# VENTILATION OF BELT CONVEYOR ENTRIES

*Submitted to*

**The American Mining Congress**
**The Bituminous Coal Operators' Association**
**The National Coal Association**

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*August 19, 1988*

## INTRODUCTION

The Mine Safety and Health Administration (MSHA) has proposed revising some of the safety standards for ventilation in underground coal mines. Among these, 75.350 contains provisions that differ from the regulations for belt conveyor entries presently given in 75.326.

The following discussions address the question, "Do the proposed revisions provide an improvement to the existing regulations as contained in §75.326?" Towards developing answers to this question, the following reviews changes in knowledge, experiences and technology regarding the application of 75.326 since it was adopted by the Congress (303(y)(1) and (2) of the Act) as an interim mandatory safety standard.

## MEASURES OF PROTECTION

The intent of 75.326 as given in the legislative history for standards 303(y)(1) and (2) of the Act were:[(1)]

1. 'To reduce high air velocities in belt and trolley haulageways because such velocities fan and propagate fire, many of which occur in those haulageways';

2. 'To reduce exposure of miners to fumes from fire because rapid air currents in the intakes to working sections quickly bring products of combustion to the section before men knew of their danger and lessened their time for escape'; and

3. 'To limit air velocities to reduce the amount of float coal dust for the purposes of minimizing dust explosions'.

The purpose of the protections intended by §75.326, were related to fire and explosion hazards in belt entries. The discussions that follow, therefore, concentrate solely on those aspects, despite the low incidence history of fire in belt entries during the past decade.

1969 KNOWLEDGE, EXPERIENCE AND TECHNOLOGY

The committees of the Congress drafting what subsequently became the Federal Coal Mine Health and Safety Act of 1969 were given the four publications described below. The testimony covering these publications entered into the record during consideration of the 1969 Act represented the limited knowledge, experience and technology on which 75.326 and the critically essential ancillary regulations were based. The ancillary regulations, contained in Title 30, CFR, include:

18.6(c) and .65: Approval and testing of belts.

75.303a: Pre-shift and during shift examination of belts.

75.316-2(b): Stoppings constructed of substantial, incombustible material should be used to separate belt haulage entries from entries used as intake and return aircourses.

75.400-2: Removal of accumulations and a regular program for clean up on belt entries.

75.701: Grounding electrical circuit in belt entries.

75.706: Deenergizing electrical circuits in belt entries on idle shifts.

75.900: Using circuit breakers rather than fuses.

75.1100-2(b): Waterlines parallel to the entire length of belts, plus fire hoses and hydrants.

75.1101-(1)(22): Deluge water sprays over main and secondary belt drives.

75.1101-23(a): Training program for fire fighting and evacuation.

-23(b): Proficiency in the use of fire suppression devices on the belt conveyor.

-23(c): Fire drills every 90 days.

75.1102: Belt slippage and sequence switches.

75.1103-1 thru -8: Belt entry fire sensing and alarms.

75.1103-4(e): Examination of belts for hot rollers and fire within two hours of a belt stoppage because of removal of power from the belt.

75.1103-9 thru -11: Belt entry fire suppression materials, techniques, communications, and fire brigade and drills.

75.1107: Fire suppression for unattended electrical components.

75.1107-1: Fire-resistant hydraulic fluids in unattended electrically powered equipment.

75.1108: Mandates use of belting approved in accordance with §18.6(c).

75.1403-5: Criteria for belt conveyor installation and examination.

75.1704-2: Escapeway drills at least once every 90 days.

75.1707: Escapeway separated from the belt and trolley haulage entries.

Considering the contents and requirements of these ancillaries, it is reasonable to incorporate them in analyses of the measure of protection resulting from modifications to the provisions of 75.326. The following four documents detail the knowledge, experience and technology in 1969 on the hazards of dust, fire, and explosions in belt entries of underground coal mines in the United States. There was other knowledge, experience and technology in Europe, particularly, Great Britain, during those years. That information, however, was not then being applied in mines; and, few persons appreciated its importance. Discussions in this report detail that knowledge as it effects safety in belt entries.

I. Westfield, James. Mine Fires and Their Control This paper summarizes knowledge and experience gained from investigations of 572 coal mine fires in the period July 1952 through October 1965. The primary danger identified was 'a short circuit of power conductors (i.e., trolley wire to rail or other ground) on the main trolley haulageway where the air velocity was exceptionally high and functional failure of the electrical circuit protective devices'. The author discussed: (1) Instantaneous protection against sustained arcs from short circuits; (2) Abandoning trolley haulage; and, (3) Ventilating the trolley haulageway with a low velocity current of air just adequate to keep the entry free of dangerous quantities of explosive gases.

Of these three solutions, only the third, limited air velocity, was practical and implementable when the Congress wrote the Act.

II. Kawenski, E. M., E. M. Murphy and R. W. Stahl, Float Dust Deposits in Return Airways in American Coal Mines, Bureau of Mines Inf. Cir. 8150 (1963). This information circular summarized the findings from 711 samples of float dust in 50 mines located in the major coal fields of the United States. The work was an essential adjunct of research in progress in the Experimental Coal Mine (see III. below) operated by the U. S. Bureau of Mines.

The mean quantity of float coal on mine surfaces in return airways was 0.02 ounce per cubic foot of entry. The mean in belt entries was seven times greater!

III. Mitchell, D. W., J. Nagy, and E. M. Kawenski. Float Coal Hazard in Mines: A Progress Report. Bureau of Mines Rpt. Inv. 6581 (1965). The studies described in this report and in (II) above were initiated by Marlin Ankeny and James Westfield (Director and Assistant Director, U.S.B.M.) in 1959.

