SME Annual Meeting
Feb. 27-Mar. 02, 2011, Denver, CO

Preprint 11-032

EVALUATION OF THE DRUM FRICTION TEST FOR DETERMINING THE FIRE RESISTANCE OF CONVEYOR BELTS

J. H. Rowland III, National Institute for Occupational Safety and Health, Pittsburgh, PA
A. C. Smith, National Institute for Occupational Safety and Health, Pittsburgh, PA

ABSTRACT

The Mine Improvement and New Emergency Response Act of 2006 (MINER Act) amended the Federal Mine Safety and Health Act of 1977 to improve the safety of mines. The MINER Act established a Technical Study Panel (the Panel) to provide independent scientific and engineering review and recommendations with respect to the utilization of belt air and the composition and fire retardant materials in underground coal mining (1). Because frictional heating is a common cause of belt fires, the Panel recommended that the Mine Safety and Health Administration (MSHA) evaluate the drum friction test to determine if such a test would contribute to conveyor belt safety beyond that provided by the Belt Evaluation Laboratory Test (BELT). This paper compares the results of the drum friction test to results from the BELT and large-scale tests for six different conveyor belts. The results are used to evaluate the drum friction test as a method to determine the fire resistance of conveyor belts.

Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of NIOSH.

INTRODUCTION

On January 19, 2006, a conveyor belt fire occurred at the Aracoma Alma Mine No. 1, an underground coal mine located in Logan County, West Virginia. Two miners were fatally injured when they became separated from their crew while trying to escape from the fire. Both died from asphyxiation due to suffocation and carbon monoxide poisoning (2). The fire most likely started from the conveyor belt being misaligned, causing the rollers to heat up and ignite the coal dust around the conveyor belt. This eventually ignited the conveyor belt. This accident, along with other mine tragedies in 2006 at the Sago Mine and the Darby Mine No. 1, which resulted in 17 additional fatalities, led to The Mine Improvement and New Emergency Response Act of 2006 (MINER Act). This legislation amended the Federal Mine Safety and Health Act of 1977 to improve the safety of mines.

The MINER Act also established a Technical Study Panel (the Panel) to provide recommendations on the utilization of belt air and the composition and fire retardant materials in underground coal mining. Among the Panel's recommendations was the application of improved belt flammability standards to belt materials used in U.S. underground coal mines. The panel recommended that the Mine Safety and Health Administration (MSHA) replace the 2G test with the BELT as the test method for approval of fire-resistant conveyor belts for underground coal mines in the United States (1).

The 2G test is a flame test using a 15-cm (6 in-) -long by 1.2-cm (0.5-in)-wide sample of belt. The sample is exposed to a flame from a Bunsen burner in still air for one minute with the transverse axis at 45 degrees. After 1 minute the flame is removed and the sample is exposed to an air velocity of 1.52 m/sec (300 ft per minute (fpm)). The belt passes the test if the flame duration is less than one minute for four samples of the same belt, or if the afterglow is less than an average of three minutes.

The BELT test measures the resistance of a belt to propagate a flame once the belt is lit. The BELT test uses a 152-cm (5-ft) -long by 23-cm (9-in)-wide belt sample. To conduct the BELT test, the belt is fastened to an angle iron rack with cover side up using cotter pins and washers to prevent it from shrinking away from the burner. The front of the rack is then placed and centered 15 cm (6 in) inside a tunnel. The ventilation for the tunnel is set at 102 m/sec (200 fpm) and the belt is ignited by applying a 0.26 m^3/min (9.2 ft^3/min) methane flame using an impinged jet methane gas burner containing 2 rows of 6 jets to its front edge with the flames evenly distributed over the top and bottom. The methane flame is removed after 5 minutes and the belt is allowed to burn until the flames are out. The belt passes the test if in three separate trials there remains a portion of the belt across the entire width that is not damaged. A belt fails the test if during any of the three trials the belt burns completely to the end of the sample (3).

