Why Monitor Concrete Temperature? And How?

Peter Taylor

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What Are We Talking About?

- Maturity
- Isothermal Conduction Calorimetry
- Field Semi-Adiabatic Calorimetry
- Heat of Hydration
- Setting Time

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Definitions

- Isothermal (constant temperature)
- Adiabatic (no energy transfer)
- Semi-adiabatic (some, known, energy transfer)

Maturity

- Using a time/temperature function to estimate strength (or other property)
- No thermal control

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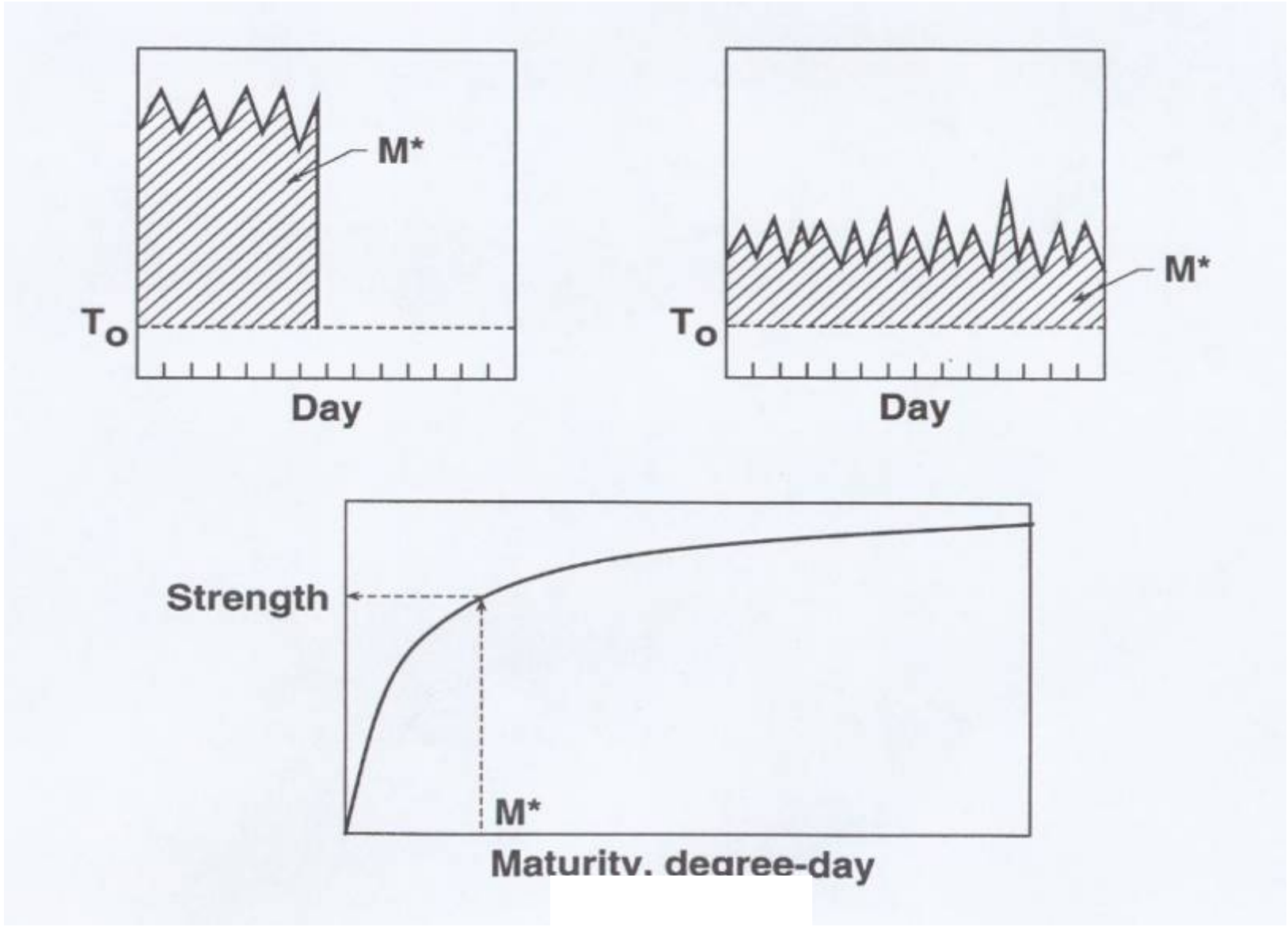
M*
To
Day
M*
To
Day
Strength
M*
Maturity, degree-day

Why?

- Replaces Temperature-Matched Curing of Cylinders in Thermal Control Plans
- Can Reduce Construction Time

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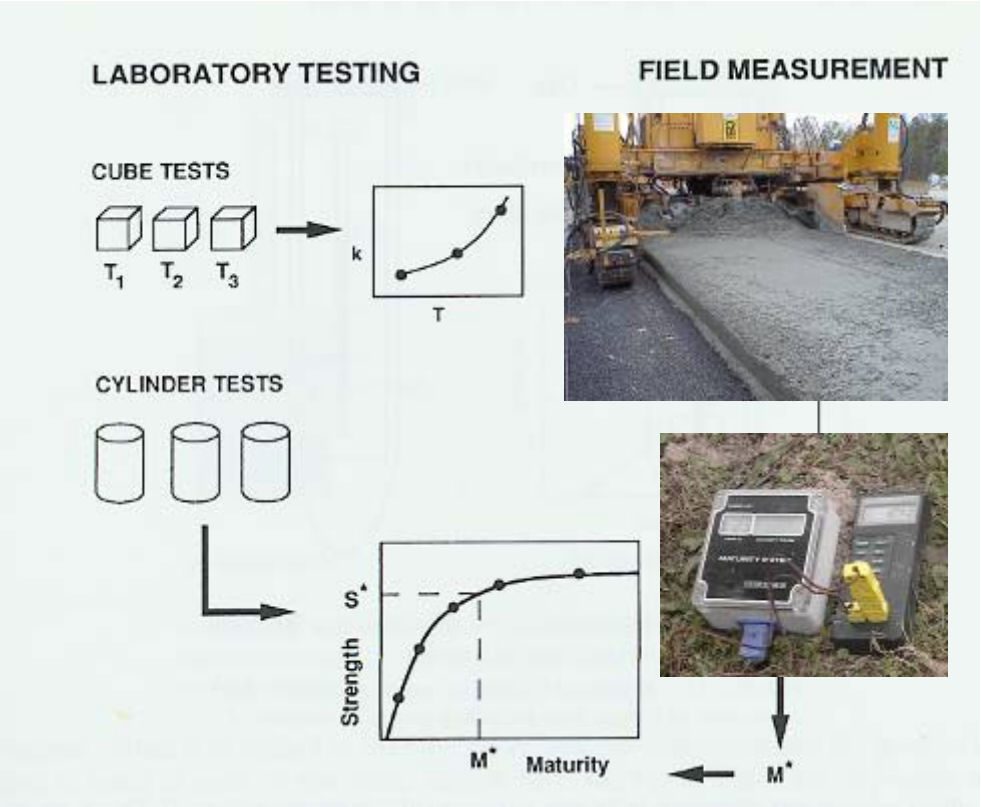
How?

