

N85-32448

PHOTOVOLTAIC MODULE SPREAD-OF-FLAME TESTING

JET PROPULSION LABORATORY

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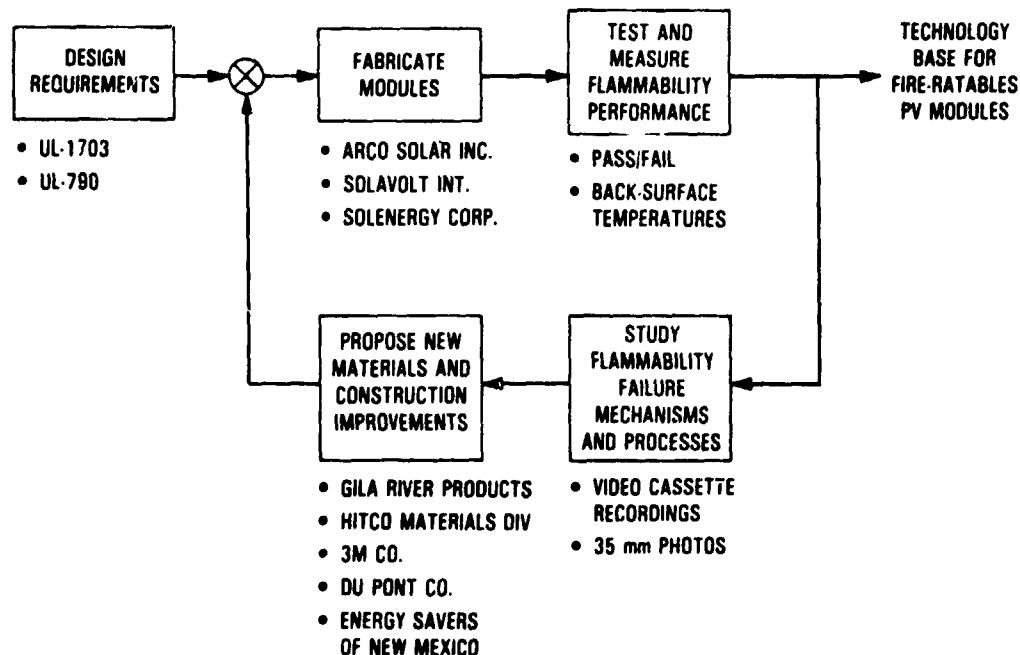
J.C. Arnett

Objective

Develop the technology base required to construct fire-ratable modules

- Evaluate the flammability of existing module designs
- Identify module design features that control flammability
- Identify improved construction concepts and materials that achieve Class A fire-resistance characteristics

Approach



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Lessons Learned From Class B Burning-Brand Tests

- **Module integrity is difficult to maintain**
 - **Glass shatters due to thermal stress**
 - **Hydrocarbon encapsulants are highly flammable**
 - **Test failures result from penetration of back-surface material;**
key failure mechanisms of the back surface include:
 - **Melting (Tedlar)**
 - **Ripping (Kapton)**
 - **Porosity (fiberglass cloth)**
- **Most promising approach is to improve back-surface integrity**
- **Synergisms exist between back-surface materials and module configuration**

