

# FR-4 Alternative Materials

(Results of Fire Tests carried out at  
RAPRA Technology Ltd)

# Materials Tested

- Toshiba material (FR-4 grade material, using a nitrogen-phosphorous compound as flame retardant)
- Isola (FR-4 grade material using phosphorous compound as flame retardant)
- “Standard FR-4” currently used at CERN (using bromine as flame retardant)
- 4th material (from Ditron) so far not tested

# Fire Tests

- **Smoke & Toxicity** (prEN 2824, 2825, 2826 which are based on ASTM E662). Four specimens tested each under flaming and non-flaming exposure.
- **Corrosivity** (IEC 752-Part 2)

# Smoke Density

- Results expressed as specific optical density which relates the optical density of the smoke to the volume of the cabinet, the length of the smoke-measuring path and the area of the specimen exposed.
- Requirement: specific optical density,  $D_s < 250$  for flaming and non-flaming modes (SI 41).

# Smoke Tests (Results)

Sample	Test Mode	Specific Optical Density, $D_s$ (average values)	
		$D_s$ max	Time to Max.
Isola	NF	(See detailed test results – very little smoke produced)	
	F	105	1019
Standard FR-4	NF	(See detailed test results – very little smoke produced)	
	F	390	616
Toshiba	NF	(See detailed test results – very little smoke produced)	
	F	105	1057

F = Flaming, NF = Non-Flaming

# Corrosivity

- Determination of degree of acidity of gases evolved during the combustion of materials by measuring pH and conductivity
- Proposed limits of pH and conductivity:
  - In relevant standard, ‘The pH value should not be less than 4.3, the conductivity less than 10  $\mu\text{S}/\text{mm}$ ’.
  - IS 41 (pH > 4, conductivity < 10  $\mu\text{S}/\text{mm}$ )

# Corrosivity Tests (Results)

Sample	pH (average)	Conductivity mS/mm (average)
Isola	4.03	23.8
Standard FR-4	3.29	40.5
Toshiba	5.26	10.39

# Toxicity

- prEN 2826 does not give limits but they are given in the 'Airbus Test' which is essentially the same.
- Mean value in ppm
  - HCl < 150
  - HCN < 150
  - CO < 3500
  - NO + NO<sub>2</sub> < 100

# Toxicity Tests (Results)

Sample	Test Mode	Gas Components (ppm, average values)					
		CO <sub>2</sub>	CO	HCN	NO <sub>x</sub>	HCl <sup>*</sup>	phosphate (mg/m <sup>3</sup> )
Isola	NF	600	0	0	0	0	0
	F	4700	260	3	11	0	3.7
Standard FR-4	NF	200	0	0	0	0	0
	F	11,750	765	4	41	33	0
Toshiba	NF	300	1	0	0	0	0
	F	10,000	485	2	25	0	13

\* or HBr gas. There is no draeger tube for measuring HBr. This gas reacts in the HCl draeger tube.