QUALIFICATION TEST FOR A/C PANEL ADHESIVES

Presented to: International Aircraft Materials Fire Test Working Group, Atlantic City

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OBJECTIVE

Develop a qualification test for flammability of adhesives used in bonded details.

PURPOSE

Establish *similarity* of bonded details.

APPLICATIONS

Certification of New Parts

ADHESIVES TASK GROUP

3M
American Airlines
Boeing
Bombardier
Bostik
C&D Aerospace
Dassault
FAA
Henkel

INDUSTRY-PROPOSED METHODS OF COMPLIANCE FOR CERTIFICATION OF INTERIOR MATERIALS

Part 2: Methods That Will Require Supporting Data

Ref. No.	Feature / Construction	25.853(a) Bunsen Burner Similarity	25.853(d) Heat and Smoke Similarity
28	BONDED DETAILS	*Testing detail **without adhesive*** to Appendix F substantiates the bonded configuration*	Test required if: A > 2 ft² Possible Test if: 1 < A < 2 ft² No test required* if: A < 1 ft²

**For FAA Qualified Adhesives?*

ADHESIVE QUALIFICATION TEST ISSUES

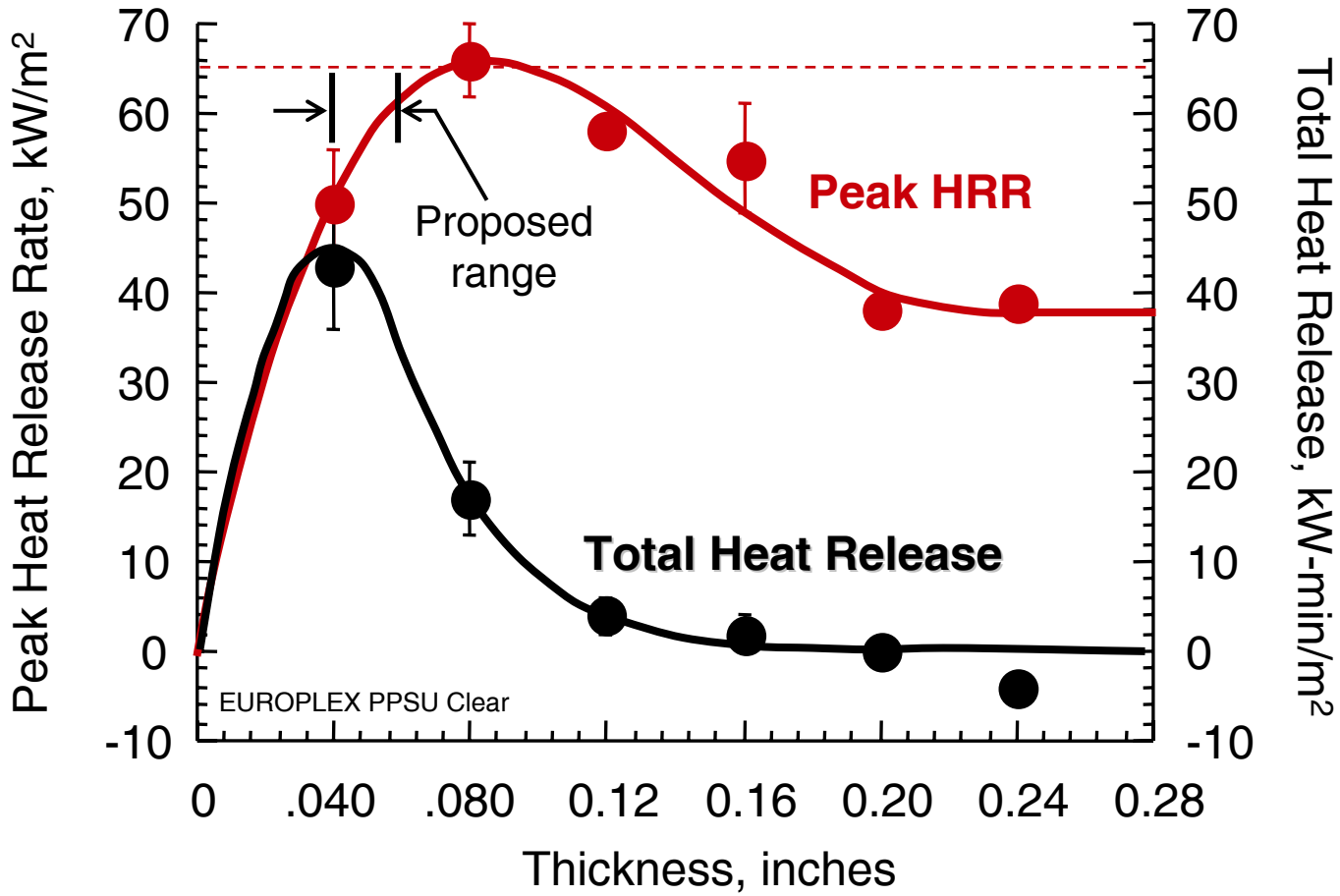
FAR 25 versus Other Measurement Method

Sample Form

Effect of Adherends

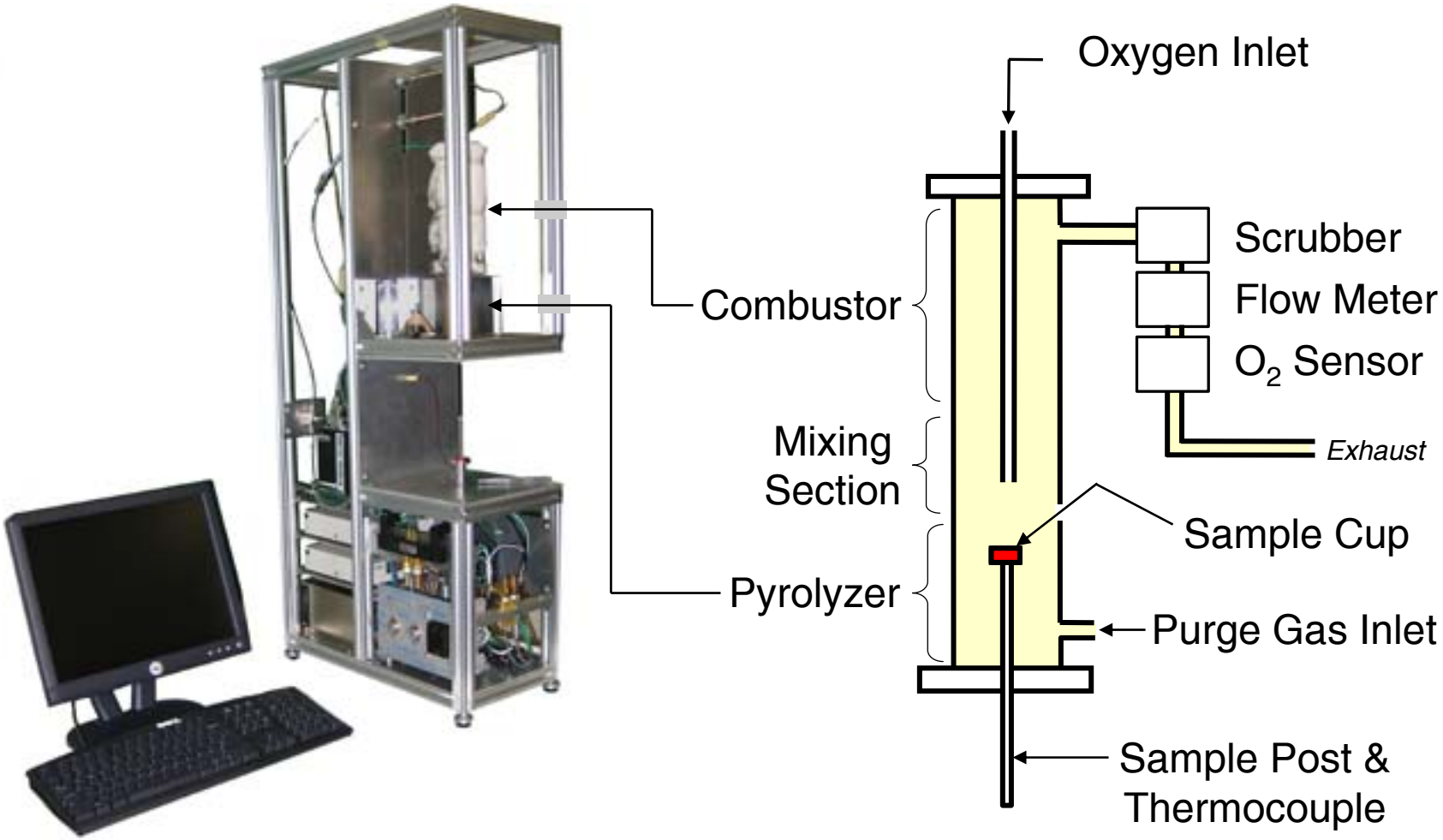
Effect of Thickness: Does thinner *substantiate* thicker?

