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# REPORT ON THE FIRE PROTECTIVE PROPERTIES OF MICON INTUMESCENT COATINGS





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OF MICON INTUMESCENT COATINGS**

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# REPORT ON THE FIRE PROTECTIVE PROPERTIES OF MICON INTUMESCENT COATINGS

## 1. SPONSOR

Micon Coatings cc  
P O Box 76204  
WENDYWOOD  
2144

## 2. USE OF THIS REPORT

The use of this report is subject to the conditions of Annexure BR 82/2.

## 3. DESCRIPTION OF COATINGS

Two types of coatings were evaluated. There were MICON WB – a water emulsion coating and MICON SB – a solvent based (white spirit) coating.

## 4. TEST METHODS AND RESULTS: MINING SPECIFICATIONS

### 4.1 Combustion Gases: NES 713 (SABS Method T1)

Approximately one gram of dry material is burned in a gas flame in an enclosed cabinet with a volume of 1 m<sup>3</sup>. The concentrations of specified gases are determined and a toxicity index is calculated by summation of the ratios of gas concentrations, calculated for burning 100 grams in 1 m<sup>3</sup> air, to the exposure levels of each gas producing fatality to man in 30 minutes.

Gases to be determined and fatality limits are:

<u>Gas</u>	<u>Concentration</u> <u>ppm</u>	<u>Gas</u>	<u>Concentration</u> <u>ppm</u>
Carbon Dioxide	100 000	Nitroux Oxides	250
Carbon Monoxide	4 000	Hydrogen cyanide	150
Formaldehyde	500	Acrylonitrile	400
Hydrogen Fluoride	100	Ammonia	750
Hydrogen Chloride	500	Sulphur Dioxide	400
Hydrogen Bromide	150	Hydrogen Sulphide	750
Phenol	250	Phosgene	25

The following gas concentrations, calculated for burning one gram of material in one cubic metre of air, were found:

<u>Gas</u>	<u>Concentration</u> <u>Micon WB</u>	<u>Concentration</u> <u>Micon SB</u>
CO <sub>2</sub>	170	220
CO	1	10
HCN	1	1
NO <sub>x</sub>	4	4
NH <sub>3</sub>	2	1
Toxicity Indices:	2.74	2.87

#### 4.2 Insulation Properties

The fire insulation properties of the coatings were determined by exposing coated 150 mm x 150 mm x 0.8 mm steel plates from the coated sides to the flame of a burner with a flame temperature of 1 100 °C and measuring the temperature of the steel plates by means of thermocouples brazed to the steel plates. An uncoated steel plate of the same dimensions was exposed in the same manner and the steel temperatures recorded.

The following results were obtained:

	<u>Temperature, ° C for</u>		
	<u>Micon WB</u> <u>300 Micron</u>	<u>Micon SB</u> <u>300 Micron</u>	<u>Steel</u> <u>(Uncoated)</u>
0	20	20	20
1	210	220	390
2	230	240	480
3	250	265	565
4	245	260	640
5	240	260	690
6	240	260	720
7	240	260	740
8	240	260	770
9	240	260	790
10	240	260	820

#### 4.3 Flashpoint of solvents: ASTM D93 Closed Cup Test Results

Micon WB is water based and the solvent (water) has no flashpoint. The flashpoint of the solvent in Micon SB was found to be 42 °C.

#### **4.4 Adhesion and Flexibility**

One coat of each of the coatings was applied to a 20 mm PC sleeved armoured cable. The cable was bent, after the coatings were dry, over a circular former with a diameter of 300 mm.

##### Results

Both coatings showed no signs of cracking or loss of adhesion.

#### **4.5 Water Resistance**

##### **4.5.1 Micon WB**

The coating did not lose its fire insulation properties after exposure to an atmosphere of 95% R.H. at 25 °C for 7 days.

##### **4.5.2 Micon SB**

The coating did not lose its fire insulation properties after immersion in water for 24 hours at 25 °C.

#### **4.6 Stability of Char**

The carbonaceous chars of both coatings did not become dislodged when subjected to an airstream with a velocity of 3 m/s.

### **5. PROTECTON OF PVC**

Samples of unplasticated polyvinylchloride (uPVC) of the type used for drain and vent pipes in buildings and water pipes in mining applications were coated with 300 micron thick Micon coatings and exposed to a radiant heat source with intensity of 25 kw/m<sup>2</sup> and pilot ignition flames in a National Bureau of Standards (USA) smoke density chamber.

Uncoated samples were exposed as a control.

Light transmission through the smoke was determined and specific optical densities,  $D_s$ , calculated.

Hydrogen chloride concentrations were determined after 10 minutes by passing one litre of the glass in the chamber through a standard sodium hydroxide solution and back-titration using methyl red as indicator.