- Use laboratory testing to develop a relationship
- Monitor concrete using temperature probes



Note: Maturity testing does not indicate quality of concrete

ASTM C1074 Maturity

- Time-Temperature Factor (°F·hr)

$$M = \sum_{t=0}^{t} (T - T_o)\Delta t$$

- Equivalent Age (days)

$$M = \sum_{t=0}^{t} e^{-Q\left(\frac{1}{T_a} - \frac{1}{T_s}\right)}\Delta t$$

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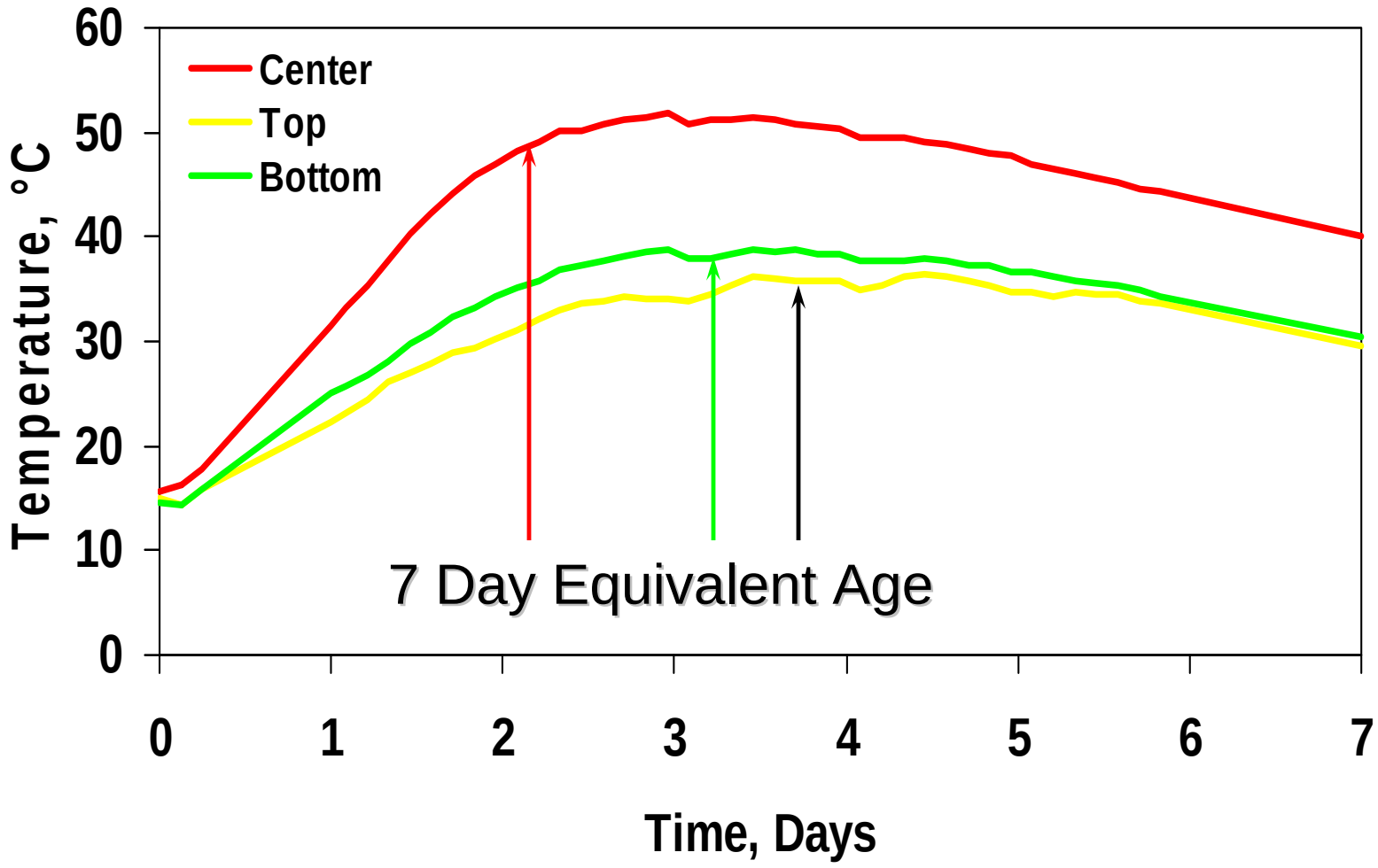
Footing Example



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But...

- Maturity relation required for each mix
- Provides an estimate of a property based on indirect measurements

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Calorimetry

- Measuring heat in paste mixtures to assess hydration kinetics
- i.e. How do system chemistry, admixtures and SCMS influence hydration
- Isothermal

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How?

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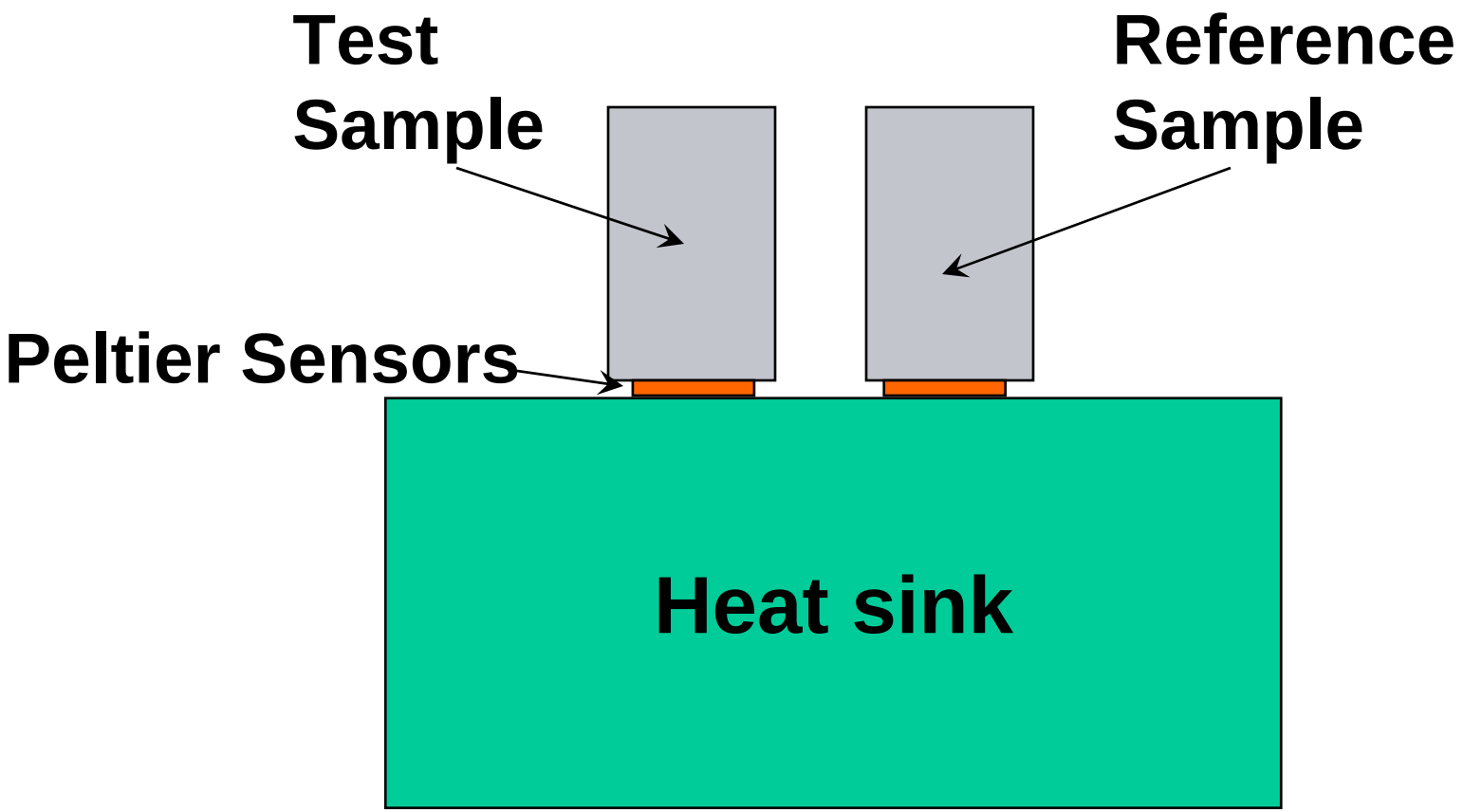
How?



