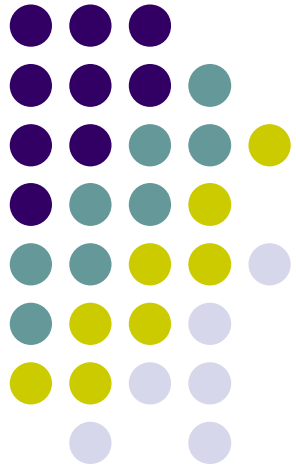
SAND2007-3783C

A Review of TufFoam Properties and Preliminary Evaluations at KCP

LeRoy Whinnery,
Steve Goods and
Tricia Wilson



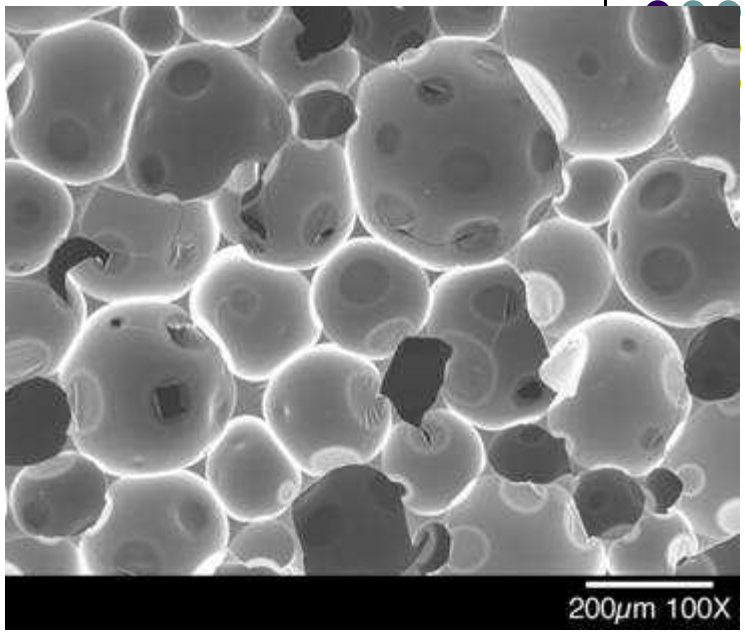
Outline

- Polyurethane Foams currently at KCP
- Compare TufFoam™ and PMDI (44307)
  - Mechanical
  - Thermal
  - Aging
- TufFoam at KCP

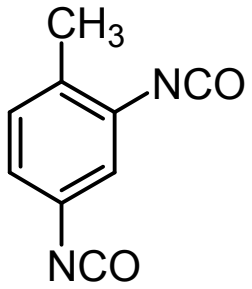
Polyurethane Foams at KCP

KCP Foam System Designation	Common Name	Comments
BKC 44402	TDI	Used extensively at the KCP to encapsulate electronic assemblies (Subassemblies of B61, B83, W87, W88). Not to be used for new production since 1991.
BKC 44320	PMDI-Pete Rand	Used to encapsulate the first (172) MC4396 TSSG's. %N numbers showed that the T-Component separated over time, foam was re-formulated ~9/96.
BKC 44320/44307	PMDI-Pete Rand Hybrid	Used to encapsulate the rest of the MC4396 TSSG production. Not recommended for new production.
BKC 44307	PMDI-Tom Neet	Used for the entire MC4390 Filter Pack production run. Has been used sparingly on surface mount components, except for the MC4611TRA (WSP) for the B61 Type 3E Trainer. The WSP had a lot of surface mount components, and had extensive environmental testing after encapsulation, with no foam related failures. Baseline for the W76-1 Stronglinks, TPD and W80-2,3 Stronglinks.
BKC 4002	Fast Reacting PAPI	Used for electronics production for B61/B83 Pull-Out switches, and B61 Nose. Pot-life is approximately 45-60 seconds.

TufFoam™



- Polyurethane Foam
- Closed-cell
- Rigid
- Water-blown
  - No Chlorofluorocarbons (CFC's)
- Modified methylene diisocyanate (MMDI) based
  - No toluene diisocyanate (TDI)
- Density range 0.032-0.8 g/cc (2-50 pcf)
- Patents Pending
- Initial application was encapsulation
  - Protect electronics from shock, vibration and impact
  - TDI replacement effort



Formulation

	PMDI	TufFoam
Polyol	Voranol 490	Voranol 490
Surfactant	DC 197	DC 193
Blowing Agent	Water	Water
Catalyst	33 LV	33 LV
Isocyanate	PAPI 27/ Voranol 490 prepol	Isonate 2181

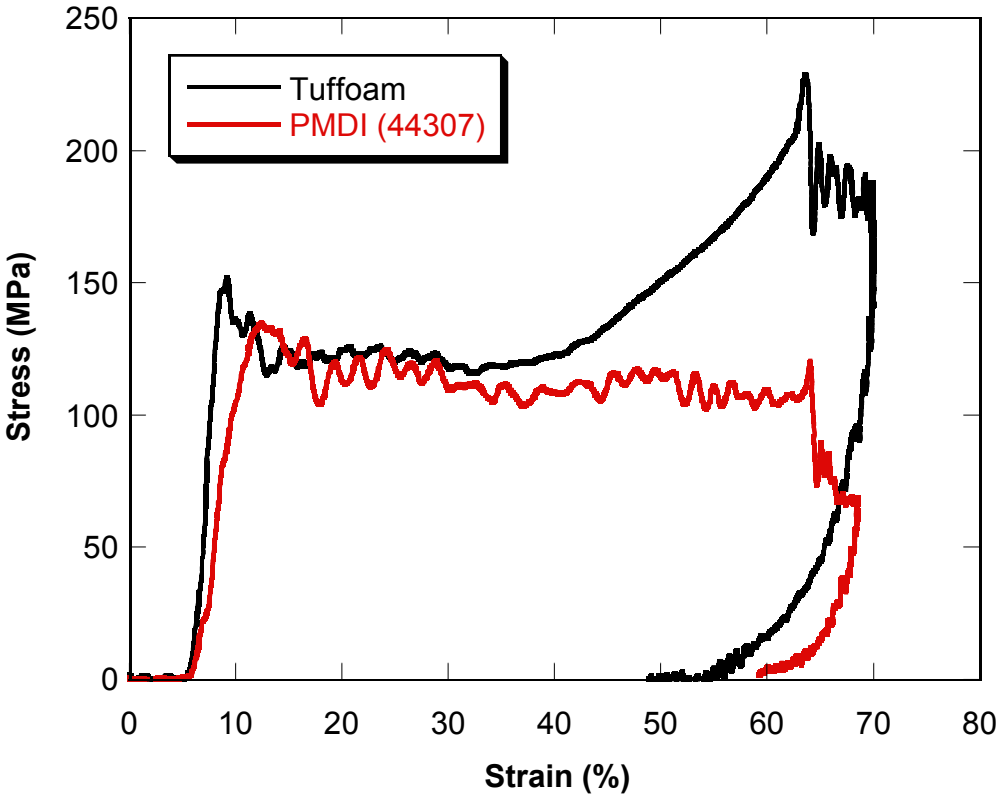
- Resin is similar, but isocyanate is different