The following results were obtained:

<u>Sample</u>	<u>Hydrogen Chloride ppm</u>	<u>Light Transmission %</u>	<u>D<sub>s</sub></u>
PVC – Micon WB	130	54	35
PVC – Micon SB	135	48	42
Unprotected uPVC	2 760	.001	660

## **6. FIRE PROTECTION OF STRUCTURAL STEEL**

Different coating thicknesses were applied to 600 mm long steel sections. The steel sections were then exposed in a furnace in which the standard time-temperature heating curve was maintained and the temperature of the steel sections were recorded.

These results were then used to calculate the required coating thicknesses to achieve a one hour fire resistance rating on steel profiles with different shape factors permitting a maximum temperature of 550 °C of the steel. Calculation methods are given in Appendix A. Agreement between calculated values and experimental values was good.

Dry film thicknesses to achieve a one hour fire resistance rating on steel sections are given in Table 1. These values are on the safe side and a deviation of about 50 micron is permissible.

TABLE 1  
 DRY FILM THICKNESS FOR A ONE HOUR FIRE  
 RESISTANCE RATING ON STRUCTURAL STEEL

<u>Ps</u> As	<u>Dry Film Thickness, Micron for</u>	
	Micon WB	Micon SB
M <sup>-1</sup>		
25	200	250
50	250	300
75	300	360
100	375	430
124	450	520
150	550	630
175	650	775
200	750	850
225	900	1 000
250	1 050	1 150
275	1 300	1 350
300	1 550	1 600
325	1 800	1 800
350	2 100	2 100
375	2 400	2 400
400	2 700	2 600

## 7. DISCUSSION OF RESULTS AND CONCLUSIONS

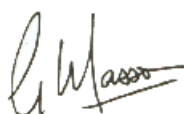
Micon WB has slightly better insulating properties at thin coating thicknesses than Micon SB but at thicker coating thickness (>1 500 micron) the solvent based material performs equally well.

As the interface temperatures of protected substrata remain low, the coatings have a significant effect on the reduction of hydrogen chloride and smoke liberation of uPVC pipes or components protected in this way. This was borne out by the large scale tests conducted at COMRO.

Micon coatings will also effectively protect combustible substrata such as wood and plastics. The materials can also be used in conjunction with glass fibre tissues to ensure better adhesion and integrity on smooth sub-strata.

Table 1 can be used to determine the coating thicknesses necessary to protect structural steel against collapse in a fire situation.

It should however be borne in mind that suitable protective topcoats may be necessary where exposure conditions are such that the coatings will be exposed to the weather or to wet and dry cycles over a long period of time. This aspect has not been investigated.



## APPENDIX A

### CALCULATION OF TEMPERATURE RISE OF STEEL SECTIONS

The temperature rise of steel sections,  $T_s$ , protected with intumescent coatings is calculated by means of the following formula:

$$T_s = \frac{k_i \cdot P_s}{d_i \cdot A_s c_s \rho_s} (T_f - T_s) \cdot t \times 60 \text{ } ^\circ\text{C}$$

Where $k_i$	=	thermal conductivity of insulation (W/m $^\circ\text{C}$ )
$d_i$	=	thickness of insulation (m)
$A_s$	=	Exposed perimeter of steel section (m)
$C_s$	=	Specific heat of steel
	=	520 J / kg $^\circ\text{C}$
$P_s$	=	Density of steel
	=	7 850 kg/m <sup>3</sup>
$T_f$	=	Furnace temperature at time t ( $^\circ\text{C}$ )
	=	$T_o + 345 \log (8 t^{1/4})$
$T_o$	=	Ambient (starting) temperature $^\circ\text{C}$
$T$	=	time in minutes
$T_s$	=	Steel temperature, $^\circ\text{C}$ at time t

As intumescent coatings have no real thickness and as the thermal conductivity decrease after intumescent, a  $\frac{k_i}{d_i}$  ratio is calculated for different coating thicknesses from the experimental results.

The shape factor,  $\frac{P_s}{A_s}$  of steel sections is calculated as in the following examples:

1. All round fire exposure (1 column)

$$\frac{P_s}{A_s} = \frac{4B + 2D - 2t}{2B \cdot t + (D - 2T)t}$$

2. Fire exposure from three sides

$$\frac{P_s}{A_s} = \frac{3B + 2D - 2t}{2Bt + (D - 2t)t}$$

Where the mass of the steel section (kg/m) is known, as can be calculated by dividing the mass by the density of steel (7 850 kg/m<sup>3</sup>)

## References

1. Malhotra, H.L. Design of Fire Resisting Structures, Surrey University Press, 1981
2. European recommendations for the calculation of fire resistance of steel load bearing elements and steel assemblies exposed to the standard fire. European Convention for Constructional Steelwork – Committee 3: Fire Safety of Steel Structures.