

# A Smouldering Cigarette on 10-Layer Whatman Filter Paper Substrate: Temperature Distribution

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# Ignition Propensity Study: Background & Objectives

## Aspects of LIP Research

- Historical overview – Ihrig and Zawadzki (2002)
- Thermophysics of free smouldering cigarettes – Baker (1970 ~ 80), Waymack et al (1997), Miura et al (2001)
- Cigarette paper & diffusion – Eitzinger (Coresta 2004)
- Computer (CFD) modelling – Eitzinger (TSRC 2004)

## ASTM2187-02b/04 Test Method

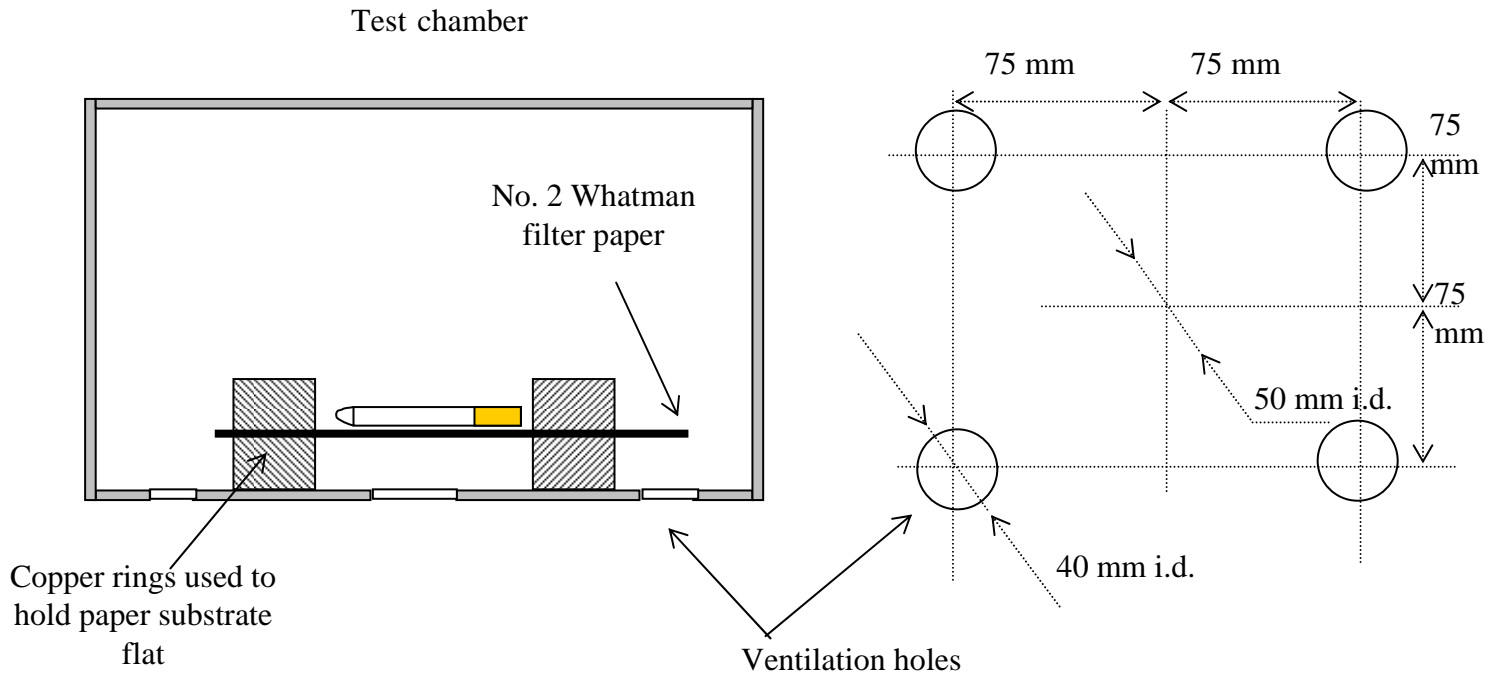
- SMI (TSRC 2004)
- Coresta LIP Task Force