TufFoam is … Tougher

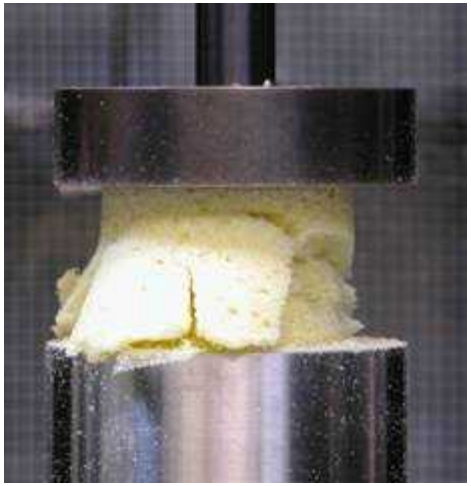
Material	measured density (lb/ft^3)	K_{IC} ($psi\text{-}in^{0.5}$)	average K_{IC} ($psi\text{-}in^{0.5}$)
REF	20.2	0.66	**0.53**
REF	20.4	0.34	
REF	20.6	0.60	
REF	20.2	0.65	
PMDI	19.1	0.96	**1.32**
PMDI	18.6	1.76	
PMDI	18.4	1.23	
TufFoam	19.4	3.02	**3.73**
TufFoam	19.4	4.36	
TufFoam	19.4	3.80	
REF	12.9	0.54	**0.50**
REF	12.9	0.50	
REF	12.9	0.49	
REF	12.9	0.46	
TufFoam	12.0	1.62	**1.68**
TufFoam	12.0	1.74	

Fracture toughness data compliments of Doug Adolf and Mark Stavig

TufFoam absorbs more energy than PMDI (44307)



TufFoam

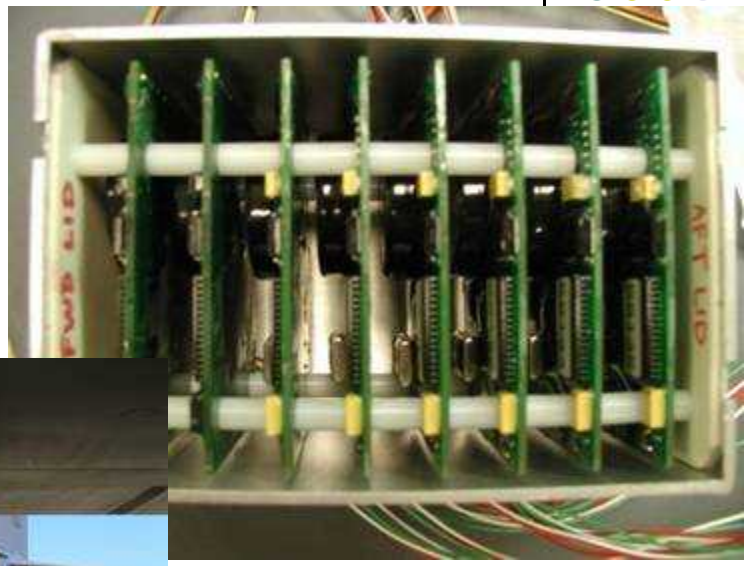


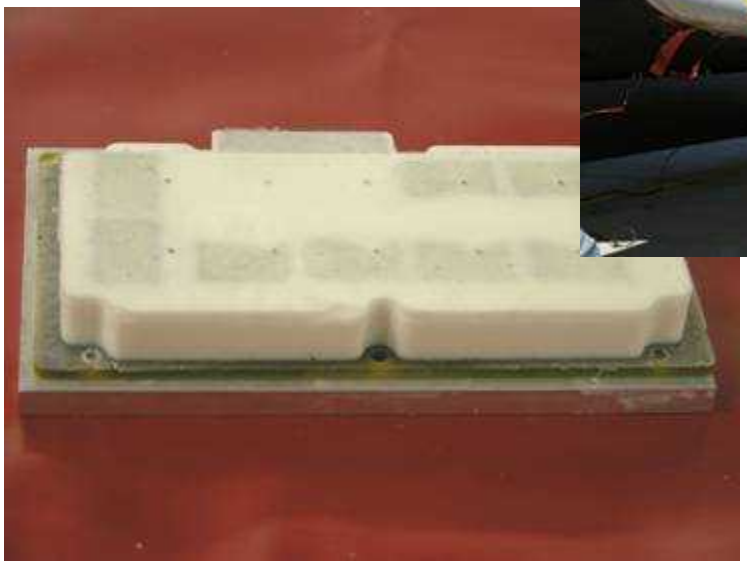
PMDI (44307)

