Kinetic Data Needs for Industry

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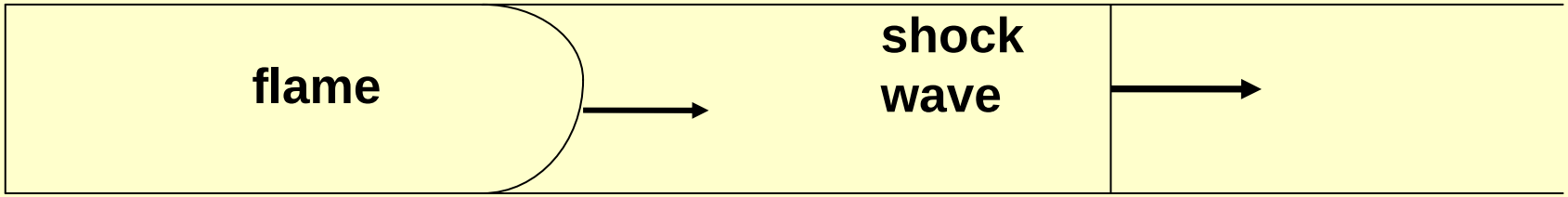
Plan of Talk

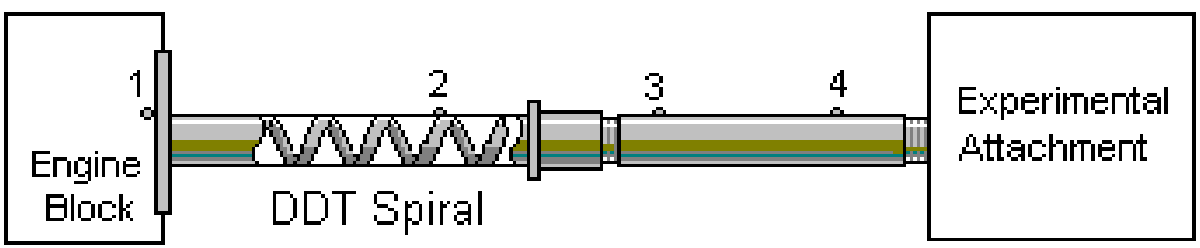
1. Flammability limits.
2. Auto-ignition and its modes.
3. Measurement of autoignition delay times.
4. Apparatus for intermediate T and p.
5. Data limitations.

Flammability Limits

- Mode of initiation must be satisfied.
- Initiation time, t_i, should be specified.
- Mixing time $< t_i < \tau$ (auto-ignition delay time and aerodynamic time).