## Objective of This Work

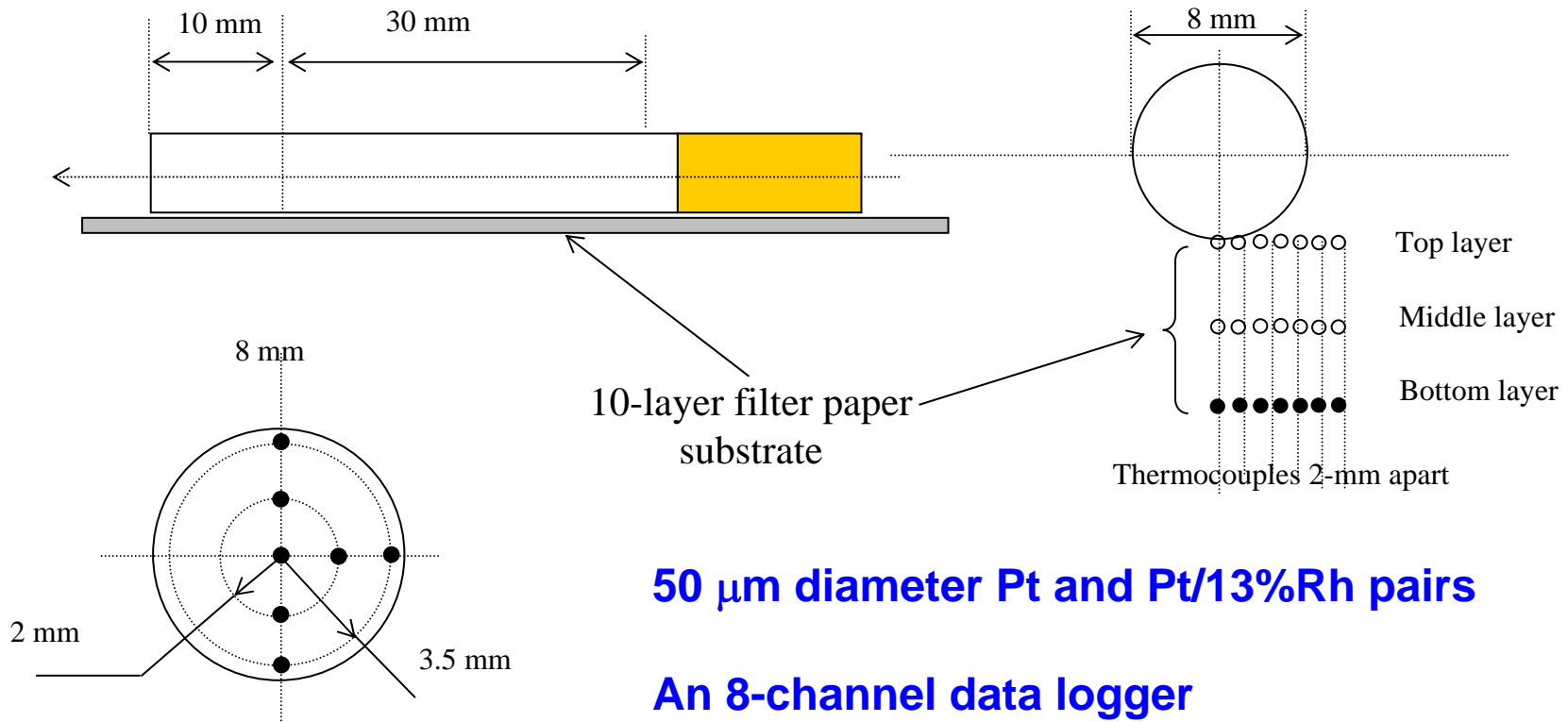
- Temperature distribution: cigarette & substrate

# Experimental Setup: Test Chamber

This work (350W x 345D x 380H, mm) vs. ASTM (292W x 395D x 340H, in mm)