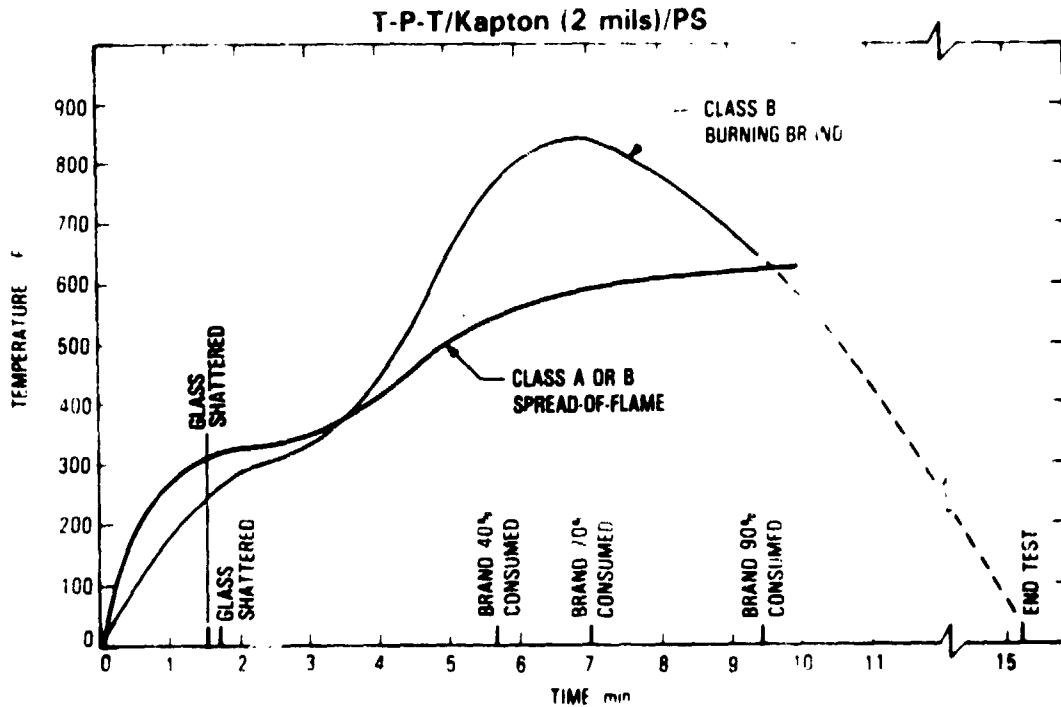
New Back-Surface Constructions Being Assessed

Material Description	Adhesive*	Configuration**	Cost, \$/ft²
Kapton (2 mils)	PS	Add-on	1.05
Kapton (2 mils)	-	Alternative	1.05
Kapton (3 mils)	PS	Add-on	1.81
Kapton (3 mils)	-	Alternative	1.81
Thermoseal mica plate (15 mils)	-	Add-on	0.37
Fiberglass - silicone rubber (one side)	-	Alternative	0.95
Fiberglass - neoprene rubber (one side)	-	Alternative	0.63
Fiberglass - neoprene rubber (two sides)	-	Alternative	0.52
T (1½ mils) - P (5 mils) - black EVA (4%)	-	Alternative	0.60
*PS - pressure sensitive			
**Add-on - material added to T-P-T; alternative - material replaces T-P-T			

Tests for Fire Resistance of Roof-Covering Materials UL-790

Fire Rating	Spread-of-Flame Test			Burning-Brand Test		
	Flame Temperature, °F	Flame Application Time, min	Allowable Flame Spread Distance, ft	Brand Size, in.	Brand Ignition Temperature, °F	Approximate Peak Module Temperature, °F
Class A	1400	10	< 8	12 x 12 x 2K	1630	1900
Class B	1400	10	< 8	6 x 6 x 2K	1630	1400
Class C	1300	4	< 13	1 1/2 x 1 1/2 x 25/32	-	-

