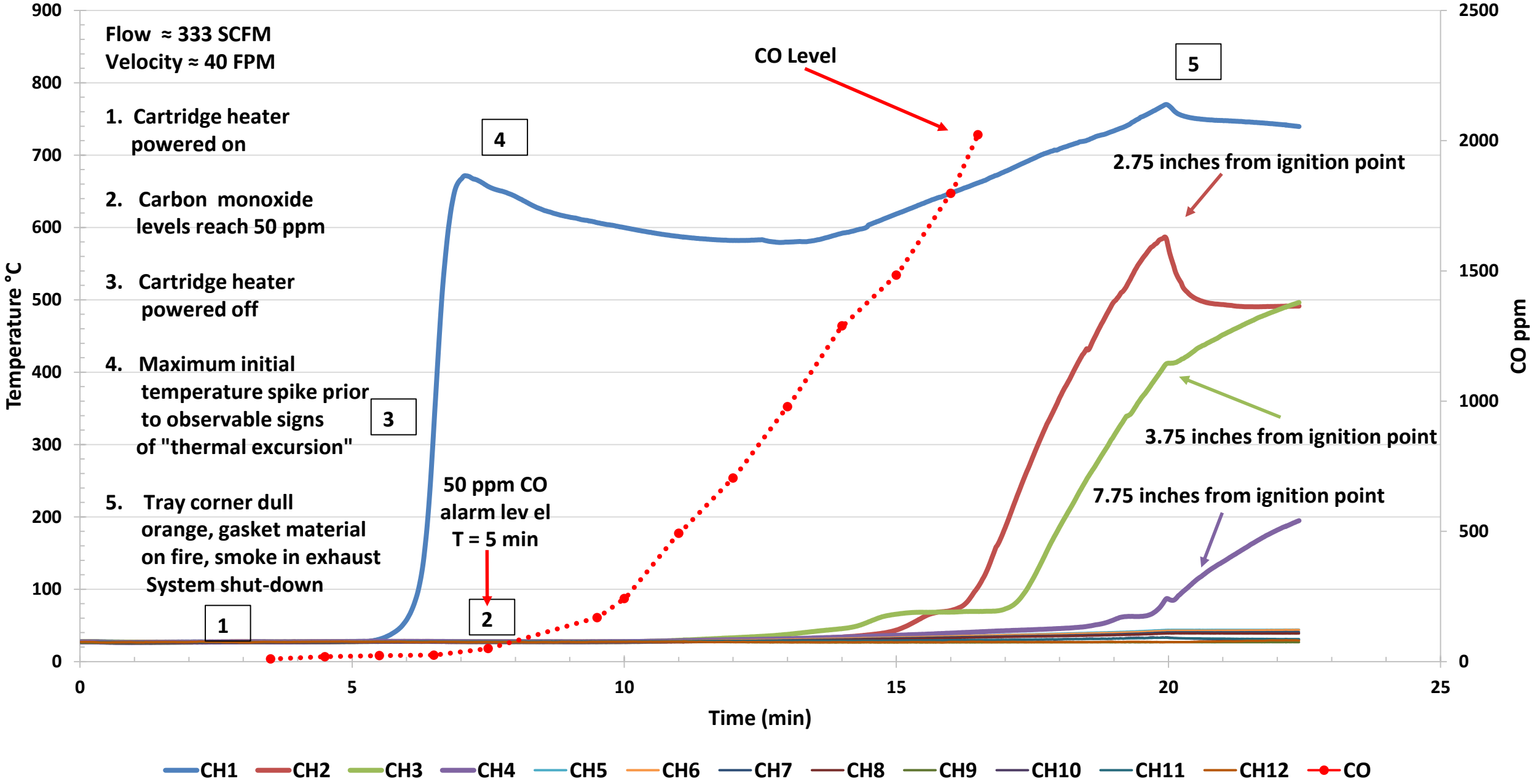

#4
#5
#6
7


S'MoRes

