Experimental Behavior of Molten Sn_xLi_y When Impacted by a Vertical Column of Water

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University of Wisconsin –Madison

Department of Engineering Physics

Fusion Technology Institute

Mark H. Anderson

Phongsan Meekunnasombat

Michael L. Corradini

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Outline

- Description of the preparation of SnLi alloy
- Description of shock tube
- Discussion of experiments
- Results
- Comparison between SnLi and PbLi
- Conclusions

Energy removal and protection with liquid metals

- There are several concepts to use liquid metals as shielding and a medium to remove thermal energy from advanced fusion designs some of the liquid blanket materials in consideration are:
  - Li
  - Flibe
  - $Pb_{83}Li_{17}$
  - $Sn_{75}Li_{25}$

  There are many technical issues that need to be evaluated; one is the possible physical-chemical interaction with water.

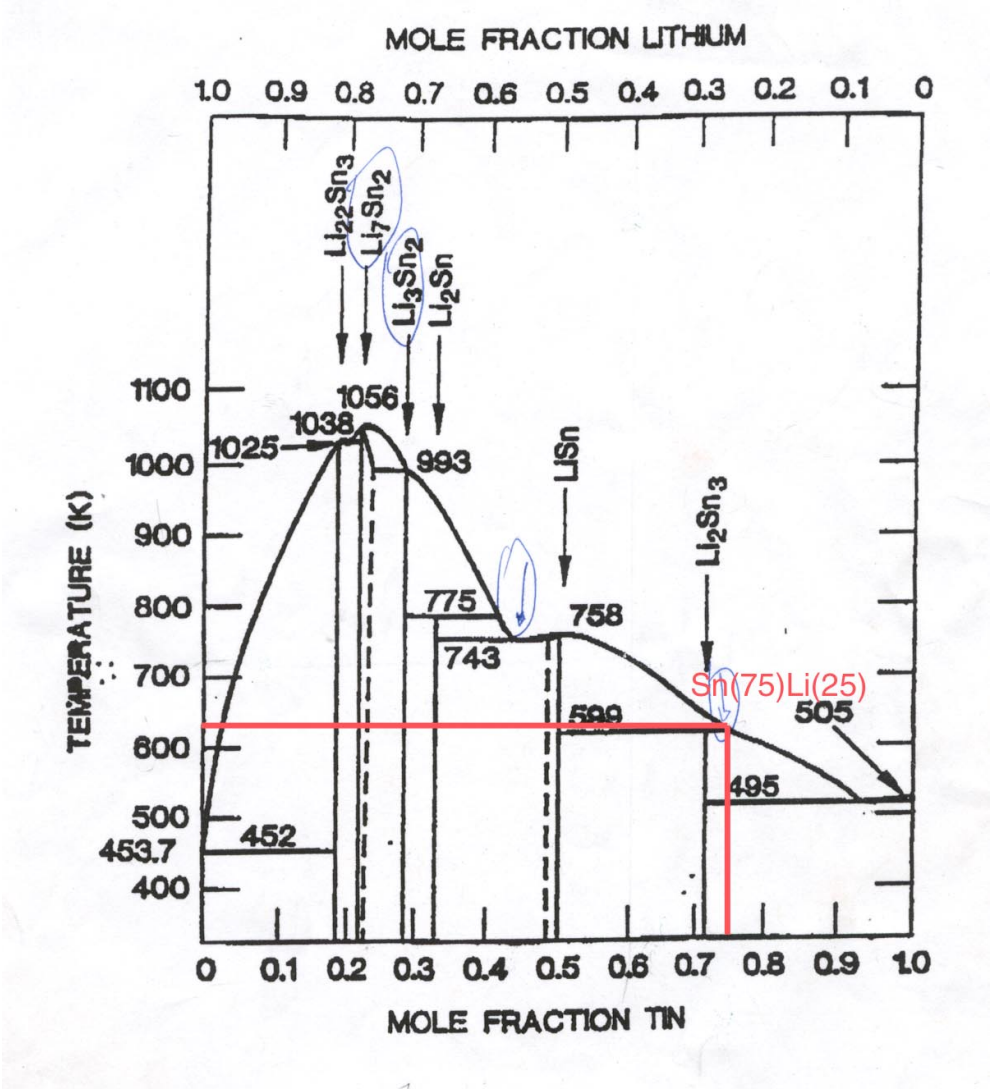
Previous studies of liquid metals in this geometry

- Vukovic (1994)
  - Gallium
  - Indium
  - Pb
  - Sn
- Farahani (1995)
  - 6061 al
  - U_3O_8-Al
  - U_3Si_2-Al
- Nelson (1996)
  - Pb
  - Pb(83)Li(17
- Anderson (2000)
  - Sn
  - Sn(75)Li(25)