The BELT test was established based on correlations between laboratory-scale tests and large-scale tests in the National Institute for Occupational Safety and Health (NIOSH) Fire Gallery (4,5). The large-scale tests were conducted using 0.91 to 1.07-m (36 to 42-in) -wide conveyor belting. The NIOSH Fire Gallery and test configuration are shown in figures 1 and 2.

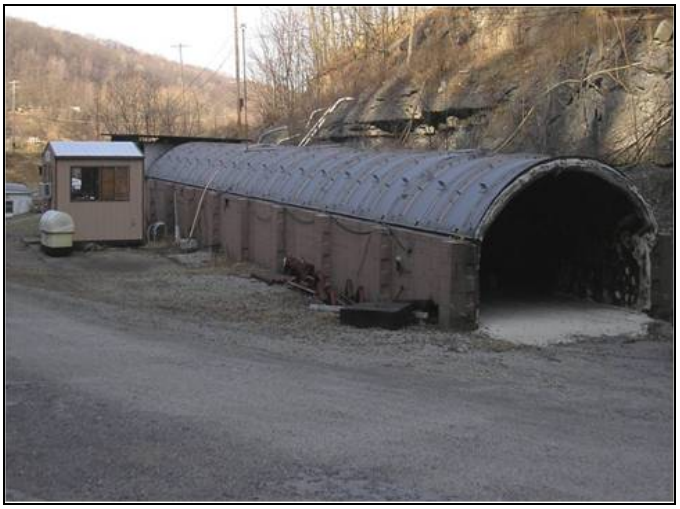


Figure 1. Outside view of NIOSH Fire Gallery.

As the mining industry began to use much wider conveyor belts, there was a concern that the laboratory-scale test results no longer correlated with results from the large-scale tests in the Fire Gallery. Therefore, additional large-scale testing was conducted in the NIOSH Fire Suppression Facility (FSF), using 1.83-m (72-in)-wide conveyor belting. The FSF and experimental configuration are shown in figures 3 and 4. The results indicated that the laboratory-scale BELT test still correlated with the results obtained in the FSF for wider conveyor belts (3).

In 2008, the BELT test replaced the 2G test as the test method for approval of fire-resistant conveyor belts for underground coal mines in the United States (6). After December 31, 2009, all belts placed in service had to be BELT-approved. The 2G-accepted belts already in use in mines at that time could continue to be used. After December 31, 2018, all conveyor belts used in underground coal mines in the United States must be approved by MSHA under Part 14 using the BELT (6).

Copyright © 2011 by SME



Figure 2. Interior view of large-scale test configuration in NIOSH Fire Gallery.



Figure 3. Outside view of NIOSH Fire Suppression Facility



Figure 4. Interior view of large-scale test configuration in NIOSH Fire Suppression Facility.

Because frictional heating is a common cause of belt fires, the Panel recommended the evaluation of a drum friction test to assess and evaluate the contribution to conveyor belt safety (1). The drum friction test is used by most major coal producing countries to evaluate the propensity of a conveyor belt to ignite due to friction. The test simulates a conveyor belt slipping over a pulley that is jammed, or a pulley rotating over a stationary conveyor belt. It is plausible that the heat produced from friction may cause the belt to ignite or may ignite combustible material in close proximity. In 1955, Schedule 28 required a drum friction test and 2G test for flame-resistant conveyor belts in the United States. However, the drum friction test was not included as part of the approval method for fire-resistant conveyor belts in underground coal mines in the U.S. when Schedule 28 was consolidated into Schedule 2G in 1968. There were issues with the drum friction test that were apparently not sufficiently resolved, so it was not included in Schedule 2G (7).

As part of the protocol for conveyor belts in their respective underground coal mines, Australia, Canada, China, Europe, India, and South Africa use the drum friction test. Table 1 lists the specifications and criteria for the countries cited (8). The drum friction test apparatus and methodology used in the different countries are similar in relation to how the test is conducted, with some differences in the criteria for passing or failing a belt. Varying weights are added to the belt to simulate an increase in tension in all the specifications except for the Australia standard. The criteria for acceptance also differ among the standard specifications in different countries. The Australia, India, and China standards consider only the belt temperature, which must be less than 325°C (617°F), with no visible sign of flame or glowing of the belt. The South Africa standard uses only a visible flame or glowing criteria.