Example: Thermoplastic Thickness Ranges

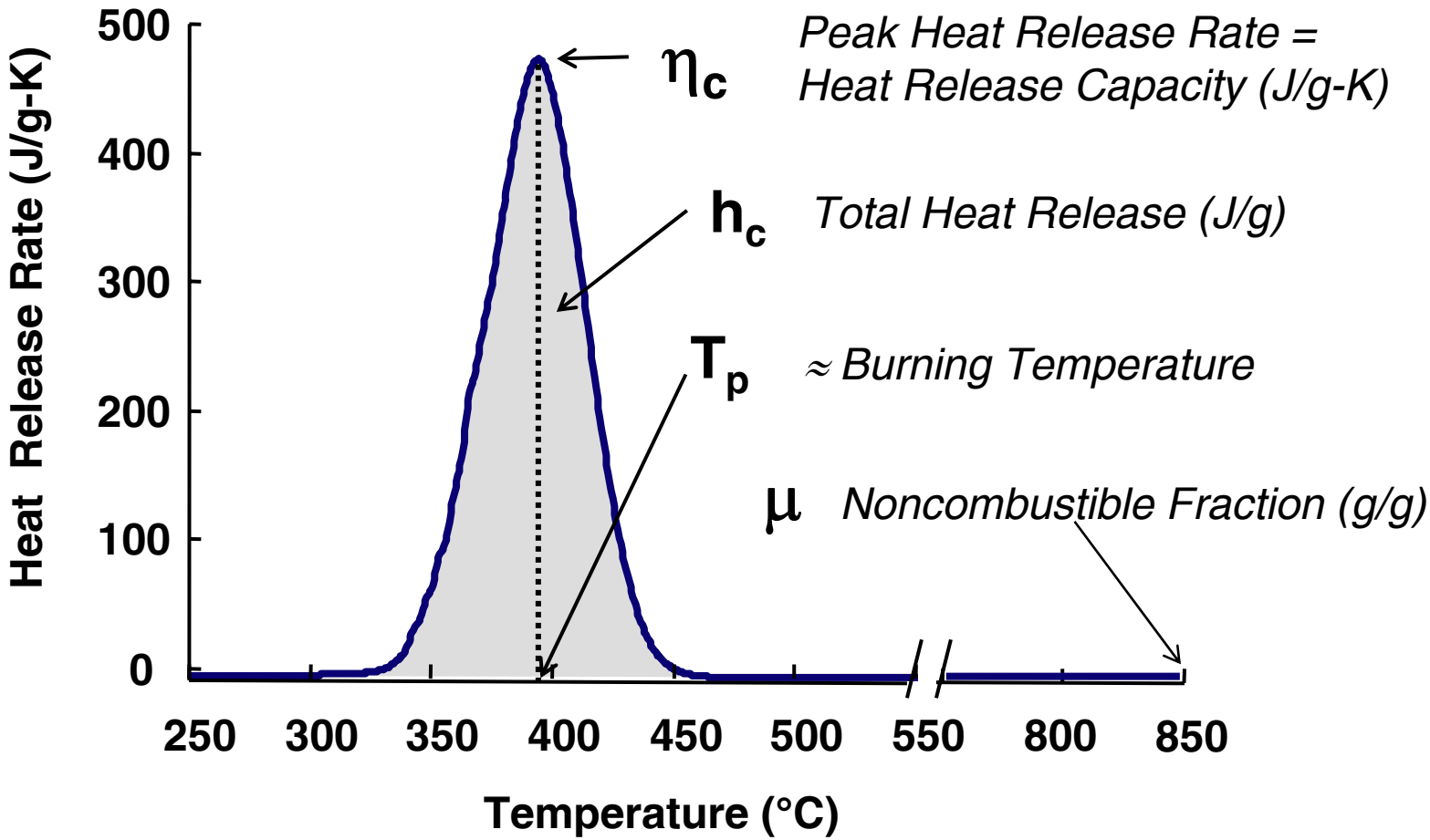


OSU Peak HRR of 0.040" ***does not*** substantiate .080"- 0.16"

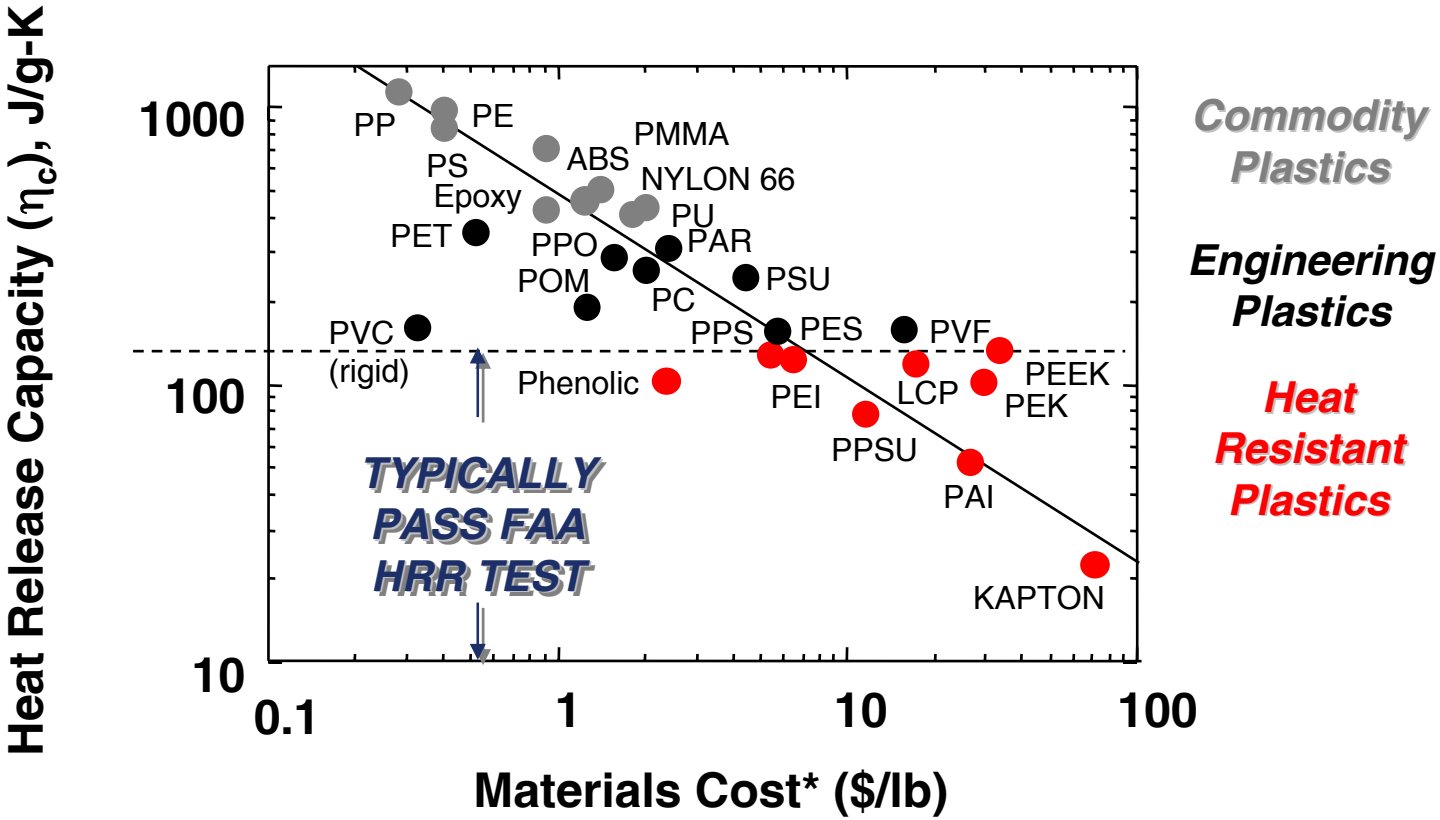
Standard Test Method for Measuring Flammability Properties of Plastics and Other Solid Materials Using Microscale Combustion Calorimetry, ASTM D 7309