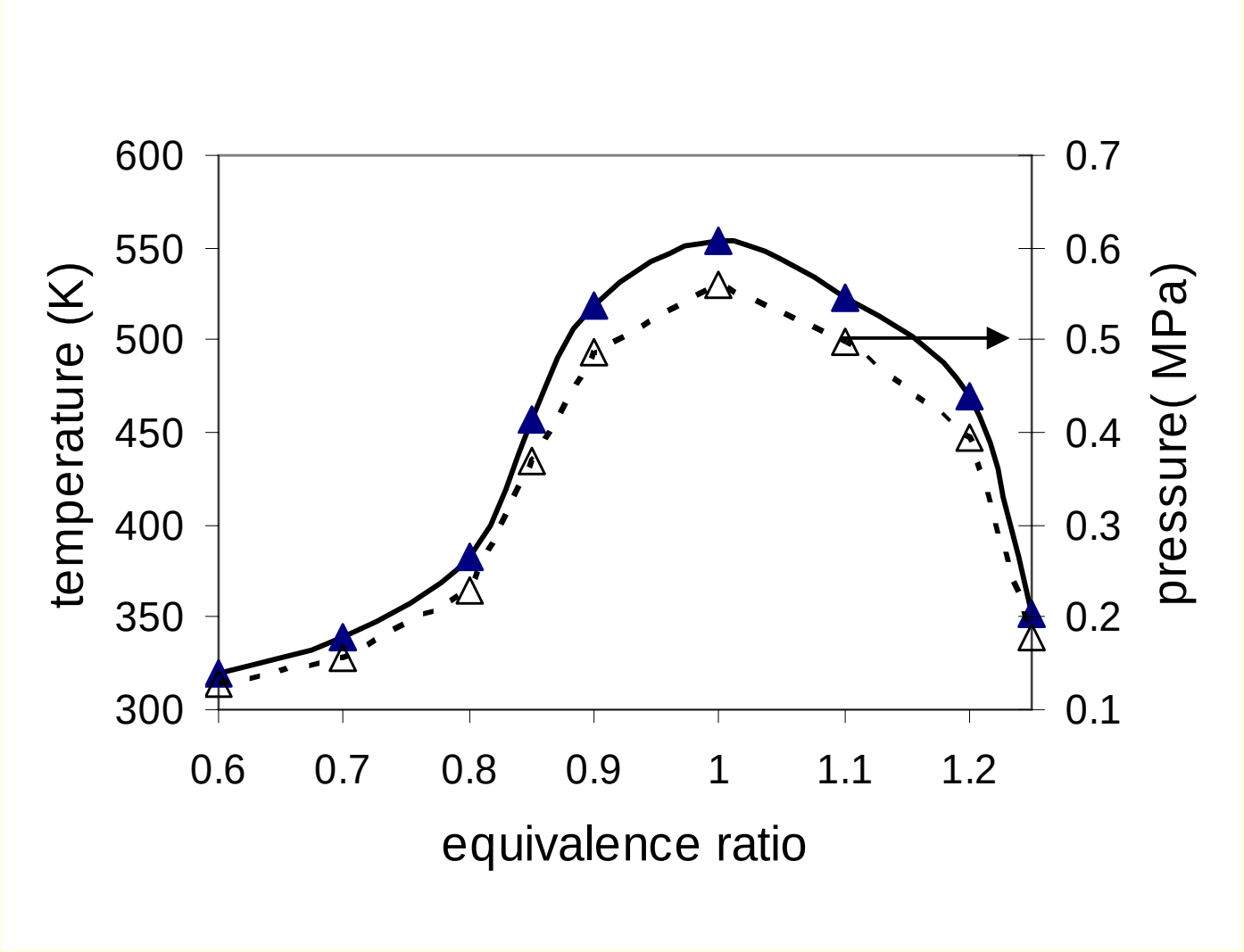
Auto-ignition in Explosions



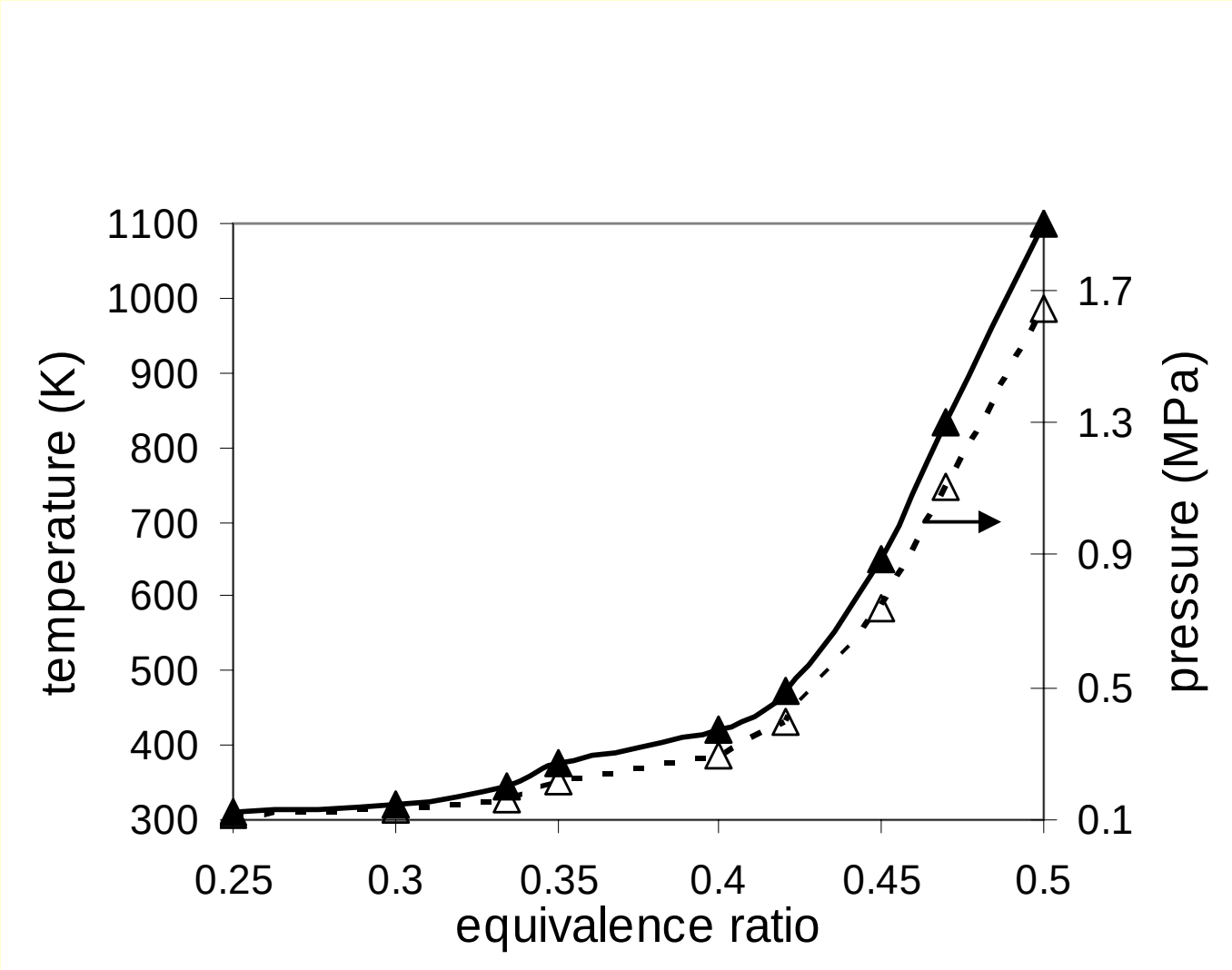