Table 1. Drum friction test specifications for different countries.

Drum Friction Test — April 2007

Country & Test Reference	Width of sample (mm)	Drum Diameter (mm)	r.p.m	Peripheral speed m/sec	Peripheral speed ft/min	Area of drum contact in²	Area of drum contact cm²	Tension N	Tension lbf	Tension kgf	Time	Ambient conditions	Max drum temp	Remarks
AUSTRALIA AS4606/AS1332 2000 AS1334.11 1993	150±1	212.8±0.3	190	2.12 +/- 0.05	417	77	501	343	77	35	To destruction or 2 hrs max.	6 tests: 3 in still air & 3 in air current (2.0m/sec)	325°C	Should not exceed max. temp., or no visible flaming or glowing
CANADA CAN/CSA M422-M87 1995	150±2	210±2	195±10	2.2	433	77	495	343 686 1029 1372 1715	77 154 231 308 386	35 70 105 140 175	60 mins +30 mins +30 mins +30 mins +30 mins	Type A1: 4 pieces tested: 2 tests each side in still & moving air 2.5 +/- 0.1 m/s	325°C	No flame or glow. Max. temp=325°C; Belting shall part in 3 hrs
								343	77	35	3 hrs	Type A2: 4 pieces tested:2 tests each side in still & moving air	325 °C	No flame or glow. Max. temp=325°C; Belting shall not part during 3 hrs testing period
								343	77	35	3 hrs	Type B1-A & B1-B: 2 pieces tested: 1 test each side in still air	400 °C	No flame or glow B1-A, B1B no Flame Max. temp=400°C; Belting shall part in 3 hrs
								343	77	35	3 hrs	Type B2: 2 pieces tested:1 test each side in still air	400 °C	No flame or glow. Max. temp=400°C; Belting shall not part during 3 hrs testing period
								343	77	35	3 hrs	Type C: 2 pieces tested:1 test each side in still air	400°C	No flame or glow. Max. temp=400°C
CHINA MT514 2002	150	210±1	200±5	2.2	433	77	495	343 686 1029 1372 1715	77 154 231 308 386	35 70 105 140 173	60 mins +30 mins +30 mins +30 mins To destruction	6 pieces tested: each side in still air & in air current (2.0±0.1m/s). Worst result repeated	325 °C	No flame or glow; Max. temp= 325°C
EUROPE EN14973 2006 EN 1554 1998	150	210±1	200±5	2.2	433	77	495	343 686 1029 1372 1715	77 154 231 308 386	35 70 105 140 173	60 mins +30 mins +30 mins +10 mins To destruction	6 tests, 3 in still air & 3 in air current (2.0±0.1m/sec)	No Limit or 450°C or 325°C	Class A, B2&C2, no flame only. No Max temp Class B1, no flame or glow. Max. temp. =450°C Class C1, no flame or glow. Max. temp. =325°C
INDIA IS3181 1992	150	210±1	200±5	2.2	433	77	495	343 686 1029 1372 1715	77 154 231 308 386	35 70 105 140 173	60 mins +30 mins +30 mins +10 mins To destruction	Equal covers. 4 tests, 2 in still air & 2 in air current (2.0±0.1m/sec)	325°C	Sample fails if there is any flame, glow or rise temp is exceeded. For belts with unequal covers, the four tests are conducted, 2 in still air &2 in moving air using the cover to the drum which gave the worst result in the original 4 tests
SOUTH AFRICA SABS971 2003	225	450	110±10	2.6	512	280	1591			22.5 34 45.5 56.5 75.5 91.5 107.5 123.5	15 mins +15 mins +15 mins +15 mins +15 mins +15 mins +15 mins +15 mins	2 pieces tested, 1 test each side in moving air 90 +/- 3 m/min		Must not show any sign of flame or glow

For the purpose of the NIOSH evaluation of the drum friction test, the following criteria were established. Each conveyor belt was tested in still air and in moving air. Also, both the top and bottom cover of the belting was exposed to the drum under still air. Most tests were conducted in triplicate to ensure reproducibility. The conveyor belt was considered to have passed the drum friction test if the temperature of the drum thermocouple remained less than 325°C (617°F) for each of the three trials in still air and moving air. The conveyor belt was considered to fail the drum friction test if the thermocouple temperature exceeded 325°C (617°F) at any time or if the conveyor belt began to flame or glow. This last evaluation criterion was established based on the most stringent foreign drum friction test criteria.