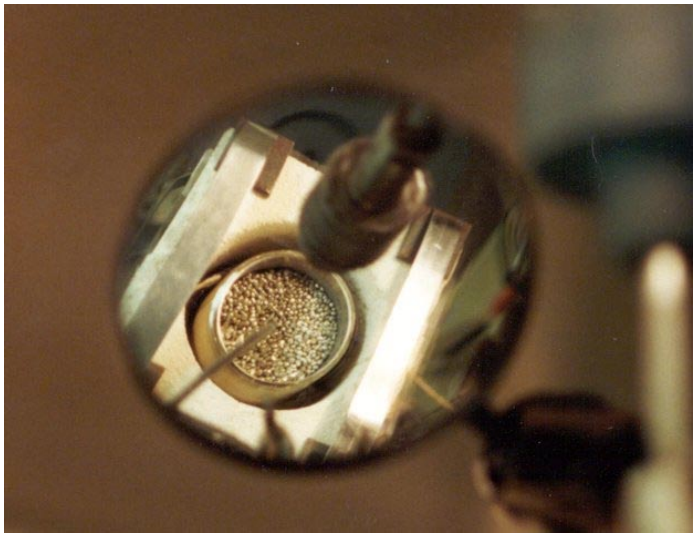
Manufacturing of kilogram quantities of $Sn_{75}Li_{25}$

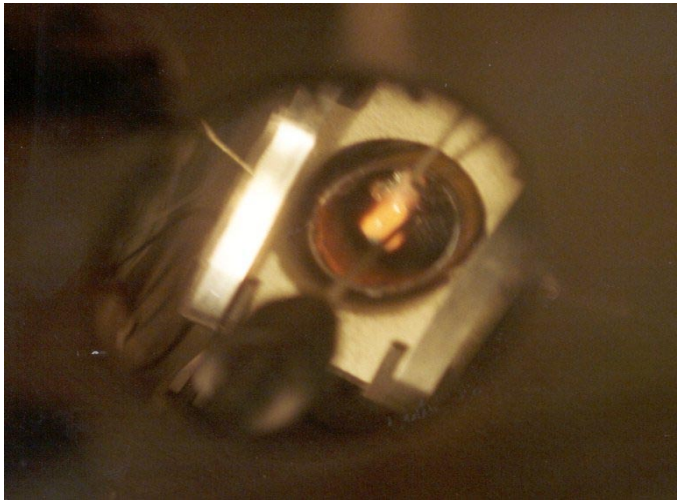
- Purge glove box with Ar
- Weigh out Sn and Li in the Ar environment to desired mass
- Melt Sn in reactor and bring to 500 C, well above formation temp of $Sn_{75}Li_{25}$
- Add Li slowly (exothermic reaction) while stirring
- Form billets of approximate mass

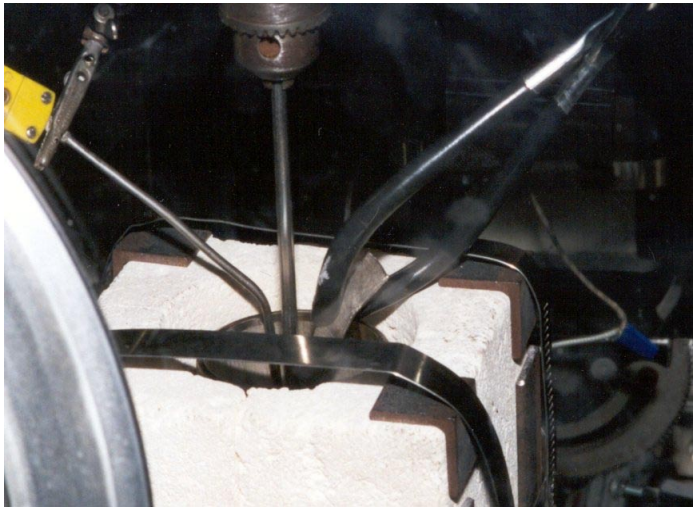
Preparation of lithium for melting

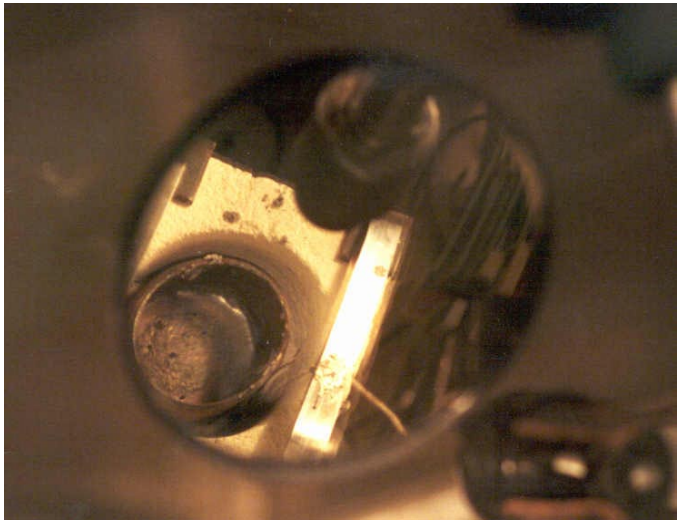


Preparation of Sn(x)Li(y)