# Temperature Measurement: Positions

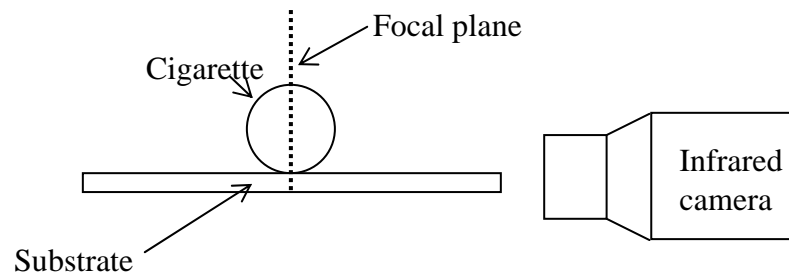
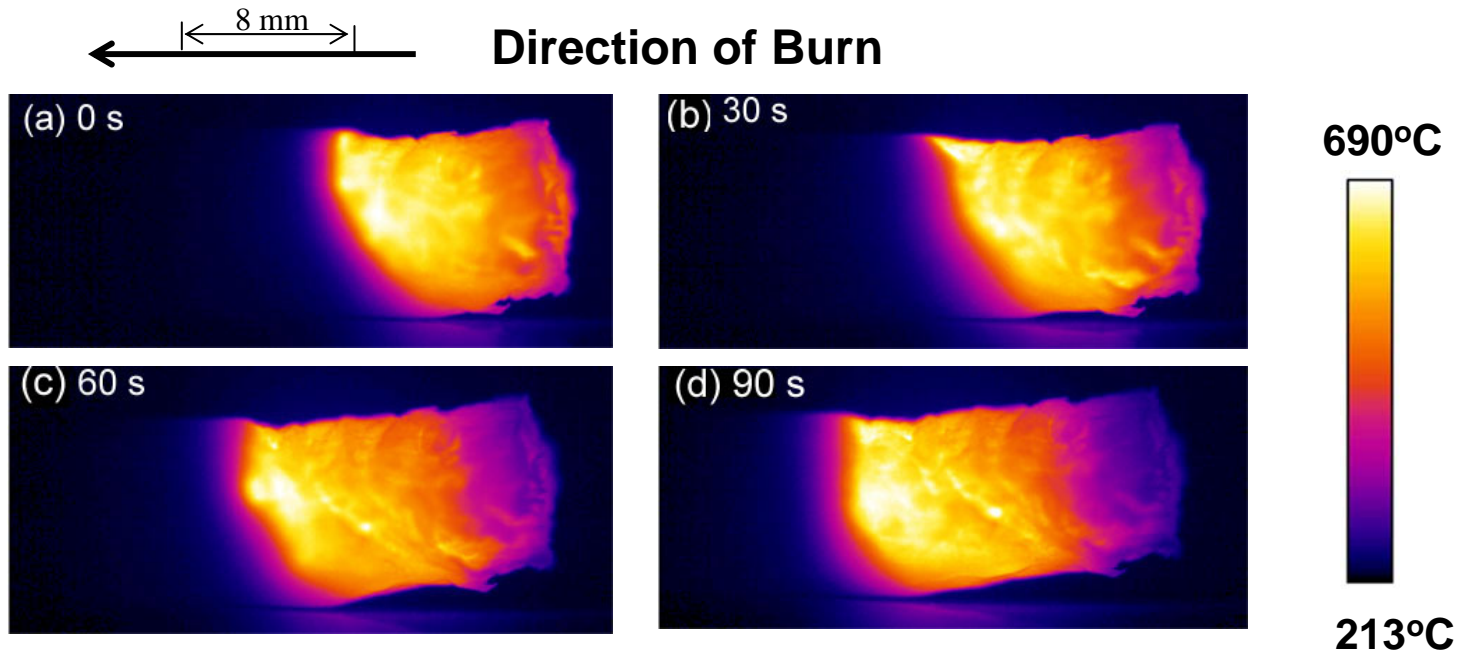