The work described in this report found:

(a) Where float coal is on mine surfaces a minimum of 80 percent incombustible was needed in the top 1/8 inch of the deposit to limit involvement of float coal in the propagation of explosion;

(b) The incombustible content could be maintained by a technique later called "trickle dusting";(2)

(c) The higher the air velocity the lower the concentration of float coal deposited along the length of the return airway; and,

(d) Once deposited, float coal was not raised into suspension and made airborne by the ventilating air flows (velocities used in these studies ranged from 50 to 550 fpm).

IV. Mitchell, D. W., S. W. Polack, E. M. Murphy, and A. F. Smith. Fire Hazard of Conveyor Belts. Bureau of Mines Rpt. Inv. 7053 (1967). Flame spread along rubber, polyvinyl chloride (PVC), and neoprene (NP) belting was described. The rubber belt was then in common use in American coal mines; it was not flame resistant. The other belts were fire resistant in accordance with Schedule 28 (now in 18.65, 30 CFR); however, in 1972-tests, the PVC and NP belting used in the above mentioned research were found to be the most flammable of all belts sold to mines.(3) Belting now available has less smoke evolution, lower toxic product concentrations and greater fire resistivity than the belting available pre-1969.(3)-(5)

All belts ignited. Ignition, however, was more difficult to achieve at ventilating air velocities of 500 fpm than at 200 fpm; and, more difficult to achieve in air flows of 200 fpm than at zero (neutral).

Once ignited, propagation of fire depended on the concentrations and temperatures of the volatiles 'pulled out' of the belting and of the oxygen in the air. Flames propagated faster when ignition had been caused by a strong rather than a weak source -- the strong source pulled more volatiles out than did the weak source. Flame propagation was 10 to 30 times faster on the rubber than on the other types of belting -- The rubber belting contained more flammable components that were more readily distilled.

The rate of flame spread was the same when air velocities were 500 and 200 fpm. Propagation at those velocities was faster than when no air flowed through the test gallery (the neutral air flow condition). This demonstrated that in the absence of forced ventilation, there was inadequate transfer of heat from the igniting zone to the belting; and, there were not enough volatiles 'pulled out' to propagate flames. Neutral in these studies, however, did not mean "neutral" as it is presently used and understood by the mining community. "Neutral" today is commonly understood to include velocities varying from perceptible movement to 50 fpm. In the research, "neutral" meant no ventilation; no fan forced air to flow through the test gallery. Rather, fire-induced throttling pressures limited inflows of the oxygen needed to sustain flames.

In tests duplicating "real-mine" conditions, small to large fires on belt conveyors were extinguished within minutes by automatically activated sprinkler heads on 30-foot-centers.

## DIFFERENCES BETWEEN 75.326 AND PROPOSED 75.350

The three key differences between present and proposed regulations for belt entries are discussed below. These are: I. Entry Separation; II. Air Velocity; and, III. Belt Air to the Face.

I. ENTRY SEPARATION

> 75.326 states: Entries used as intake and return aircourses shall be separated from belt haulage entries [and the stoppings should be permanent as per 316.2(b)].
>
> 75.350(b)(2) and (c) proposes: Entries used as escapeways and return air courses shall be separated from belt haulage entries [and the stoppings shall be permanent and durable as per 333(d)(1) and (4)].

The first difference is that the proposed 75.350 does not require isolating belt from non-escapeway intakes, including track entries. The second difference is the proposed 75.350 requires use of permanent stoppings, whereas in 75.326 their use is recommended.

The "measure of protection" of 75.326 was to be obtained, in part, by isolating the belt from all other entries. Permanent, durable stoppings as proposed in 75.350 increase the likelihood of achieving isolation, at least with respect to escapeways and returns; and, would provide at all times a greater measure of protection as does 75.326.

The question that remains is, "What effects do open, adjoining connections between a belt and other non-escapeway intakes have on propagation of fire, escape time, and float-coal concentrations?".

Propagation of Fire

Where stoppings are not permanent and durable, their presence or absence between parallel airways is not a critical factor in fire propagation. Smoke and fumes either may or may not flow into adjoining entries; and, air in those entries may or may not flow into the entry on fire depending on many variables, chief among which are pounds of coal or wood burning, the locations of crosscuts with respect to the fire, the "leakiness" of the stoppings and pillars, and whether the area is relatively flat, rising, or dipping.

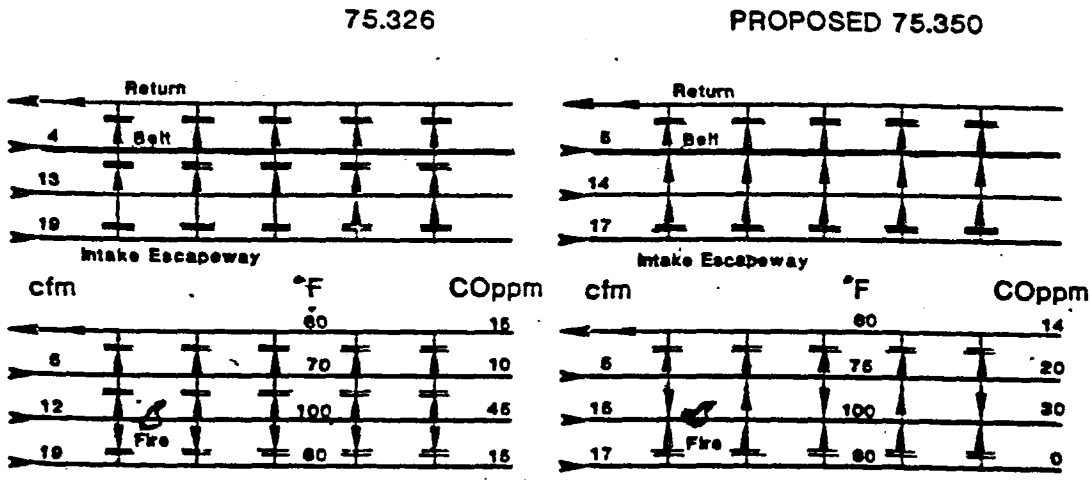
The sketches below illustrate this for one ventilation network in a relatively flat area. "Flat" was selected for briefness-sake. Fire in a rising or dipping entry is a special and severe condition, requiring good understanding of buoyancy and throttling pressure development and the interactions among those pressures and mine and barometric pressures.