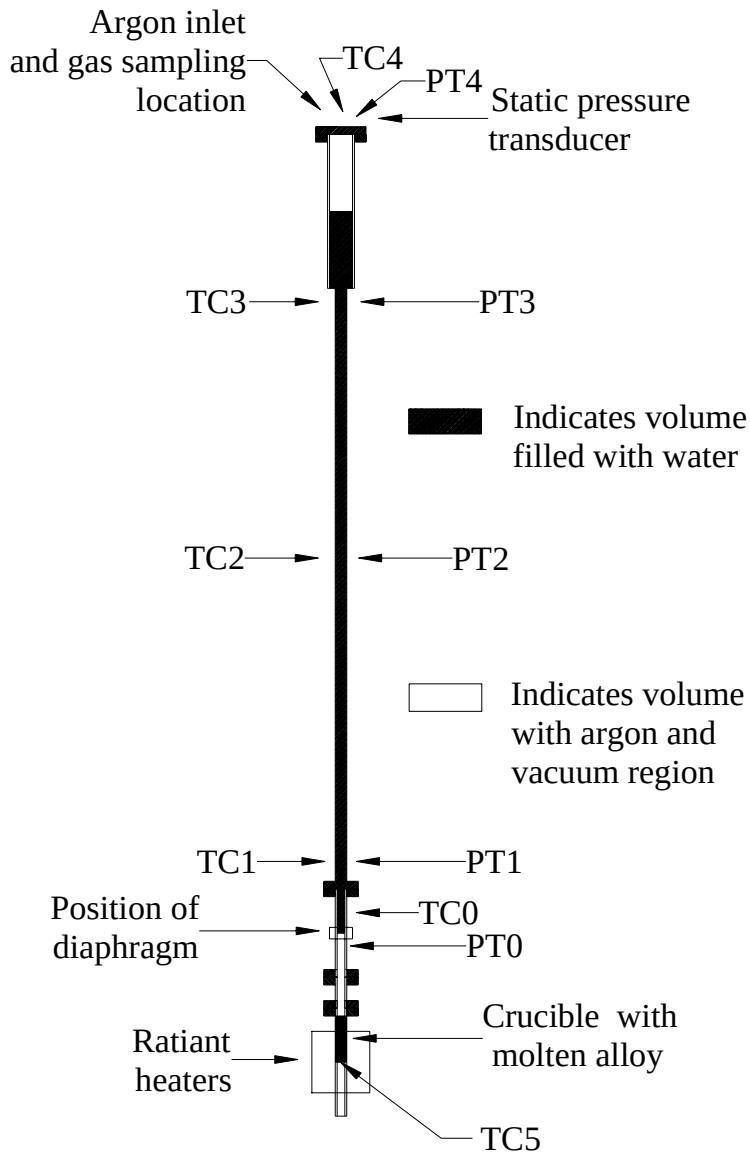




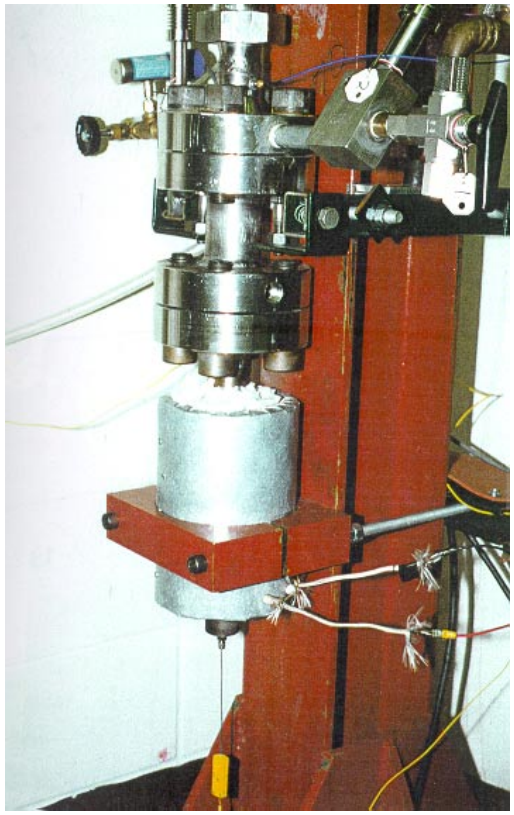
Billets prepared for $Sn_{75}Li_{25}$ water interaction study

