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FLAMMABILITY TESTS ON THE CONVEYOR BELTING INVOLVED IN THE FIRE AT THE GASPE COPPER MINE, APRIL 1,1987

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by

K.J. Mintz*

ABSTRACT

Samples of conveyor belting retrieved from the Gaspe Copper mine in Murdochville, a rubber/steel cord type, were subjected to various flammability tests. The samples failed the small-scale flame test of the Canadian Standards Association Standard M422-M87, as well as the less stringent flame test used in the U.S.A. The critical oxygen index was 20.5%, slightly lower than that of a fire-resistant, natural rubber/fabric conveyor belting, and well below those of fire-resistant beltings. The minimum auto-ignition temperature was 330°C. The hot-plate ignition test, which measures the minimum temperature of a hot surface required to produce flaming ignition, yielded 550°C, well below values for fire-resistant belting. In summary, the belting was definitely a nonfire-resistant type.

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KEYWORDS: flammability, fires, conveyor belting

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INTRODUCTION

A fire at the Gaspe Copper Mine in Murdochville, Quebec on April 1, 1987 killed one miner, destroyed a conveyor belt of about 2000 m length and effectively closed the mine for an extended period of time. M. Bernard Pominville, of the Laboratoire de police scientifique, Ministere de la Justice (Quebec), as part of his investigation, requested flammability tests to be carried out on samples cut from a small section of undamaged belting from the mine.

The Canadian Explosive Atmospheres Laboratory (CEAL) has been certifying conveyor belting for use in underground mines since 1957(1). Those beltings meeting the requirements have a maple leaf containing the letters "EMR" embossed or imprinted on the material, along with the certification number. CEAL has no regulatory authority with respect to the use of certified belting in the mines. This authority, with a few exceptions, rests with the individual provinces.

The EMR certification requirements have been changed a number of times since 1957, usually in the direction of increased stringency. As of Aug. 18, 1987, CEAL has been certifying conveyor belting to the CSA Standard M422-M87, which was published in May, 1987(2). The CSA Standard comprises 6 different categories, the lowest level of fire-resistance (Type C) being approximately equal to the now superceded EMR requirements. The Standard comprises a small-scale flame test, a drum-friction test, an anti-static test and a large-scale gallery flame propagation test.

In support of the development of the CSA Standard, CEAL has carried out research on alternative small-scale tests. The critical oxygen index test, used widely for measuring the relative flammability of plastics, was adapted for use with conveyor beltings(3). Similarly, the minimum auto-ignition temperature test, also used for plastics, has been used by CEAL for determining the relative flammability of several nonmetallic materials considered for usage in mines(4). In order to evaluate the tendency of conveyor belting to ignite on a hot surface, the hot-plate ignition test was developed by CEAL(5).

In this report, the results of various small-scale flammability tests are presented and discussed.

FLAMMABILITY TESTS

CSA M422-M87 small-scale flame test

In this test, the end of a 12.5 mm wide x 150 mm long sample of belting is exposed to a Bunsen burner for 60 s, which is then removed and the time for flame and glow to be extinguished is measured. The temperature of the burner flame, measured just above the tip of the inner cone, is adjusted to be 900 °C. For Types A1 and A2 the flames are required to go out within 40 s, for the other types, within 60 s.

The samples for this test were cut so as to include one steel cord in approximately the centre. During the application of the flame, small burning particles (spark-like) were thrown from the sample. After the burner was removed, the flame on the sample spread quickly until the entire sample was consumed. There was no doubt that the belting failed this test.

In order to gain an idea of how much ignition was required, the burner was applied for shorter periods of time (to different samples each time). Down to only 2 s, the flame on the sample continued to accelerate when the burner was removed. For 1.5 s application time, there was only a small flame on the sample when the burner was removed, but after a few seconds, the flame started to accelerate. For 1 s application time, the flame on the sample went out as soon as the burner was removed.

For comparison, a piece of nonfire-resistant conveyor belting (rubber/fabric) was subjected to the test as described in the previous paragraph with essentially identical results. There was, however, one significant difference. When the fan was turned on after the fire was well-established, the fire on the Gaspe Copper sample quickly covered the entire sample, whereas, with the rubber/fabric sample, the flame was blown out.

Mine Safety and Health Administration (MSHA) Flame Test

This test(6) is similar to the CSA small-scale flame test, but is less stringent because of two factors: (a) the maximum temperature of the bunsen burner flame is only 760°C (7); (b) the fan is turned on (producing a velocity of 300 FPM) immediately after the burner is removed at the end of the 60 s application. The reason for the latter is to stimulate glow, which could present a source of ignition in a "gassy" mine (i.e.

one that contains substantial concentrations of methane). Its side effect is usually to blow out the flame and thereby make the test less severe than for the "still air" test (5).

For the Gaspe Copper sample, when the fan was turned on after the burner was removed, the flames spread over the entire sample; the entire piece burnt. Hence, it failed the MSHA test.