CONVEYOR BELTING

Six different conveyor belts typical of those used in the U.S. mining industry were evaluated using the drum friction test apparatus. Two of the belts met the two different U.S. standards—2G-accepted and BELT-approved. Three of the belts met three different foreign fire resistance standards—Australian, British, and German. One of the belts did not meet the U.S. fire resistance standards and is considered non-fire-resistant. This type of belting is allowed in underground metal/nonmetal mines. Three different types of belt material were

Copyright © 2011 by SME

selected: polyvinyl chloride (PVC), styrene butadiene rubber (SBR), and chloroprene. Five of the six belts were purchased new from the manufacturer. New U.S. 2G-accepted belting was not available, so an inventory of used 2G-accepted belt was obtained. Table 2 shows the type of belt material, standard approval, construction, strength, and cover dimensions of the belts evaluated in this study.

Table 2. Belts evaluated in this study.

Belt type	Standard	Ply	Strength, piw[1]	Cover thickness
Neoprene®	Australian	3	600	3/16 x 1/16 in
Polyvinyl chloride	British	solid woven	800	2 x 2 mm
Styrene butadiene rubber	NFR[2] US	4	800	3/8 x 3/32 in
	2G US	3	600	3/16 x 1/16 in
	BELT US	3	600	3/16 x 1/16 in
Chloroprene	German	3	600	3/16 x 1/16 in

[1]Pounds per inch of belt width (widely used in the US)
[2]Non-fire-resistant

EXPERIMENTAL DESCRIPTION

The drum friction test apparatus, shown in figure 5, is designed to simulate the movement of conveyor belting over a stuck roller or drum. A 10-horsepower motor is used to turn a 20.3-cm (8-in)-diameter by 35.6-cm (14-in)-long steel drum. An infrared instrument is used to count the number of revolutions per minute (rpm) of the spinning drum. To measure the temperature of the drum, a thermocouple is housed on the inside of the drum 0.05 cm (0.02 in) below the surface and halfway along the length of the drum. A load cell is used to measure the weight on the belt. The load cell is connected to a steel H frame that holds the weights. The top of the load cell is connected to a chain that passes over a sprocket and is connected to the bottom clamp for the belting. This system allows for stretching of the belt as weight is added during the test. An exhaust system consisting of an 86- cm (34-in)-wide by 61-cm (24-in)-long square steel frame with a 30- cm- (12-in) diameter hole cut in the center hangs over the top of the drum. The 30-cm (12-in)-diameter stainless steel ducting is inserted into the opening of the steel frame and is exhausted to the outside of the building. The airflow above the drum due to the exhaust fan ranges from 0.67 – 1.06 m/sec (132 - 208 fpm).



Figure 5. Drum friction test apparatus.

EXPERIMENTAL PROCEDURE

Prior to conducting a drum friction test, the drum surface is scoured using P220 sandpaper to remove any rust or foreign material. The drum rotation rate is set to 221 rpm and a video camera is set up to record the test. A 15-cm (6-in)-wide by 145-cm (57-in)-long piece of belting is attached to the apparatus and hung over the drum. Weights are attached to the end of the belting to provide tension. A computer data acquisition system is set up to measure the temperature of the drum, its rpm, and the load force on the conveyor belt. To conduct the drum friction test in moving air, a perforated pipe, shown in figure 6, with a single row of holes facing the drum is mounted parallel to the drum between the top and bottom of the belt. The distance between the drum and the perforated pipe is 61 cm (24 in). The airflow is set to 2.0 m/sec (400 fpm) using a vane anemometer measurement between the belting, 20 cm (8 in) from the drum. A weight of 34.9 kg (77 lb) is hung from the end of the belt to provide tension. The data acquisition is turned on to start recording, then the power to the drum friction is turned on and the steel drum begins to rotate. Weight is added in the increments shown in table 3. The test is allowed to run until the belt breaks or catches fire.

