REHAU
Unlimited Polymer Solutions

Fire Properties of uPVC

International Business Development
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1. Fire Report Synopsis

Summary of PVC Combustion Properties	
Ignitability	uPVC (material for windows) is very difficult to ignite using common ignition sources
Heat Release	Burning materials release heat and the rate of release affects the severity of the fire; This in association with ignitability largely affects the rate of flame spread. Both the rate of heat release and the total rate of combustion of PVC are significantly lower than other common thermoplastics
Spread of flame and resistance to sustained combustion	PVC has limited spread of flame characteristics and achieves very high classifications in National Building Fire Tests. PVC tends to form a protective carbonaceous layer (or char). This insulates the material below and excludes oxygen necessary for combustion. The Hydrochloric Acid emitted acts as a combustion inhibitor.
Smoke Density	Smoke Density is similar to wood under smouldering conditions but greater under flaming conditions
Toxicity of Combustion gases	Although Hydrogen Chloride is a main combustion product of PVC, the toxic potency of the combustion gases of PVC is similar to and definitely not significantly worse than those produced from natural or synthetic materials. The build up of toxic fumes will be slow compared with rapidly burning materials of similar toxic potency.
Overall	Resistance to ignition and how well flame is supported and spread are the most significant properties which contribute to fire safety. PVC is considerably good in this respect and this is recognised by the **UK Building Regulations**. The toxic properties of PVC decomposition products are similar to that of most other materials. Overall therefore, PVC is a widely accepted material which does not present a greater fire hazard than any other natural or synthetic materials

2. Ignitability

Typical ignitability test results for rigid and flexible PVC as compared to wood.

Property	Test Method	uPVC	Flexible PVC	Wood
Flash Ignition Temperature(°C)	ASTM D1929	400	330-380	210-270
Self Ignition Temperature (°C)		450	420-430	400
Oxygen Index (%)	ISO4589	50	23-33	21-23
ISO Radiant Cone	ISO5657			
Ignition time in seconds at 30 KW m2		112	50-75	
Ignition time in seconds at 50 KW m2		33	17-26	4-30
Needle Flame Test	IEC 695-2-2	Non-ignitable	Ignitable with plasticiser levels	Easily ignitable in 20 seconds

Table 1 – Ignitability Results

→ PVC is actually more difficult to ignite than wood.

3. Heat Release

Burning materials release heat and the rate at which they do so largely determine the severity of the fire. One factor affecting this is the *heat of combustion* of the particular material and for uPVC it is 20kJ/g which is significantly lower than most common thermoplastics and organic materials including wood, hardboard and the like.

Material	Thickness (in mm)	Total Heat Release (MJ/m2) at 10 mins
Pine	25	91
Hardboard	6	62
Chipboard	12.5	57
Oak	25	45
ABS	3	27
Flexible PVC	2.25	33
uPVC	3	17

Table 2 - Ohio State University Calorimeter Test at Typical *End Use Thicknesses*

→ Both the rate of heat release and the total rate of combustion of uPVC are significantly lower than other common thermoplastics and materials.

4. Spread of Flame, Resistance to Sustained Combustion

Country	Test Method	Classification
UK	BS476 Part 7	Class 1(a)
	BS476 Part 6	Class 0(b)
France	NF P92-501	M1
Germany	DIN 4102 Part 1	B1
USA	ASTM E84	Class 1

(a) Class 1 can usually be achieved when it is reinforced or when it is fitted to a non-combustible backing, e.g. cladding of concrete walls with PVC sheets. According to BS476 part 7, materials which become detached from their substrate, thereby rendering impossible the action of the pilot frame, are deemed unclassifiable.

(b) Class 0 of the UK building Regulations which is achieved by appropriate performance of both parts 6 and 7 of BS476.

Table 3 - National Building Tests

→ In national building tests, uPVC compositions qualify for the best possible classifications for combustible building materials.

5. Smoke Emissions

Under non-flaming conditions, most plastics produce similar smoke densities to wood. Under flaming conditions, PVC and fire retardant plastics produce more smoke than wood.

Material	Thickness	Maximum Specific Optical Density	
		Non Flaming	Flaming
PLASTICS			
UPVC	3	400	580
Polyethylene	3	590	83
FR-Polyethylene	3	790	780
Polypropylene	3	550	162
FR-Polypropylene	3	820	600
Polystyrene	3	476	960
PMMA	3	63	117
Flexible PVC	0.75	430	650
OTHER MATERIALS			
Hardboard	3	580	74
Pine	6	551	142
Plywood	6	432	64
Chipboard	19	620	405
Oak	19	581	243
Plasterboard	12	77	83
Wool Carpet	6	388	217
Natural Rubber (Black)	2	721	762

Table 4 - NBS Smoke Chamber Results

However, in actual fire conditions, other factors (e.g. fuel load, ventilation conditions, spread of flame, char stability) influence smoke. It is hence preferable to carry out large scale fire tests.

Wall Lining	Heat Release in 13 mins (MJ)	Maximum Smoke Density at Door (OD/m)	Smoke Yield (g)
Plasterboard Control	28	1.6	106
UPVC(2.3mm thick)	30	8.3	384
Wood (5.8mm thick)	90	9.6	>750

Table 5 – Test for Actual Fires

6. Toxicity of Combustion Gases

→ A conclusion of the Huggett and Levin paper (research publication reproduced in the National Building Regulations UK) is that PVC decomposition products are not significantly more toxic than other commonly used building materials.

	Toxic Potency (mg/l min)
Carbon Monoxide	150-190
Hydrogen Chloride (vapour)	210
Hydrogen Chloride (aerosol)	253

Table 6 – The Higher the Required Dose, the Lower the Potential Toxicity

7. Use in Window Frames and External Cladding

The use of uPVC in windows has long been established in Europe and is now rapidly expanding around the globe. Recent tests carried out by the fire research station in the UK have shown no difference in fire performance between uPVC and traditional wood. UPVC, when correctly formulated obtains high ratings under the *Building Regulations* (1985), approved documents B, for which performance is assessed by BS476 Parts 6 and 7.

8. Conclusion

→ It is hence concluded that uPVC is in fact at least as safe as conventional materials such as wood or even safer.

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