The two sketches to the left represent four entries, from top to bottom, return, belt, non-escapeway intake, and intake escapeway in compliance with 75.326.

The two sketches to the right represent the exact same conditions except for the absence of stoppings between the second and third entries, the belt and a non-escapeway intake, in accordance with provisions proposed in 75.350. The entries are 72 square feet in cross-sectional area. The data for the upper left hand sketch are from a ventilation survey in an operating coal mine. The stoppings had a resistance equal to well-constructed, mortar-coated, dry-stacked, solid concrete block, stoppings that comply in all respects to proposed 75.333(d).

The top sketch in each set indicates pre-fire flows (cfm x 1000). In the bottom sketch, a fire is consuming one pound of coal per minute in the non-escapeway intake, the third entry from the top. Temperatures (°F) and carbon monoxide concentrations (CO ppm) are those that would exist 3/4 hour after that rate of burning (1 lb./min.) was attained, a time selected to assure flows had reached the working section.

COMPLIES WITH




Propagation of fire depends on:

1. Fuel - The supply in coal mines is readily available;

2. Oxygen - The supply in ventilated areas is adequate during the early stages of a fire. For example, an air flow at 50 fpm in an entry having an area of 100 square feet contains sufficient oxygen to sustain complete combustion of at least 6 ounces of coal per minute -- perhaps a pound or more for the less than complete combustion that generally occurs; and,

3. Temperature of the air flowing from the fire — temperatures of 200°F and higher liberate the volatiles and tars that propagate flames.

Looking at the sketches, no important differences in these three factors exist. The presence or absence of stoppings between the belt entry and non-escapeway intake, therefore, should have no effect on propagation of fire.

Escape Time

The second "measure-of-protection" test was exposure of miners to fumes from the fire and their receiving warning of the danger in time for escape. Again, looking at the sketches and considering what they teach, it is reasonable to find where warning results from detection of carbon monoxide, this "measure of protection" should be achieved by compliance with proposed 75.350 sooner than by compliance with 75.326. Also, the fire-induced pressure imbalances (see arrows) between the non-escapeway and escapeway intakes in the area complying with 75.326 caused CO to leak into the intake escapeway (note: 15 ppm in bottom entry, bottom left-hand sketch). Smoke would come with that CO. Compliance with stopping requirements of 75.326, therefore, could adversely effect the escape of miners.

In contrast, the absence of stoppings, as would be permitted by the provisions of proposed 75.350, prevents development of the fire-induced pressure imbalances that forced fire gases and smoke into the intake escapeway.

Float Coal

The third "measure-of-protection" test is the effect of having or not having stoppings between the belt and other non-escapeway intake on float-coal concentrations. Nothing in these sketches, nor in experience, nor from knowledge gives reason to believe stoppings affect float-coal concentrations. Those concentrations are affected mainly by:

1. Quantity of float coal made airborne -- the greater the quantity in terms of time (e.g., x pounds per hour) the higher the concentrations in downstream deposits;

2. The velocity of the ventilating air -- the higher the velocity the lower the concentration; and,

3. Roughness of rib-roof surfaces -- the more irregular the surface and the more ledges (such as headers and timber sets) the higher the concentration.

II. AIR VELOCITY

> 75.326 states: ... and each operator ... shall limit the velocity of the air coursed through belt haulage entries ...
>
> 75.350(b)(3) and (c)(1) proposes: ... shall have a velocity of at least ...

The proposed velocity differs greatly from that implied in .326. The "measure of protection" of 75.326 was intended to be obtained mainly by limiting air velocities. As stated, the intents were to reduce velocities to militate against:

1. Fanning and thereby propagating fire;
2. Bringing products of combustion to the section before miners knew of their danger; and,
3. Dangerous concentrations of float coal dust.

## Fanning and Propagating Fire

In coal mine fires, the most important fuel is not the coals, but rather the volatile gases and tars 'pulled out' of the coal by heated air. These gases and tars mix with oxygen in the airstream. If these are hot enough and within the correct, critical concentrations, flames are produced.

Were it not for those gases and tars, propagation of fire would be slow. For example, flames burning into coal ribs and roof might penetrate to depths of less than 1/2 inch per hour and spread along the coal at rates of from one inch to one foot per minute.[(6)-(9)]

Fanning the fire. What effect does the velocity of the ventilating air have on fanning the fire? More velocity fans a fire. But, how much more is "more"?

Forcing air through a fire removes heat. Should the quantity (not velocity) of air be large enough and cool enough to remove heat faster than it is being generated, the fire goes out.[(10)-(19)] Try to light a match and keep it burning in a strong, cold wind. Consider the ventilation network previously shown in the discussion on Entry Separation (p. 9). That network consisted of four entries, a return, belt, non-escapeway intake, and intake escapeway. For the following discussions, the simulated fire consumed 10 pounds of coal per minute. Simulated air flows into the fire were 75 fpm (5400 cfm), 190 fpm (13,700 cfm), and 370 fpm (26,700 cfm). For these conditions:

| Air Velocity, FPM | Temperature (°F)/Volatiles (%) | | |
|---|---|---|---|
| | 100' | 300' | 500' Downstream |
| 75 | 630/8.8 | 330/8.6 | 180/8.4 |
| 190 | 330/3.2 | 210/3. | 160/2.9 |
| 370 | 270/2. | 210/2. | 160/2. |

Temperatures and volatile concentrations must exceed 200°F and 4.8 percent before flames develop. Data such as these and thoughtful reason aid in understanding how and why more air might limit if not prevent fanning the fire. More air can reduce temperatures and volatile concentrations.