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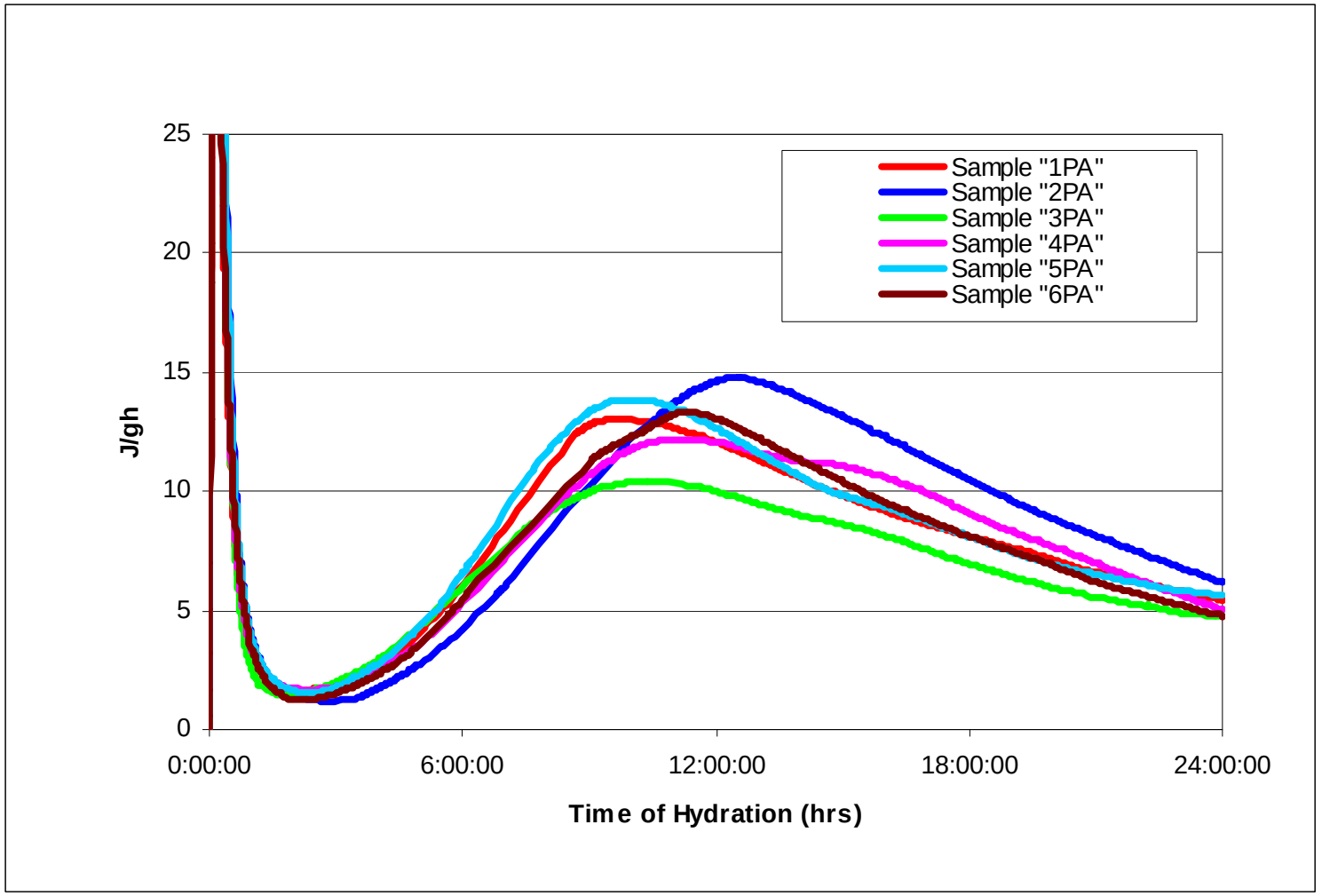
Why?



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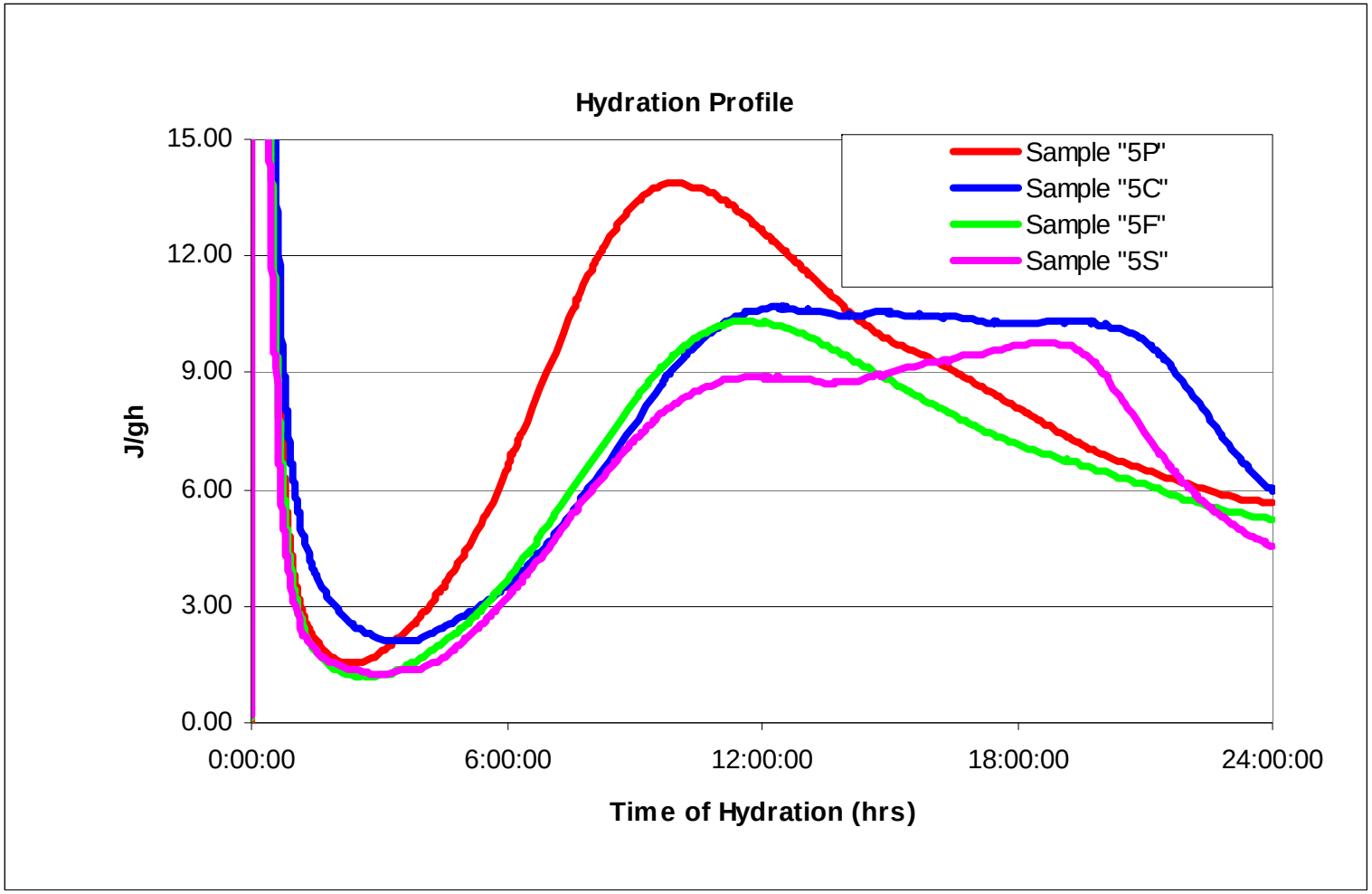
Why?



