Heat and Fire Properties of Low Smoke Zero Halogen Materials of Power Cables

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INTRODUCTION

Oxygen Index & Temperature Index of materials describe the inherent fire retardant property of the materials. Halogen content and Smoke density measurements are related to the toxic content and smoke content of a particular material. Heat Release describes the amount of energy available in the material. The LSZH materials are of either thermoplastic or thermoset materials and they emit low smoke and no halogen while burning. This paper presents the fire properties, physical properties and the heat release measurement data of LSZH cable sheathing materials. Physical properties such as tensile strength and elongation at break of LSZH cable sheathing materials with and without aging are also measured. The functional groups of the materials are determined by performing Fourier Transform Infrared Spectroscopy (FTIR).

EXPERIMENTAL PROCEDURE

Three LSZH materials are molded as per standard requirement and the following tests were carried out

- Oxygen Index
- Temperature Index
- Smoke density
- Halogen content
- Heat Release
- Fourier Transform Infrared Spectroscopy (FTIR)
- Tensile Strength and % Elongation before and after ageing

Evaluation of LSZH Materials

The table 1 shows the results of the three different LSZH materials.

Table 1. Fire and Physical properties of LSZH materials

Sl. No	Parameters Measured	LSZH 1	LSZH 2	LSZH 3
1	Oxygen Index in %	35.5	50	**39**
2	Temperature index (°C)	320	400	**340**
3	Halogen Content %	Nil	Nil	**Nil**
4	Smoke Density in %	4.8	6.5	**5.8**
5	Tensile Strength before ageing (N/mm^2)	11.04	8.62	**8.84**
6	Tensile Strength after ageing (N/mm^2)	11.67	8.71	**9.60**
7	Elongation at break before ageing (%)	122.5	44.8	**60.5**
8.	**Elongation at break after ageing (%)**	**97.7**	**35.0**	**52.5**

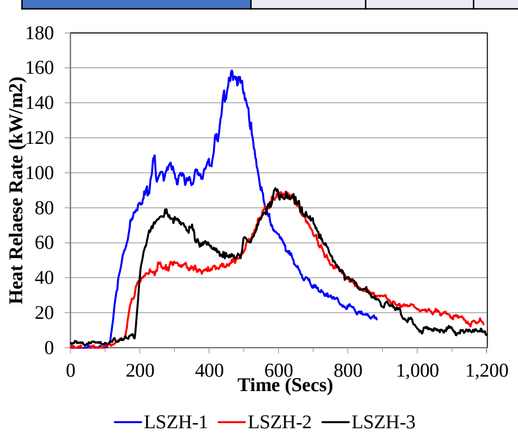
LSZH material 2 has the highest oxygen index and indicates the improved flame retardancy. LSZH 1 has high tensile strength and elongation at break. For all the three LSZH materials the value of tensile strength after ageing has increased.

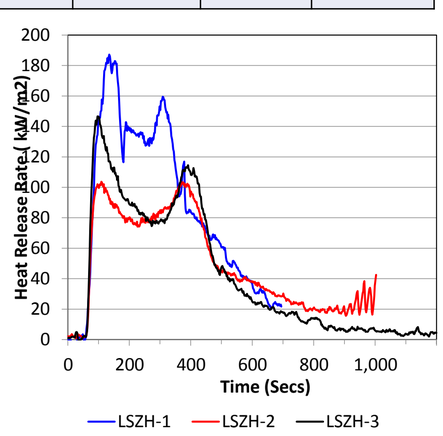
Heat Release Measurements of LSZH Cable Materials

Figure 1. A view of Cone Calorimeter

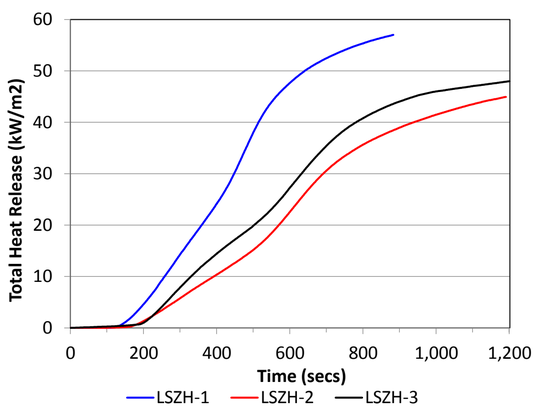
The Cone Calorimeter is used for measurement of heat release and it works in the principle of Oxygen consumption calorimetry. At two different thermal fluxes 25 kW/m^2 & 50 kW/m^2, the heat release of LSZH materials are carried out