Propagating the fire. To propagate fire requires:

1. Temperatures in the flows downstream from the fire to be hot enough to "pull" volatile gases and tars out of the downstream coals;

2. The concentrations of those volatile gases and tars to be within their combustible limits (for example, 5 to 15% is the range for methane by itself); and,

3. The gases, tars, and oxygen to be hot enough to produce flames.

Only when these three requirements are met does higher velocity become serious. The higher the velocity the greater the quantity of air. The greater the quantity of air the greater the quantity of oxygen. The greater the quantity of oxygen the higher the potential burning rate. An air flow in a belt entry complying with 75.326 typically averages 5,000 cfm (for example, 50 fpm in a 100 sq. ft. area). The oxygen in that flow is sufficient to sustain complete combustion of at least 6 ounces of coal per minute. That is not a small fire. It liberates almost 5,000 BTU/min.

Compliance with the velocity limitations required by 75.326, therefore, does not protect against fanning and propagating fire. Additionally, in the event of fire, low velocities exacerbate:

a) Smoke rollback against the ventilating air flow;

b) Methane-hydrogen layers acting like a wick bringing flame from the fire back against the ventilating air flow towards the fire fighters and into areas that might contain gases and coal dust -- such as the faces or, in a retreating panel, the gob; and,

c) Development of a fuel-rich fire.

Adequate air velocities and quantities are the sole means to limit if not prevent hazards such as these.

Rate of propagation. The velocity of the ventilating air has little to no affect on how fast flames propagate through an entry. For example, in full-scale fires with highly flammable polyurethane foams, flames propagated through the entry at a rate of 25 fpm while ventilating air velocities were 200 and 1000 fpm.(6)(20) With conveyor belts, of a quality now available for use in mines, flames did not propagate in air flows of at least 800 fpm.(3)(11)(21)

Escape Time

Limiting the velocity, as required by 75.326 was believed necessary 'to reduce exposure of miners to fumes from fire because rapid air currents in the intakes to working sections quickly bring products of combustion to the section before miners knew of their danger and lessened their time for escape'.(1) From this wording it seems reasonable to believe the Congress intended to achieve timely warning of fire in belt haulage entries not only by limiting the velocity but by having 'devices on all belts which give warning automatically when a fire occurs' (see 75.1103).

Heat activated point-type sensors have been the principal accepted means for giving automatic warning. The most common types activate at temperatures greater than 135°F; this assumes that sensors are dry and free of dust.

<u>Timely warning by compliance with 75.326</u>. What does "timely warning" mean as defined by velocity of ventilating air and a 135°F point-type sensor within 125 feet of the fire? This question has been answered by a number of investigators.(7)(10)(11)(15)(16)(18)(21)(22) The following two examples supplement that knowledge. These examples were developed using the same ventilation network described in Entry Separation (p.9). The fire, however, was moved into the belt entry because only there, in the belt entry, are the point-type sensors required by present regulations. The first questions asked were, "For velocities and conditions in compliance with present regulations:

1. What is the smallest fire, in terms of coal burning rate, that would activate a 135°F point-type sensor within 100 feet inby the fire?

2. When after that rate of burning is reached might the sensor activate an alarm?

3. What concentration of CO is likely at the section tailpiece when the alarm is given?

The following answer these three questions for two selected, but commonly used, air flows:

| Air velocity, fpm | 55 | 220 |
|---|---|---|
| Coal burning rate, lb./min., to activate 135°F sensor 100 ft. inby | 1-3/4 | 2 |
| Alarm activated, minutes after rate established | 45 | 30 |
| CO at tailpiece at time of alarm, ppm | 62 | 65 |

Note in these data, the alarm is 15 minutes later at the lower velocity. Because other factors are basically the same, this indicates limiting the velocity might expose miners to an unrecognized danger when complying with the velocity limitation in 75.326.

"Timely warning" in accordance with the provisions of 75.326 means 30 or more minutes for the ventilation network used in these examples.

Timely warning by proposed 75.350. Using the same network as above, except stoppings are not between the belt and non-escapeway intake; and, with fires burning 1-3/4 and 2 pounds of coal per minute (the rates of burning needed to activate the 135°F sensors), the questions asked were:

1. At what ventilating air velocity would a sensor 1900 feet inby be activated by a concentration of 10 ppm CO in the air stream? and,

2. When after that rate of burning (1-3/4 and 2 lbs./min.) is reached might the sensor activate the alarm?

When a fire burns 1-3/4 and 2 pounds of coal per minute continuously, a sensor 1,900 feet inby would be activated by 10 ppm of CO in air flowing at velocities as high as 875 and 1,000 fpm (87,500 and 100,000 cfm respectively). Alarm would be given in fewer than two minutes. These lead to major improvements to the safety of miners as compared to what is attainable through compliance with 75.326. Without question, the provisions of the proposed 75.350, so far discussed, at all times provide at least the same and generally a far greater measure of protection as 75.326.

Float Coal

The third intent of 75.326 was to limit air velocities to reduce the amount of float coal dust for the purposes of minimizing dust explosions.

As stated, in the discussion of Bu. Mines R.I. 6581, Float Coal Hazard in Mines, research found the higher the ventilating air velocity the lower the float coal concentration. How then do float coal deposits develop in belt entries? Spillage is a major cause. This happens when the quantity of coal loaded on the belt exceeds the carrying-capacity of the belt. Carrying-capacity is a function of belt width, belt speed, and troughing design. Most spillage is observed within 50 feet of the loading or transfer points.

A second important cause -- one that occurs along the length of a conveyor -- is vibrations and pulsations transmitted from the moving belt into the coal. These depend mainly on belt speed, belt tension, idler and roller spacing, and on the straightness of the belt.

Another important cause is dust embedded into and caked onto the belt. Some of this dust falls from the belt because of the vibrations and pulsations previously mentioned.