Numbers represent pressure transducer location

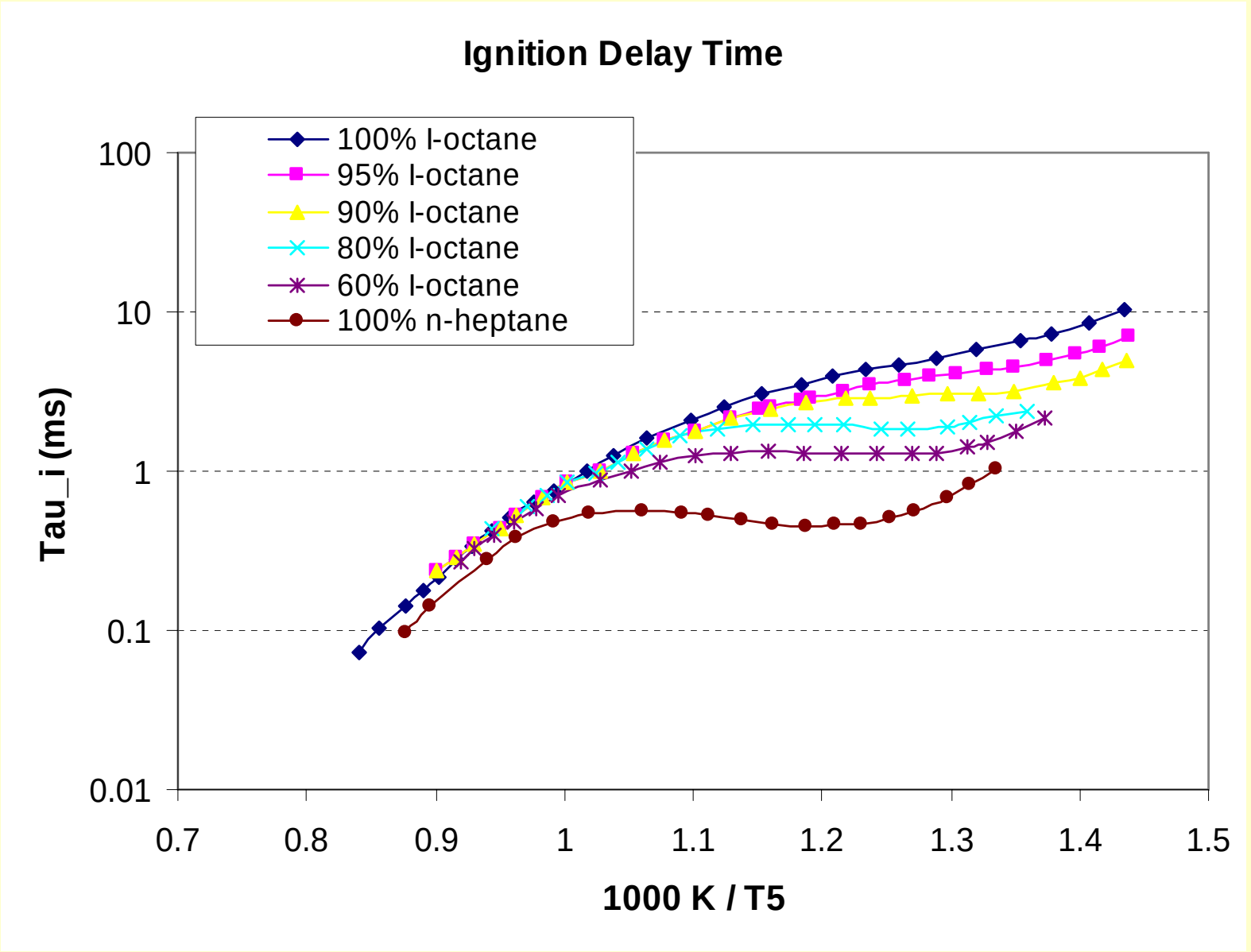
CH_4-air shocked temperature and pressure