THERMAL COMBUSTION PROPERTIES FROM MCC



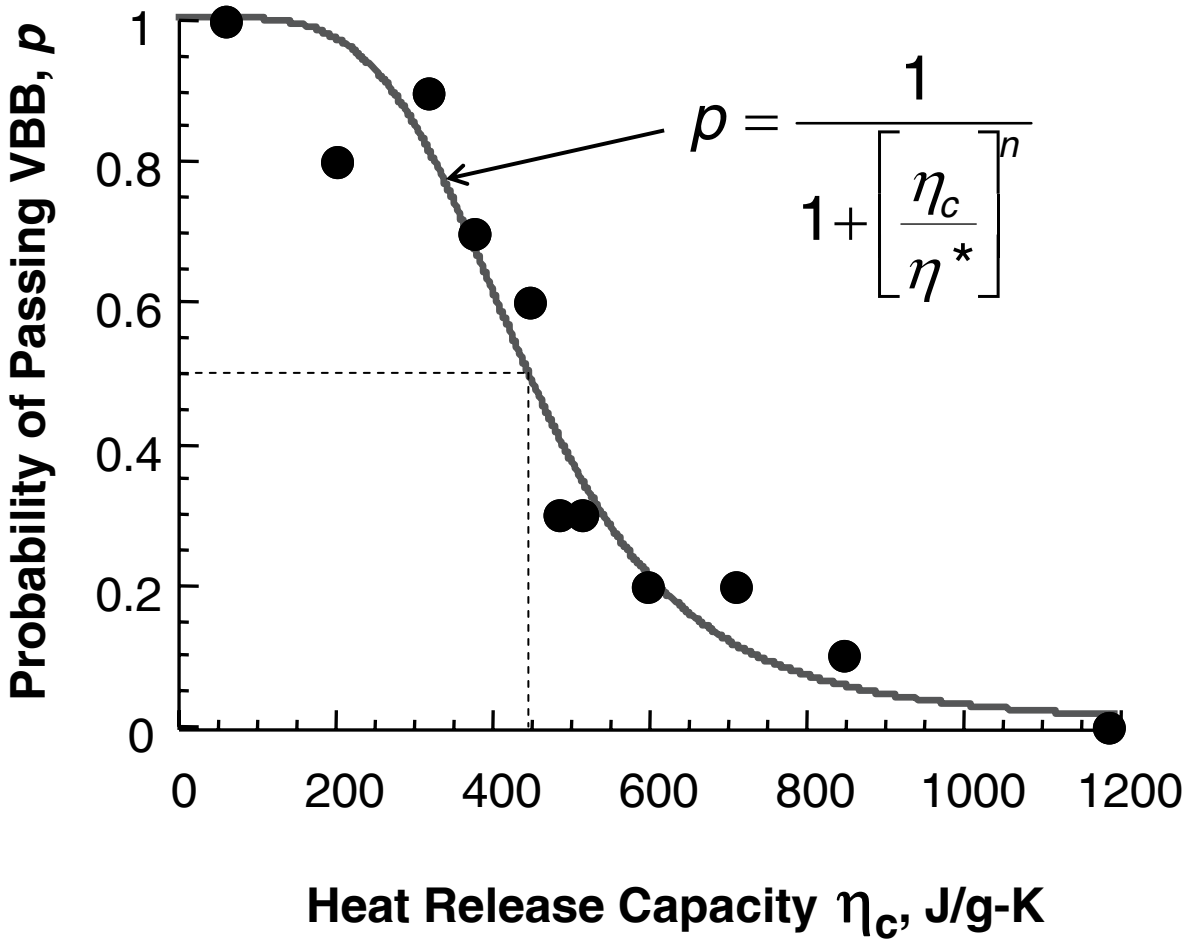
HEAT RELEASE CAPACITY VERSUS COST OF PLASTICS



*Truckload Prices, 2001

VERTICAL BUNSEN BURNER TEST (114 plastics)