Data Recorder/Data Logger

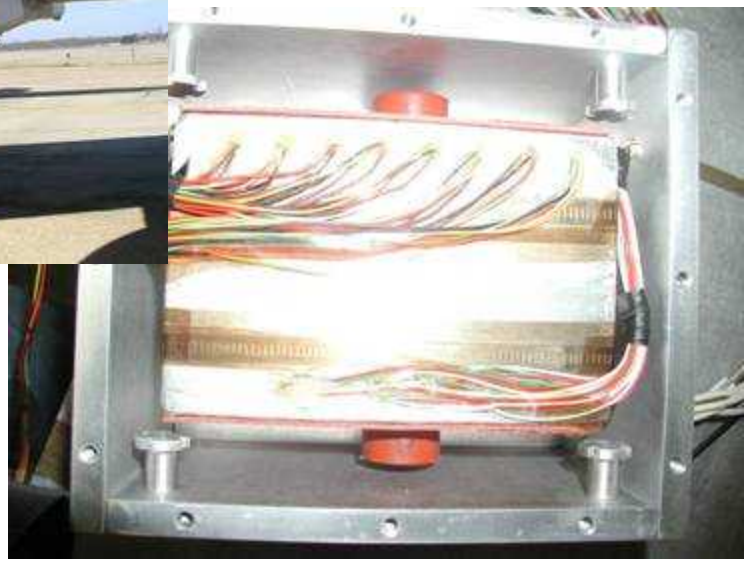
W80-3

CFTU





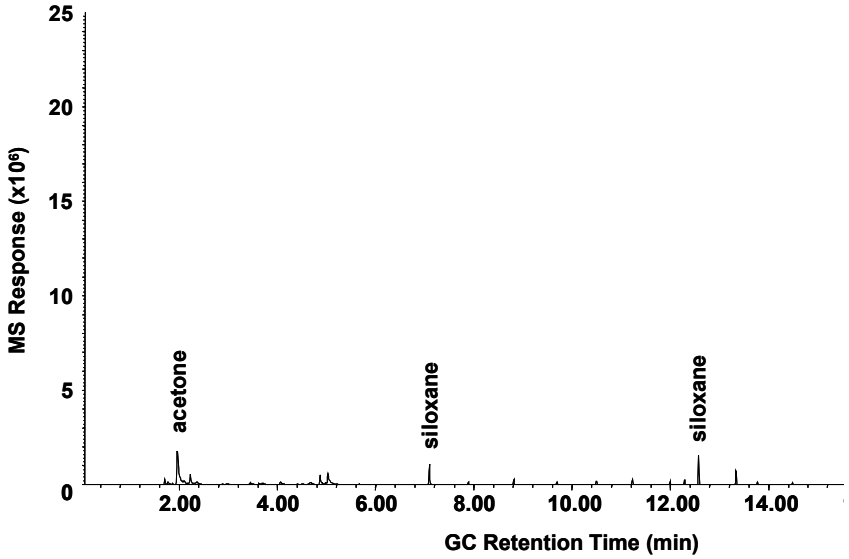
With Telemetry group (8233)



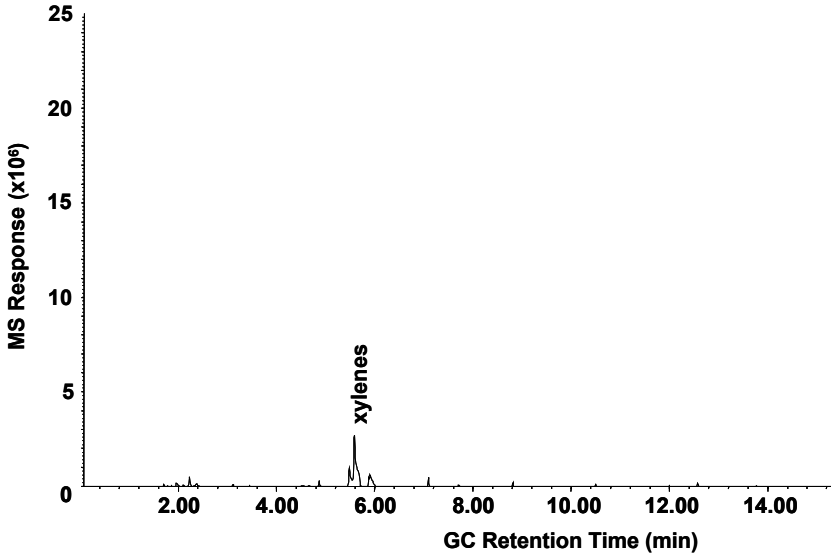
TufFoam in High g Environments

- Drop Table test-mechanical functionality
  - 5,000g over 600 µsec
  - TufFoam showed no ill effects
  - Anomaly in memory stack
- RNEP JTA Advancement Test (RJAT)-12/04
  - 3,000-4,000g over 20ms