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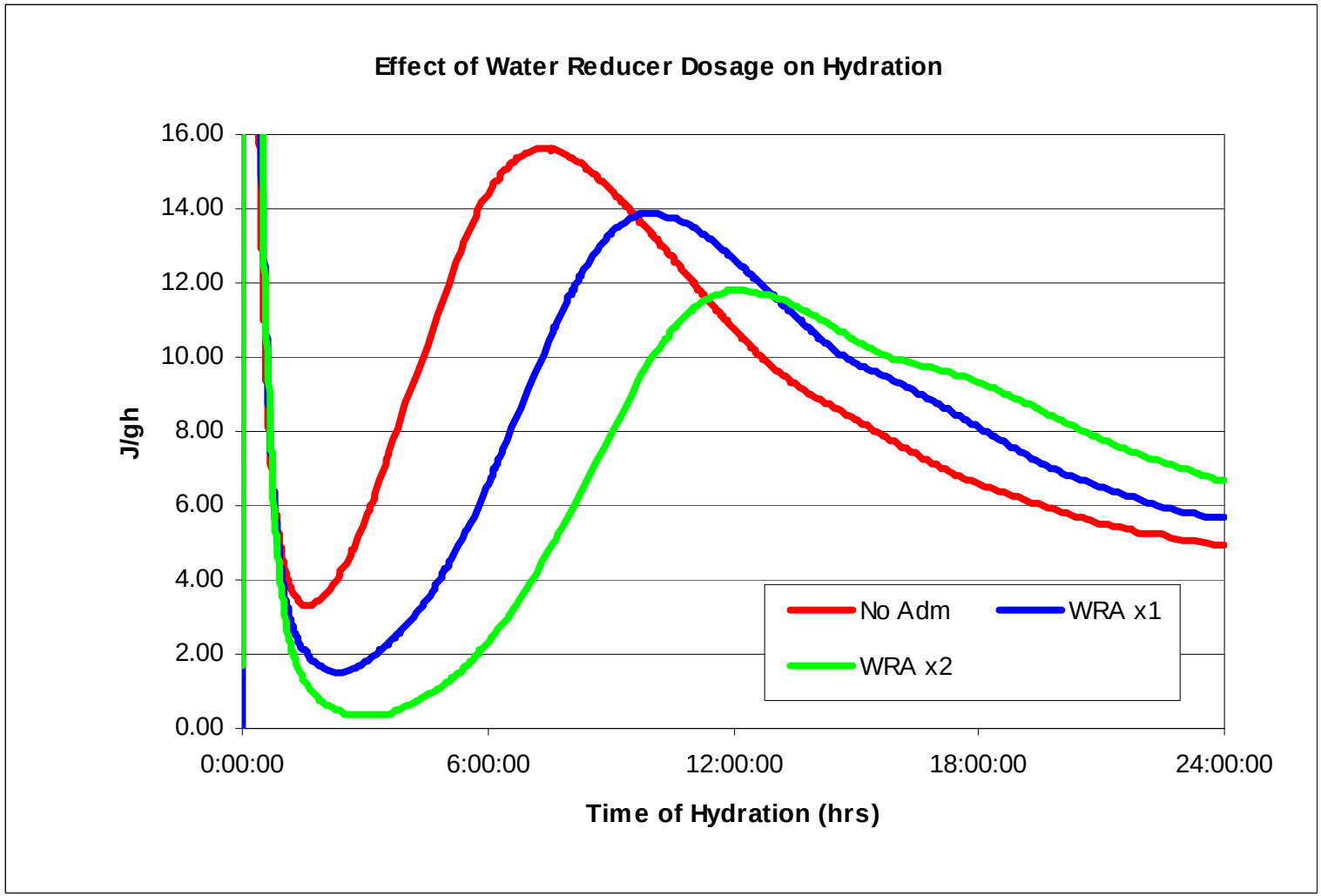

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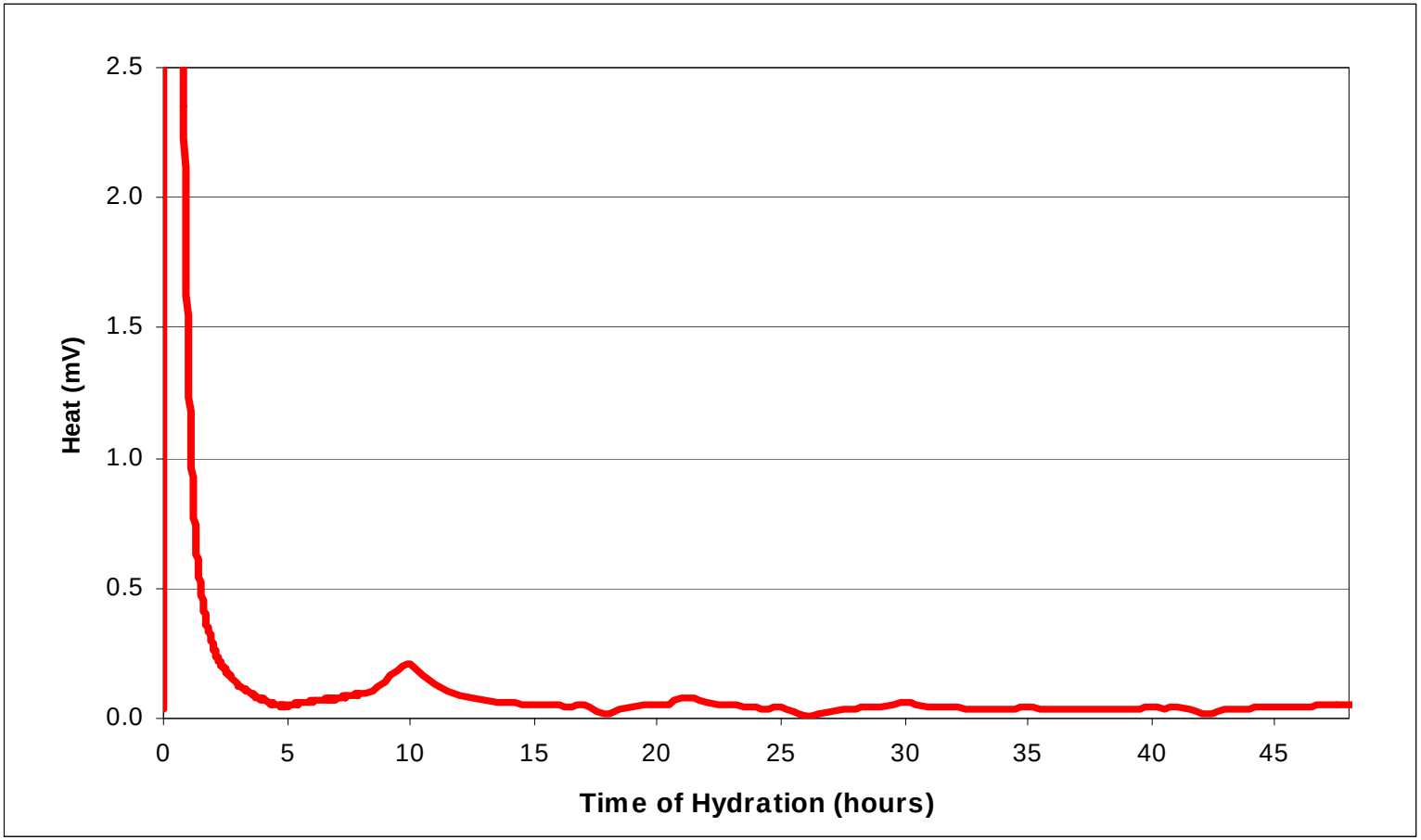
Why?