Probability of Passing the UL 94 V-0 Requirement

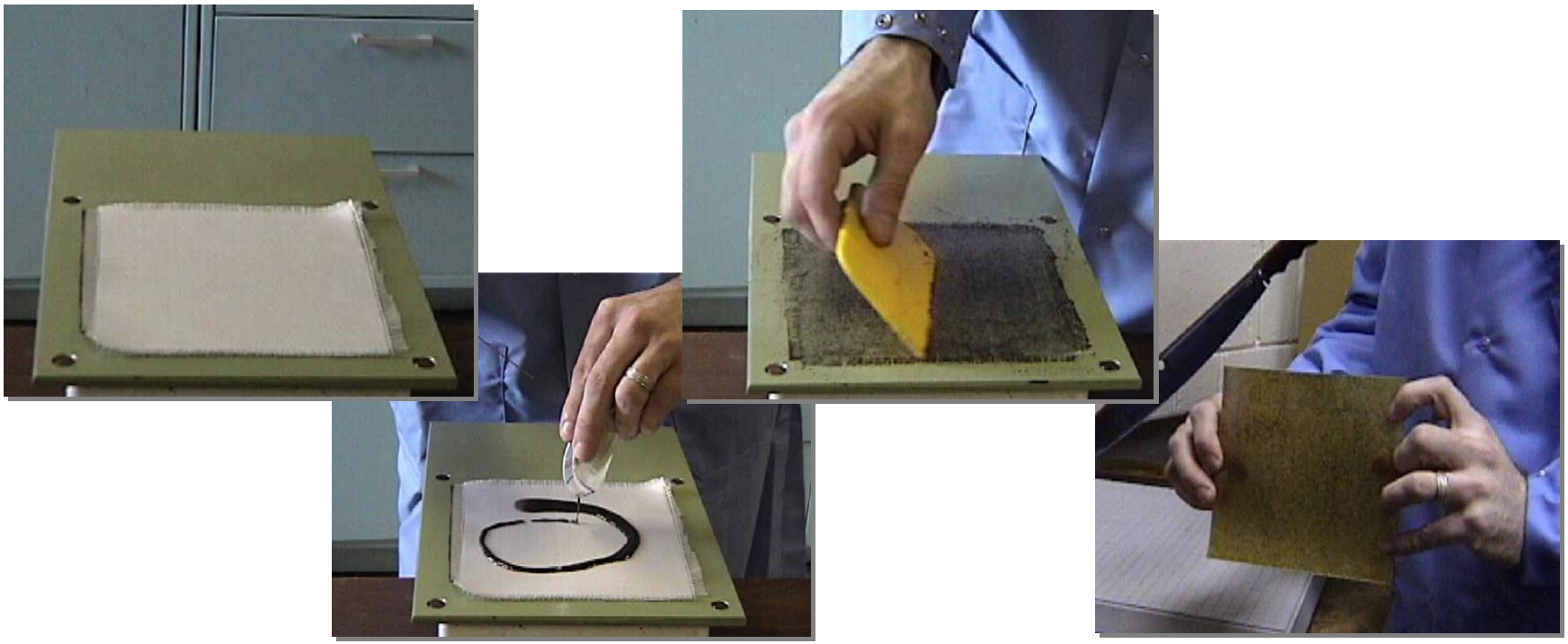


ASTM D 3801

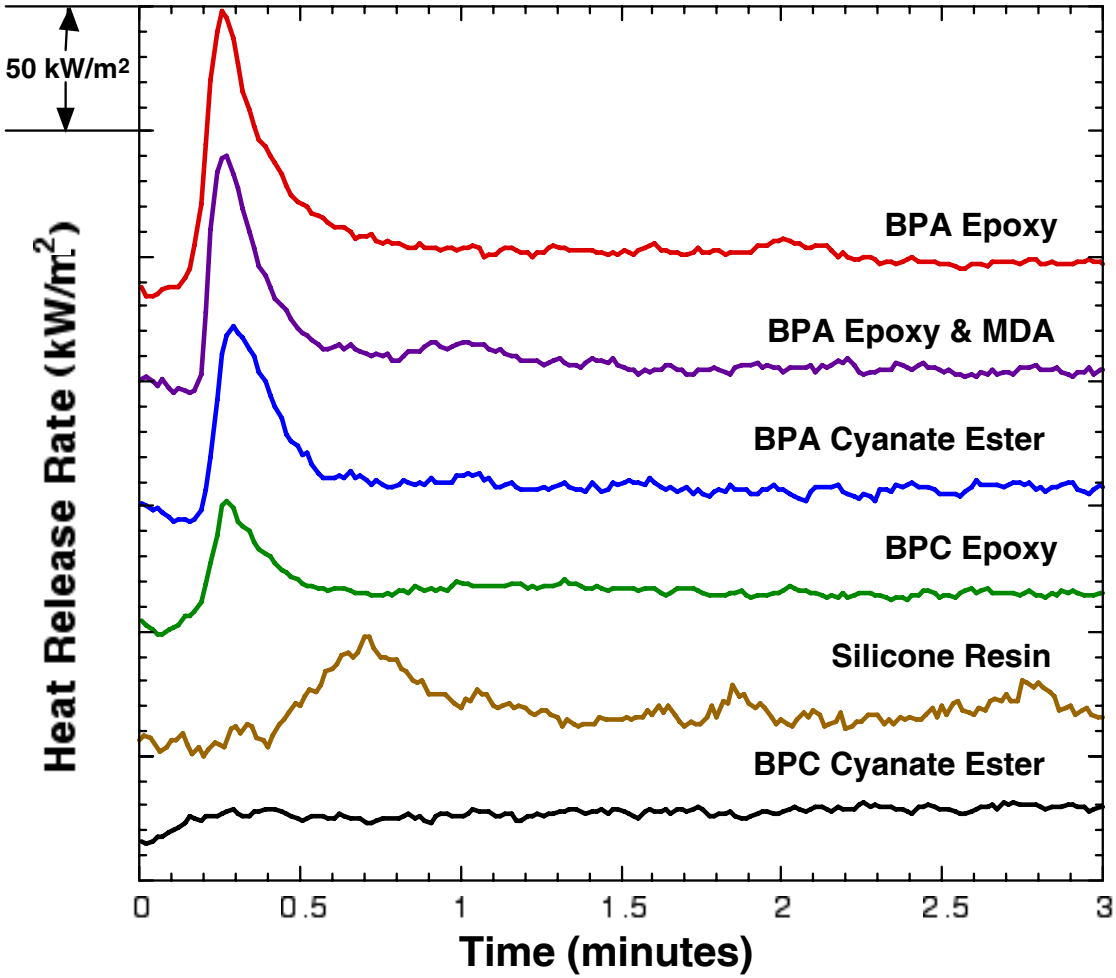
η^*= 448 J/g-K
n = 4.46
R = 0.97

HAND LAY-UP OF ADHESIVE / RESIN OSU SAMPLES

- Fiberglass-reinforced adhesive samples are made by hand lay-up.
- Samples cured between two Teflon-coated aluminum plates in heated press.
- Cured samples trimmed to 6″ x 6″ for OSU HRR testing.
- Resulting samples ~ 40% resin by weight.