What about the mine ventilating air? Assume a belt traveling at a speed of 650 fpm and air flowing in the opposite direction at 250 fpm -- a combined velocity of 900 fpm. Won't that be a cause? No. Were the coal and dust free of excess moisture then, under the most ideal conditions, a velocity of almost 1,000 fpm would be the lowest at which dust might begin to be raised.[(23)-(25] Add a little water, have a reasonably arced surface such as is commonly formed by coal on a conveyor, a velocity close to 2,000 fpm might cause dust to be raised.[(23)-(25)]

In summary, the hazard of float coal is controlled by compliance with regulations given in 75.400 and Part 70. The hazard results from causes of which ventilation is not one.

## III. BELT AIR TO THE FACE

75.326 states: In any coal mine opened after March 30, 1970 ... such air shall not be used to ventilate active working places.

75.350(b) proposes: When intake air is coursed through a belt conveyor entry to ventilate a working place, ...

The proposed use of air from belt entries in working places impacts only the second "measure-of-protection" test; that is, how would the use of air coursed through a belt entry into a working place affect exposure of miners to fumes from fire and their time for escape? Towards answering this question, consider how the safety of miners is enhanced or diminished by ways used to ventilate belt entries in an effort to comply with 75.326. Two ways are used:

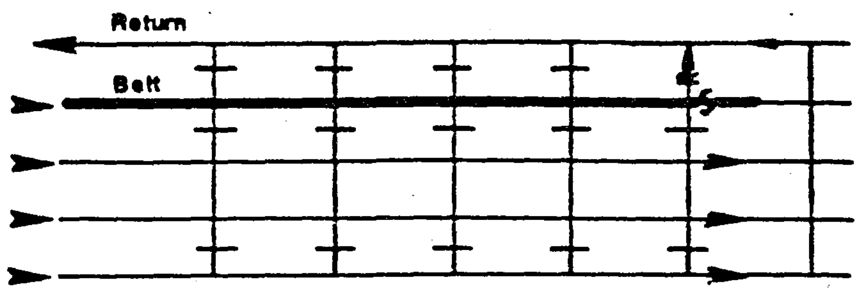
1. Directing air towards but not to the face(s); and,
2. Directing air from the tailpiece to the return.

### Directing Air Towards the Face

Belt entries can be ventilated by introducing intake air near the mouth of the section, coursing this air inby. Ventilation controls, such as check curtains across the belt entry -- generally outby the tailpiece, always outby the last open crosscut -- direct flows into the return. How the air is directed into the return depends on the relative locations of the belt and return entries, as discussed below.

Directing air through a crosscut. In single-split systems of ventilation, developing butts and room-and-pillar panels for example, the belt entry might be immediately parallel to the return. Air in the belt entry then can be directed into the return through a crosscut. The quantity of air can be controlled by a regulator (R) in the crosscut.

These conditions are illustrated in the following sketch.



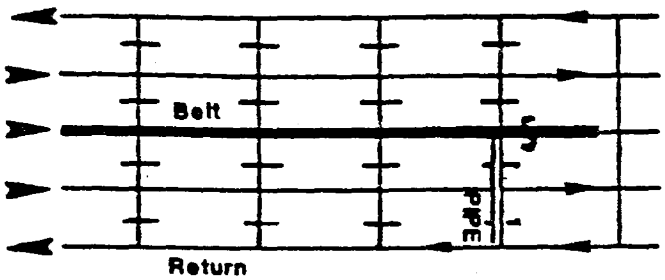

The advantage of this is air flows in the same direction as does water if the pipeline is in the belt entry. The critical importance of this is discussed later.

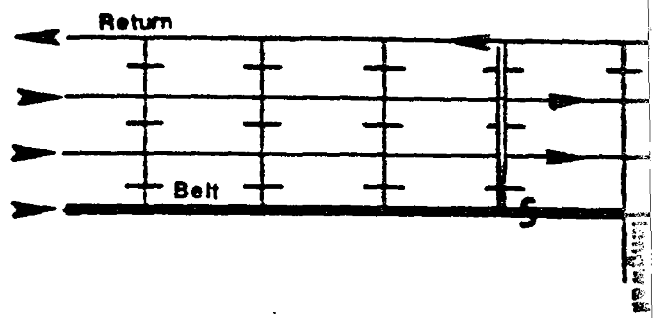
Disadvantages Include:

a) Pressure differentials and imbalances are exacerbated by the check curtain and regulator. These cause leakages through the check curtain and through stoppings between the belt and intake entries.

b) Fire within 100 feet of the return connection could burn undetected and go out of control endangering everyone in the working place. This assumes the point-type sensor is inby the return connection, a reasonable assumption.

Directing air through a pipe. In other ventilation schemes, two-split ventilation or longwall panels for example, the belt entry often is a number of entries away from a return. Obviously, air from the belt entry cannot be coursed directly through a crosscut into the return. When trying to comply with 75.326, some mine operators extend a ventilation pipe or pipes from the belt entry into the return. These sketches illustrate two common examples.




The advantage of this is that air flows in the same direction as water. Disadvantages include:

a) The ventilation pipe reduces clearance in entries through which it passes. This is hazardous to miners who travel through or work in those entries -- consider the headroom in a 4-foot-high entry through which a 12- or 18-inch pipe crosses;

b) If the point-type sensor is inby, fire could burn undetected with the potential for disastrous consequences.

To analyze piped-air flows to the return, consider flows through a 4-entry panel for a developing longwall. The base data are from a ventilation survey of a mine in the West Virginia panhandle. The base was changed as follows:

a) Air was directed from the intake into the belt entry at the mouth of the panel;

b) Twenty (20) 1-foot-dia. fiberglass ducts were extended from the belt entry across the roofs of the intake escapeway and track entry into the return;

c) A check curtain was placed across the belt entry 60-feet inby the 20 ducts and 60-feet outby the belt tailpiece.