Core sample of material sent for confirming analysis

Schematic of Liquid Shock tube

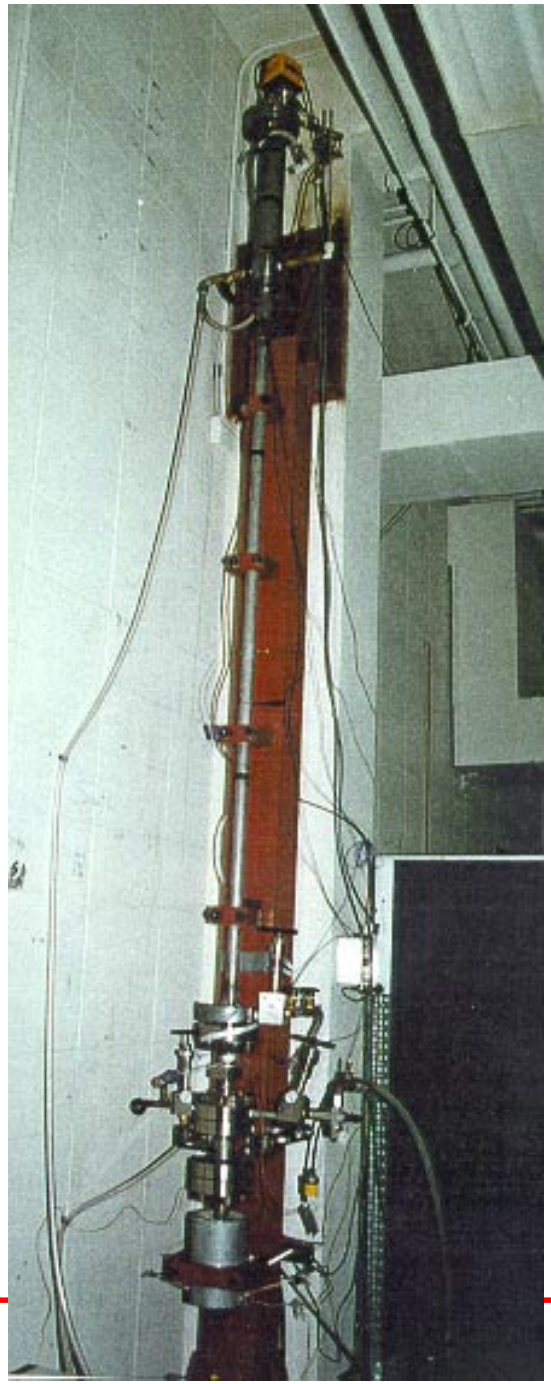


Photos of the shock tube

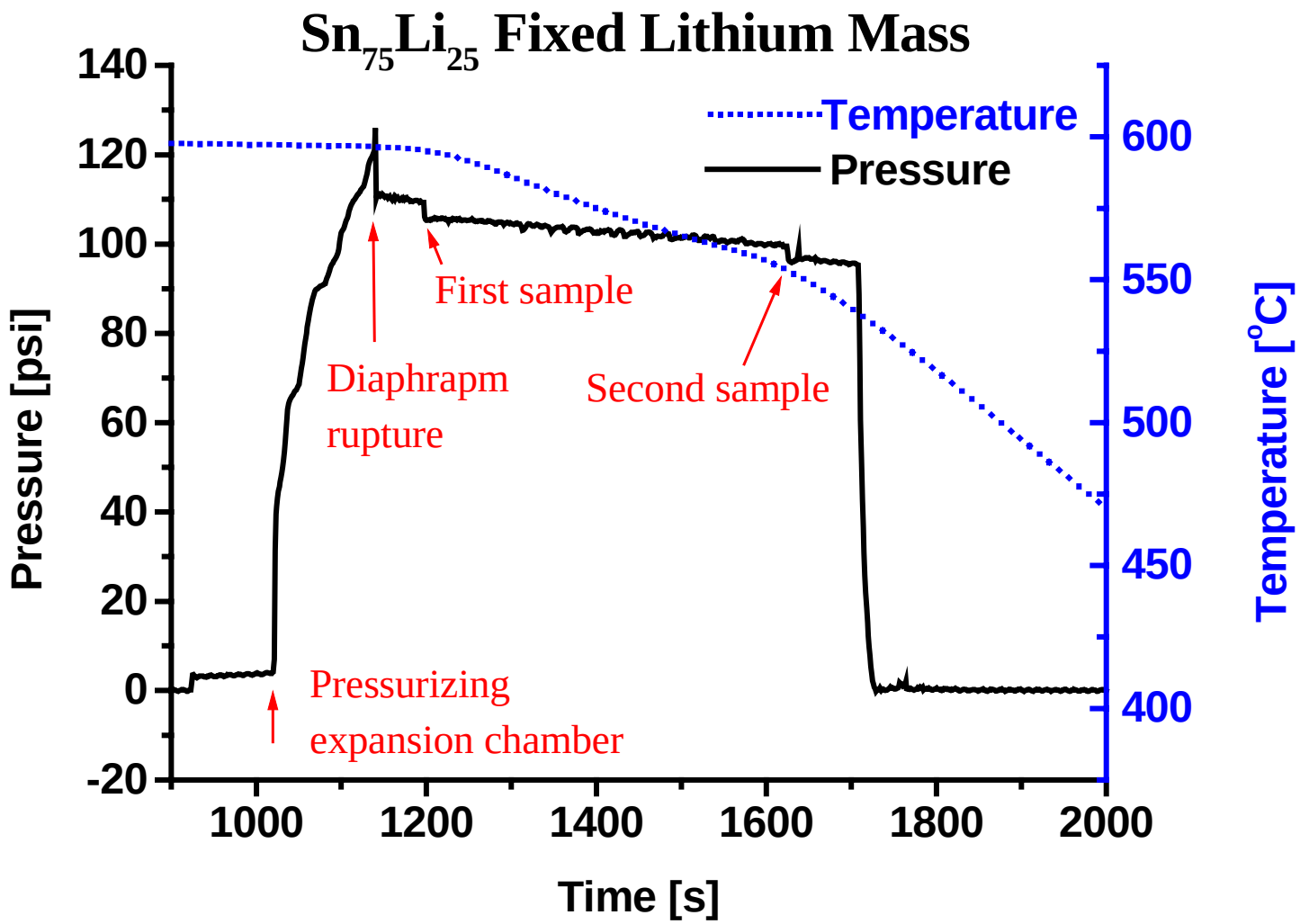


Diaphragm section and melt section.