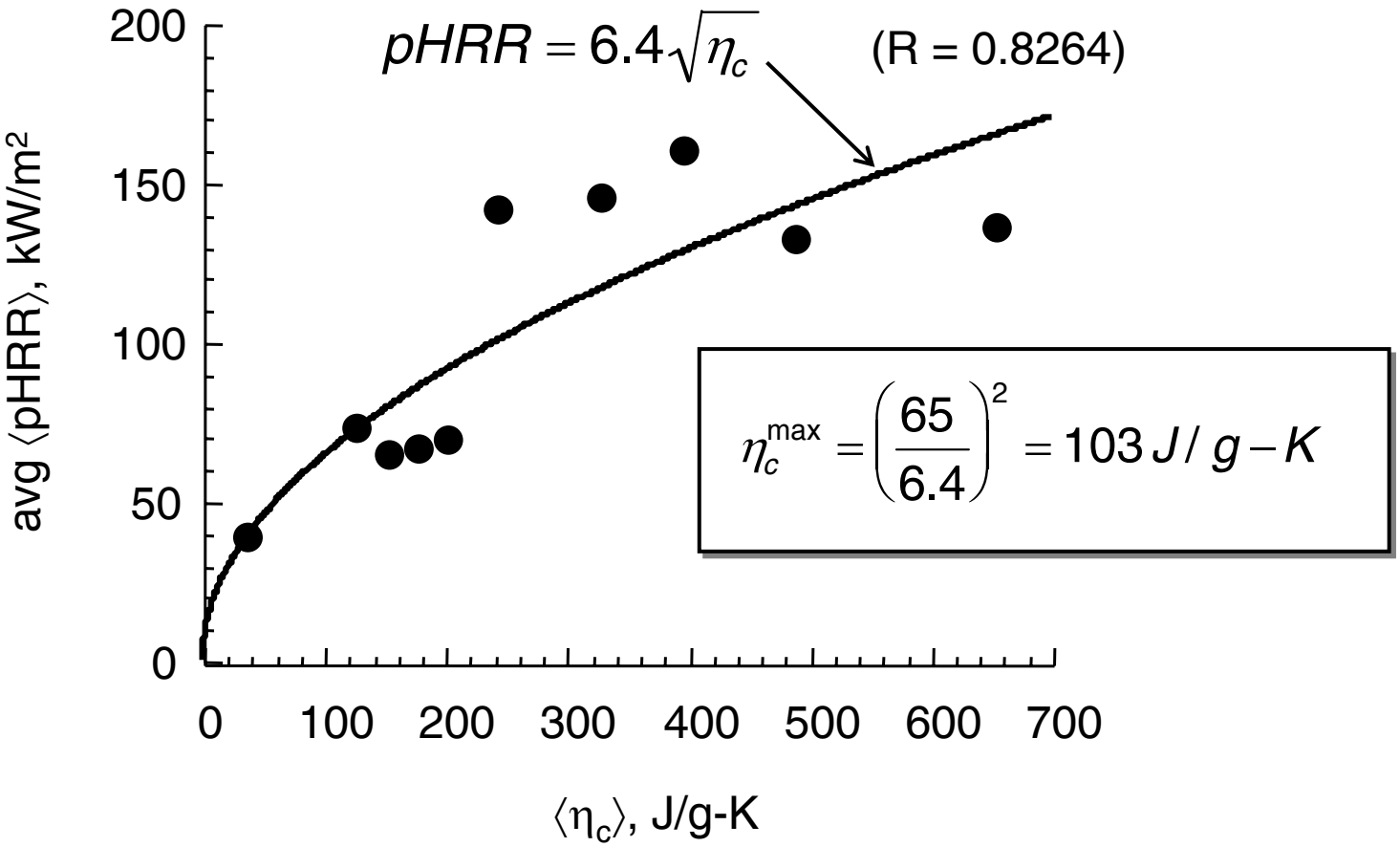
OSU TESTING OF ADHESIVE RESINS



Resin	Peak HRR (kW/m²)	2-min HR (kW-min/m²)
BPA Epoxy	111	44
BPAE + MDA	88	26
BPA CE	72	28
BPC Epoxy	48	28
Silicone Resin	33	12
BPC CE	13	13

OSU PHRR (binned data) 101 RESINS AND PLASTICS)

Maximum Heat Release Capacity from Curve Fit



OSU Data for AIRCRAFT CABIN MATERIALS

$\langle \eta_c \rangle$	η_c	pHRR	y	$p = P/(P+F)$
36	1	8	P	9/10 = 0.90
	9	25	P	
	10	59	P	
	13	13	P	
	15	66	F	
	22	31	P	
	29	55	P	
	50	30	P	
	105	54	P	
127	108	92	F	6/10 = 0.60
	115	61	P	
	120	49	P	
	120	123	F	
	121	60	P	
	121	52	P	
	127	109	F	
	129	64	P	
	136	65	P	
174	140	69	F	3/10 = 0.30
	141	110	F	
	152	90	F	
	153	30	P	
	155	85	F	
	156	45	P	
	159	72	F	
	173	106	F	
	192	36	P	
254	196	32	P	4/10 = 0.40
	201	74	F	
	203	65	P	
	215	213	F	
	215	150	F	
	230	97	F	
	235	258	F	
	248	55	P	
	261	44	P	
355	265	188	F	0/10 = 0.00
	276	199	F	
	295	93	F	
	298	211	F	
	301	232	F	
	316	166	F	
	345	115	F	
	349	207	F	
	359	90	F	

Etc.