The findings were:

1. Twice as much air leaked through the check curtain than could flow through the 20 ducts into the return.

2. "Fire" in the belt entry 60 feet outby the 20 ducts, caused smoke and fumes to:

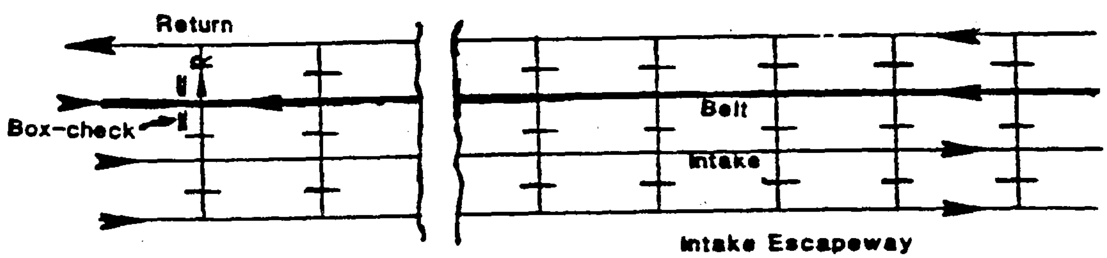
i. Leak through the check curtain into the faces; and,

ii. Leak through stoppings into the intake escapeway.

3. The 135°F point-type sensors inby the fire activated only after the rate of burning reached one pound of coal per minute.

Air Flows Away From the Face

A common method of ventilation is to introduce intake air into the belt entry at the tailpiece. This air flows outward in the same direction as the coal on the belt. The air is then directed into the return by a stopping across the belt entry. The belt passes through an opening in the stopping; this is called a "box-check".




Advantages include:

a) It satisfies the requirements of 75.326;

b) The belt entry is ventilated by a split of its own air; and,

c) Dust in the belt entry is carried outby the faces towards the return.

Disadvantages include:

a) Air flowing into the mouth of the belt entry through the box check often is at extremely high velocities, several thousands of feet per minute. This raises dust off the belt[(23)-(25)] creating a potential hazard between the box check and the return.

b) The quantity of air in the belt entry is controlled by a regulator in the connection between the belt entry and return. Because of leakages* only a fraction of the belt air flow is in the upper reaches of the belt entry -- for example, in a 6,000-foot-long belt entry it is reasonable to measure a quantity at the tailpiece that is less than 30 percent of the flow through the regulator.

c) Air flows in the opposite direction to water flows in pipelines. Heat from the fire destroys the holding-ability of the pipe coupling; the water line separates outby the fire. To fight the fire, however, fire fighters must be inby, thereby, creating hazardous exposure. Providing water to fight the fire would be more difficult.

d) As shown by previous data, where heat-activated point-type fire detection is relied on a small fire could burn undetected. With air flows carrying odors from the fire into the return, the chance is lost for miners in the working places to receive warning of the fire while it is still small, thus lessening their time for escape.

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*200 to 300 cfm per inch water gage differential can be expected to leak through a 100 sq. ft., solid concrete block stopping with montared joints and mortar coating.

Smell

Many miners know from experience the nose is the best detector of fire. In tests with conveyor belts made hot with friction, highly sensitive electronic detectors had not yet activated when miners 600 feet downstream noted irritation of their respiratory tracts.[11] The superiority of the nose as compared to CO sensors for detecting burning wood is evident from the following data (unpublished work by J. Rockett, NBS, for U. S. Bureau of Mines investigation of the spread of toxic products in the Sunshine Mine Fire, 1972).

| Air Flow, cfm | Minimum detectable wood burning rate, lb./hr. by | |
|---|---|---|
| | People | 10 ppmCO sensor |
| 3,000 | 1/10-1 | 1-1/3 |
| 50,000 | 1-1/2-17 | 23 |
| 90,000 | 3-30 | 42 |

Thus, miners should smell fire long before it becomes hazardous.

CONCLUSIONS

The provisions of proposed 75.350 will provide a greater measure of protection to miners than do those in 75.326. Those provisions are:

a. Allowing intake air in belt entries to be used to supplement ventilation of the working faces. This additional air also reduces respirable dust and methane concentrations, thus enhancing the safety of miners. Further, odor-recognition and the early warning of fire given by CO sensors should protect miners from hazardous concentrations of fumes from fire.

b. Isolating belt entries from the intake escapeway. By not requiring stoppings between the belt and adjoining non-escapeway intakes, the effects of ventilating-pressure and fire-induced-pressure imbalances on leakages into the escapeway are minimized. This makes escape safer.

How does it reduce float coal dust? Blow it thru the (a

c. Permitting air velocities consistent with safe mining practices. In belt entries, this should: Reduce float coal concentrations; lessen the chance for ignition and propagation of fire; give more rapid warning of a developing fire; and, militate against smoke rollback, methane layering, and fuel-rich fires.

ADDENDA

The proposed 75.350 requires belt entries be separated by stoppings from returns. There are good reasons why belts could be and perhaps should be in the return. Provisions to permit this should be considered.

The proposed 75.350 specifies CO warning and alarm levels at 10 and 15 ppm above ambient respectively. This needs to be reconsidered. The presence of 10 ppm, for example, can mean different things in different mines and in some situations can be produced by non-fire sources. A CO detector would alarm at 10 ppm above ambient when:

| Coal burning, lb./min. | Air, cfm |
|---|---|
| 1/10 | 5,000 |
| 1/2 | 30,000 |
| 2 | 100,000 |

The question should not be ppm or equivalency to 135°F point-type sensors on 50 or 125 foot centers. The question should be, "How big can the fire be before alarm is given?" The answer is mine-specific; based on fire protection, reaction, mine design.

# RESUME

## Professional Experience

Donald W. Mitchell, P.E., has spent the plurality of his past thirty years providing health and safety expertise in the areas of fires, explosions, ventilation, polymer flammability and toxicity, rescue-recovery, ground control, and safety regulations. His education, background and experience are more fully outlined below.