**50  $\mu\text{m}$  diameter Pt and Pt/13%Rh pairs**

**An 8-channel data logger**

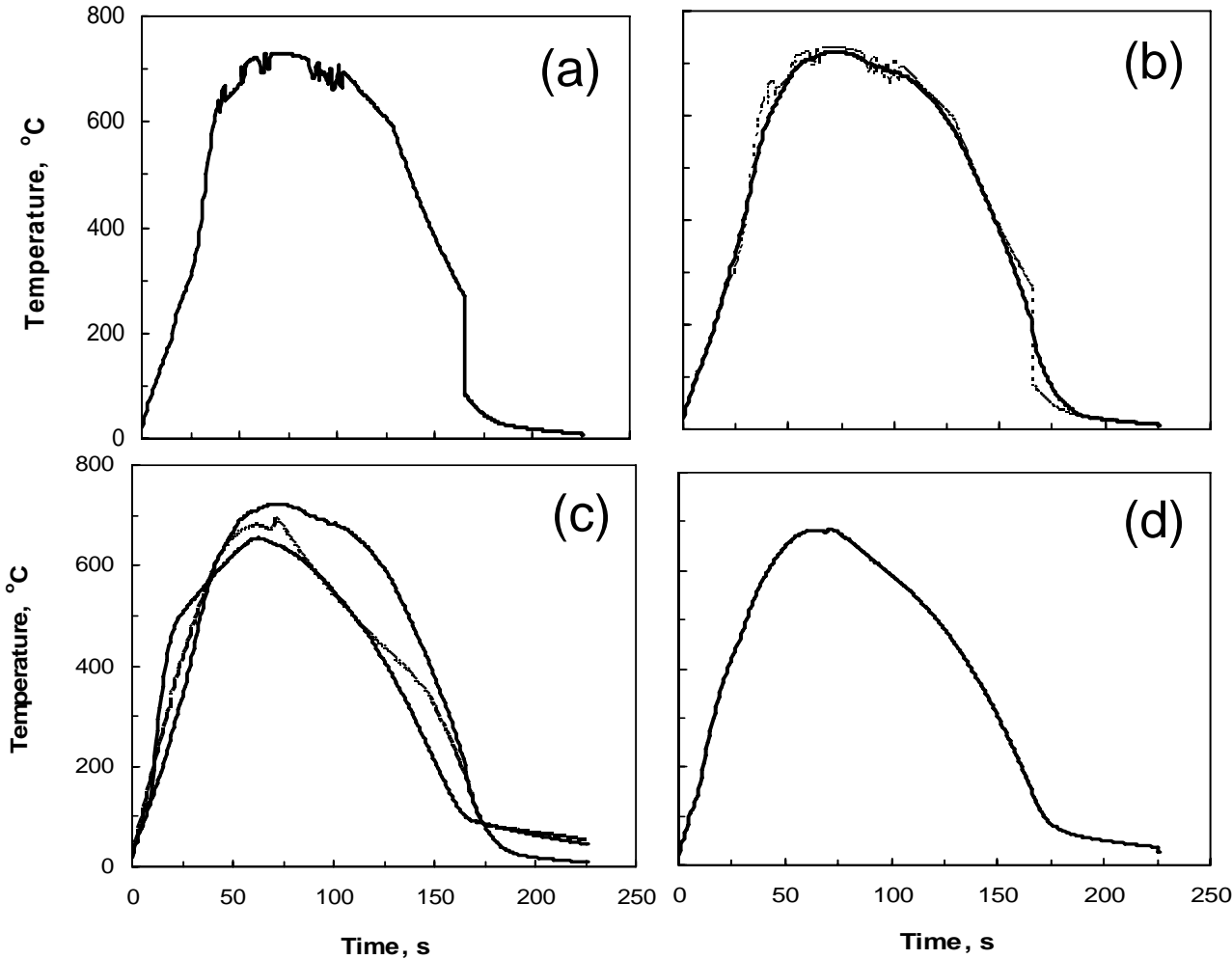
**Commercial StateExpress 555 cigarettes  
(King Size with 11 mg 'tar')**