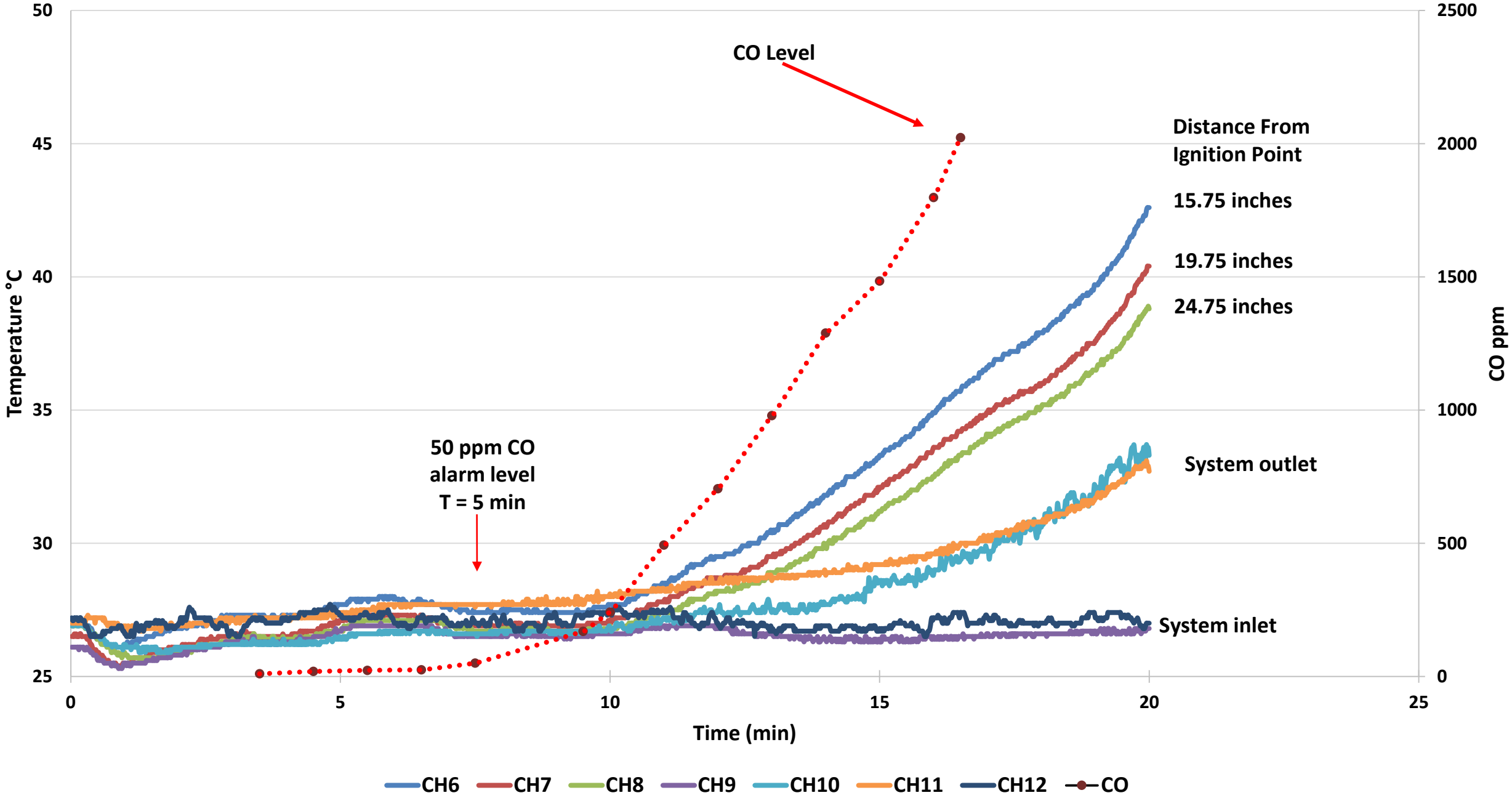
Type II Tray Ignition Studies, Temperature Vs. Time