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But...

- Small paste samples
- Fixed temperature
- May not flag all aluminate reaction problems
- Takes up to 24 hours
- Other techniques?

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Field Semi-Adiabatic Calorimetry

- Measuring heat in mortar /concrete to assess hydration kinetics
- i.e. Is the system hydrating?
- Semi(ish) adiabatic

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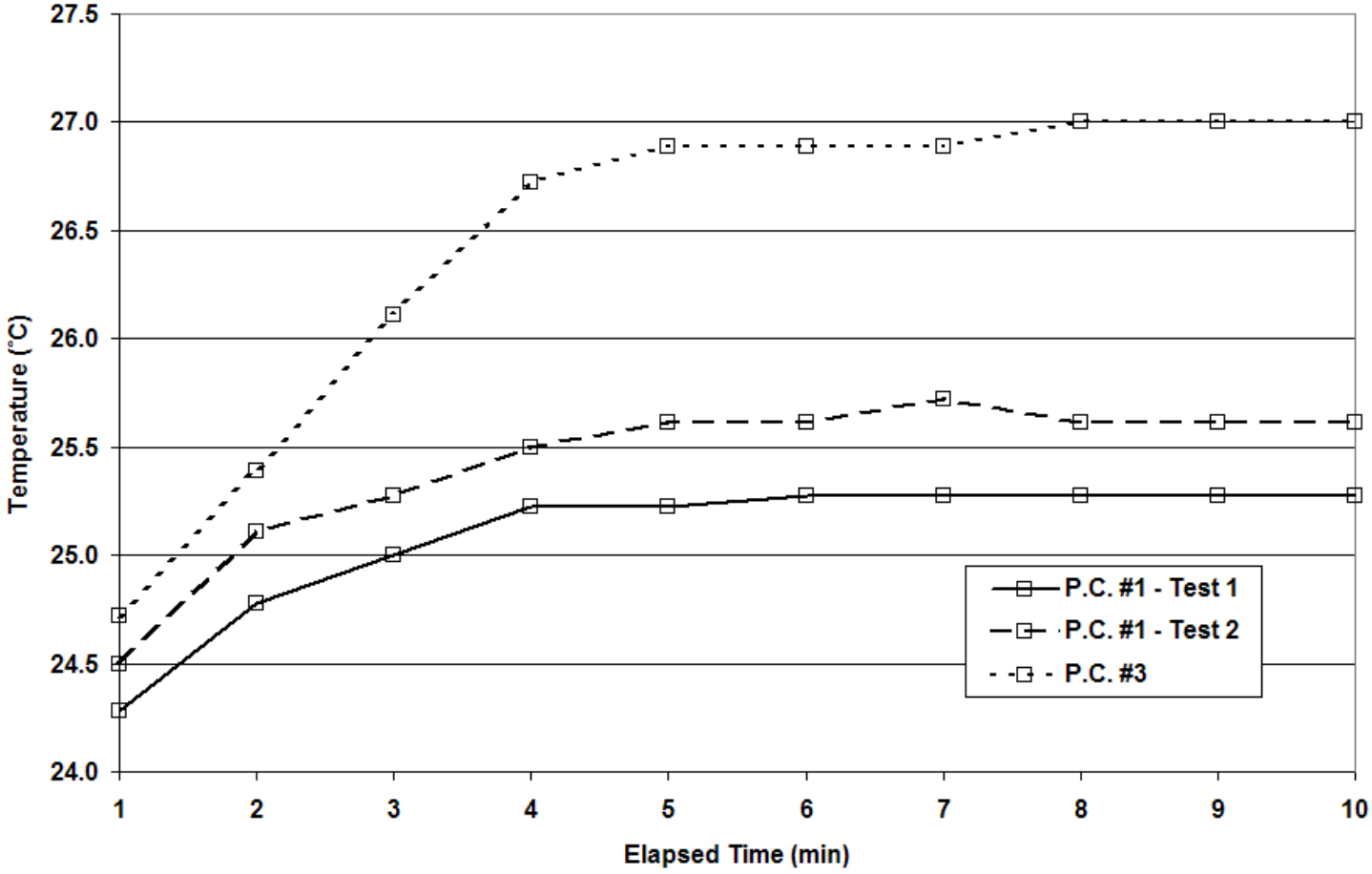
How?

Why?