# Infrared Thermal Imaging: Observations

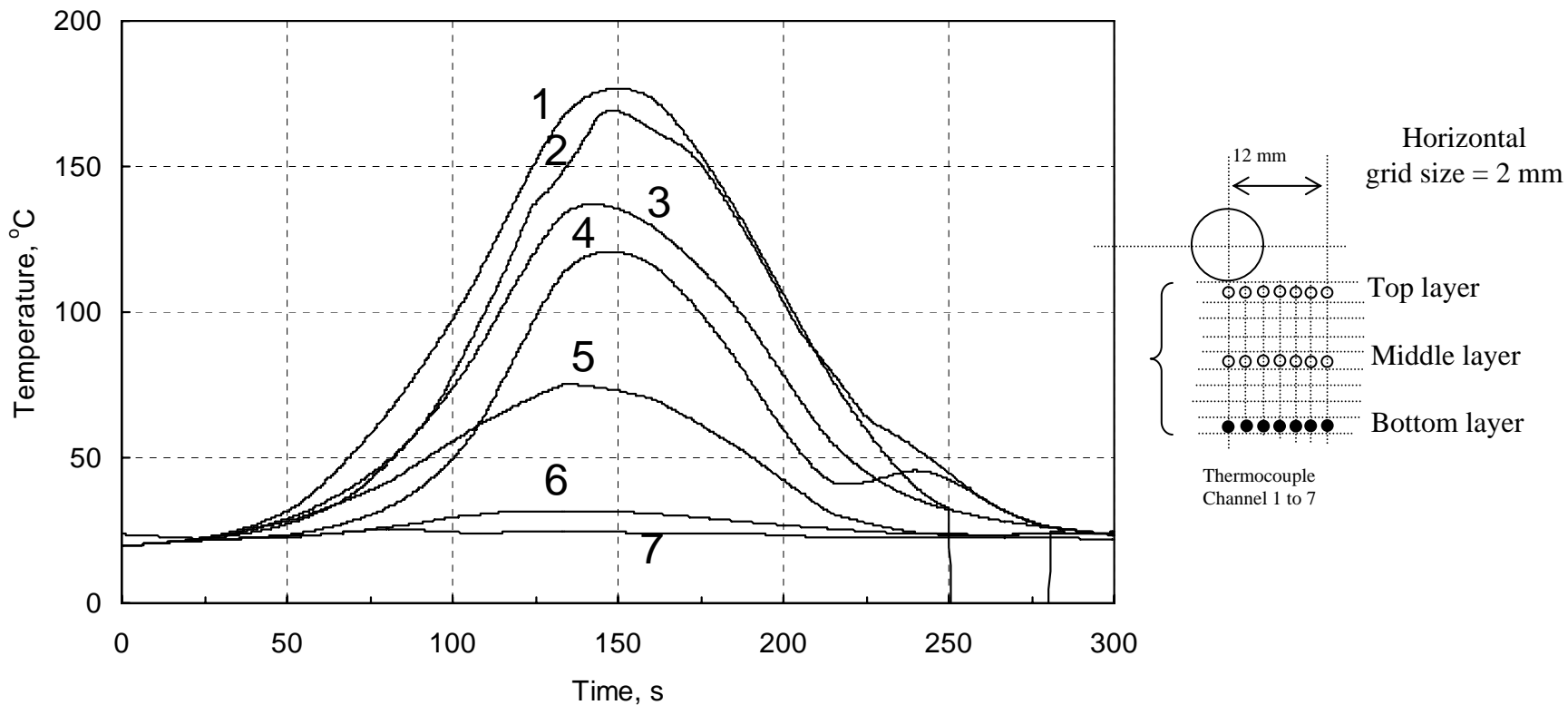


# Thermocouple Outputs: An Example

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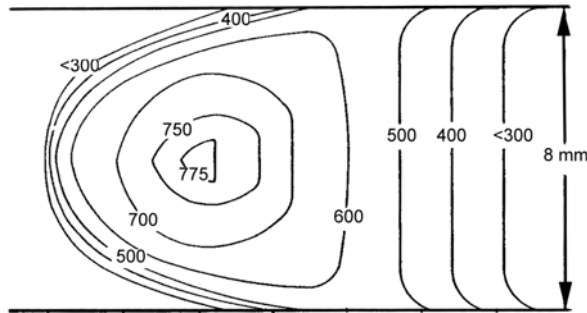