Solid Phase Micro-Extraction (SPME) Off Gas Analysis



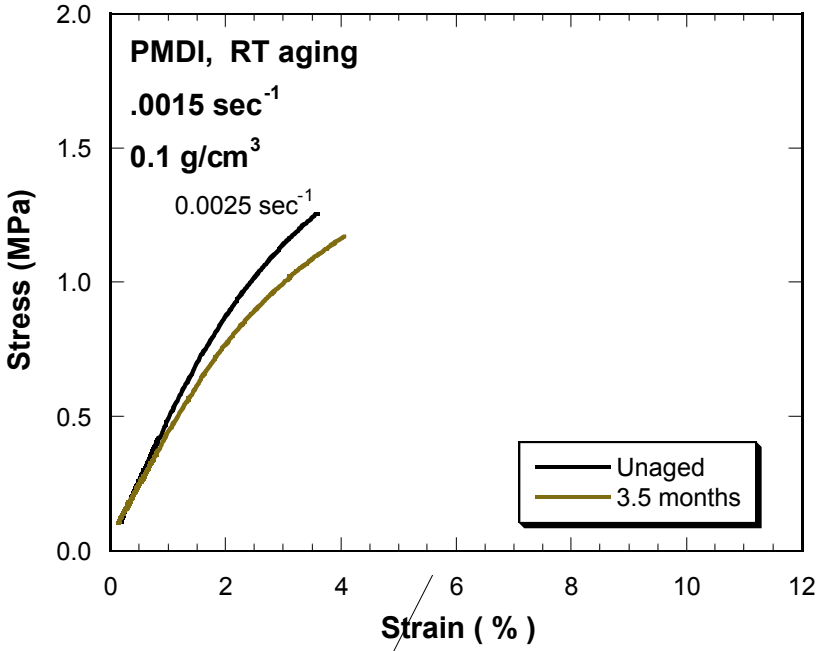
TufFoam™

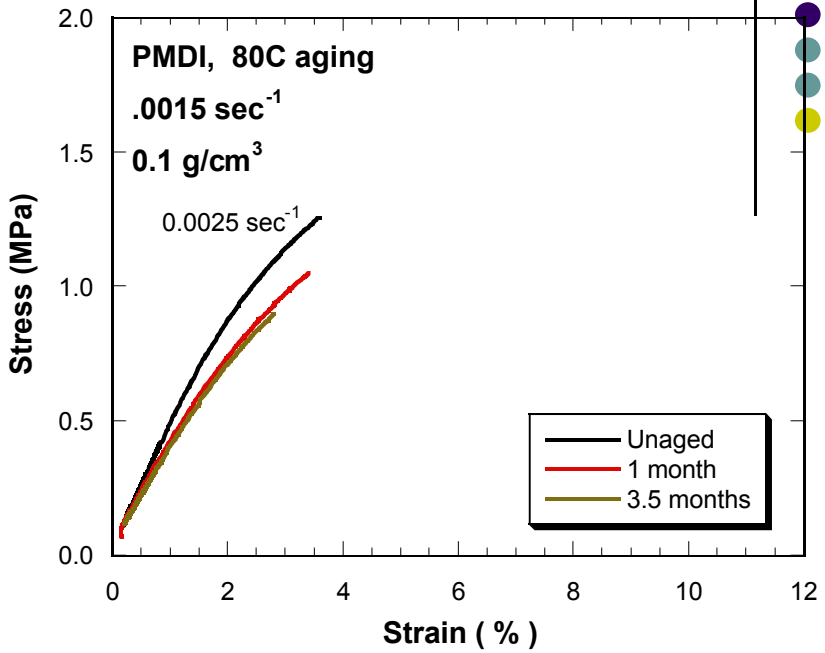


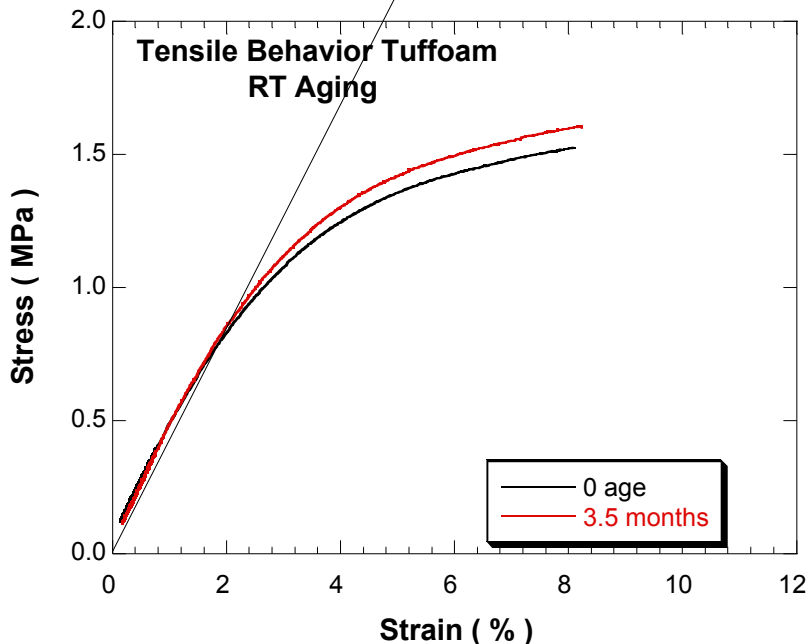
TDI Foam

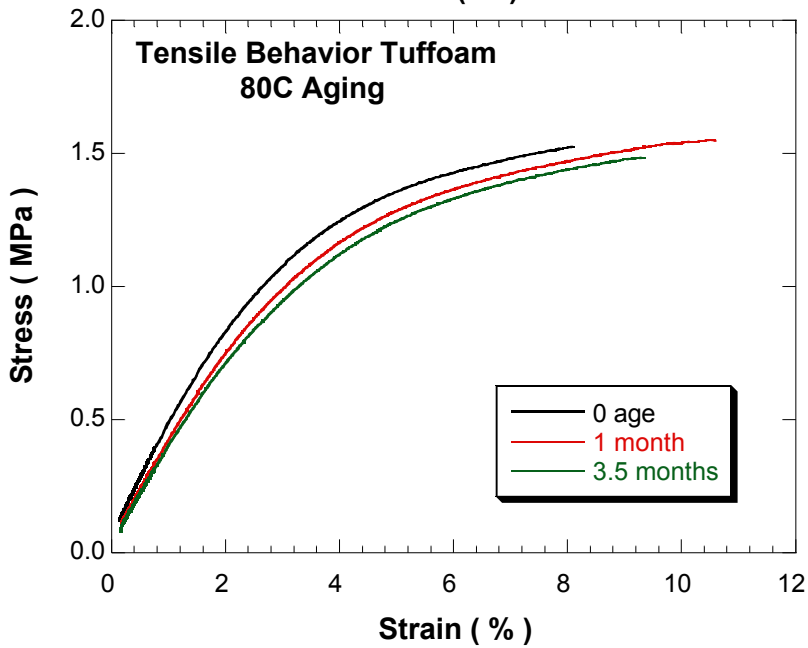
- Very little outgassing, even at 70°C

44307R/44320T is much more brittle than TufFoam

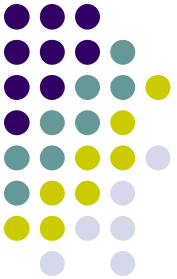








Tensile data comparison for 6pcf (0.1 g/cc) foams

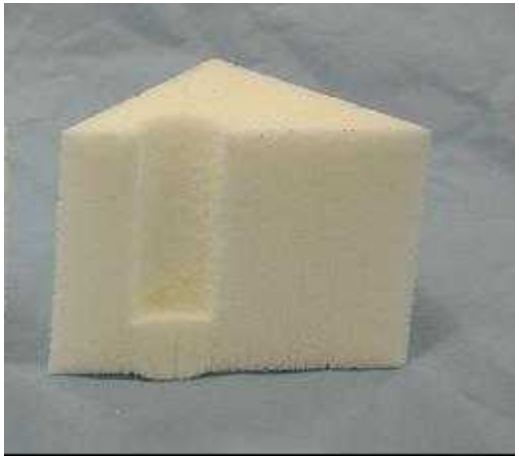


Foam	Max. Strain, %
44307	2.3
44307R/44320T	<4
44320	5.7
44402 (TDI)	5.1
TufFoam	8-10