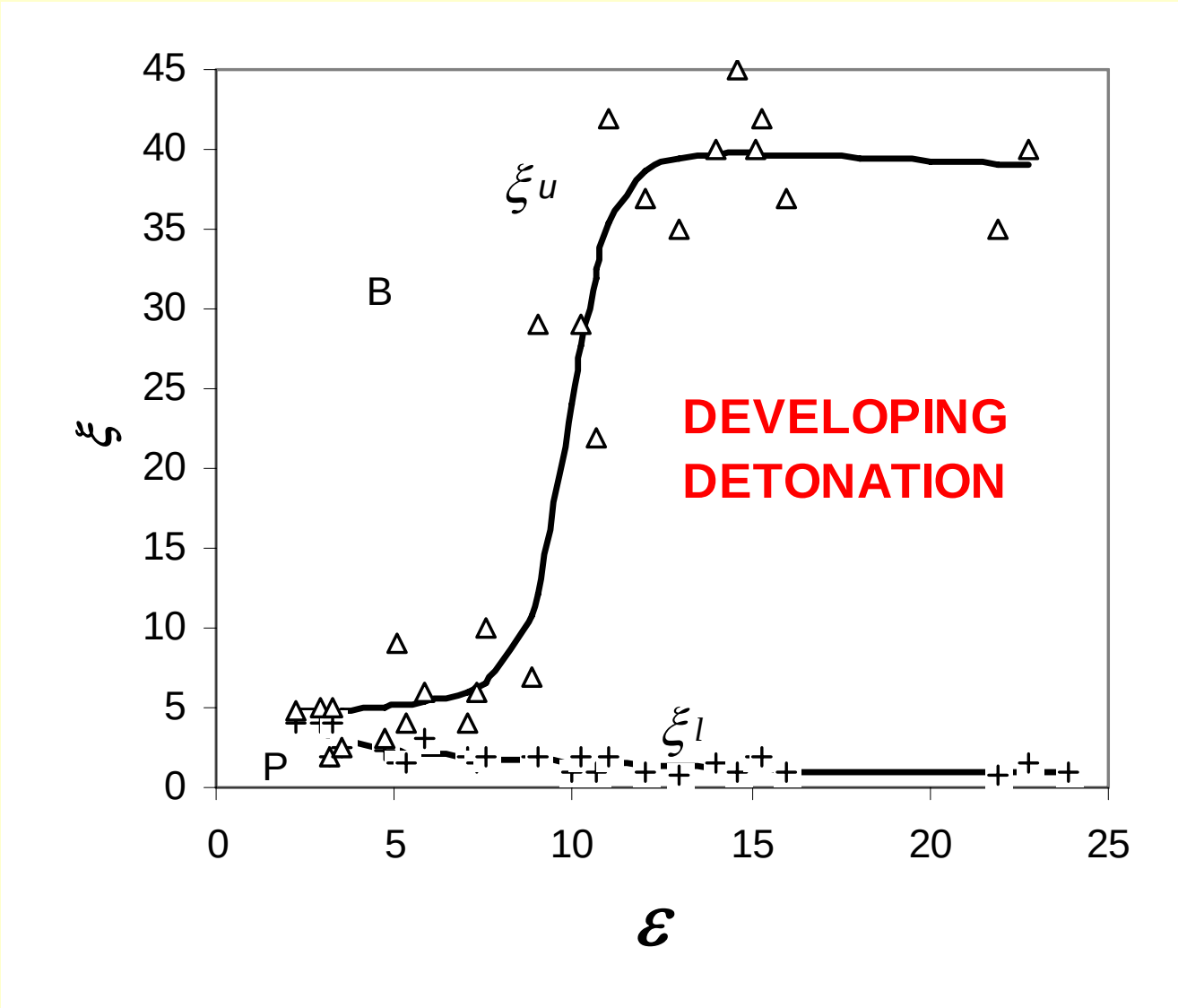
H_2-air shocked temperature and pressure



