Belt Entry Ventilation Review:
Report of Findings and Recommendations

U.S. Department of Labor
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Mine Safety and Health Administration
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BELT ENTRY VENTILATION REVIEW
REPORT OF FINDINGS AND RECOMMENDATIONS

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EXECUTIVE SUMMARY

In March of 1989, Assistant Secretary of Labor for Mine Safety and Health David C. O'Neal requested that a special study be conducted to review safety questions surrounding the ventilation of belt conveyor entries in underground coal mines. In particular, a thorough review was requested of safety factors involved in the use of belt entry air at the working face, a practice followed at some 80 underground coal mines in the United States.

A review committee was assigned to this project consisting of MSHA engineers and specialists and headed by the director of MSHA's Office of Program Policy Evaluation. In developing this report, the committee has:

-- Analyzed the legislative and litigation history of belt ventilation;
-- Reviewed the history of fires in belt entries;
-- Made on-site surveys of ventilation systems on 17 mining sections in 10 mines;
-- Reviewed published literature and Bureau of Mines research; and
-- Examined inspector and operator respirable dust sampling data.

Based on information from all these sources, the committee has concluded that safety improvements can be made in belt conveyor entries of underground coal mines, particularly in the area of fire protection. In addition, the committee has concluded that directing belt entry air to the face can be at least as safe as other ventilation methods provided carbon monoxide monitors or smoke detectors are installed in the belt entry. Also, in the event of a belt fire, proper design of such a ventilation system can protect escapeways from rapid smoke contamination.

Contributing to this report were: George M. Fesak, Chief, Office of Program Policy Evaluation, chairman; Dale R. Cavanaugh, Supervisory Safety and Health Standards Coordinator; Robert W. Dalzell, Chief, MSHA Approval and Certification Center; John M. DeMichiei, District Manager, MSHA Coal Mine Safety and Health District 9; Kenneth T. Howard, District Manager, MSHA Coal Mine Safety and Health District 5; and Ronald J. Schell, Chief, Division of Safety, Coal Mine Safety and Health.

The committee's conclusions and resulting recommendations are listed below.

CONCLUSIONS

1 Fire hazards to miners can be reduced by the use of improved belt materials. Additionally, belt entry fires can be prevented through belt maintenance, belt entry clean-up, and rock dusting.

2 Physical separation of entries enhances escape capability but does not protect the intake escapeway from contamination since all stoppings offer opportunities for air leakage.

3 Mine design can provide improved intake escapeway separation, reduce ventilation pressure differences between entries, and induce potential leakage away from the intake escapeway, thereby enhancing the safe escape of miners.

4 Directing air inby through the belt entry and to the return outby the section loading point without significant restriction complies with section 75.326. However, directing air inby through the belt entry and to the return through a restrictive regulator or pipe overcast does not comply with section 75.326.

5 Directing air outby through the belt entry to the return complies with section 75.326. However, there are problems associated with fire fighting.

6 Directing belt air to the face provides protection equivalent to other ventilation methods which comply with section 75.326, provided a carbon monoxide (CO) or other improved monitoring system is used.

7 Performance of CO monitoring systems is superior to the performance of point-type heat sensors. However, dilution at higher air quantities can decrease warning times between alarm and belt flame propagation. Tests suggest that smoke detectors offer potential for improved fire detection.

8 Training in proper evacuation procedures is critical to the safe escape of miners from inby a developing fire.

9 Test data do not support limiting belt entry air velocity on the basis of belt flame propagation.

10 Normally, air velocity in belt entries will have no impact on float coal dust generation or entrainment. In those instances where high velocities exist or where dispersal occurs, technology for control is available.

11 Except for current coal bed belt fire tests, the Bureau of Mines research on the growth and propagation of mine fires does not address the impact of air velocities on the burning rates of coal and wood as found in mine entries.

RECOMMENDATIONS

1 Increased emphasis should be placed on belt maintenance, belt entry clean-up, and rock dusting.

2 Emphasis should be placed on proper construction and maintenance of stoppings separating intake escapeways from other intake entries.

3 Sections should be designed by entry location, number of entries, or pressure differential, to enhance the protection of the intake escapeway from contamination by fires in adjacent separated entries.

4 Intake escapeways should be maintained free of potential fire sources unless such sources are protected by fire suppression or other acceptable devices.

5. Directing air inby through the belt entry and to the return through a restrictive regulator or pipe overcast does not comply with section 75.326 and should be discontinued.

6 Training should include drills in communication and evacuation techniques and include precautions to be taken for escape through smoke.

7 Belt entries used to ventilate working places should be equipped with carbon monoxide monitoring systems or smoke detectors. MSHA and the Bureau of Mines should encourage development and testing of improved smoke detectors. MSHA should initiate the development of performance standards for CO monitors and smoke detectors. MSHA should continue to stress maintenance of CO monitoring systems.

8 MSHA should consider requiring improvements to or replacement of point-type heat sensors.

9 Where belt air is directed outby from the section, water lines should be relocated from the belt to a separate intake entry to facilitate fire fighting activities.