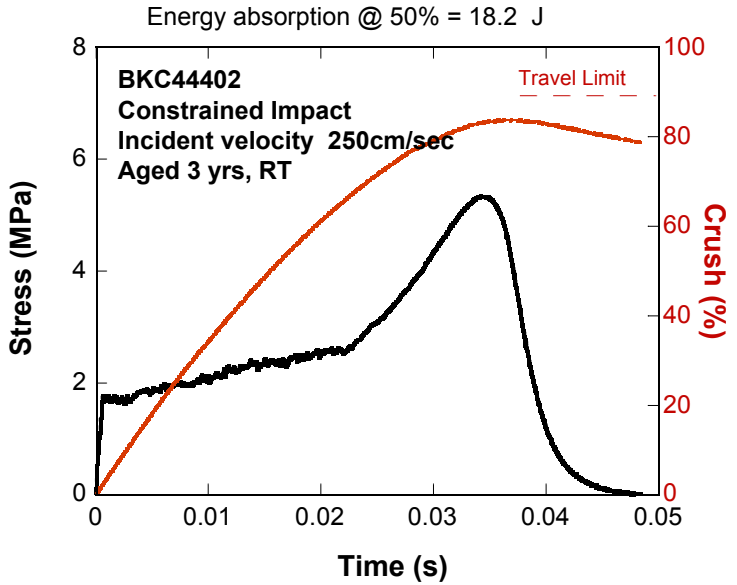
- 44307 & 44402 data from Tom Neet
- 44320 data from Pete Rand

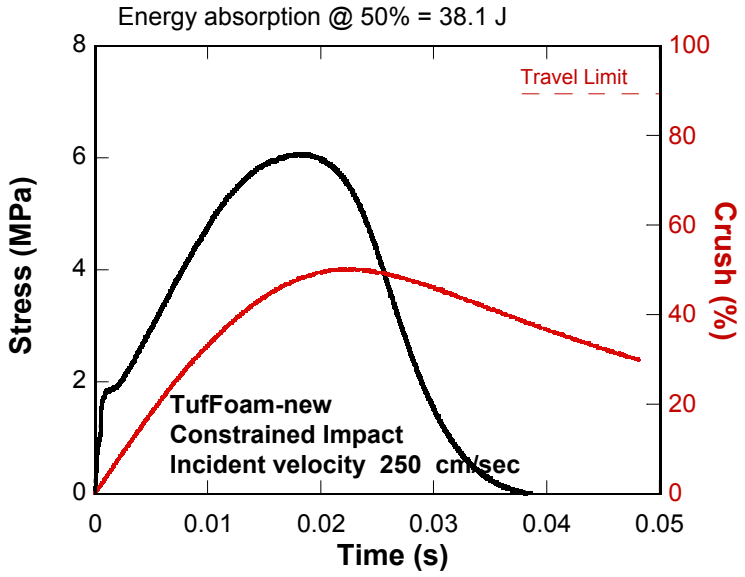
Constrained Impact

TDI



TufFoam

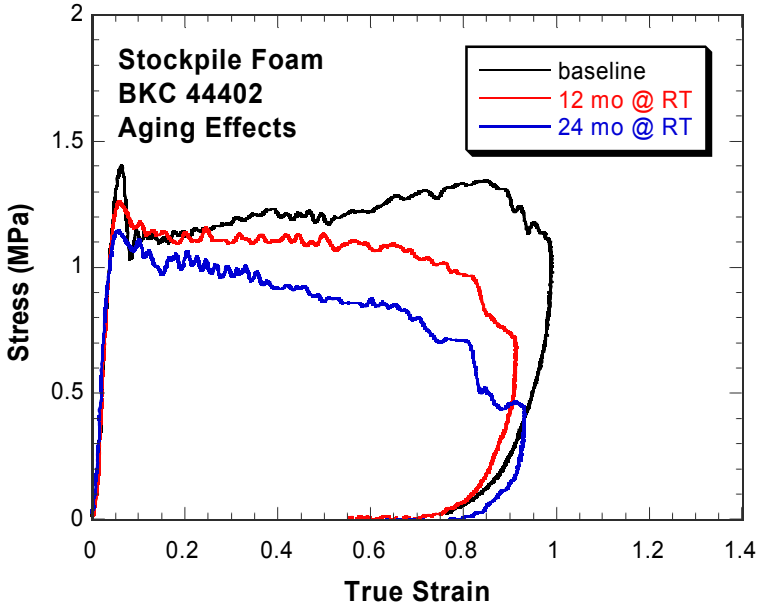


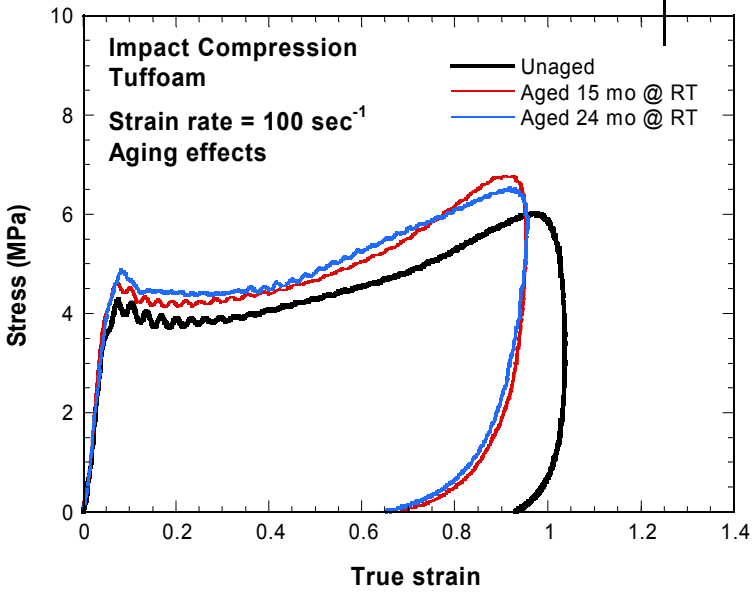


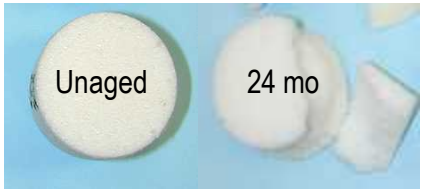
TufFoam spreads the load, limiting the travel of the plunger by approximately half.