The Critical Oxygen Index Test

In the COI test, the minimum oxygen concentration is measured at which a sample will burn in a candle-like configuration. It should be understood that just because a particular material has a COI above 21% does not mean that it will not burn in air; with a different configuration and a stronger ignitor, it may. The COI provides a useful ranking of the flammability of materials (9). Most work has been done on pure materials; we have extended its application to conveyor beltings (5).

The standard method (8) calls for measuring the time that the sample burns after it is ignited; if it burns longer than 3 minutes, then the COI is at or below the % O_2 used in that test. The 3 minute limit is not purely arbitrary: usually by that time, the fire has either become self-propagating or has gone out.

In order to determine whether or not the steel cord has any effect on the COI, tests were carried out on full thickness samples containing the steel cord and samples only 15 mm thick not containing the steel cord.

Results for the former are:

% O_2	time to extinguish (min:s)
18.1	0:03
19.4	0:18; 0:53
20.2	2:19; 2:37
20.4	2:18; 2:38
20.5	>3 (sample burning vigorously)
20.6	>3 (sample burning vigorously)

Results for the latter are:

% O_2	time to extinguish (min:s)
20.4	3:11; 2:55
20.5	3:01; >3 (sample burning vigorously)
20.6	>3 (sample burning vigorously)

These results indicate that the steel cord has no significant effect on the COI, which in both cases is 20.5%. By comparison, the non-fire resistant rubber/fabric belting has a COI of 20.9%. Fire-resistant conveyor belting generally has a COI of >27%.

The Minimum Auto-Ignition Temperature (MAIT) Test

In this test(10), a small (3 g) sample is suspended in a tubular furnace through which air is passed in an upward direction. A thermocouple below the sample measures the temperature to which the sample is exposed. A thermocouple on the sample indicates the presence of any exotherm. Placing the furnace in a rising-temperature mode provides an approximate determination of the MAIT. The precise MAIT is determined under a constant temperature mode, in which a sample is placed in the furnace already at the testing temperature.

In the rising temperature mode, white smoke was observed at 330°C and flames at 360°C. The constant-temperature mode test results were as follows:

Furnace T (°C)	time (min.) to observation of:		Sample T(°C)	
	smoke	flame	smoke	flames
382	3.0	4.2	325	355
352	3.6	4.3	325	340
331	3.9	5.1	305	325
325	4.0	--	300	--
313	4.1	--	285	--

When flames occurred, the temperature of the sample increased very rapidly. For furnace temperatures just below the MAIT, a small exotherm occurred: the sample combusted completely, but without flames. From the above data, the MAIT is 330 °C; the accuracy is about ±10 °C.

For comparison, the MAIT of the nonfire-resistant rubber/fabric belting was determined earlier to be 470°C. Patten (11) has reported the MAIT to be 350°C for polyethylene and 490°C for polystyrene.

The Hot-Plate Ignition (HPI) Test

Although this test was originally developed for determining the propensity for a conveyor belting to ignite on a hot surface (e.g. a stopped conveyor on a hot idler pulley), it can also be used as a general small-scale flammability test (5). The test consists of placing a 25 x 25 mm sample of the belting on a hot stainless steel plate that has been heated in a muffle furnace. At a sufficiently high temperature, the sample will burst into flame after an induction period which is a function of the temperature. Below a certain critical temperature, the sample will smoulder and combust completely, but will not burst into flames. Because this critical value is somewhat dependent on the sample size, the HPI test should be considered as a relative test of flammability.

Tests were carried out on the Gaspe Copper belting using: (a) the entire thickness, including the steel cord; (b) half the thickness without the steel cord. All the test data are shown in Fig. 1. The points with the arrows attached are samples that did not burst into flames. There were two trials (those >120 s at 580-590°C) which are somewhat inconsistent with the others; the reason for this is not known. The data suggests that the steel cord raises the surface ignition temperature slightly, but the data are not sufficiently precise to make a definitive statement. The critical temperature seems to be about 550°C; our previous testing on the nonfire-resistant rubber/fabric belting gave a value of of about 570°C. Fire-resistant beltings gave 670 - 730°C, depending on their quality of fire-resistance.

CONCLUSIONS

All the small-scale tests carried out lead to the unmistakable conclusion that the rubber/steel cord belting used in the Gaspe Copper Mine was not fire-resistant. Furthermore, this belting performed, in all of these tests, slightly worse than the nonfire-resistant rubber/fabric belting. This was rather surprising, since the fabric of a belting is usually the more flammable part and therefore replacing it with a steel cord would be expected to decrease its flammability. Clearly, the composition of the rubber of the Gaspe Copper belting must be more flammable than that of the natural rubber/fabric belting. Barring any means of extinguishing it, a fire on this belting, once started, would be expected to spread rapidly in the direction of the air flow.

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FIG. 1. HOT PLATE IGNITION TEST