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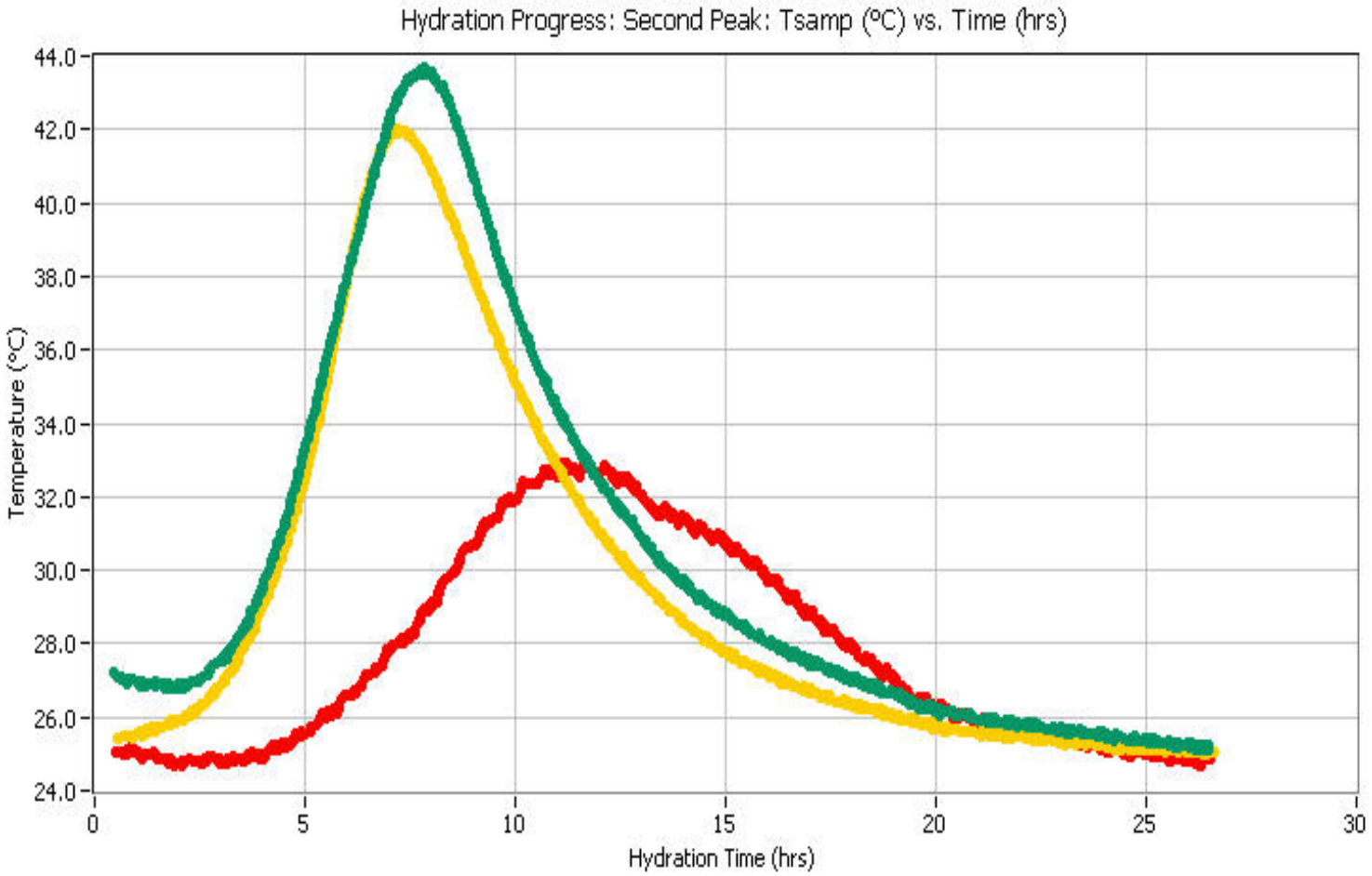

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But...

- Coarse
- Takes time

Heat of Hydration

- Measuring heat generated by a cementitious system (paste)
- Used for heat calculations in mass concrete
- Adiabatic / Semi adiabatic

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Why?

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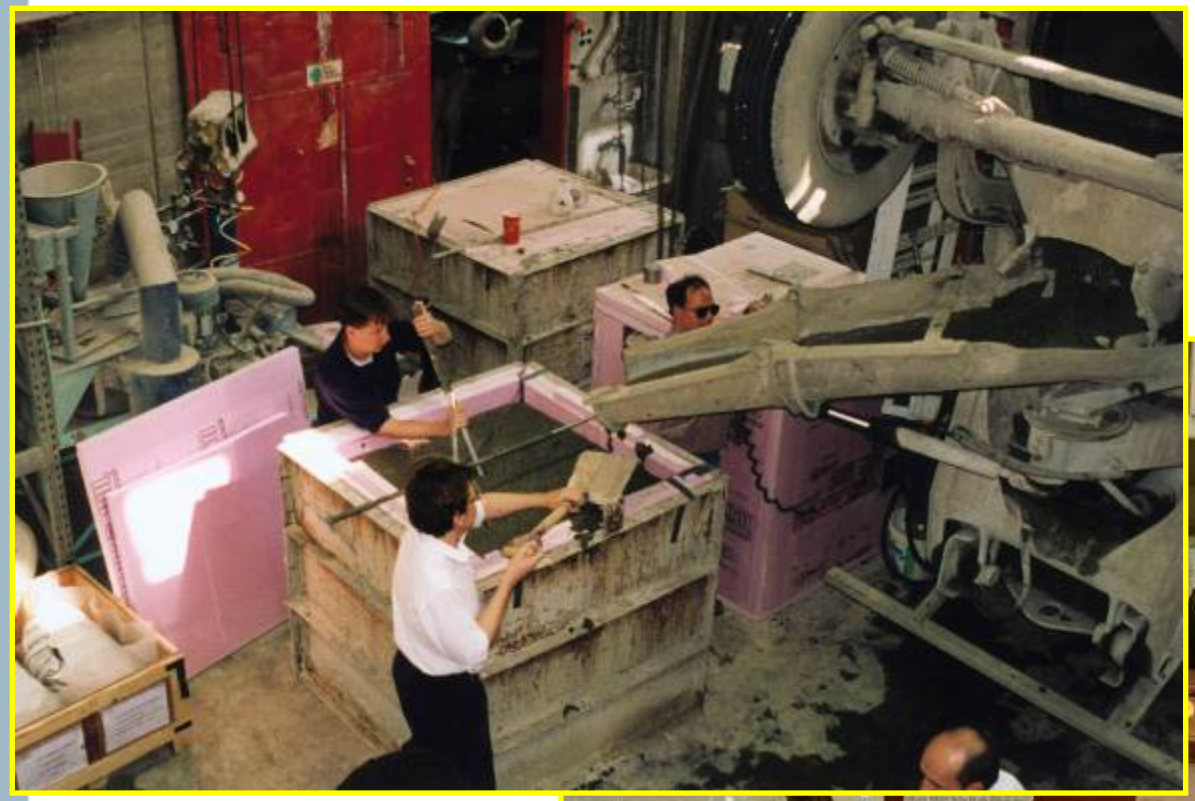
How?



