KELSAN TECHNOLOGIES

RESEARCH & DEVELOPMENT REPORT

# Assessment of Flammability Characteristics of LCF & HPF Solid Stick Products

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Project: 535
Report Number: 0011

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# Assessment of Flammability Characteristics of LCF & HPF Solid Stick Products

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## Executive Summary

Kelsan Technologies' polymer based LCF & HPF Solid Stick products were tested to assess their flammability and flame retardancy characteristics. As there is currently no industry wide standard to assess these performance characteristics, the products were assessed using the following ASTM test methods:

1. E2008-99 Standard Test Method for Volatility Rate by Thermogravimetry
2. D4982-95 Standard Test Methods for Flammability Potential Screening Analysis of Waste
3. D2863-00 Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
4. D635-98 Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position

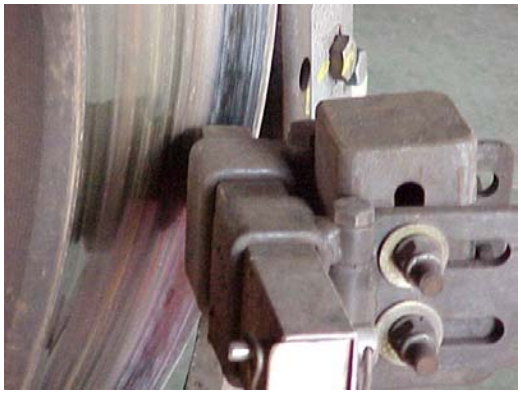
A *flammable solid* is typically defined as a nonexplosive material that is capable of producing fire as a result of friction, water exposure, air exposure or retained heat from synthesis or processing, or when ignited burns so *vigorously* and *persistently* so as to create a hazard.

**Within the scope of this definition, testing of the LCF and HPF solid stick products, using ASTM methodology, has resulted in a non-flammable classification. In comparison, a typical rail grease evaluated was observed to be highly flammable.**

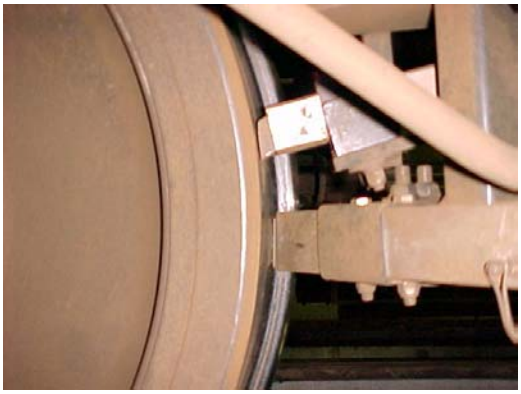
LCF & HPF products were observed to ignite when subjected to a direct flame source (D635-98) but *immediately* extinguished upon removal of the flame. Both products are formulated with a flame retardant polymer compound. **Rail grease, on the other hand, was observed to burn vigorous ly once ignited, even after the flame was removed.**

## Introduction

The objective of this study was to investigate the potential fire hazard associated with the use of Kelsan Technologies' LCF and HPF solid products in transit applications. Kelsan Technologies provides its' transit customers with a preformed stick that consists of a flame retardant thermosetting polyester resin that encapsulates the proprietary friction modifiers to control the coefficient of friction for top of rail and flange applications.



*LCF Application*



*Combined LCF & HPF Application*

A common question that has arisen is whether the LCF and HPF products are classified as *flammable* materials. A *flammable solid* is usually defined as a nonexplosive material that is capable of producing fire as a result of friction, water exposure, air exposure or retained heat from synthesis or processing, or when ignited burns so *vigorously* and *persistently* so as to create a hazard.

Kelsan Technologies solid stick technology is designed to transfer the proprietary friction management additives to the top of rail or flange location through the decomposition of the polymer carrier. This decompostion process is caused by the *friction* generated between the solid stick and wheel tread/flange under an applied pressure. Typically, temperatures at this interfacial area can reach 500 °C and above. Usually, it is only the interfacial area that is exposed to those high temperatures; the bulk of the product maintains the environment temperature. In countless commercial trials, the exposure of the finished product to these high temperatures at the interfacial area, has never created a fire hazard. Furthermore, as a thermsetting resin is used in the manufacture of the solid stick, the product maintains dimensional stability (ie does not melt) under those conditions.