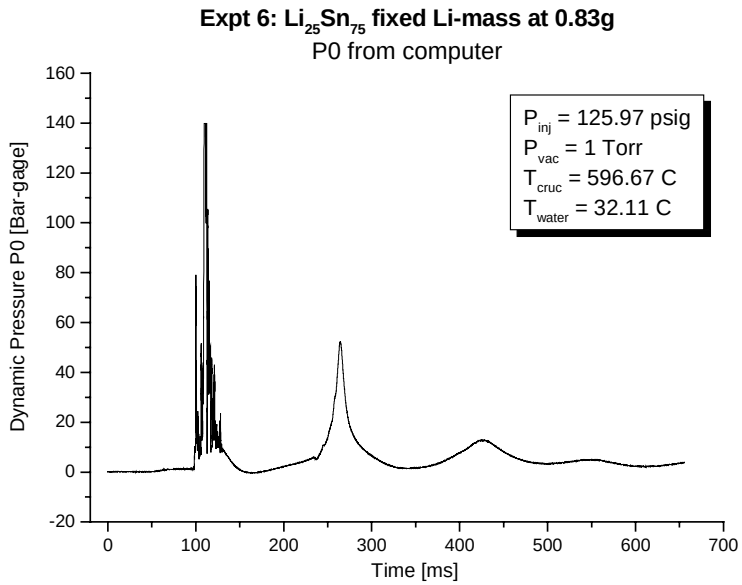
Liquid Shock tube.

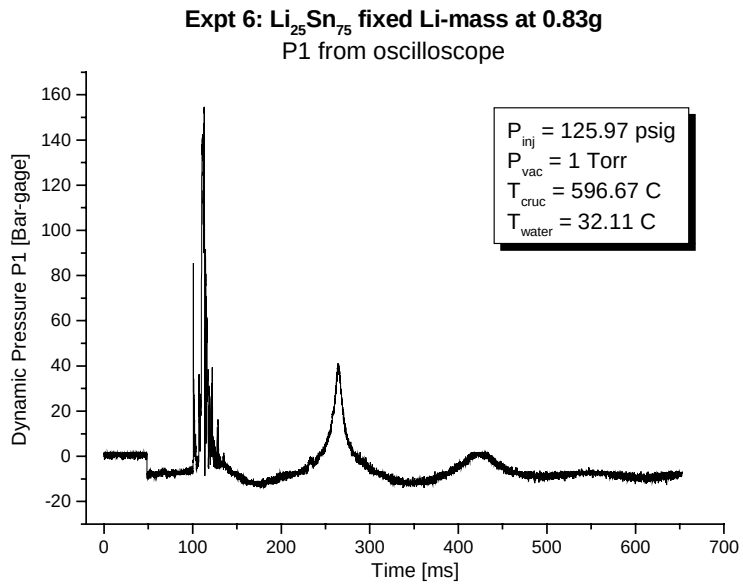


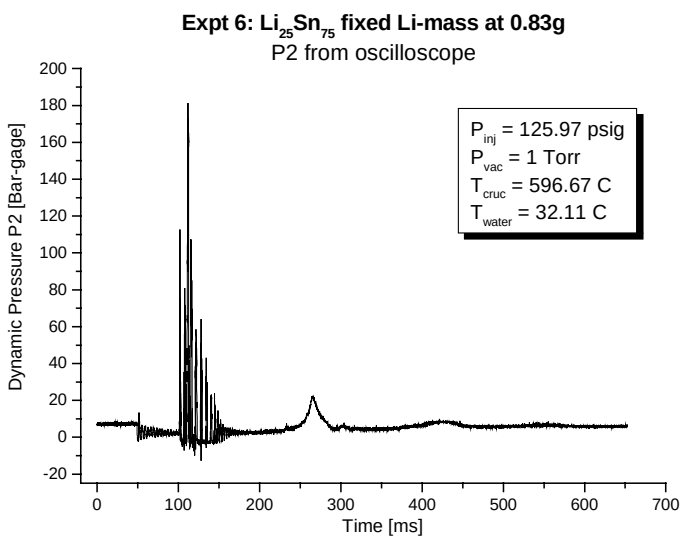
Characteristic pressure and temperature profile

