Lethal combustion product evaluation of polymeric materials used in power cables

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ABSTRACT

The toxic gases evolved during combustion of materials are very dangerous and harmful to human life and equipment. The evaluation of toxicity is made through determination of toxicity of fire gases and halogen content by analytical methods. Smoke levels and rate of production of smoke CO, CO_2 gases were determined using 3 metre cube smoke apparatus and cone calorimeter. The extent of flame propagation and charred portion were determined in flame propagation test on bunched cables. The results have been presented and discussed.

KEYWORDS

Toxicity, lethal gases, combustible gases.

INTRODUCTION

The generation of lethal combustion products is of primary importance in the assessment of “fire hazard” resulting from cable materials during fire accidents. The fire safety requirements in the international standards are based on exigencies of the fire behavior of individual materials that are used in the cable design. PVC compounds have been used for decades as insulation / sheathing material in cable manufacturing due to its excellent electrical, mechanical and chemical properties. However, halogen acids, which are generally produced during combustion, are highly suffocating and can cause problems of corrosion to electrical apparatus and metallic structures even months after the fire.

Statistics indicate most of the fire victims die or affected by smoke rather than the Asphyxia which is the principal mechanism of intoxication, mediated by oxygen depletion, carbon monoxide inhalation and sometimes even by hydrocyanic acid inhalation. In recent times due to increase in fire accidents and with loss of lives and property, regulatory authorities have enforced strict laws and regulations to minimize the risk of fire by assessing ‘Fire hazard’ of materials used in any industry. Therefore interest has centered in the development of polymers which evolve less smoke and toxic gases. PVC materials are replaced with EVA and poly olefin based low smoke zero halogen (LSOH) materials which are free of Chlorine, Fluorine, Bromine and Iodine.

The fire safety is addressed through small scale flammability, smoke / toxicity of fire gases, determination of halogen acid generated and the performance criteria is based on guidelines laid in the international standards. A study was undertaken in the laboratory of Central Power Research Institute, Bangalore, India to assess the toxicity products that are generated during combustion of wires and cables. This paper presents and discusses the toxicity of the products of combustion in terms of small molecular species arising when a small sample of a material is completely burnt in excess air under specified conditions. The evaluation of the toxicity of fire gases is made through the determination of the fire gases as per NES 713 standard. Halogen acid determination was carried out in accordance with IEC 754 part 1 & 2 standard methods and is discussed. Smoke levels and rate of production of smoke, CO, CO_2 gases were determined using 3 metre cube smoke apparatus, and cone calorimeter. Further Char analysis has been done using Fourier Transform Infrared spectrometer.

Toxicity products of combustible polymers

Polymeric materials are generally composed of hydrocarbons and are specifically made of small units bonded into long chains. Carbon makes up the backbone of the molecule and hydrogen atoms are bonded along the backbone. Polymers like Polypropylene, polybutylene, polystyrene and poly methyl pentene contain only carbon and hydrogen. Even though the basic structure of many polymers is carbon and hydrogen, other elements can also be involved. Oxygen, Chlorine, Fluorine, Nitrogen, Silicon, Phosphorous and Sulfur are other elements that are found in the molecular composition of polymers [1]. Polyvinyl chloride (PVC) contain chlorine. Nylon contains nitrogen. Teflon contain fluorine. Polyester and polycarbonates contain oxygen. Some inorganic polymers have a silicon or phosphorous backbone instead carbon backbone.

Factors influencing fire and smoke characteristics of cables

The generation of heat, smoke, toxic and corrosive fire products depends on several factors like

- The generic nature of materials and presence or absence of additives such as fire retardants
- The construction, size and laying of cables
- The presence or absence of the combustibles & heat sources
- The availability of air and the movement of fire products with air and the presence or absence of fire suppression / extinguishing agents

Corrosive gas emissions

Polymeric cables containing halogens, sulphur and phosphorous all form corrosive acid gases and liquids. Emissions of hazardous and corrosive gaseous substances are quantified by the acid gas tests and