As the composition of the solid stick technology is inert in the presence of water and air, it does not react violently producing a fire hazard. Although there is heat generated in thermosetting the resin during the *manufacturing* process, the customer recieves the finished, completely reacted, product. Since all polymeric materials do burn when exposed to a prolonged high temperature flame source, the question as to whether it burns consistently and vigourously typicall refers to the *flame retardancy* characteristics of the composition. In the case of Kelsan Technologies LCF & HPF solid stick technology, both products have been formulated with a flame retardant thermosetting resin.

Unfortunately, there are no industry standards to assess the flammability characteristics of LCF & HPF solid stick friction modifier products. However, there are alternative test methods available to assess the flammability and flame retardancy characteristics of a *composition*. For example, a limiting oxygen index test can identify the level of oxygen required to support initial combustion whereas a horizontal burning test can investigate how aggressively a product will burn once ignited. Subsequently, the following generally accepted ASTM methods were used in the investigation:

1. E2008-99 Standard Test Method for Volatility Rate by Thermogravimetry
2. D4982-95 Standard Test Methods for Flammability Potential Screening Analysis of Waste
3. D2863-00 Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
4. D635-98 Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position

These test methods will be explained in further detail in the next section.

## ASTM Test Methodology

### E2008-99 Standard Test Method for Volatility Rate by Thermogravimetry

#### Scope (ASTM Definition)

This test method covers procedures for assessing the volatility of solids and liquids at given temperatures using thermogravimetry under prescribed experimental conditions. Temperatures typical for this test method are within the range from 25 °C to 500°C. This temperature range may differ depending upon the instrumentation used. This test method is intended to provide a value for the volatility rate of a sample using a thermogravimetric analysis measurement on a single representative specimen.

#### Objective

This (modified) test method was used to define the thermal stability of the polymer based LCF & HPF products. As discussed previously, high temperatures are generated by the friction generated between the stick and the rotating wheel/flange, this test is used to define specifically at what temperature does thermal decomposition of the product does occur. This test was also helpful in identifying if such decomposition can also occur at much lower temperatures.

### D4982-95 Standard Test Methods for Flammability Potential Screening Analysis of Waste

#### Scope (ASTM Definition)

These test methods are used to indicate the fire-producing or fire-sustaining potential of wastes. The following test methods can be applied to waste liquids, sludges, or **solids** (Sections Test Method A-Test Sample Exposed to Heat and Flame Test Method B-Test Sample Exposed to Spark/Flame Source). These test methods should be used to measure and describe the properties of materials, in response to heat and flame under controlled laboratory conditions and is not used solely to describe or appraise the fire hazard or fire risk of materials under actual fire conditions. However, results of these tests may be used in addition to all other factors that are pertinent to a fire hazard assessment of a particular end use.

#### Objective

Test method A was used as a preliminary test to assess the flammability of the solid LCF and HPF product. As the previous method is used to measure volatility of the product when exposed to heat, this method can also qualify if such exposure leads to a fire hazard.

### D2863-00 Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)

#### Scope (ASTM Definition)

This test method covers a fire-test-response procedure. This test method describes a procedure for measuring the minimum concentration of oxygen that will just support flaming combustion in a flowing mixture of oxygen and nitrogen. Methods are provided for testing materials that are structurally self-supporting in the form of vertical bars or sheet up to 10.5 mm thick. These methods are suitable for solid, laminated or cellular materials characterized by an apparent density greater than 15 kg/m3. The methods may also be applicable to some cellular materials having an apparent density of less than 15kg/m3. A method is provided for testing flexible sheet or film materials while supported vertically. This test method may be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to solely describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.