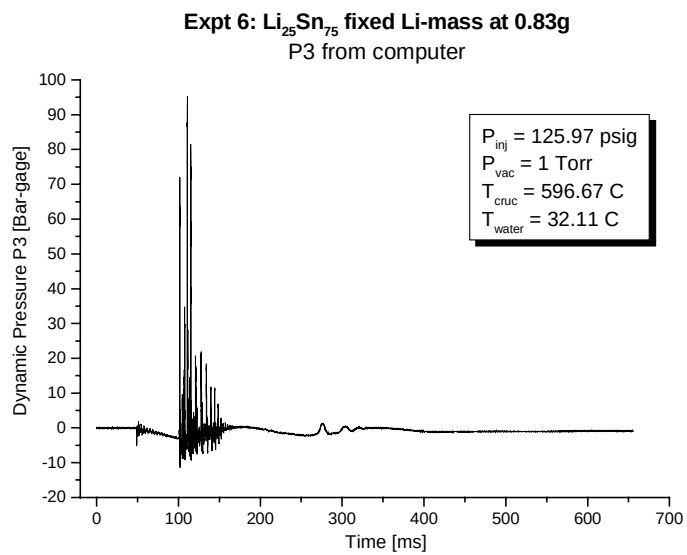


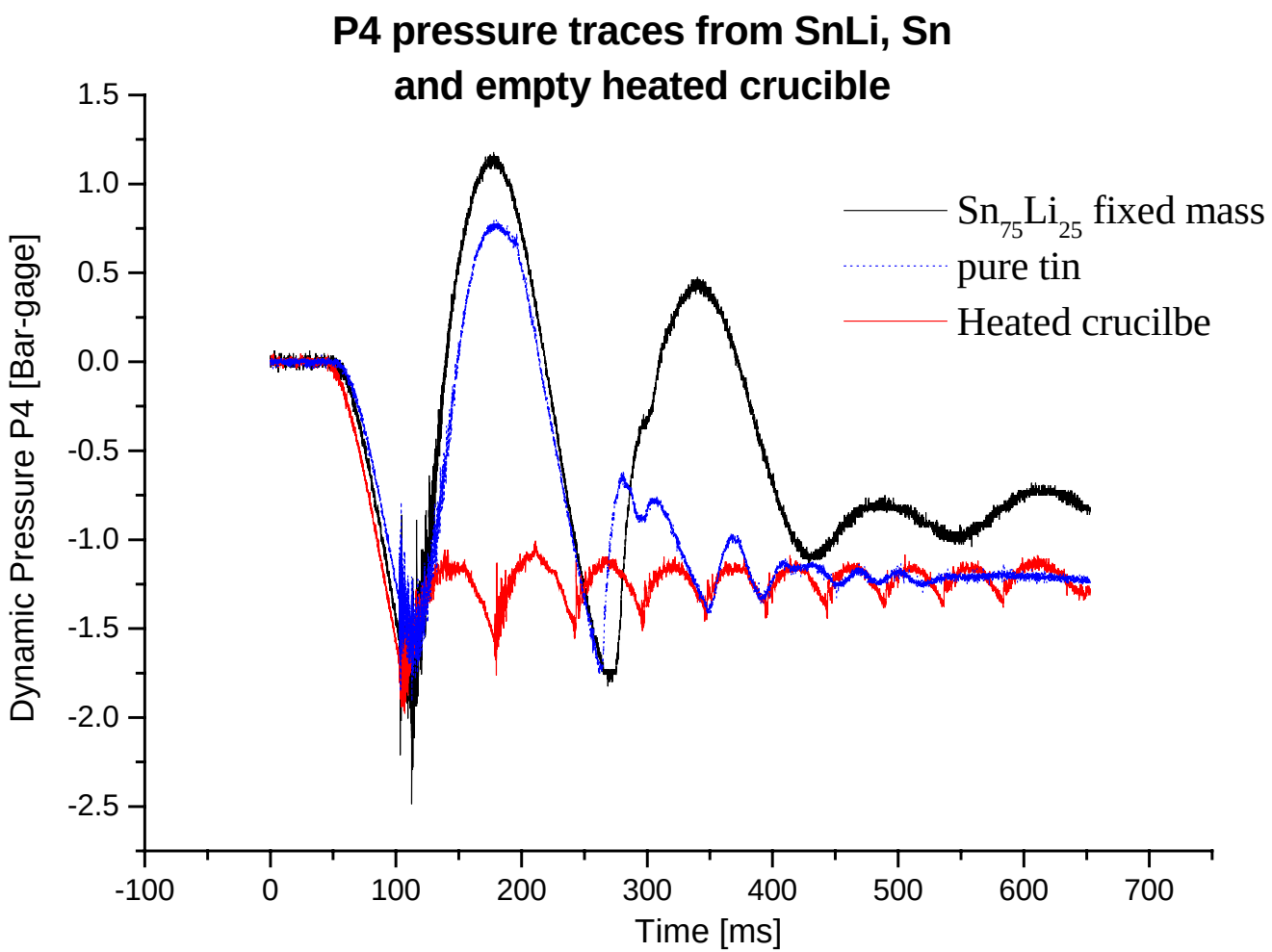
Examples of dynamic pressure plots



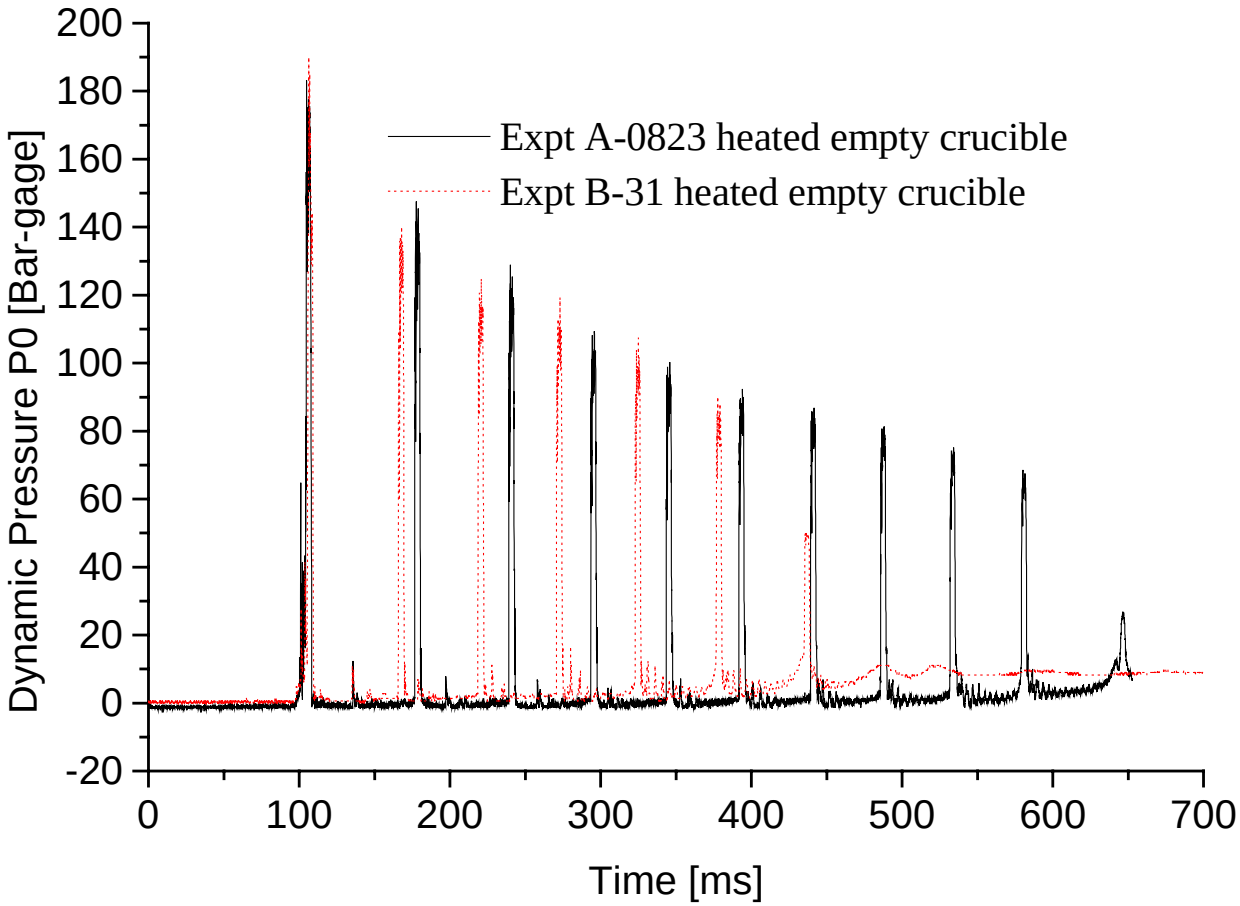




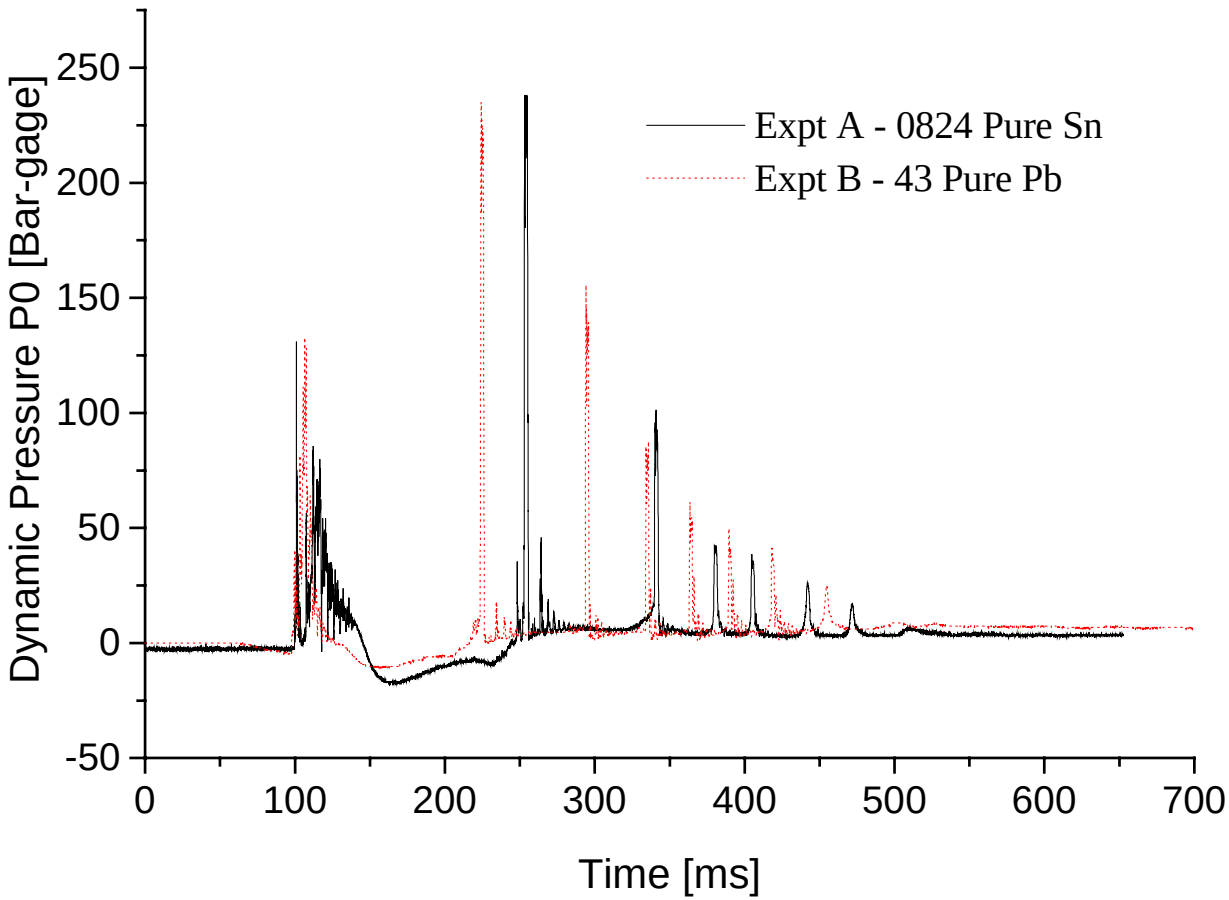



P4 pressure traces from SnLi, Sn
and empty heated crucible
Dynamic Pressure P4 [Bar-gage]
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-100
0
100
200
300
400
500
600
700
Time [ms]
Sn75Li25 fixed mass
pure tin
Heated crucilbe