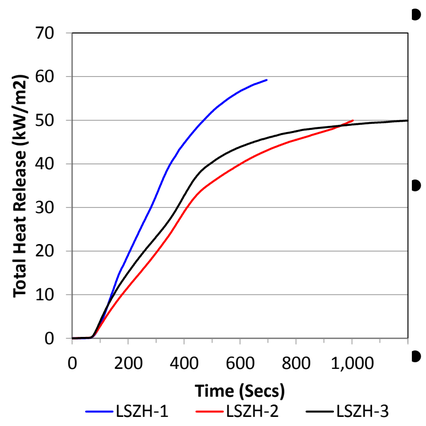
Parameters	Material					
	LSZH 1		LSZH 2		LSZH 3	
	25 kW/m^2	50 kW/m^2	25 kW/m^2	50 kW/m^2	25 kW/m^2	50 kW/m^2
Initial Mass (g)	40.1	37.8	43.3	44.3	43.2	43.2
Thickness (mm)	3.5	3.5	2.8	2.8	3	3
Time to Ignition (sec)	131	43	158	57	164	56
Time to Flame out (Secs)	802	527	1105	1002	984	979
Mass Lost (g)	21.2	21.4	39.9	38.3	21.5	21.3
Total Heat Release MJ/m^2	56.7	59.2	44.7	49.8	47.4	49.8
MAHRE kW/m^2	80.1	114.2	44.7	74.0	51.4	83.7
HRR (Peak)	158.5	187.1	89.3	103.7	91.2	146.6
Time to HRR Peak (secs)	464	134	620	108	590	96
Fire growth rate index (FIGRA) kW m^{-2} s	0.34	1.4	0.14	0.96	0.15	1.53



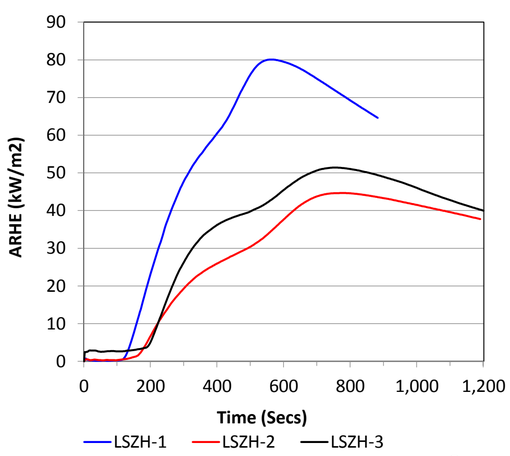


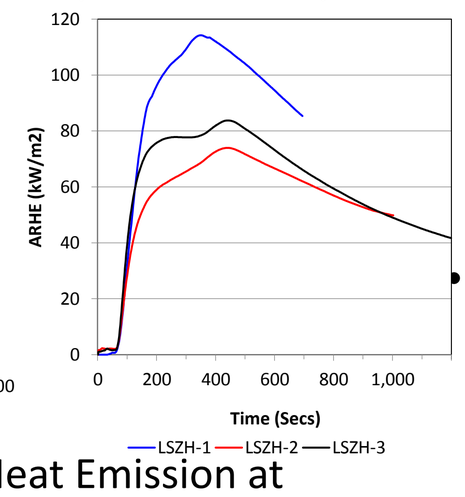
Heat Release Rate at 25 kW/m^2 & 50 kW/m^2





Total Heat Release at 25kW/m^2 & 50kW/m^2





Average Rate of Heat Emission at 25kW/m^2 & 50 kW/m^2

Fourier Transform Infrared Spectroscopy

The FTIR spectrum of three LSZH materials was compared to understand their bonding structures.

LSZH 1 & 3	Functional group/assignment	LSZH 2	Functional group/assignment
3429	Alcohol and hydroxy compound, Hydroxy group, H-bonded OH stretch	2950	Saturated Aliphatic Alkyl C-H Stretch –CH3 asymmetrical stretch, Methyl CH
2915	Methylene C-H asymmetric stretch	1488	Nitrogen-oxy compounds Aromatic nitro compounds
2849	Methylene C-H symmetric stretch	1194	Phosphorus-oxy compounds, Aromatic phosphates (P-O-C stretch)
1734	Carbonyl compound, Aldehyde, aromatic combination band	1080	Silicon-oxy compounds, Organic siloxane or silicone (Si-O-Si), Alkyl-substituted ether, C-O stretch
1015	Cyclohexane ring vibrations	905	symmetric stretching vibration of P=O
731	aromatic C-H out-of plane bend	850	diethylphosphinic acid
661	C-Br stretch or alkyne C-H bend.	774	(P-O).

DISCUSSION

- LSZH 1 has good tensile and elongation even after ageing
- LSZH 1 has higher heat release rate and Lower Oxygen index value
- Oxygen index value of LSZH 2 is much higher and the heat release rate is lower
- Fire properties of LSZH 2 & 3 are very high, however the physical properties are comparatively low
- FTIR reveals that the LSZH 1 & 3 are having similar functional groups and the LSZH 2 is of different functional groups.
- Higher mineral content in the zero halogen material may alter the physical and other properties

CONCLUSION

- Tensile and elongation strength of LSZH materials are low indicating the low flexibility of the materials.
- They have very good fire and smoke properties, however the heat release are more
- LSZH 1 material has very good balance of both tensile, elongation, fire and smoke properties, however the heat release and the burning rate of the material is more than the other which has low tensile and elongation properties.
- The optimum selection of flame retardants or filler materials are required in order to achieve all the properties including heat release.
- LSZH materials should retain all its properties during long run