#### Objective

This test was used to determine at what oxygen level is required to support initial combustion of the LCF and HPF products. As the oxygen level in air is approximately 20 %, LOI (Limiting Oxygen Index) results below 20 % indicate that the product would easily ignite. As the LOI value increases, combustion becomes increasingly difficult. When the LOI value is above that

of the oxygen content in air, the composition is usually classified as unable to support flaming combustion.

### D635-98 Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position

#### Scope (ASTM Definition)

This test method covers a small-scale laboratory screening procedure for comparing the relative rate of burning and/or extent and time of burning of self-supporting plastics in the form of bars, molded or cut from sheets, plates, or panels, and tested in the horizontal position. This test method should be used to establish relative burning characteristics of plastic materials.

This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be solely used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment that takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.

#### Objective

This test method was employed to assess whether the LCF & HPF composition would persistently burn once ignited.

## Test Results

### E2008-99 Standard Test Method for Volatility Rate by Thermogravimetry

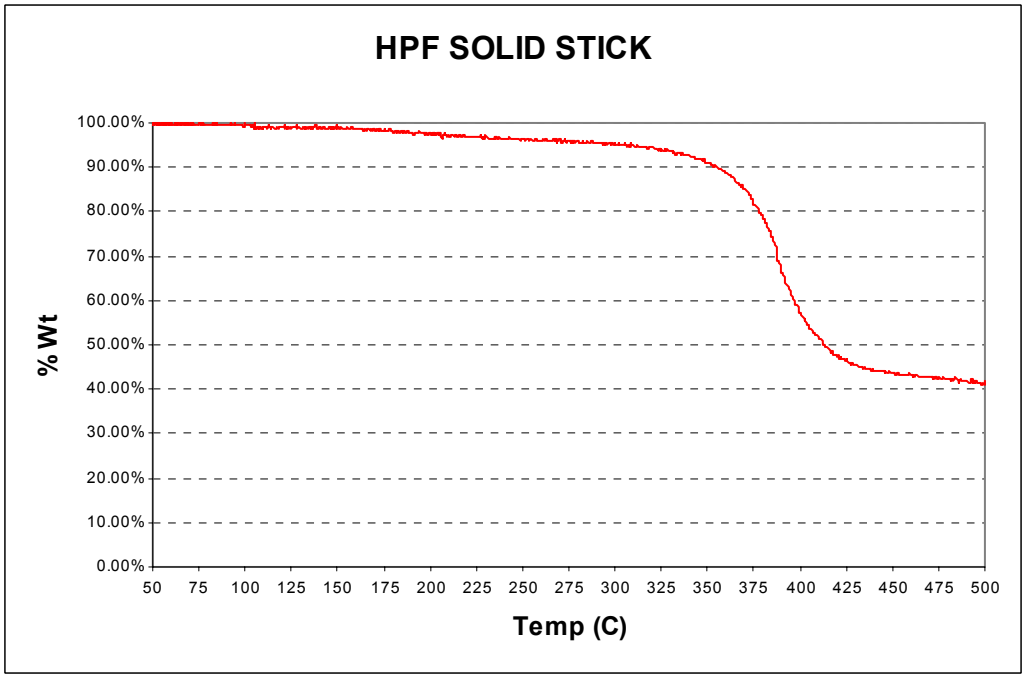



*Figure 1: Thermogravimetric Analysis of HPF Solid Stick Product*

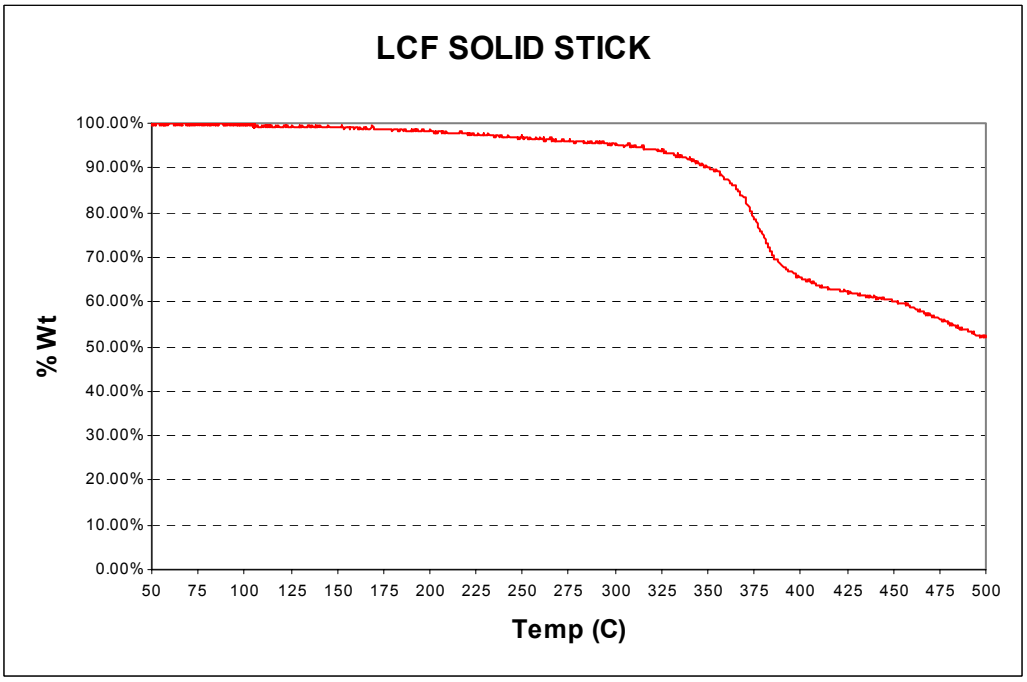



*Figure 2: Thermogravimetric Analysis of LCF Solid Stick Product*

Figures 1 & 2 exhibit the stability of the LCF & HPF products under normal operating conditions. Oxidization, where the polymer component is decomposed, does not occur until

temperatures exceed 350 °C. These types of temperatures are typically only found at the wheel rail/interface.