# Thermocouple Outputs: An Example

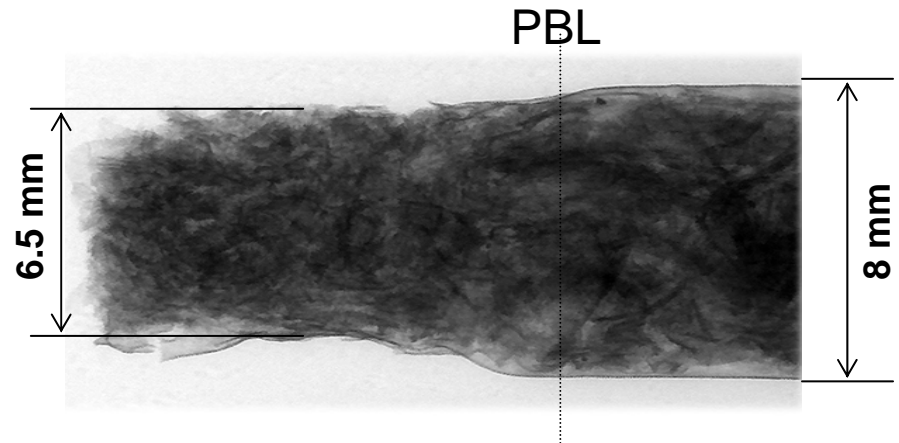


# Modern Low “Tar” Cigarette: Coal Shrinkage

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R.R. Baker, 1974, Nature 247:405



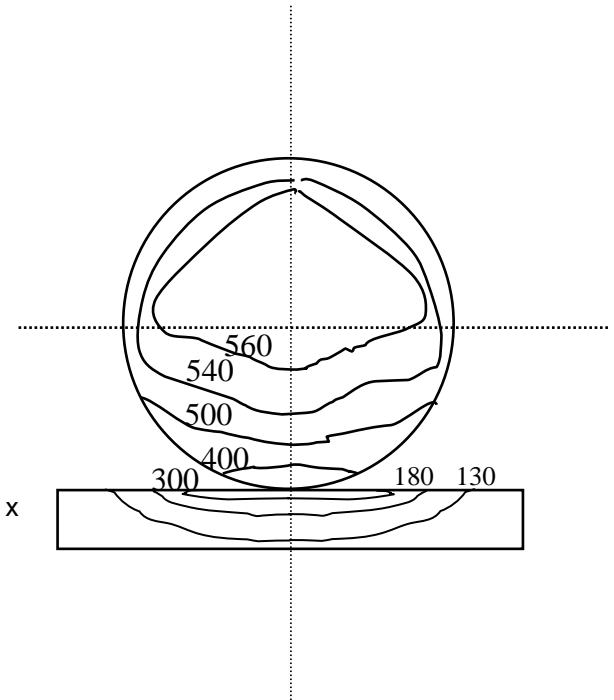
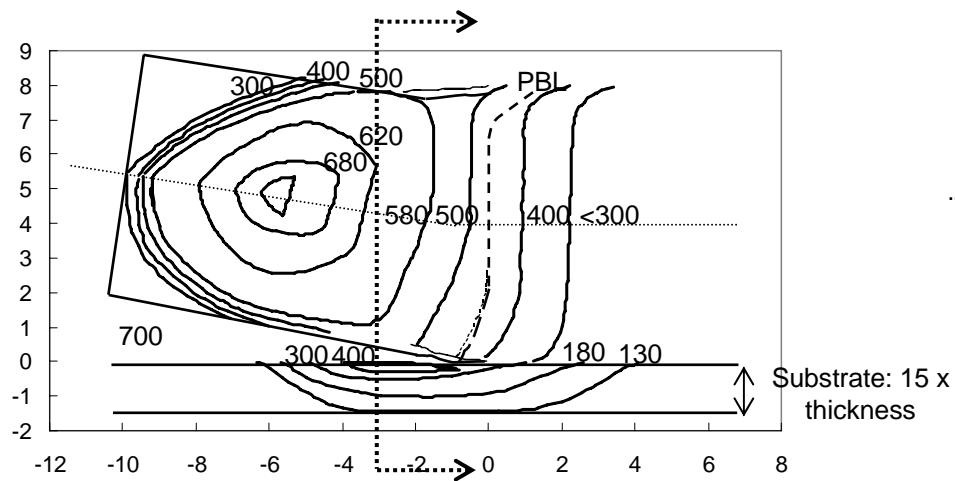
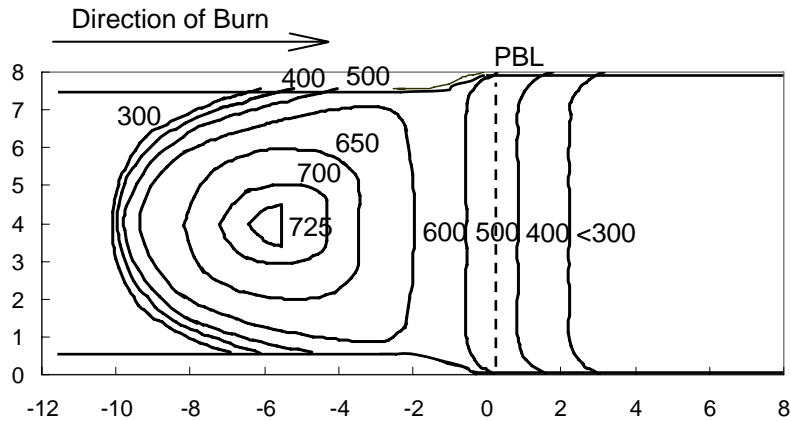
X-ray image of coal after smouldering burn