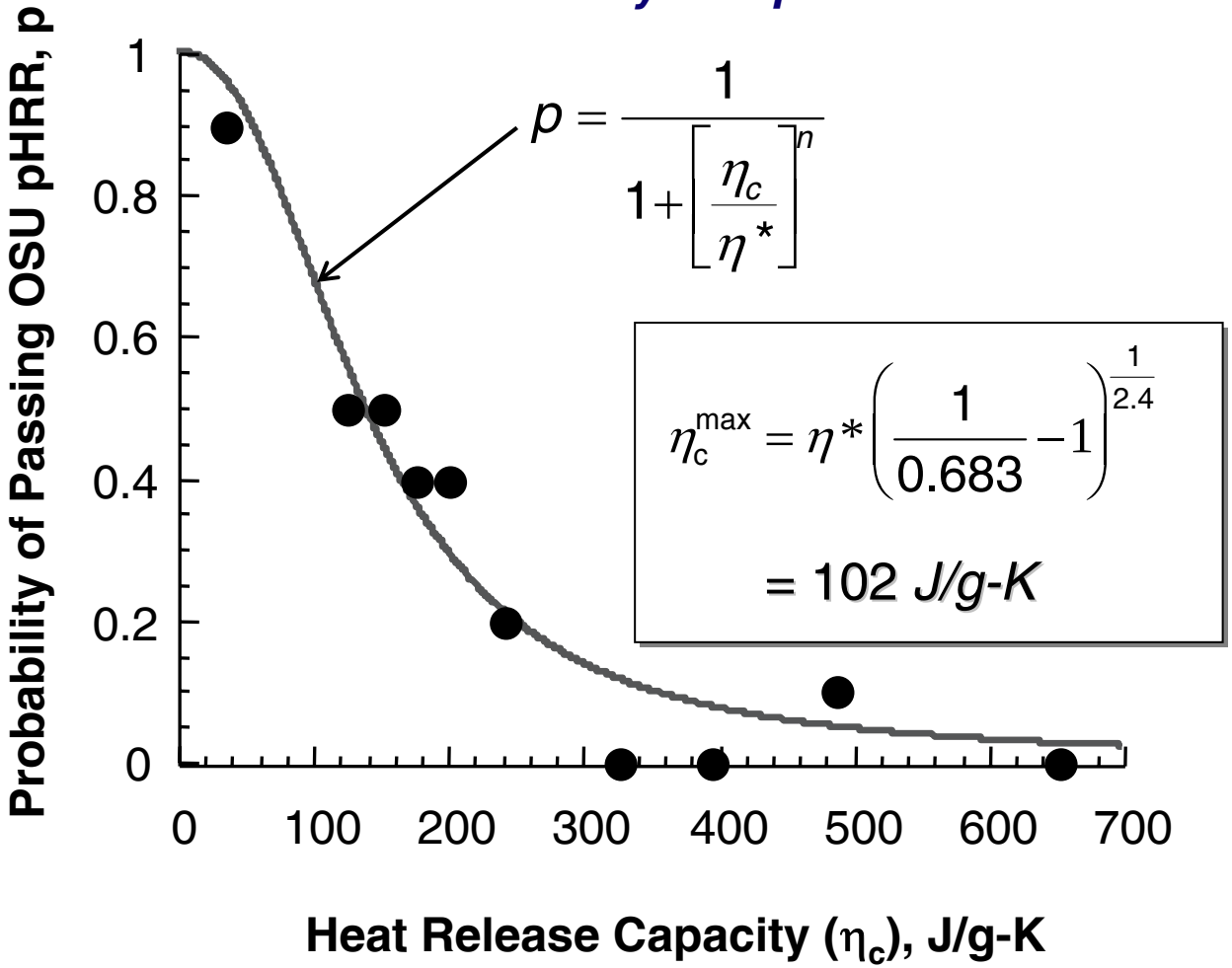
Transform Quantitative Data into Qualitative Data Using Pass/Fail Criterion

14 CFR 25.853

- HRR $\leq$ 65 kW/m^2 = Pass **= P**
- HRR > 65 kW/m^2 = Fail **= F**

OSU PHRR (101 RESINS AND PLASTICS)