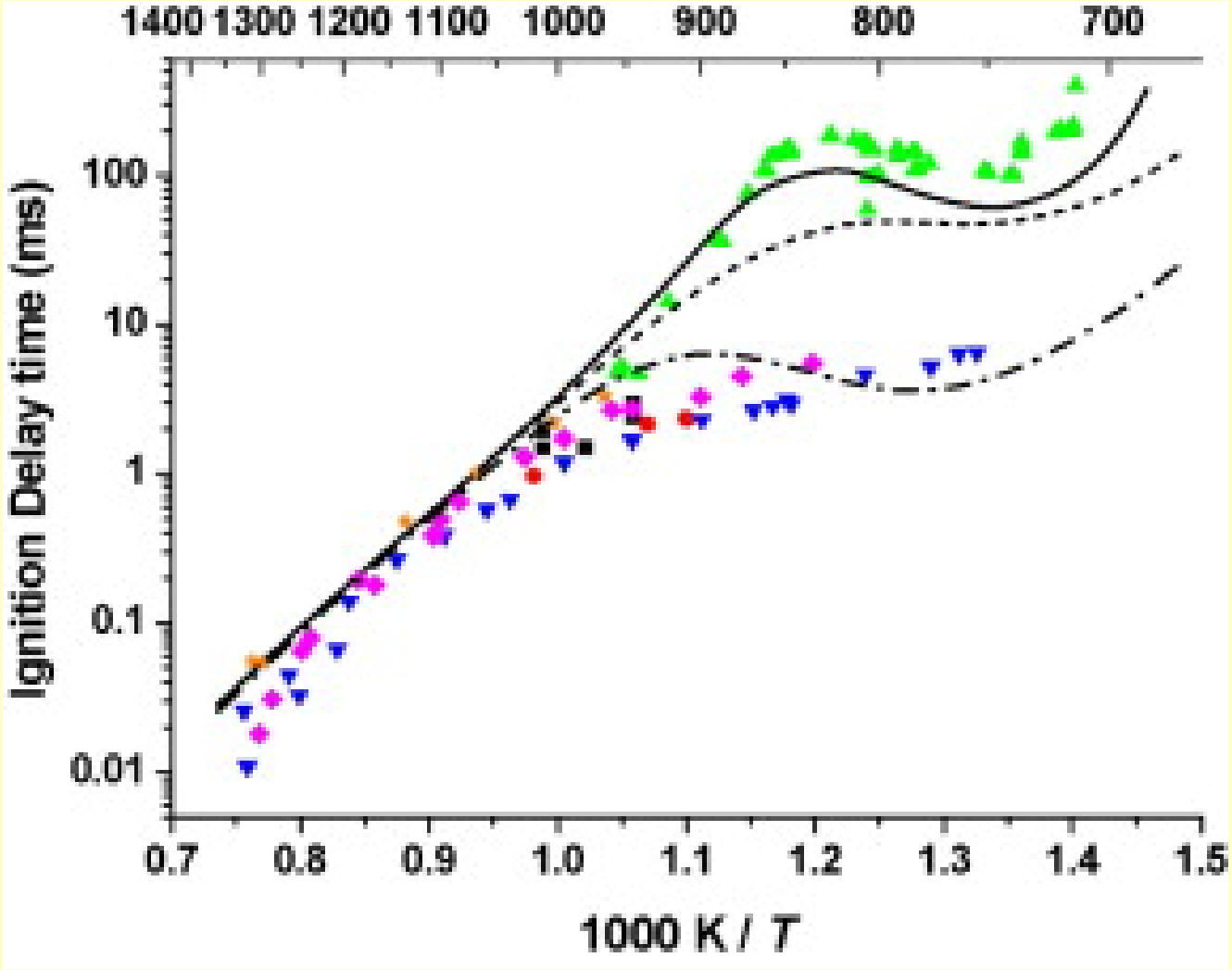
Autoignition Delay Times, 4 MPa



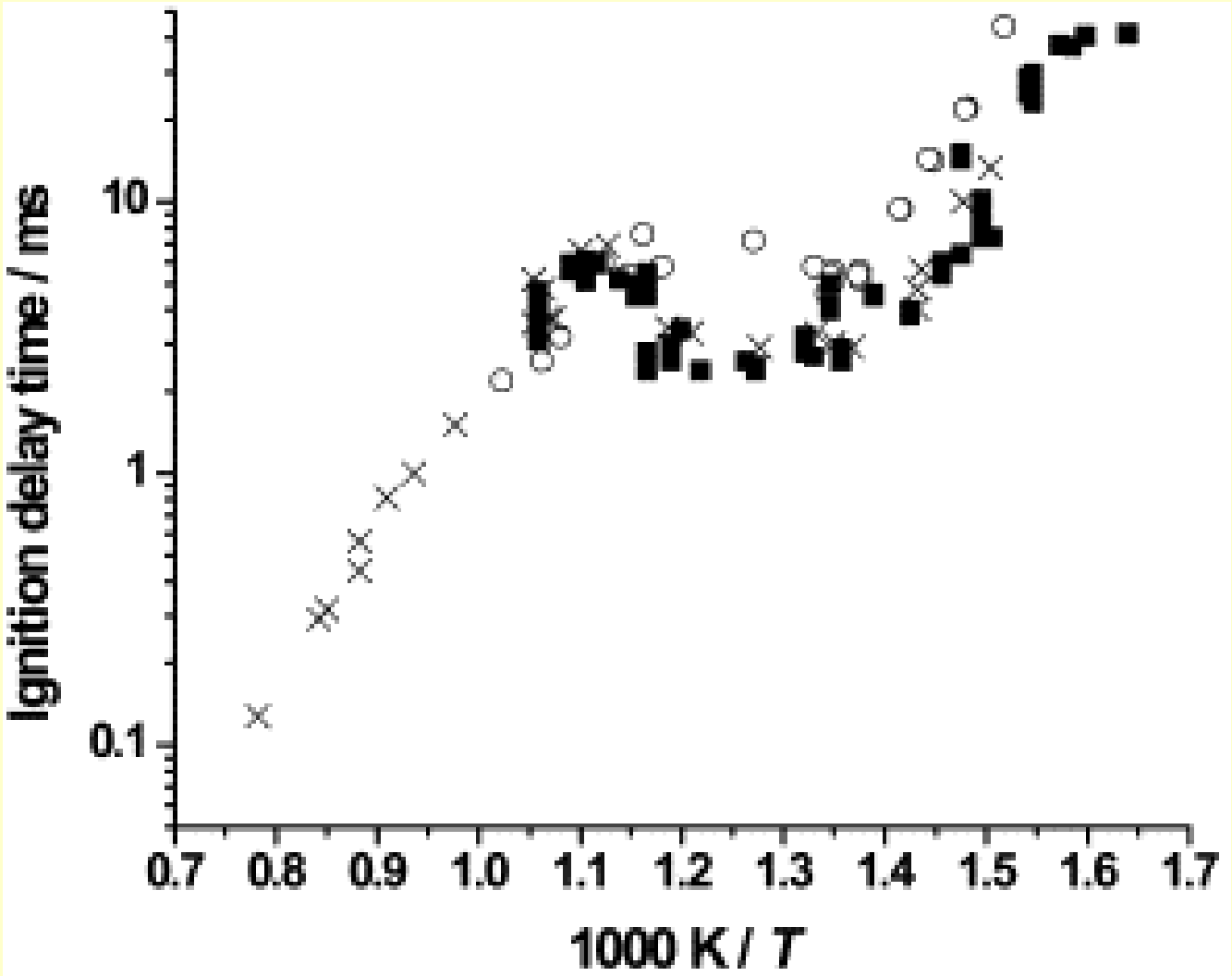
Peninsula of Detonation at Hot Spots