Coal shrinkage can be significant for modern low “tar” cigarettes that use expanded tobacco and reconstituted materials

Natural buoyancy may be established surrounding the coal in IP tests

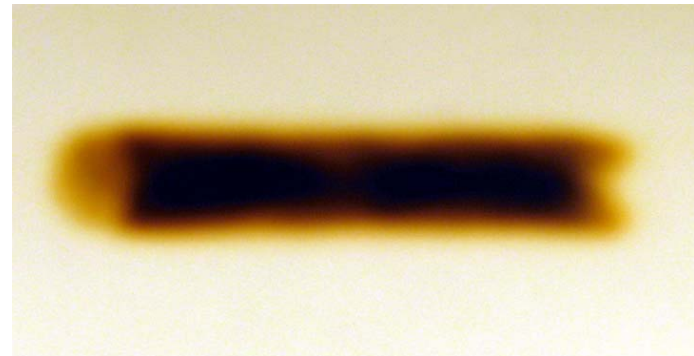
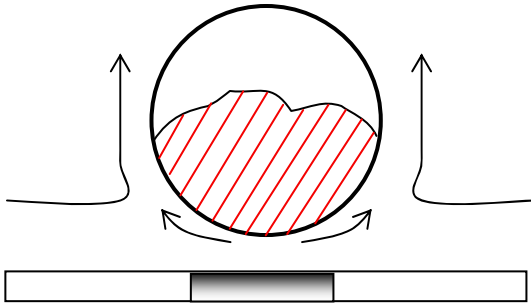
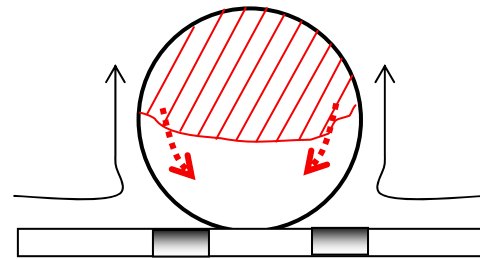
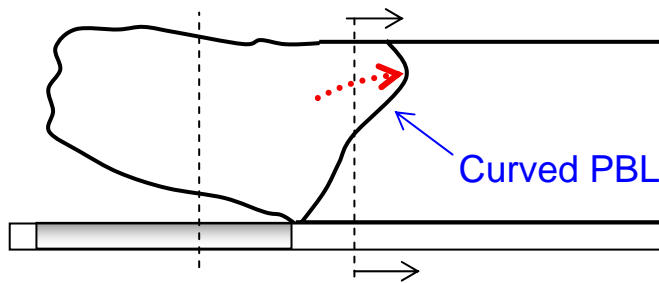


# Steady-State Temperature Distribution



# Phenomenological Summary

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# Conclusions

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- Smouldering propagation during IP tests remains intermittent
- Lower half of the coal: losing heat to the substrate & unable to sustain smouldering on its own
- Upper half of the coal: higher temperature and driving the smouldering process
- The test cigarettes achieved 27% reduction in LBR in the IP test. This “contact” LBR may be useful in studying the interaction between the cigarette and the substrate

# Fundamental LIP Research: Challenges

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- Understanding diffusion, paper structure, band materials
- Further temperature measurements: transition states
  - from free smouldering to the substrate
  - from the steady-state to extinguish on the substrate
  - in and out of the bands
- Computer modelling

Acknowledgement: P.D. Case and R.R. Baker