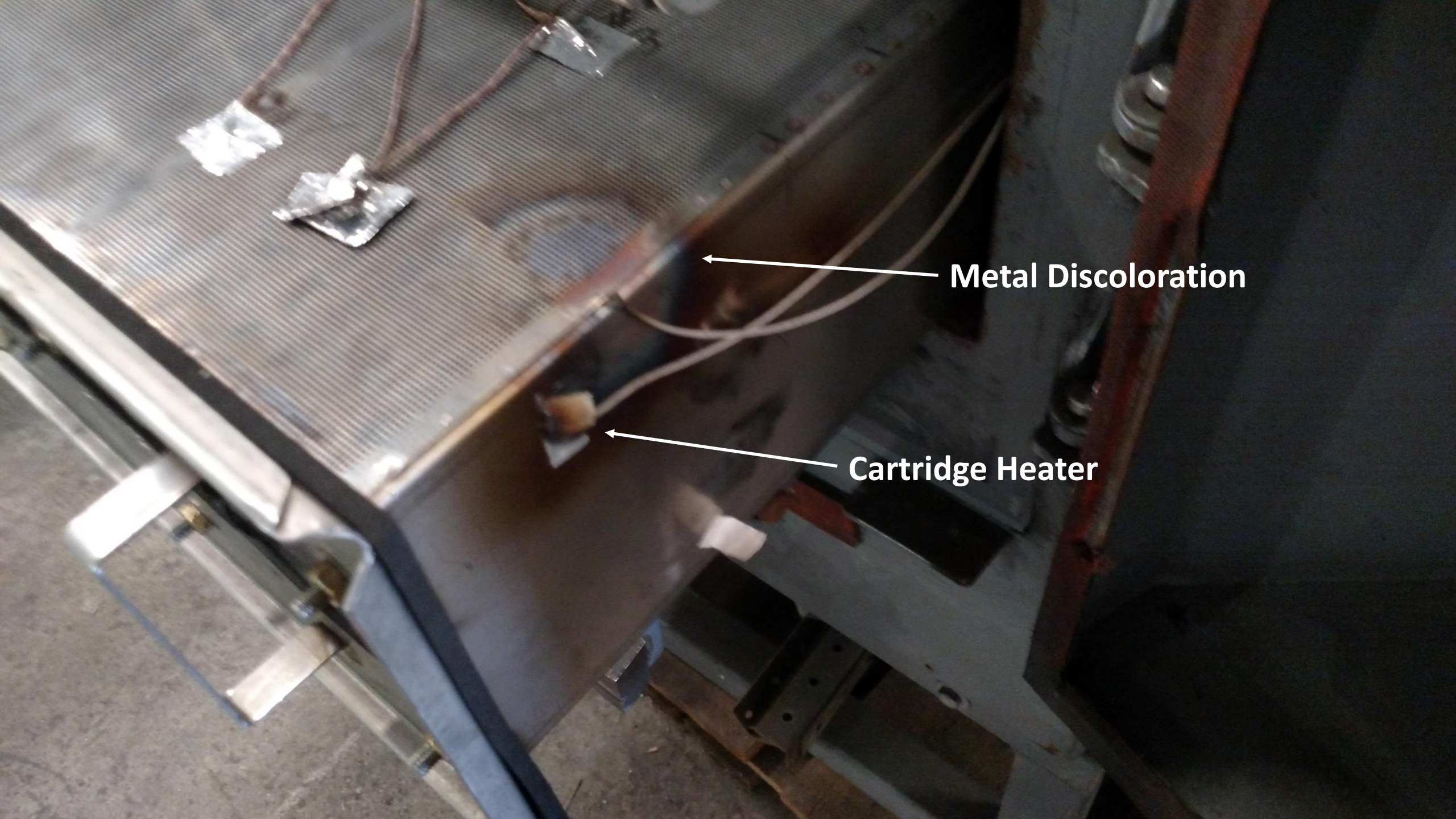
Type II Tray Ignition Studies, Temperature Vs Time and CO Concentration