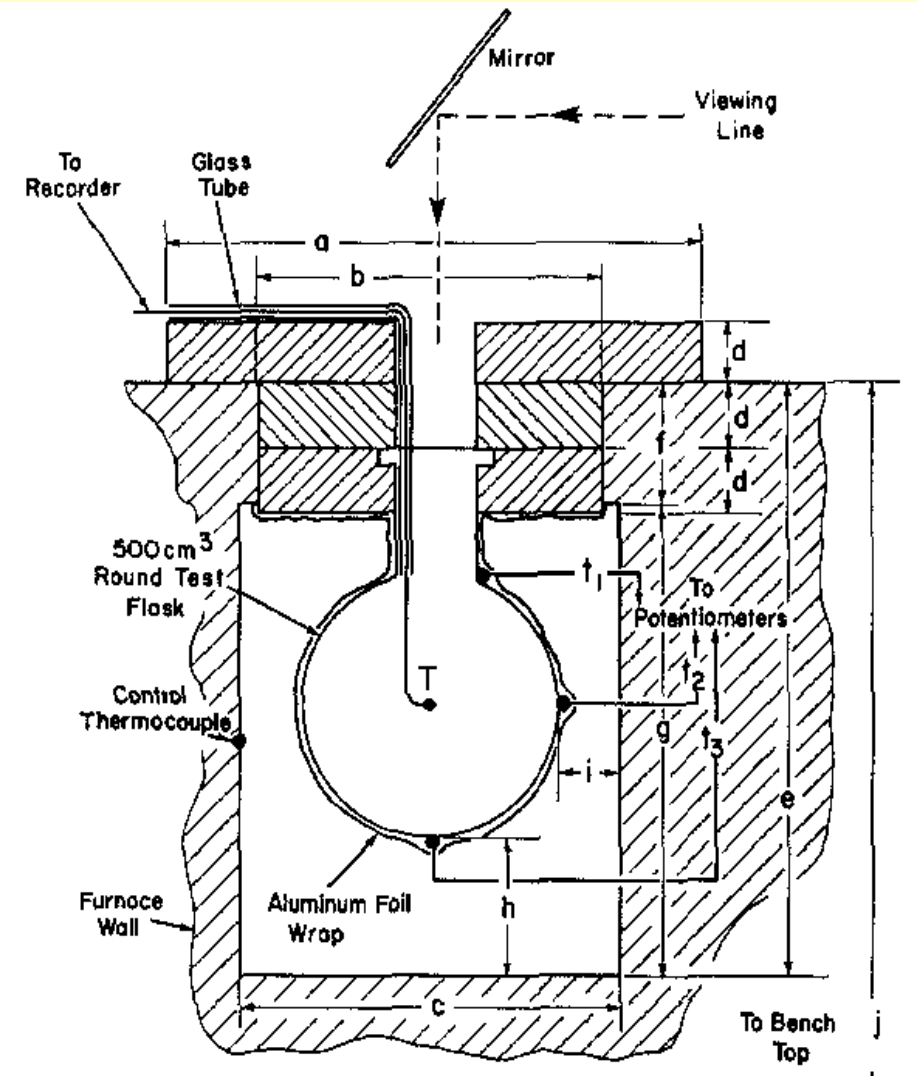
Propane-air Auto-ignition Delay Times $\phi = 0.5$, p=30 atm.



n-heptane-air Auto-ignition Delay Times $\phi = 1.0$, p = 10 atm.