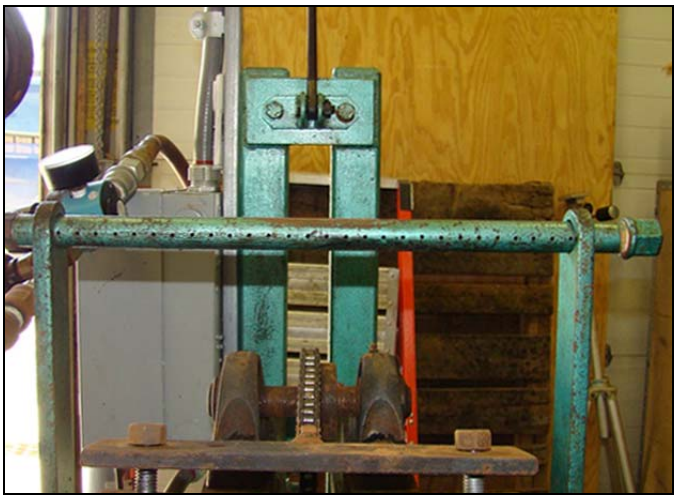


Figure 6. Perforated pipe used in moving air tests.

Table 3. Time-weight increments for belt friction test.

Weight added (kg)	Tension (N)	Time duration (minutes)
34.9	343	60
34.9	686	30
34.9	1029	30
34.9	1372	10
34.9	1715	10
34.9	2056	To destruction

Each of the six belts was tested in still air and in moving air with the underside of the conveyor belt in contact with the drum. In addition, each belt was tested in still air with the top, or carrying, side of the conveyor belt in contact with the drum. The conveyor belt passed the drum friction test if the temperature of the drum thermocouple remained less than 325°C (617°F) for each of the three trials in each test configuration. The conveyor belt failed the drum friction test if the thermocouple temperature exceeded 325°C (617°F) at any time or the conveyor belt began to flame or glow.

RESULTS

The Neoprene® belting failed the drum friction test in all three test arrangements. The temperature exceeded 443°C (830°F) in all the tests. The belt tested in the still air arrangement broke at the earliest time with the least weight. Large quantities of smoke were generated as the belt began to heat up during each test. The belt did not show any signs of flame or glowing during any of the testing. However, as the belt started to come apart, tiny embers of the belt were glowing but quickly went out by the time they hit the metal pan below the drum. The results of the Neoprene® belting tests are shown in table 4. An example of the temperature increase of the drum thermocouple as weight was added to the belting is shown in figure 7.

Table 4. Drum friction test results of the Neoprene® belt.

Copyright © 2011 by SME

Trial	Failure load (N)	Break time of belt (minutes)	Temperature (C)	Flame / glow
Still air 1	1029	92	474	no
Still air 2	1029	113	480	no
Still air 3	686	73	483	no
Moving air 1	1029	119	486	no
Moving air 2	1715	220	444	no
Moving air 3	1029	92	470	no
Top still air 1	1715	140	486	no
Top still air 2	2056	165	480	no
Top still air 3	2056	156	479	no

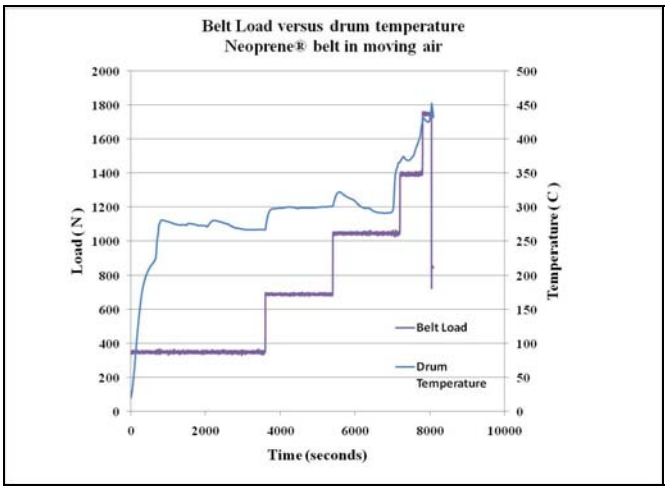


Figure 7. Plot of drum temperature versus belt load in Neoprene® belt friction test.