Module Back-Surface Temperature History: Spread-of-Flame and Burning-Brand Tests



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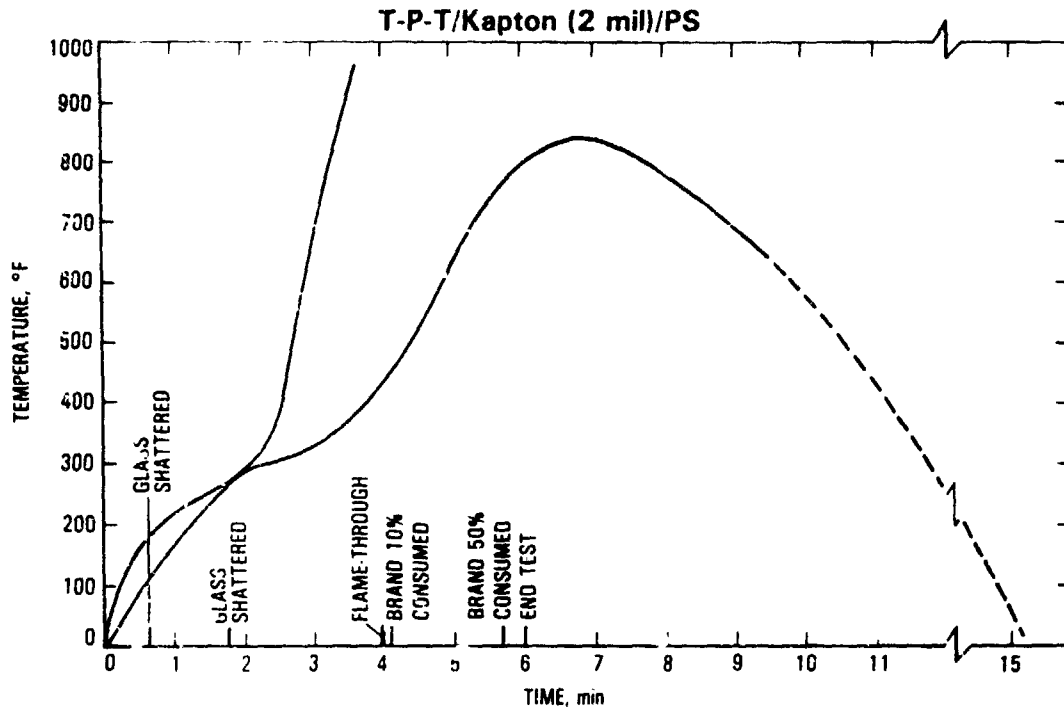
Flammability Test Summary

Module Back-Cover Configuration	Test Results*		
	Flame	B Brand	A Brand
T-P-T/Kapton (2 mils); PS**	●	●	○
K-P-T/Kapton (2 mils); TS**		○	
T-P-T/Kapton (3 mils); PS	●		○
Kapton (2 mils)	●	●	
Kapton (3 mils)	●		○
T-P-T/fiberglass - fine-woven (stabilized); TS		●	
T-P-T/fiberglass - fine-woven (stabilized); PS		○	
Fiberglass - fine-woven (stabilized)		○	
Fiberglass - silicon rubber (one-side)	●	●	
Fiberglass - neoprene rubber (one-side)	●	●	
Fiberglass - neoprene rubber (two-sides)	○		
T-P-T/thermoset mica plate (15 mils)	○		
T (1 1/2 mils) - P (5 mils) - black EVA (4%)	○	○	
Aluminum foil (3 mils) in four-layer laminate		●	○
T-P-T/stainless steel foil (2 mils); PS		●	●

*● - Pass; ○ - Fail

**PS - pressure sensitive adhesive; TS - thermoset adhesive

Module Back-Surface Temperature History:
Class A and Class B Burning-Brand Tests



Summary

- Candidate back-surface materials are available for Class B fire-ratable modules
 - T-P-T/Kapton (2 mils)/PS
 - Fiberglass-silicone (one side)
 - Fiberglass-neoprene (one side)
 - Aluminum foil (3 mils) in four-layer laminate
 - Stainless steel foil (2 mils)

- Class A burning-brand test is much more severe than the Class B burning-brand test

- Additional innovative materials needed to pass Class A burning-brand test

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Future Work

- **Characterize temperature-time history of Class A burning-brand and conduct exploratory tests of candidate Class A module constructions**
 - **Gila River Products - proprietary material**
 - **HITCO Materials Division - Refrasil, proprietary material**
- **Assess fire-test impact on module edges and array joints**
- **Assess applicability of UL-790 to other rooftop installation methods**