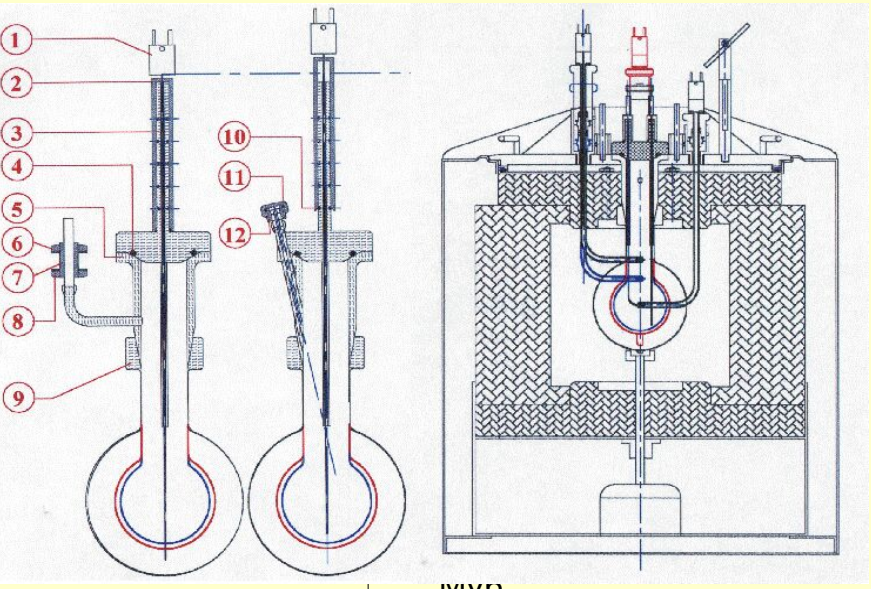


Auto-ignition Temperature Bomb ASTM E 659 – 78 (2005)

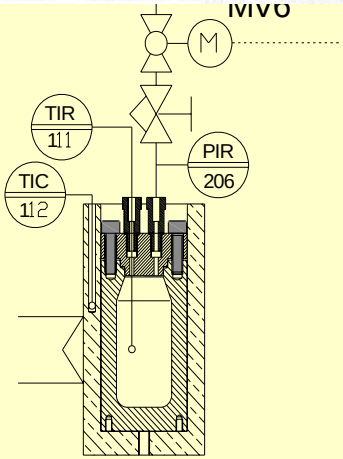


- Atmospheric pressure
- T max approximately 600°C
- 500 ml borosilicate glass
- 10 minutes observation
- Liquid samples
- Open vessel
- Ignition appearance of a flame accompanied by a sharp T rise

New apparatus developed in (SAFEKINEX)