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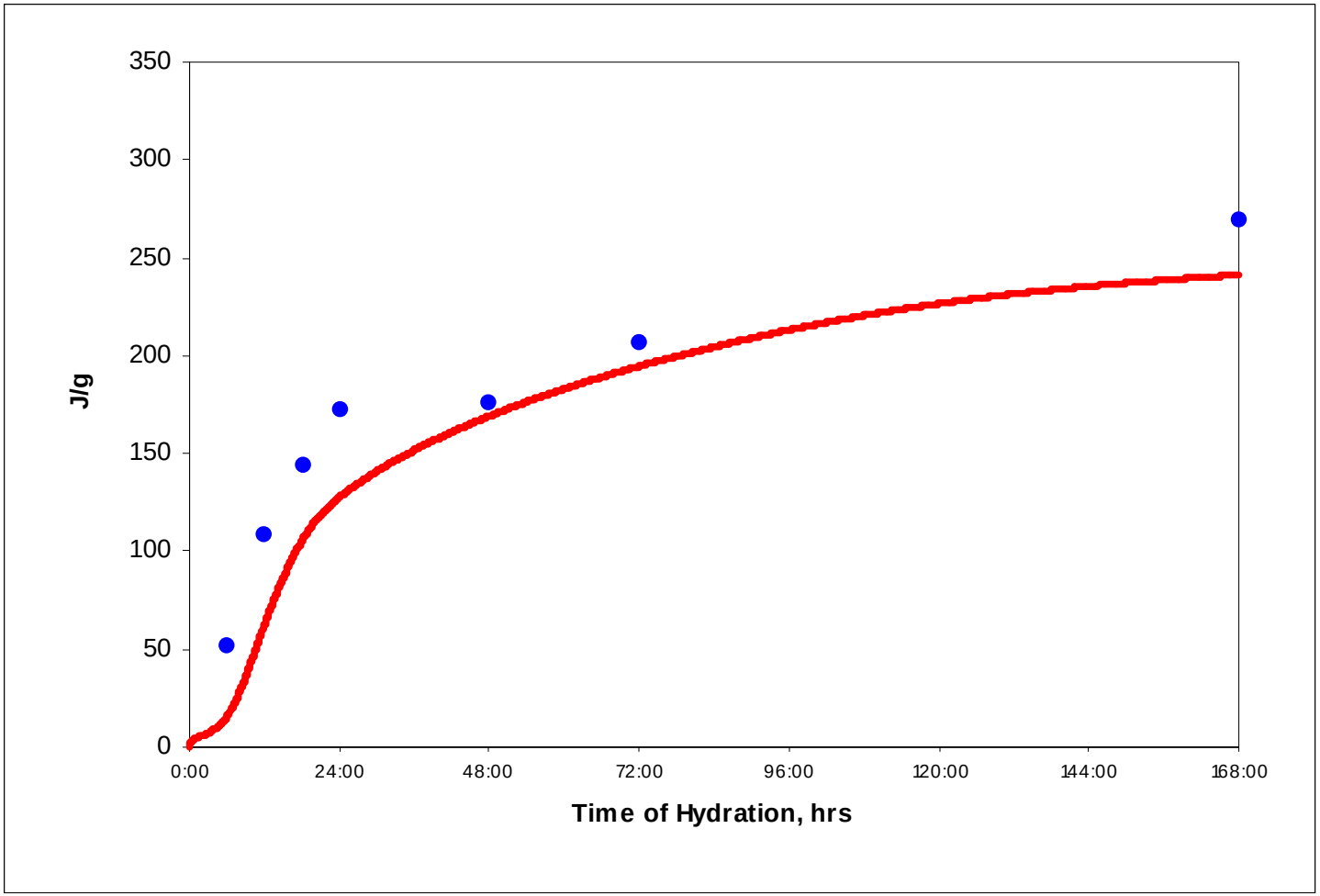
How?


350
300
250
200
150
100
50
0
J/g
0:00
24:00
48:00
72:00
96:00
120:00
144:00
168:00
Time of Hydration, hrs

But...

- Not standardized
  - yet

Time of Set

- Using temperature monitoring to measure time of set
- Semi-adiabatic

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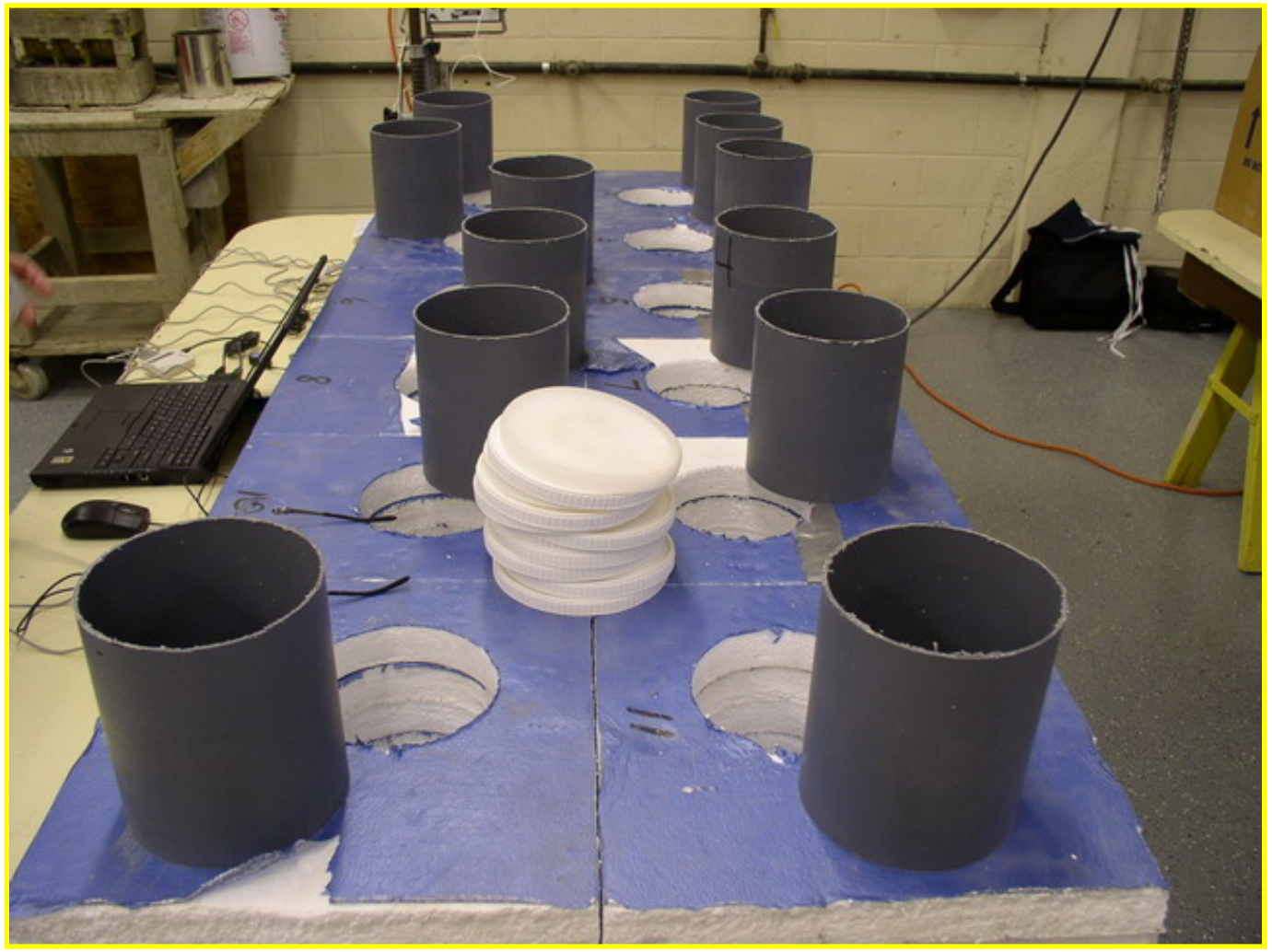