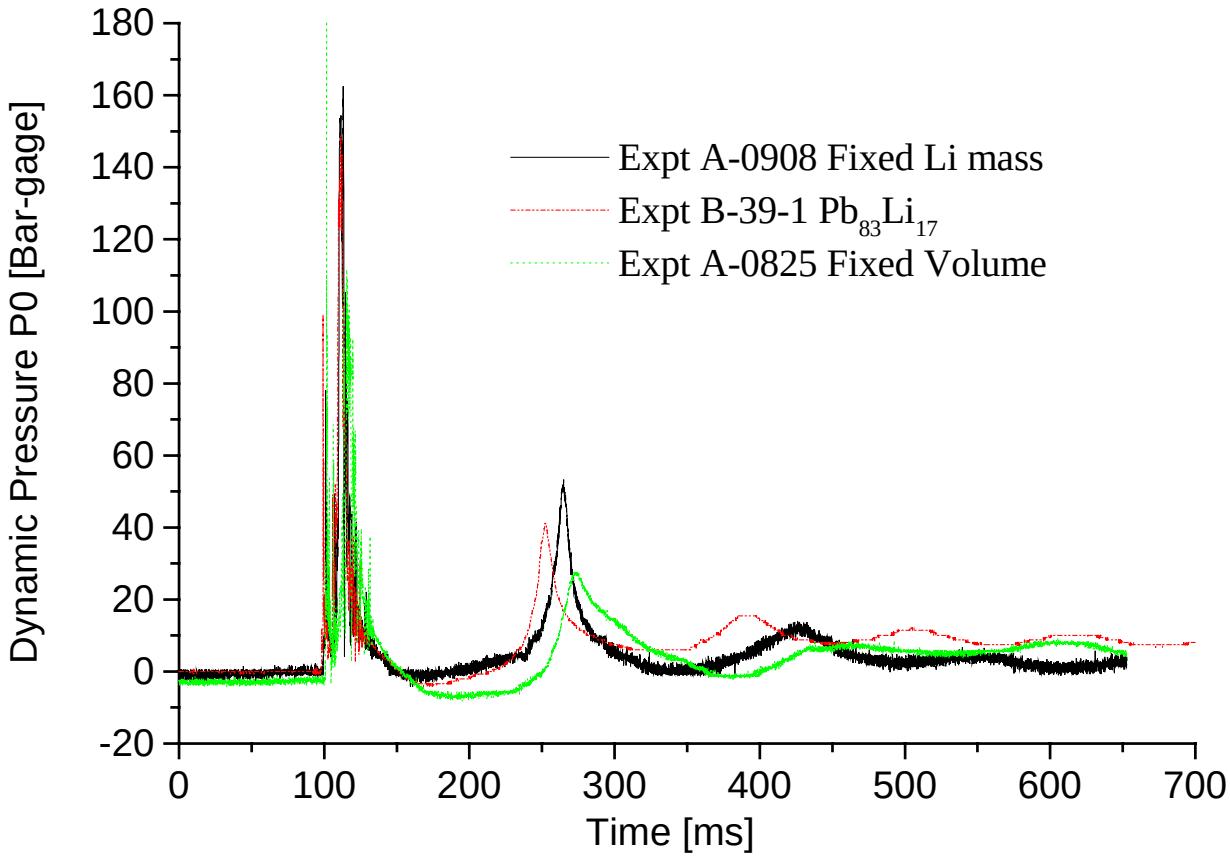
PT0 pressure trace for heated crucible
(Anderson et al. and Nelson et al.)



PT0 pressure trace of Sn and Pb



PT0 pressure trace for lithium alloys



Debris from Sn and SnLi experiments

Summary of experimental results:

Nelson et al. (1996)	Expt.#	P. Rupture [MPa]	T_{melt} [C]	T_{H20} [C]	Melt Weight [g]	Melt Volume [cm^3]	Lithium [mmoles]	H_2 Generated [mmoles]	Lithium reacted %	
									30 s.	300 s.
Heated empty	B-31-1	0.951	576	30.7	none	none	0	NA	NA	NA
Pb	B-43-1	0.917	587	61.1	146.08	12.88	0	NA	NA	NA
PbLi	B-39-1	1.080	592	27.9	119.57	10.60	120.6	33.7	?	55.9
Anderson et. al.										
Heated empty	A-0823	0.925	585	30.6	none	none	0	NA	NA	NA
Sn	A-0824	0.908	579	28.6	90.28	12.35	0	NA	NA	NA
Approx. same volume as B-39-1	A0825	0.964	566	31.1	75.04	11.34	206.7	77.0	36.79	43.7
Approx. same Li moles as B-39-1	A-0908	0.970	596	32.1	40.41	6.11	119.6	26.4	40.9	44.2

Overall Summary

- Experiments indicate a qualitative similarity between $Pb_{83}Li_{17}$ and $Sn_{75}Li_{25}$
  - The dynamic pressure traces at each location look similar
  - The hydrogen generated and lithium reacted are consistent
- Reaction rate of both alloys shows a marked reduction as compared to pure Li
- Further work is underway to compare the integral energetics and expand the database