The construction of the PVC belt on the top cover (carrying side) is equal to the thickness and construction of the bottom cover, so the belt was tested in only two of the test configurations—still air and moving air. The PVC belt in both test arrangements failed the drum friction test. The roller thermocouple exceeded 322°C (612°F) in all tests. A small amount of smoke was observed during the tests and there was no flame or glow of the belt. There was no difference in still air versus moving air in terms of the amount of weight the belt was subjected to before the belt broke. The PVC belt broke apart in each test within eight minutes. The results of the PVC belt tests are shown in table 5.

Table 5. Drum friction test results of the PVC belt.

Trial	Failure load (N)	Break time of belt (minutes)	Temperature (C)	Flame / glow
Still air 1	343	4	322	no
Still air 2	343	6	349	no
Still air 3	343	6	340	no
Moving air 1	343	6	354	no
Moving air 2	343	8	348	no
Moving air 3	343	8	338	no

The SBR non-fire-resistant belt failed the drum friction test in all three test arrangements, exceeding 427°C (800°F) in all the tests. Large quantities of smoke were generated as the belt began to heat up during the tests. The belt did not show any signs of flames during any of the testing. However, as the belt started to come apart, tiny glowing embers of the belt were observed but quickly went out by the time they hit the metal pan below the drum. The belt broke apart in the first 30 minutes in each test in the moving air test configuration. The belt tested in moving air was the worst case, breaking apart in 28 minutes or less. The results of the SBR non-fire-resistant belt are shown in table 6.

The 2G-accepted belt failed all three test configurations of the drum friction test. Please note that there is one less trial test in the still air arrangement for the underside of the belt due to availability of belting. The roller temperature exceeded 400°C (752°F) in all the tests. In all three test arrangements, no flame was visible. The still air and the moving air produced very similar results in weight and breakage time. In the moving air, the belt broke with the 343 N weight load, while in the third trial the belt broke with the 686 N weight load. In the third trial, the breaking of the belt occurred within one minute of adding the weight to bring the load to 686 N. The results of the SBR 2G-accepted belt are shown in table 7.

Table 6. Drum friction test results of the non-fire-resistant belt.

Trial	Failure load (N)	Break time of belt (minutes)	Temperature (C)	Flame / glow
Still air 1	686	81	455	no
Still air 2	1029	115	491	no
Still air 3	1029	100	485	no
Moving air 1	343	21	513	no
Moving air 2	343	18	510	no
Moving air 3	343	28	500	no
Top still air 1	343	32	500	no
Top still air 2	686	76	524	no
Top still air 3	686	75	480	no

Table 7. Drum friction test results of the SBR 2G-accepted belt.

Trial	Failure load (N)	Break time of belt (minutes)	Temperature (C)	Flame / glow
Still air 1	343	37	481	no
Still air 2	343	24	499	no
Moving air 1	343	29	465	no
Moving air 2	686	61	480	no
Moving air 3	343	40	400	no
Top still air 1	1713	140	570	no
Top still air 2	686	87	518	no
Top still air 3	2056	158	508	no

The SBR BELT-approved belt also failed the drum friction test for all three test configurations. The roller temperature exceeded 400°C (752°F) in all the tests. There was no sign of flames during any of the testing, even though large quantities of smoke were generated. As in several of the other belt tests, glowing embers of the belt were observed when the belt broke apart, but the embers quickly went out after falling into the metal pan below the drum. The belt tested in the still air arrangement with the bottom of the belt contacting the roller was the worst case. The belt broke at the 686 N load in two of the trials, and in the other trial the belt broke within one minute after weight was added to bring the load to 686 N. The BELT-approved belt results are shown in table 8.

Table 8. Drum friction test results of the SBR BELT-approved belt.