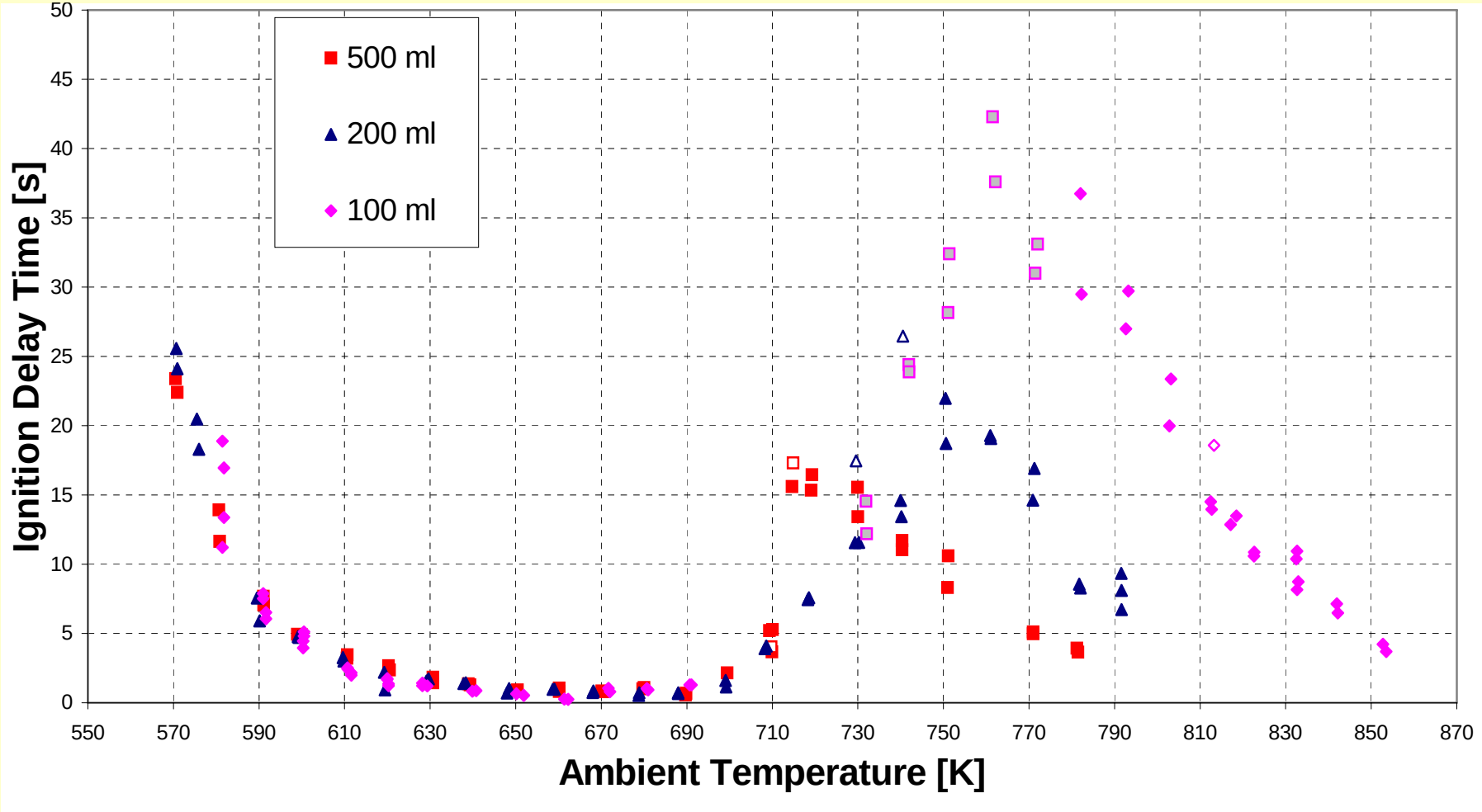


TUD AIT vessel 100, 200, 500 ml,
Semi-closed vessel, quartz,
Two thermo- couples inside,
steering possibility,
Operation at (sub-)ambient pressure



BAM AIT vessel 200 ml,
closed vessel, stainless steel,
thermo- couple in the centre
Operation at elevated pressure

Auto-ignition times for different volumes; 100, 200, 500 ml



Problem of intermediate *T* and *p*

- Shock tube: $\tau <$ shock duration
- RCM: $\tau >$ compression time
- ASTM: $\tau >$ mixing time

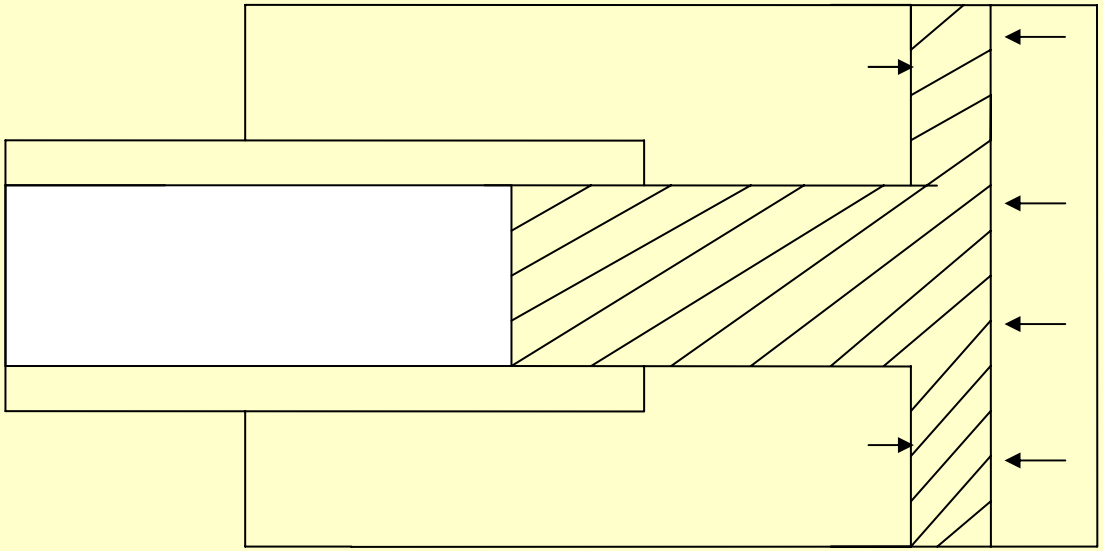
  $\tau <$ *a*erodynamic time
- Proposed flying piston:

  $\tau >$ compression time

Proposed Flying Piston

Ensures $\tau >$ mixing time

All mixing at low *T*



Data Limitations

1. At high *T* and *p*:

   Laminar burning velocity, Markstein numbers, Flame quench stretch rates.

2. At intermediate *T* and *p*:

   Autoignition delay times.

3. Autoignition/detonation transition.

References (1)

- Slides 4-6: D. Bradley, M. Lawes, Kexin Liu, “Turbulent flame speeds in ducts and the deflagration/detonation transition,” Combust. Flame **154** (2008) 96-108.

- Slide 7: K. Fieweger, R. Blumenthal, G. Adomeit, “Self-ignition of S.I. engine model fuels: a shock tube investigation at high pressure,” Combust. Flame **109** (1997) 599-619.

- Slide 8: D. Bradley, C. Morley, X. J. Gu and D. R. Emerson, "Amplified Pressure Waves during Autoignition: Relevance to CAI Engines", SAE paper 2002-01-2868, (2002), in SP-1718 "Homogeneous Charge Compression Ignition

References (2)

- Slides 9 -10: S.M. Gallagher, H.J. Curran, W.K. Metcalfe, D. Healy, J.M. Simmie and G. Bourque, “A rapid compression machine study of the oxidation of propane in the negative temperature coefficient regime,” Combust. Flame 153 (2008) 316-333.

- Slides 11-13: H. Pasman, A. Pekalski, I. Kirillov, “Self-ignition in gaseous mixtures, still a great challenge to understand,” ISHPMIE Conference, St.Petersburg, 2008.

- Slide 15: M. Pöschl and T. Sattelmayer, “Influence of temperature inhomogeneities on knocking combustion,” Combust. Flame 153 (2008) 562-573.

The End