## Education

| | |
|---|---|
| M.S., Mining Engineering, Columbia University | 1951 |
| B.S., Mining Engineering, Penn State University | 1948 |
| Labor Management, U.C.L.A. | 1968 |
| Research Management, University of Wisconsin | 1962 |
| Research Organization, Brookings Institute | 1962 |
| Labor Relations, Scranton University | 1949 |
| Electronics, Yale University (Army Air Force) | 1943 |

## Professional Society Participation

Mine Foreman, Commonwealth of Pennsylvania No. 6562 Arthracite Mine Foremans Certificate 7/14/49
Registered Professional Engineer, Commonwealth of Pennsylvania, 1978-date
General Chairman, Coal Mining Section, National Safety Council, 1981-82
Chairman, Engineering Committee, Coal Mining Section, National Safety Council, 1962-1980
Member, Engineering Standing Committee, National Safety Council, 1982-date
Chairman, Program Committee, Coal Mining Section, AIME, 1964
Advisor, Polymer Section, Society of Plastic Industry, 1962-66
Board of Directors, National Mine Rescue Association, 1984
Chairman, Engineering Committee, NMRA, 1984
Member, Committee on Mine Rescue Procedures, NMRA, 1981-date
Member, Coal Mining Institute of America, 1954-date
Member, National Fire Protection Association Committee 123, 1979-date

## Publications

Authored and co-authored 84 papers, particularly on ventilation, fires, rescue-recovery, explosions, roof control, sealants, foamed plastics, ventilation controls, transportation and mineral resource analysis.

## Patents

Process and method for quenching incipient gas-air explosions, No. 677,511 (1970).

Honors

Two Secretary of Labor's Recognition Awards, Department of Labor
Meritorious Service Citation, Department of the Interior
Six Outstanding Efficiency Ratings, Department of the Interior
Robert Peele Award, Columbia University
Krumb Scholar, Columbia University
Sigma Gamma Epsilon
Tau Beta Pi

Significant Accomplishments

Chairman, MSHA Task Force Underground Storage of Oil, Nuclear Wastes and Natural Gas
Coordinator of inter-agency development of technical matters in defense of litigations arising from the Sunshine and Hyden mine disasters
Assistant Coordinator, Director's (Bu.Mines) Task Force to implement the Federal Coal Mine Health and Safety Act of 1969
Technical Advisor to the Indonesian Government in the establishment and growth of the mineral industries with particular reference to coal
Technical Advisor to the New York-New England Interagency Committee on mineral deposits in the subject area
Technical Advisor to the Department of Defense -- classified
Designed and supervised Bureau of Mines multi-entry research mines
Developed and led Bureau of Mines research into longwall mining, roof control, transportation, ventilation control, mine sealants, fires and explosions (1961-1974)
Introduced resin-bolting concepts into the United States
Introduced fiber (steel and polypropelene) reinforced concrete concepts into mines
Developed radiographic and microdensitometer techniques for sensing fracture initiation and strains in mine strata
Co-developed means for interpreting fire and post-explosion evidence in mines; systems for remote sealing and gas-inerting of mine passageways through boreholes; continuous rock-dusting techniques now known as "trickle dusting"; high-expansion foam; urethane foam; and, standards for piping methane in mine passageways, storage of oil adjacent to mining, and acceptance criteria for materials used in mines.

Work Experience

September 1, 1982: Donald W. Mitchell, P.E., a consultant firm.
October 1979 to September 1, 1982: Manager, Pittsburgh Division, Foster-Miller, Inc. Responsible for the conduct of contract work involving mine health and safety, fire prevention and control, and industrial safety.
July 1978 to October 1979: Chief Mining Engineer, Gates Engineering Co., Responsible for the direction of contract work on mine operations and reserves. Advisor to the National Academy of Engineering Committee on use of plastics in underground environments.

Work Experience (Con't)

July 1974 to July 1978: Principal Mining Engineer (GS-15 [8] in the office of and special advisor to the Assistant Administrator, Technical Support MSHA (MESA). Responsible for reorganization of and Chief, Approval and Certification Center and Mine Emergency Operations. Technical Advisor to the Assistant Secretary of Labor, the Administrator, and the Assistant Administrator -- Metal/Non Metal and Coal Mine Health and Safety in the underground storage of oil, nuclear wastes and natural gas adjacent to mining operations; mine fire and explosion analysis and investigation; interpretation of Parts 18-35, and Sections 302-304, 311, 314, 315, 317 and 318 of Part 75, P.L. 91-173; longwall mining; and mine degasification. Had key staff responsibility in the overall planning, program coordination, review and evaluation of MESA-Bureau of Mines health and safety research.

October 1966 to July 1974: Supervising Mining Engineer, Project Coordinator-Engineering Applications, Mining Research Center, United States Bureau of Mines. Responsible for research in the study of rock mechanics, roof control, strata control, mine transportation and explosion and fire hazards in coal mines.

July 1959 to October 1966: Assistant Chief, Branch of Dust Explosions and Chief, Mine Experiments Section, Health and Safety Research Center. Responsible for the conduct, overall planning, direction and review of research on coal-mine explosions, float-dust control, high-expansion foam, rigid urethane foam, water infusion, mine fires and dust allayment.

March 1957 to July 1959: Technical advisor to the Government of Indonesia in the establishment and growth of their mineral industries with particular reference to the improvement and expansion of the mining of solid fuels.

March 1954 to March 1957: Mining Engineer, Branch of Dust Explosions of the above-mentioned center. Was responsible for the conduct of research in the Experiemental Coal Mine.

April 1951 to March 1954: Mining Engineer, Boston, Mass., and Mt. Weather, VA field offices, United States Bureau of Mines. Responsible for analysis of mineral economics in the New York-New England states and on classified investigations.

October 1949 to April 1951: Master's candidate, School of Mines, Columbia University.

June 1948 to October 1949: Engineer-in-Charge, Gangway Development, Southern District, The Hudson Coal Company, Scranton, PA.