Copyright © 2011 by SME

Trial	Failure load (N)	Break time of belt (minutes)	Temperature (C)	Flame / glow
Still air 1	686	61	354	no
Still air 2	343	18	405	no
Still air 3	686	77	368	no
Moving air 1	1029	102	476	no
Moving air 2	686	65	484	no
Moving air 3	686	86	483	no
Top still air 1	1029	117	581	no
Top still air 2	1029	114	572	no
Top still air 3	1372	129	598	no

The chloroprene belt also failed the drum friction test in all three test arrangements. The roller temperature exceeded 372°C (702°F) in all tests. There was no visible flame or glow to the belt. The belt tested in the still air arrangement was the worst case. The belt in the still air setup broke with the 343 N load in two of the trials, while in the other trial the belt broke within one minute after weight was added to equal the 686 N load. The test arrangement for moving air and the still air with the top cover exposed to the drum gave the same results, breaking under the 1029 N load. The results are shown in table 9.

Table 9. Drum friction test results of the chloroprene belt.

Trial	Failure load (N)	Break time of belt (minutes)	Temperature (C)	Flame / glow
Still air 1	343	16	412	no
Still air 2	686	60	380	no
Still air 3	343	15	372	no
Moving air 1	1029	110	411	no
Moving air 2	1029	100	424	no
Moving air 3	1029	106	417	no
Top still air 1	1029	108	503	no
Top still air 2	1029	90	536	no
Top still air 3	1029	94	543	no

DISCUSSION

The large-scale and the BELT tests measure the resistance of a belt to propagate a flame once the belt is ignited. The large-scale test was designed to simulate a belt fire in a mine once the belt is ignited to evaluate its flame propagation characteristics. In the best-case scenario, and as the basis of the BELT method, flame propagation should be greatly limited if the belt is ignited. The ability to self-extinguish would depend on the fire resistance characteristics of the belt in use. The BELT test was developed as an easier and less expensive method to evaluate the same flammability and flame propagation characteristic as the large-scale test. The belt friction test, on the other hand, is designed to measure the frictional ignition characteristics of belting.

Table 10 shows the pass/fail results of the six belts evaluated in this study and the results of the same belts in large-scale and BELT tests. The six belts evaluated in this study all failed the belt friction test under the conditions described in this paper. The non-fire-resistant and 2G-accepted SBR belt also failed the large-scale and BELT tests. The Neoprene®, BELT-approved SBR, and chloroprene belts passed the large-scale test and the BELT test but failed the drum friction test. The PVC belt passed the large-scale test but failed the BELT and the drum friction test.

Table 10. Large-scale, BELT, and drum friction test results.

Type	Standard	Large-scale pass/fail	BELT pass/fail	Drum friction pass/fail
Neoprene®	Australian	P	P	F
PVC	British	P	F	F
SBR	Non-fire resistant	F	F	F
SBR	2G US	F	F	F
SBR	BELT US	P	P	F
Chloroprene	German	P	P	F

The drum friction test is design to evaluate the ignitability of a belt based on friction. The six belts that were tested in this study each failed. In each case smoke was generated but the belt did not show any signs of flame nor did any of the belts glow. All of the belts broke within in a 3 hour period. Based on the current use of the BELT test for approval of use in underground U.S. coal mines and the test results from this study, the drum friction test appears to be a much more stringent approval test since all six belts failed this test.

In this study, all the belts failed due to the belt exceeding the maximum temperature of 325˚C (617˚F), the temperature used in the worldwide belt friction test standards. However, in no case did the belting reach the point of flames or glowing. Also, all of the belting eventually broke in these tests. This indicates that if a roller became frozen or jammed and belt friction occurred, the belt would probably break before it reached temperatures high enough to be ignited. It is possible that the high temperature might ignite another nearby combustible material such as coal dust or grease, which if not extinguished could lead to the ignition of the belt. However, based on the large-scale and BELT test criteria, the belt would not be able to sustain the fire and the flame would self-extinguish. Therefore, based on the results of this study, the BELT test provides an adequate level of safety with respect to the fire resistance of approved conveyor belting in U.S. underground coal mines. Also, based on the results of this study, the belt friction test does not add any additional degree of safety beyond that provided by the BELT test. It should be noted that this study did not evaluate all types of belts from all manufacturers and does not take into consideration the possibility of other belts behaving differently.