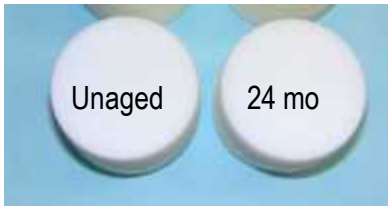
Foam Aging

TufFoam shows no such decrease in impact performance thru 2 yr of aging





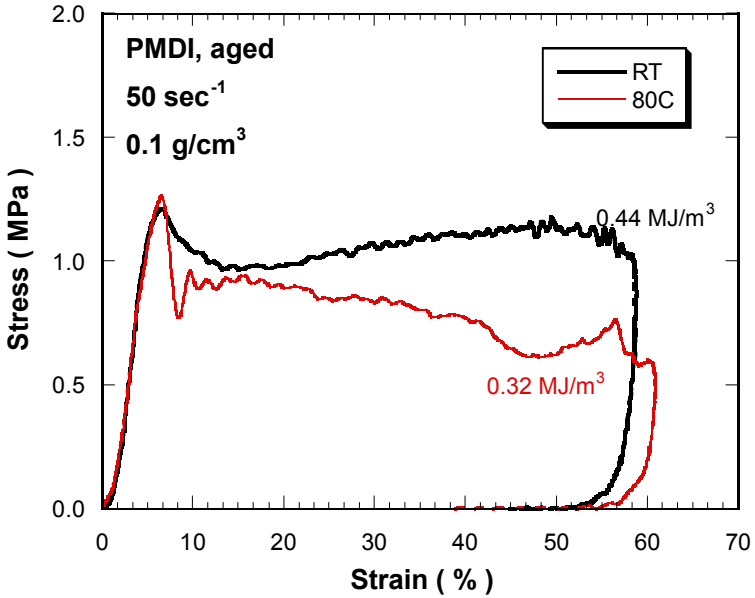


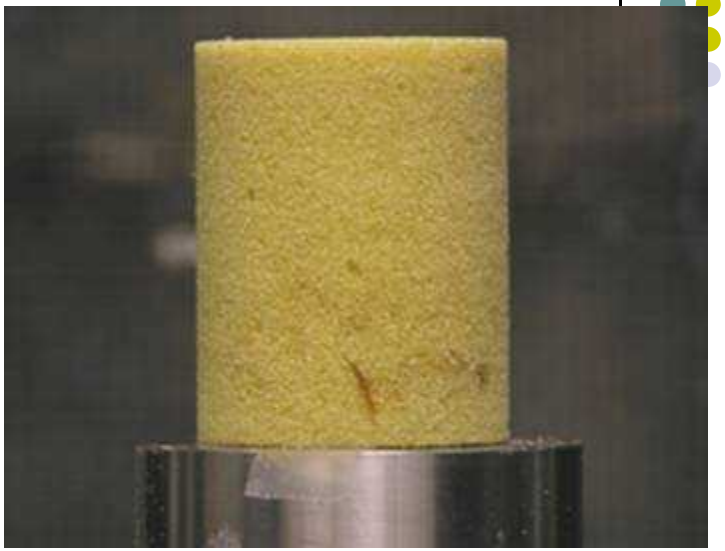


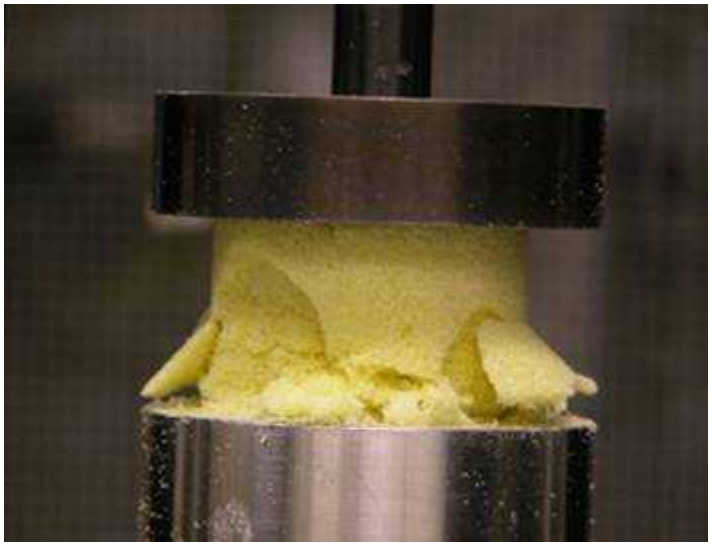
Stockpile (TDI) foam exhibits measurable loss in toughness

TufFoam foam retains toughness after extended aging

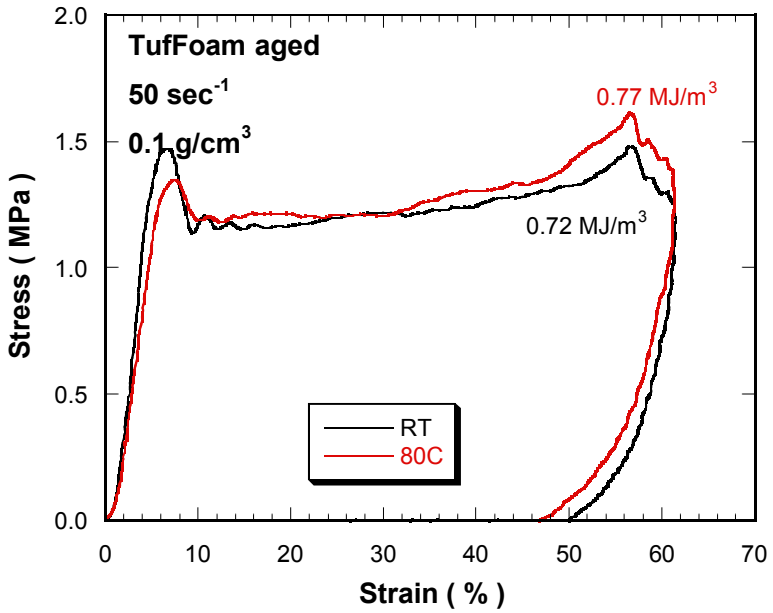
PMDI (44307R/44320T) Impact Testing-14 Weeks