### D4982 Standard Test Methods for Flammability Potential Screening Analysis of Waste

Samples of both LCF & HPF were exposed to heat and flame as per procedure outlined in Method A. In both cases, the samples were considered to have positive flammability *potential*. When exposed indirectly to a flame source (heat only) no combustion was observed for either sample. When both samples were exposed to a direct flame, ignition did occur but immediately extinguished once the flame was removed. In comparison, when a typical rail grease was exposed **indirectly** to a flame source (heat only) **combustion was observed** indicating that the material was **flammable**.

### D2863 Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics

The following table highlights the test results from the LOI testing. In both cases, the determined LOI value was higher than the amount of oxygen found in air. As discussed previously, this means that both products will only ignite and combust in an oxygen rich environment.

| **LCF SOLID STICK** | | | **HPF SOLID STICK** | |
|---|---|---|---|---|
| Ignition | Non-Ignition | | Ignition | Non-Ignition |
| 21.8 | - | | 21.8 | - |
| - | 21.0 | | - | 26.0 |
| 21.5 | - | | 26.8 | - |
| - | 21.2 | | - | 26.4 |
| 21.3 | - | | 26.5 | - |
| - | 21.2 | | - | 26.4 |
| 21.3 | - | | 26.5 | - |
| 21.3 | - | | Oxygen Index = 26.5 % | |
| Oxygen Index = 21.3 % | | | | |

### D635- Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position

The following table exhibits the burning characteristics of the LCF & HPF products once ignited. In both instances, the product did not burn vigorously or consistently. In fact, the products consistently self extinguished almost immediately during the commencement of the test.

| | Sample | Burned Length (mm) | Time (s) | Linear Burn Rate (mm/min) | Self Extinguished |
|---|---|---|---|---|---|
| LCF SOLID STICK | 1 | 0 | 0 | 0 | Yes |
| | 2 | 0 | 0 | 0 | Yes |
| | 3 | 0 | 0 | 0 | Yes |
| | | | | | |
| HPF SOLID STICK | 1 | 0 | 0 | 0 | Yes |
| | 2 | 0 | 0 | 0 | Yes |
| | 3 | 0 | 0 | 0 | Yes |