SUMMARY

Five different types of conveyor belting that were deemed acceptable for use in underground coal mines by different worldwide flammability standards and one non-fire-resistant belt were evaluated for fire resistance using a drum friction test method. The results were compared to results from previous large-scale and laboratory-scale BELT conducted by NIOSH. The six types of belts evaluated in this study all failed the belt friction tests under the conditions described in this paper, based on the temperature of the belt roller. There was no visible flame or glow for any of the belts tested in this study, which was also a criterion for a belt failing the test. In every trial of every test configuration, the belt broke. The non-fire-resistant and 2G-accepted SBR and PVC belts also failed the BELT test. However, the Neoprene®, BELT-approved SBR, and chloroprene belts passed the BELT test but failed the drum friction test. Based on the current use of the BELT test for approval of use in underground U.S. coal mines, the drum friction test appears to be a much more stringent approval test, since all six belts failed this test. However, based on the large-scale and BELT test criteria, the belt would not be able sustain the flame and would self extinguish. Therefore, based on the results of this study, the BELT test provides an adequate level of safety with respect to the fire resistance of approved conveyor belting in U.S. underground coal mines, and the belt friction test does not add any additional degree of safety beyond that provided by the BELT test.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the MSHA for assisting in obtaining and setting up the drum friction test. The authors want to thank our Lake Lynn Laboratory colleagues and the Wolverine

Copyright © 2011 by SME

contractors for assisting in fabricating parts for the drum friction test apparatus. The authors also acknowledge John Soles and Richard A. Thomas, National Institute for Occupational Safety and Health, for conducting the tests and compiling and analyzing the data. Without all of the people mentioned, this research would not have been completed.

REFERENCES

1. Mutmasky, J., Brune, J., Calizaya, F., Mucho. T., Tien, J, and Weeks, J., 2007. Final Report of the Technical Study Panel on the Utilization of Belt Air and the Composition and Fire Retardant Properties of Belt Materials in Underground Coal Mining, December 2007,131 pp.

2. Murray, K., Pogue, C., Stahlhut, R., Finnie, M., Webb, A., Burke, A., Beiter, D., Francart, W., Tjernlund, D., and Waggett, J., 2006 Aracoma Alma Mine #1 Aracoma Coal Company, Inc. Stollings, Logan County, West Virginia. Report of Investigations I.D. No. 46-08801 Mine Safety and Health Administration, January 19, 2006, 164 pp.

3. Rowland, J. and Smith, A., 2010. Flammability of Wider Conveyor Belts Using Large-Scale Fire Tests. SME Annual Meeting Phoenix, AZ, Feb 28-Mar 3 2010 Preprint 10-206, 6 pp.

4. Verakis, H.,1991. Reducing the Fire Hazard of Mine Conveyor Belts. Proceedings of 5th U.S. Mine Ventilation Symposium, Morgantown, WV, June 3-5, 1991 (Yang YJ, ed.), pp. 69-73.

5. Verakis, H. and Dalzell, R., 1988. Impact of Entry Air Velocity on Fire Hazard of Mine Conveyor Belts. Fourth International Mining Ventilation Conference. Brisbane, Queensland, Australia pp. 375-381.

6. U.S Code of Federal Regulations 30 CFR 14.

7. Verakis, H., 2007. Conveyor Belt Fire Test Methods – A Review and Analysis. Mine Safety and Health Administration, Technical Support, Approval and Certification Center, West Virginia, August 2007, 32 pp.

8. Wang, T. and Normanton, G., 2007. A Comparison of Worldwide Safety Test Standards. Submission to Final Report of the Technical Panel on the Utilization of Belt Air and the Composition and Fire Retardant Properties of Belt in Underground Coal Mining. MSHA/OSRV Document number 216 May 27, 2007.

Copyright © 2011 by SME