Probability that pHRR ≤ 65 kW/m²

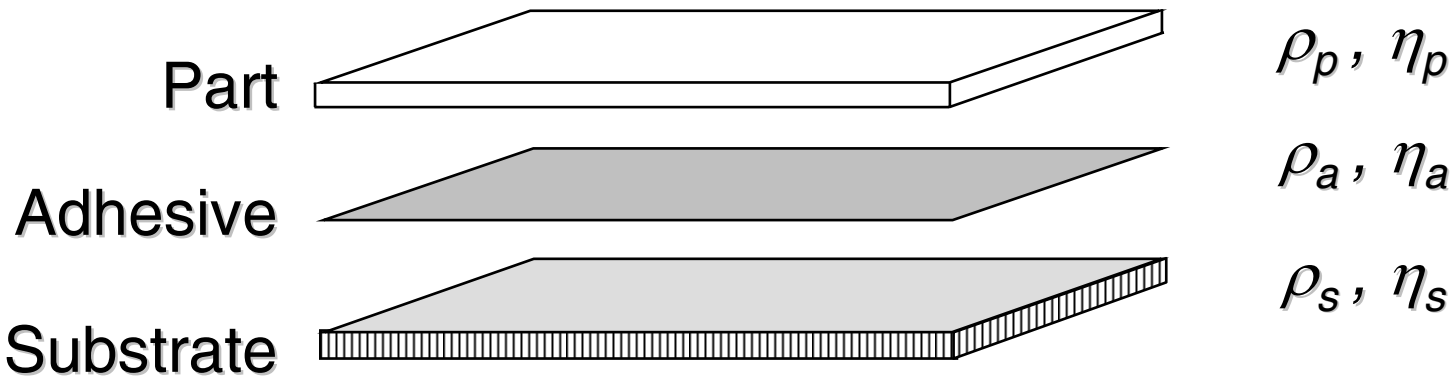


14 CFR 25

η^*= 140 J/g-K
n = 2.4
R = 0.97

EFFECT OF ADHERENDS and THICKNESS (Additive Approach Using MCC Data)

$$\eta_{construction} = m_p\eta_p + m_a\eta_a + m_s\eta_s$$



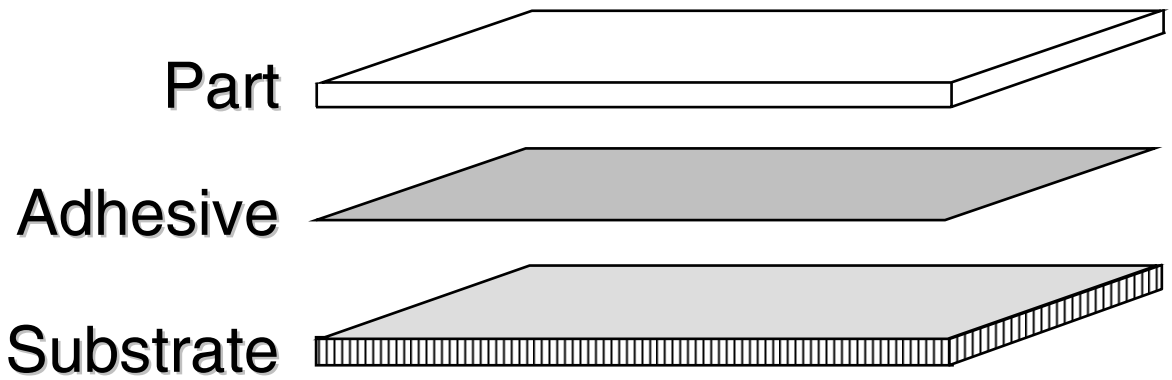
ρ_i = Areal Density of Layer *i*, g/m^2

η_i = Heat Release Capacity of Layer in MCC *i*, J/g-K

m_i = Mass Fraction of Layer $i = \rho_i/\Sigma\rho_i$

EFFECT OF ADHERENDS and THICKNESS (ThermaKin Numerical Burning Model)

Transient energy and mass balance calculation



T_i, ρ, h_c, E, A, etc.

T_i, ρ, h, E, A, etc.

T_i, ρ, h, E, A, etc.

T_i = Thickness of Layer i, cm

ρ_i = Density of Layer i, g/m^3

h_i = Heat Release of Layer, J/g

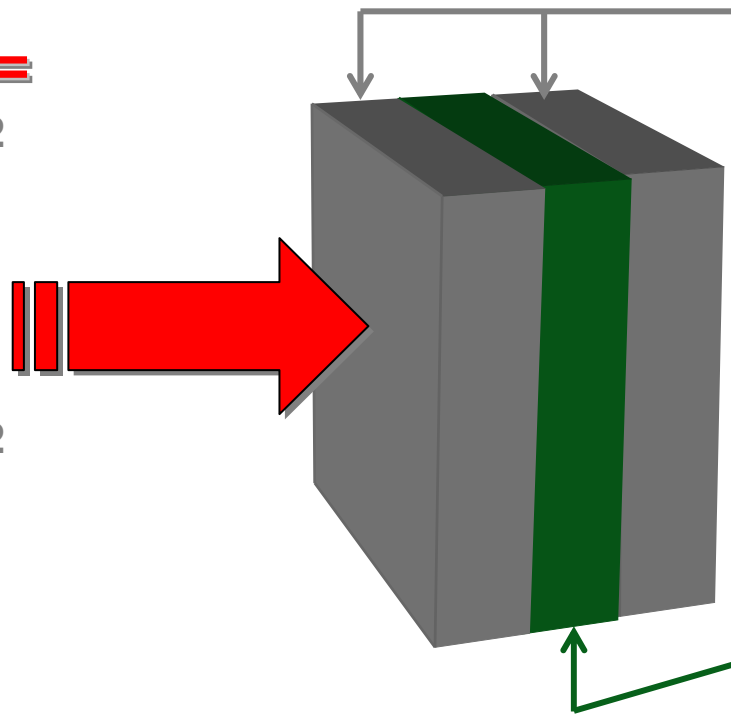
E_i, A_i = Thermal Decomposition Kinetic Parameters of i

OSU HRR OF BONDED CONSTRUCTION (ThermaKin Simulation)

Heat Flux = 35 kW/m^2 (OSU)

+

15 kW/m^2 (Flame)



Substrates = 1/16″ (1.5 mm) Thick Charring Plastic (Polycarbonate)

Adhesive Layer Thickness = 0.2, 0.5, 1 and 1.5 mm

h_c = 2X Substrate

OSU HRRs of BONDED CONSTRUCTIONS (ThermaKin)