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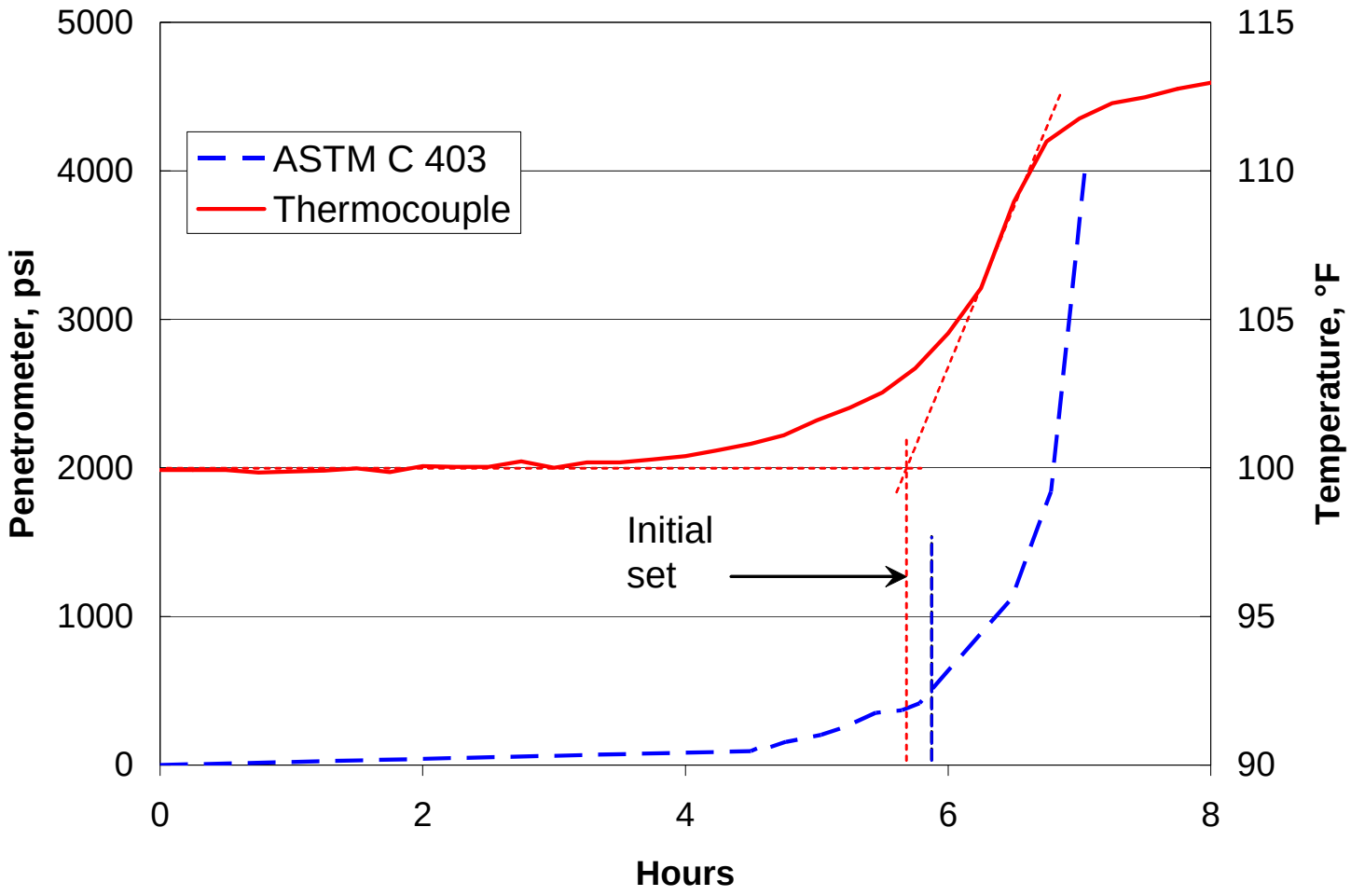

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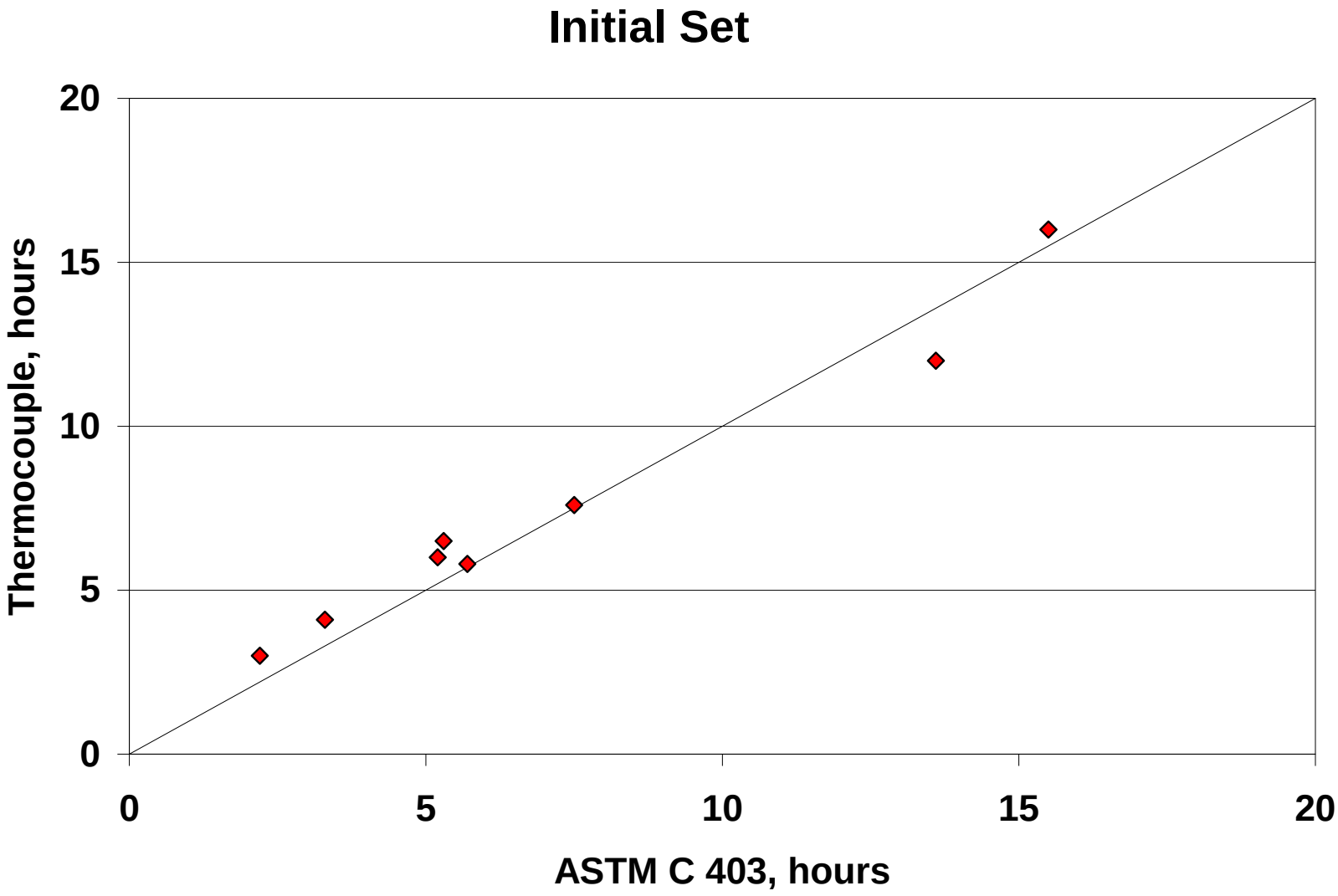
Initial Set
Thermocouple, hours
20
15
10
5
0
0
5
10
15
20
ASTM C 403, hours

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Summary

- Useful data can be collected
  - For characterizing materials
  - Investigating interactions
  - Tracking uniformity
  - Timing finishing activities
  - Tracking hydration
- Use the right equipment for the right application

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