June 1946 to June 1948: Miner's Helper, Eddycreek Colliery, The Hudson Coal Company during school vacations.

March 1944 to January 1946: 1st Lt. C.O., BACC#2, 5th Air Force

November 1942 to March 1944: Private to 2nd Lt. Army Air Corps

June 1941 to November 1942: Engineering Corps, H.C. Frick Coke Company, Uniontown, PA.

September 1940 to June 1941: Student, School of Mines, Pennsylvania State University.

May 1940 to September 1940: Miner's Helper, Carbondale Colliery, The Hudson Coal Company.

PUBLICATIONS

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Mitchell, D. W. Fuel Statistics for New England.
Mitchell, D. W., and C. H. Broedal. Graphite.
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Mitchell, D. W., and G. W. Stewart. Peat in NE and NY.
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Mitchell, D. W. Factors Influencing the Choice of Mining Machines. AIME Trans. 1951.

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# RESUME

C. William Parisi graduated from the Colorado School of Mines, Golden Colorado, in 1941 with an E.M. (Engineer of Mines) professional degree. He is a member of Theta Tau, an honorary engineering fraternity.

Immediately after graduation, he went to work with the Pittsburgh Coal Company as a trainee. The program lasted two years, during which time he worked as an underground laborer; assistant chemist in a central coal preparation plant; underground coal preparation engineer dealing with coal blasting procedures, equipment maintenance engineering, mine ventilation surveys, and general engineering in the company's engineering department.

At the completion of the program, he became assistant to the mine superintendent as Somers Mine, Banning No. 1 Mine, and Ocean Mine, respectively. While at the mines, he passed the Pennsylvania State Mine Certification examinations as fireboss, assistant mine foreman, and first grade mine foreman.

In 1947, he became the mine foreman at Montour No. 10 Mine, a large, highly gaseous and modernly mechanized mine. He remained as mine foreman until October, 1954, when he was promoted to director of safety for Pittsburgh Coal Company, which by this time, had become a division of Consolidation Coal Company.

In February, 1969, he was appointed chief inspector for the eastern portion of the mines owned and/or operated by the parent company, Consolidation Coal Company. This responsibility included all mines in Pennsylvania, Tennessee, Virginia, and West Virginia.

In May, 1972, he was named safety director for Consolidation Coal Company, which included mines in Illinois, New Mexico, North Dakota, Ohio, Pennsylvania, Tennessee, Utah, Virginia, West Virginia, and Alberta, Canada.

During his mining career, he participated in numerous mine fires and explosions and has acquired considerable experience in the field of mine fire protection, fire fighting, mine sealing, and mine recovery operations.

He retired from Consolidation Coal Company on April 1, 1983, after forty-two years of continuous service. He is currently a private consulting engineer.

He is a life member of the Mine Inspectors' Institute of America; a life member and past president of the National Mine Rescue Association; past general chairman of the Coal Mining Section, National Safety Council; past president of the National Council, Holmes Safety Association; life member and past president of the Veterans of Mine Rescue, Pittsburgh District; and a life member of the Pittsburgh Coal Mining Institute of America. He has served on safety committees for the Bituminous Coal Operators' Association, the West Virginia Coal Association, and the Keystone Coal Operators' Association. In 1983 he was the recipient of the Don Kingery Safety Award and the Holmes Safety Association's highest safety award.

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(5) Hartstein, A. M. et als. Coal MineCombustion Products: Conveyor Belts. U. S. Bureau of Mines R.I. 8107 (1976).

(6) Mitchell, D. W., et al. Fire Hazard of Urethane Foam in Mines, U. S. Bu. Mines R.I. 6837 (1966).

(7) Roberts, A. F. and Clough, G. Propagation of Fires in Passages Lined with Flammable Material, Combust. Flame 11, pp. 365-376 (1967).

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Mr. Mitchell is one of the foremost mine-fire engineers in our Nation. He has had major responsibilities in sealing, recovery and analysis of more than 50 fires in operating coal mines as well as several hundreds of Experimental Mine fires. His recent successes in controlling the fires and then recovering the Wilberg (Utah), JW3 (Alabama), and Cumberland (PA) mines are considered outstanding by the Mine Safety and Health Administration as well as by the mining industry.

Don Mitchell is the Co-Chairman of the National Fire Protection Association's Technical Subcommittee drafting standards for fire prevention and control in underground coal mines. He Chairs the National Mine Rescue Association's Engineering and Procedures committees. He provides mine-fire and explosion expertise to Bethlehem Steel, Consolidation Coal, Diamond Shamrock, Dorchester Fuels, Enery Mining, Ensign-Bickford, Hartford Insurance, Island Creek, Jim Walters, Maben Energy, McIntyre Mines, North American Coal, Occidental Oil Shale, Empire Energy, U.S. Steel, Utah Power and Light, and Westmoreland Coal.

Mr. Mitchell, with a B.S. degree in Mining Engineering from the Pennsylvania State University and a M.S. from Columbia University, began his more than 40 years of mining as a Miner's Helper in Hudson Coal Company's Carbondale Colliery. His in-depth knowledge of mines and mining began with his work as a miner, fire boss, section foreman (Commonwealth of Pennsylvania's Anthracite Mine Foreman's Certificate No. 6562) and engineer-in-charge of gangway development in the Eddycreek, Baltimore and Loree collieries.

While with the United States Bureau of Mines, Mr. Mitchell was Chief of Mine Experiments, Asst. Chief of the Branch of Dust Explosions, Chief of Engineering Applications and Ground Control, and co-chairman of the task force that developed the regulations implementing the Federal Coal Mine Health and Safety Act of 1969.

While with the Mine Safety and Health Administration (MESA and MSHA), Mr. Mitchell was in charge of Mine Emergency Operations, Chief of the Approval and Certification Center, and Chairman of the task force for underground storage of oil, natural gas, and nuclear wastes.

Mr. Mitchell's resume and list of more than 80 publications are attached.