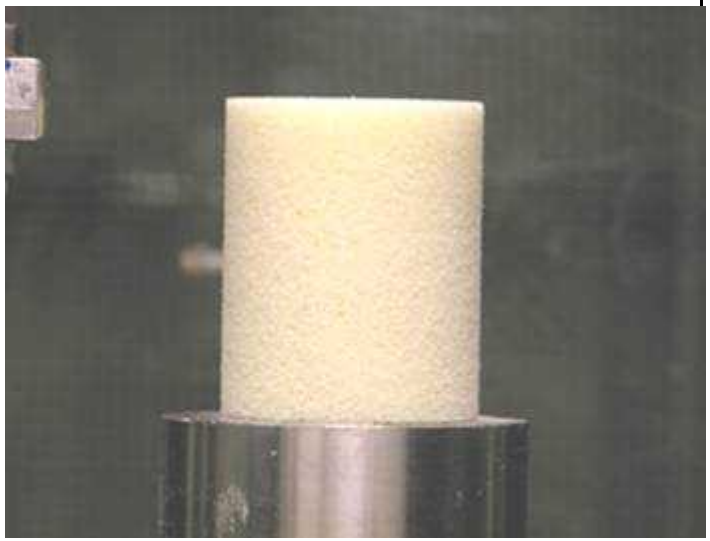


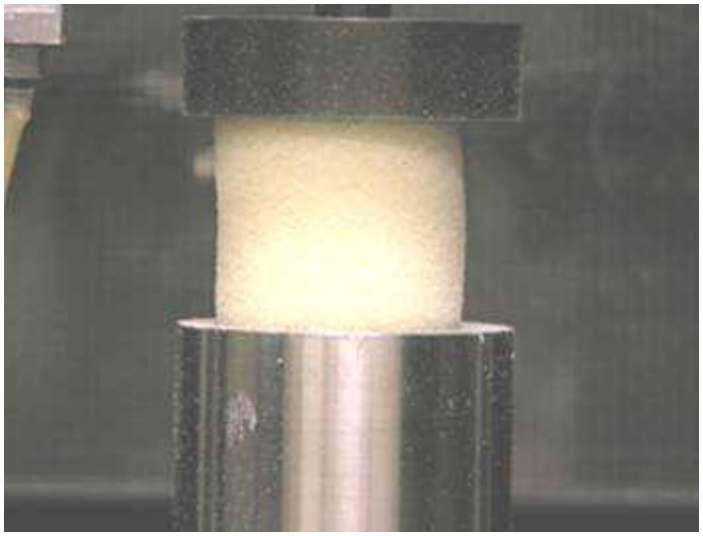


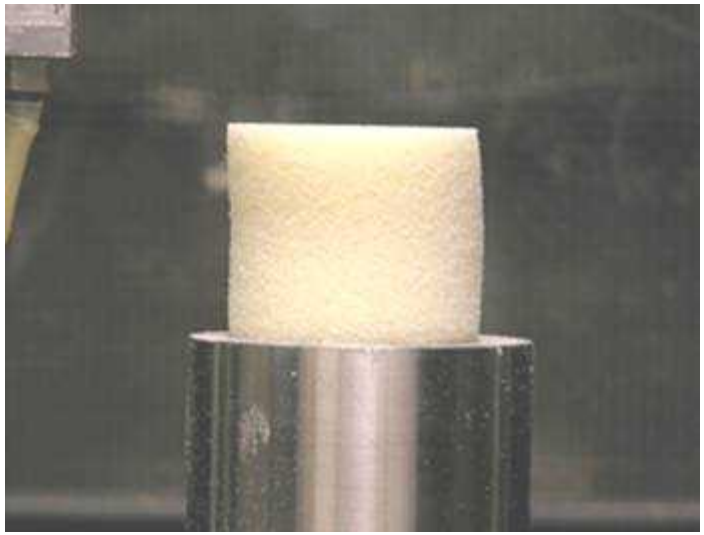


TufFoam Impact Testing-14 Weeks

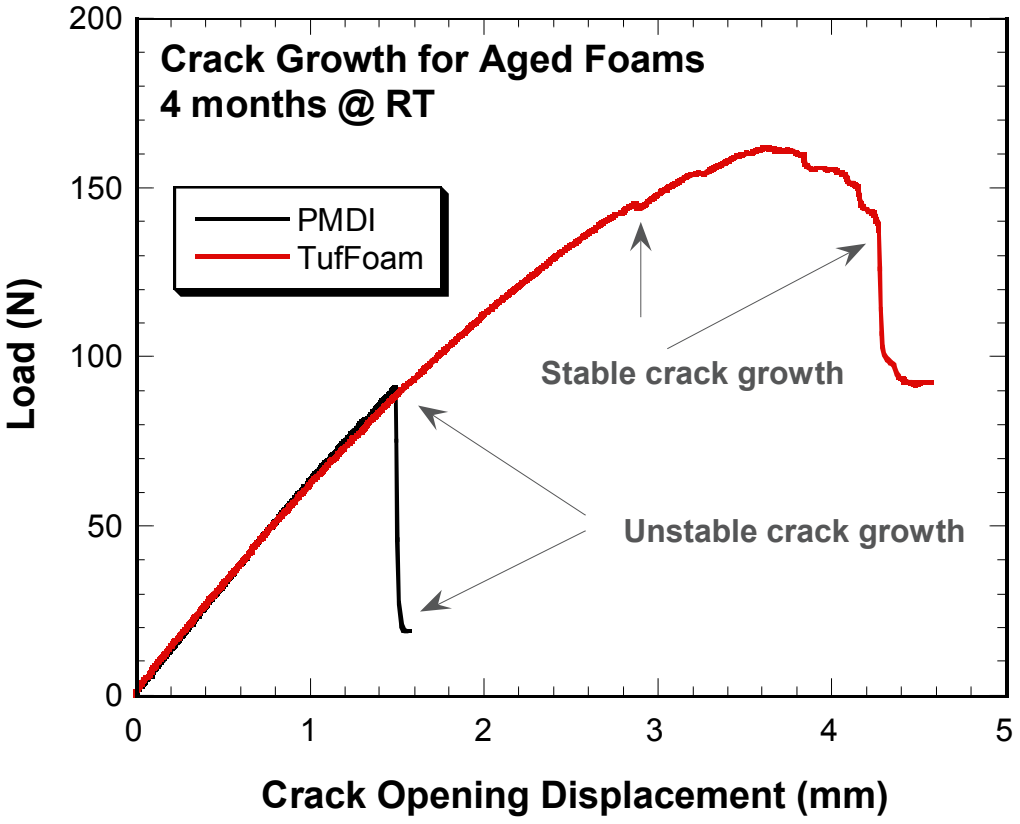


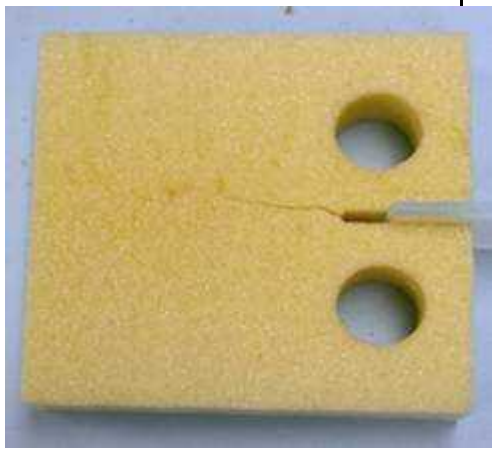




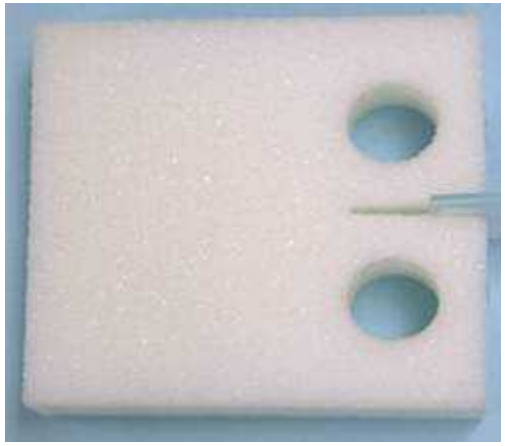


Crack Resistance of Encapsulant Foams, RT aging



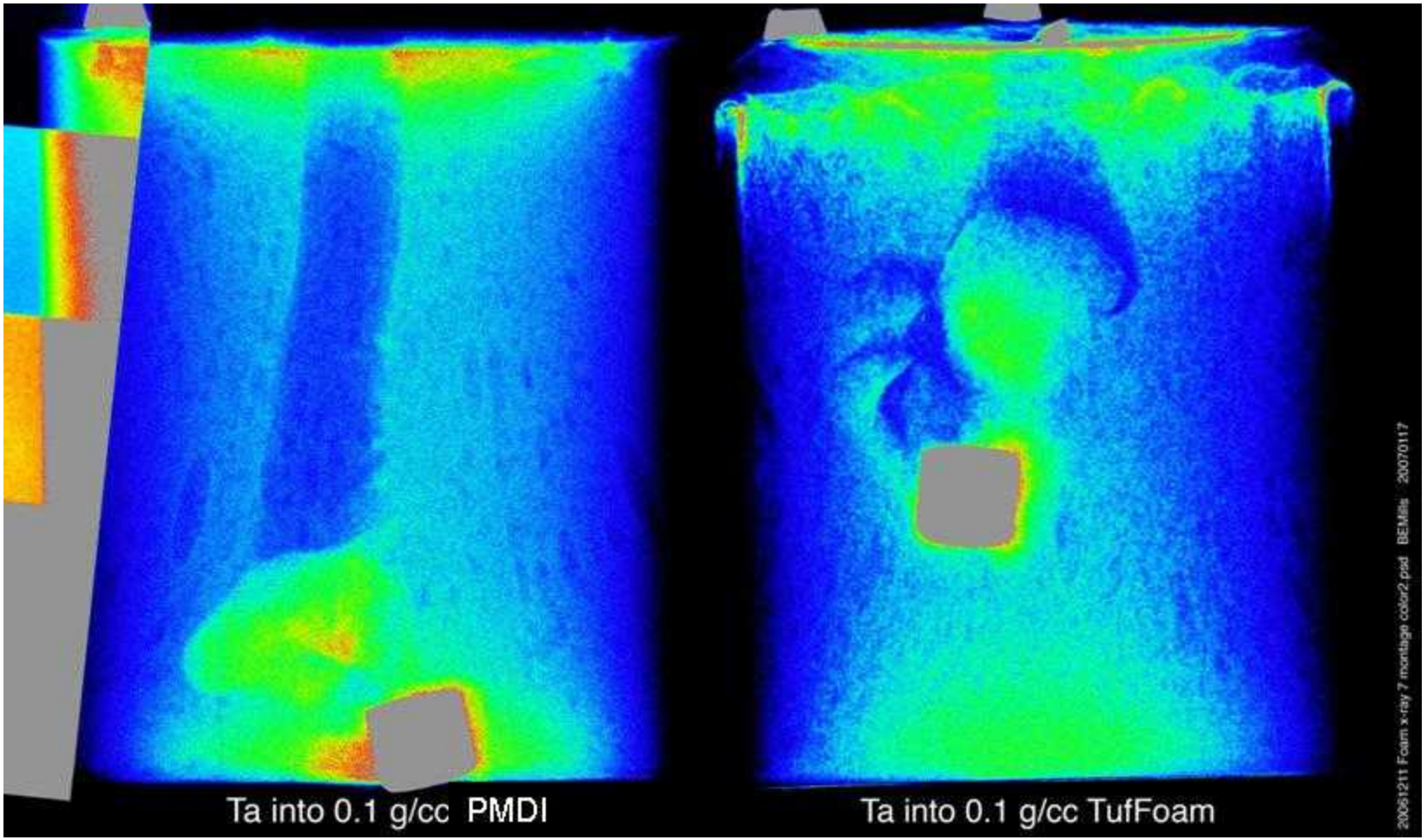


PMDI 4 mos @ RT



TufFoam @ 4 mos @ RT

The final resting place for the Ta slug in PMDI (44307R/44320T) determined by the metal plate at the bottom, whereas the TufFoam stops the slug long before it gets near the plate.



Heavy Penetrator Sled Test

Summary

- **PMDI makes brittle foams**
  - 44307 or
  - 44307R/44320T
- We have noticed an exotherm problem in processing either PMDI foam
- Not much difference in quasi-static compression with age
- TufFoam shows significantly greater resistance to fracture in impact and tensile testing

Acknowledgements

- Pat Keifer
- April Nissen
- Roger Watson
- Jeff Chames
- Chris Binns
- Doug Adolf
- Mark Stavig
- Jeff Braithwaite-ESC Funding