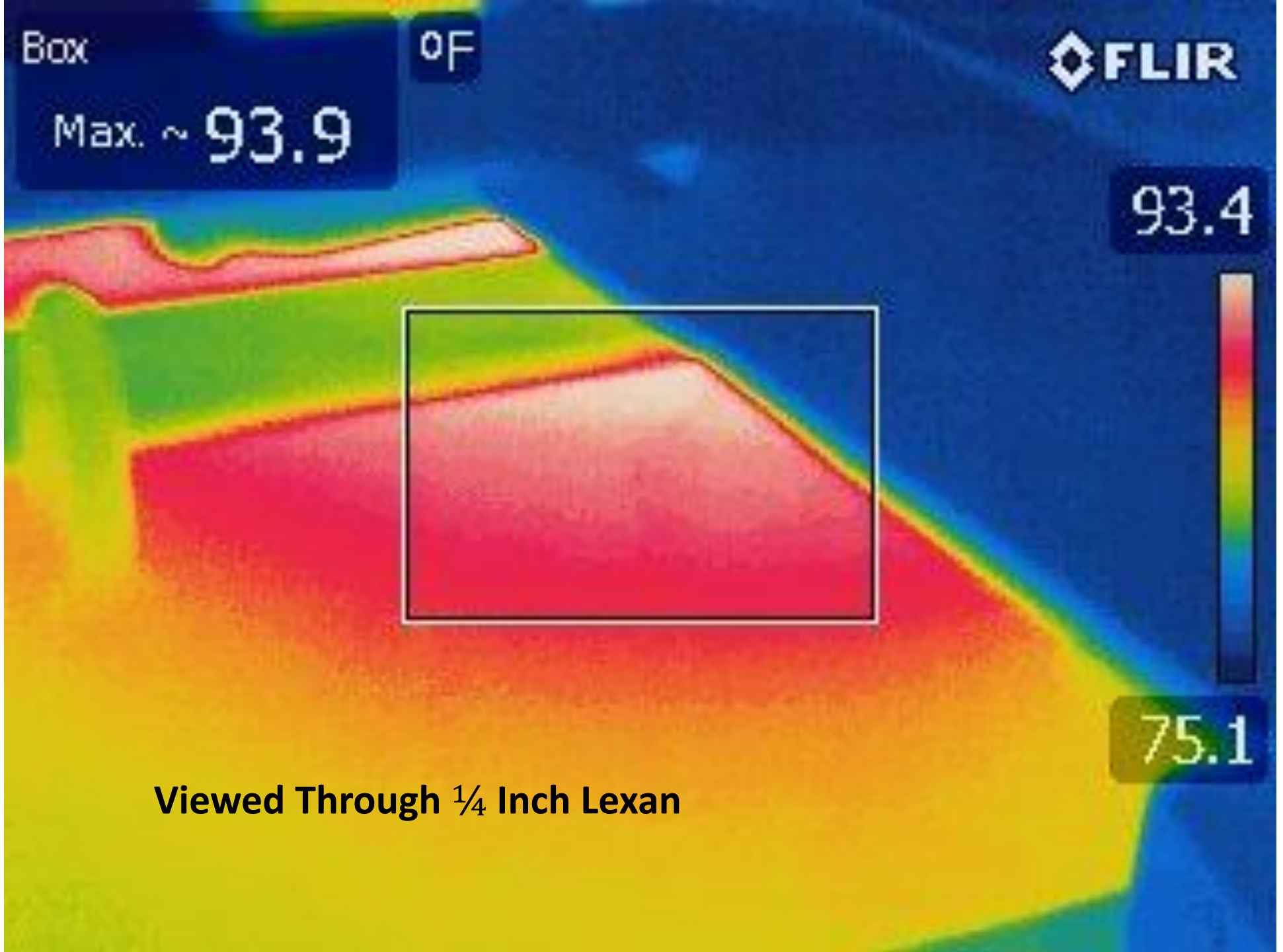


Type II Tray Ignition Studies, Temperature Vs Time and CO Concentration

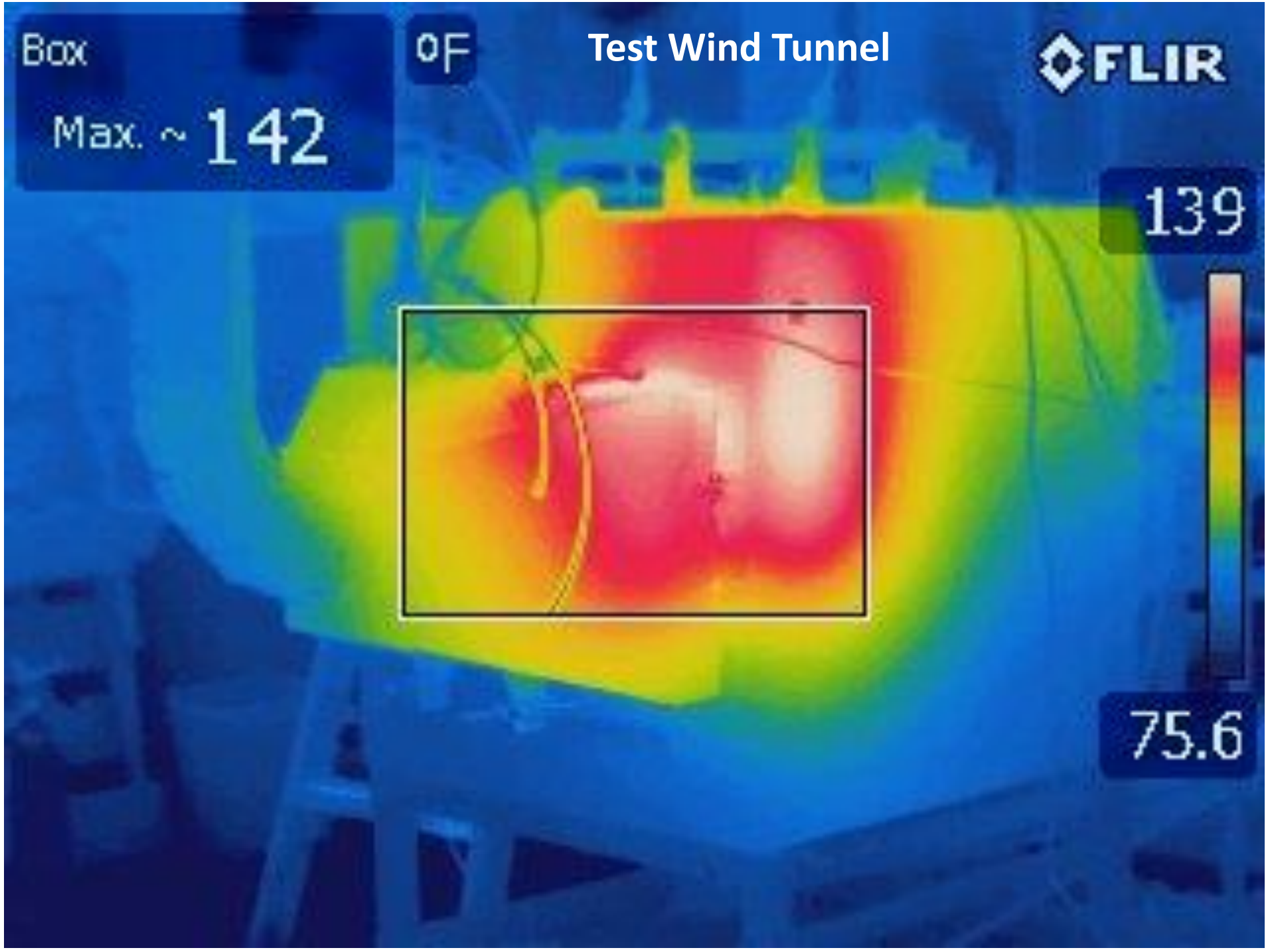



Metal Discoloration


Metal Discoloration
Cartridge Heater

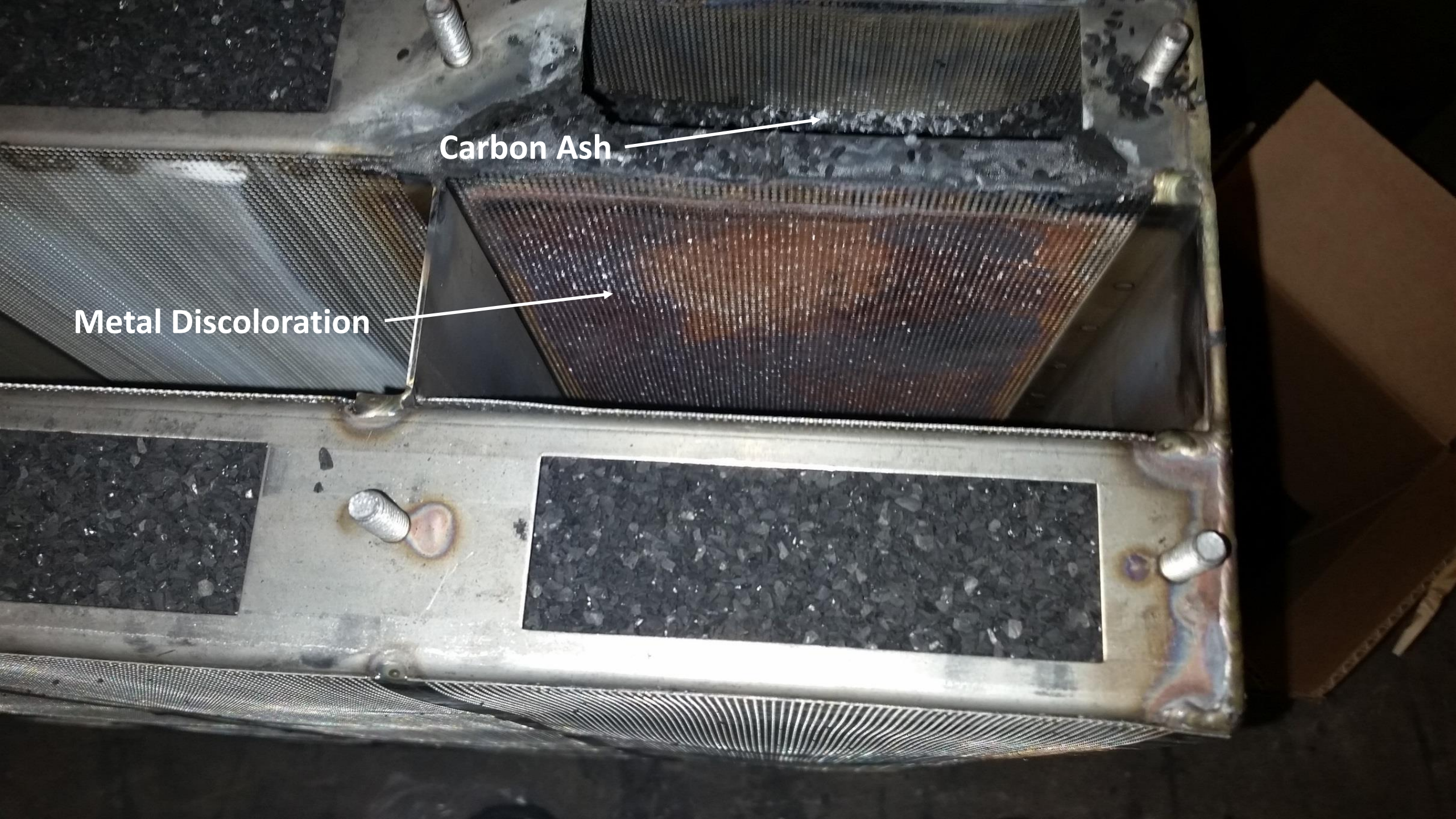


Viewed Through ¼ Inch Lexan


Box
Max. ~ 142
°F
Test Wind Tunnel
FLIR
139
75.6


Burnt Gasket Material


Burnt Gasket Material


Carbon Ash
Metal Discoloration

Conclusions

- CO monitoring is effective as a means of fire detection in adsorber beds
- Thermocouples used for fire detection in adsorber beds may only be useful if they are located where the fire starts
- Thermocouples downstream of an adsorber bank may only indicate a fire once the problem reaches extreme levels
- Stopping air flow stops the fire (no more oxygen)
- High and High-High temperature alarm points may not be as useful for fire detection in adsorber beds as simple CO monitoring

Questions?