10 Further research should be conducted to evaluate the impact of air velocities on underground fire fighting and to provide information on the growth and spread of mine fires involving materials other than conveyor belts.

INTRODUCTION

The Assistant Secretary of Labor for Mine Safety and Health formed a special committee on March 24, 1989, to objectively review the major aspects of the issue surrounding the use of belt air to ventilate active working places in underground coal mines. Specifically, the Assistant Secretary asked the review committee to consider the relevant legislative history, current technology, and changes in the mining industry which have occurred since 30 CFR 75.326 became effective in 1970.

In addressing its charge, the review committee determined that two studies should be undertaken by the Agency to augment existing data. The first study involved an analysis of the effects that using belt air to ventilate working places has had on respirable dust levels. The second study involved evaluating mines to determine the current state of compliance with section 75.326. Specifically, the study focused on the degree of isolation that exists between the belt entry and other entries.

The committee also undertook an analysis of the fires that have occurred in belt entries, conducted an examination of the existing literature and Bureau of Mines research associated with the issue, and reviewed the legislative and judicial history of 30 CFR 75.326.

BACKGROUND

LEGISLATIVE HISTORY AND LITIGATION EXPERIENCE

Section 75.326[1] is derived without substantive change from section 303(y) of the Federal Coal Mine Health and Safety Act of 1969 (Coal Act). Originally, both the Senate and House versions of section 303(y) included belt and trolley haulage entries within the coverage of the same section. Thus, both the Senate and House versions of the bill required physical separation of belt and trolley haulage entries from intake and return aircourses, required air velocities to be limited in belt and trolley haulage entries, and prohibited these entries from being used to provide ventilation to working places. Both versions of the bill also included the existing distinction between mines opened prior to the effective date of the provision and those opened after.

The most complete statement of the legislative purpose of this provision is provided by the Senate. In reporting its version of the bill, the Senate described the goals as follows:

> The objective of the section is to reduce high air velocities in trolley and belt haulageways where the coal is transported because such velocities fan and propagate mine fires, many of which originate along the haulageways. Rapid intake air currents also carry products of the fire to the working places quickly before the men know of the fire and lessen their time for escape. If they use the return aircourses to escape, the air coursed through may contain these products and quickly overtake them. Also, the objective is to reduce the amount of float coal dust along belt and trolley haulageways. [Reference 15, p. 65].

From the Senate's statement of purpose, it is clear that a primary motivating factor behind enactment of this provision was a high incidence of fires in belt and trolley haulage entries prior to 1969. [Reference 19]. To minimize the hazards to miners from such fires, the bill aimed to reduce the flow of air

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[1]Section 75.326 states in part: "In any coal mine opened after March 30, 1970, the entries used as intake and return air courses shall be separated from belt haulage entries, and each operator of such mine shall limit the velocity of the air coursed through belt haulage entries to the amount necessary to provide an adequate supply of oxygen in such entries, and to insure that the air therein shall contain less than 1.0 volume per centum of methane, and such air shall not be used to ventilate active working places...."

in belt and trolley haulage entries and isolate these entries from intake and return aircourses. The three hazards the bill was designed to address were:

1 rapid spread of fire,

2 rapid contamination of working places from the products of combustion and the resulting reduction in escape time; and

3 excessive float coal dust accumulation in belt and trolley haulage entries.

The original version of the House bill mirrored the Senate version. A subsequent amendment to the House bill, however, modified the application of the provision such that it solely addressed belt haulage entries. Ventilation of trolley haulage entries was addressed elsewhere.

Section 75.326 contains a grandfather provision which allows mines opened prior to 1970 to use belt air where necessary. Based on a 1971 opinion of the Associate Solicitor, the Agency has consistently applied 30 CFR 75.326 to allow the belt entry to be used to provide additional ventilation to working places, where necessary, in new development areas of mines opened prior to March 30, 1970. The determination of "need" has been made by the Coal Mine Safety and Health district manager in exercise of the ventilation plan approval authority in 30 CFR 75.316. At present, approximately 20 mines have approved ventilation plans permitting the use of belt air to ventilate working places.

Approximately 2 years after the March 30, 1970, effective date of 30 CFR 75.326, the first petition for modification requesting permission to use the belt entry to ventilate active working places was filed by Island Creek Coal Company for its Virginia Pocahontas No. 4 Mine (VP No. 4 Mine).

Under section 101(c) of the Mine Act and its predecessor, section 301(c) of the Coal Act, a petitioner may request modification of the application of any mandatory safety standard based upon either of two grounds. The petitioner may request a modification either because an alternative method of achieving the result of the standard exists which will at all times guarantee at least the same measure of protection afforded the miners by the standard or because application of the standard to the mine will result in a diminution of safety to miners at the mine. Agency investigators recommended granting the Island Creek petition for modification based upon their conclusion that application of the standard would result in a diminution of safety to miners at the VP No. 4 Mine due to excessive methane liberation and the inherently poor roof conditions of the mine.

The United Mine Workers of America (UMWA) originally opposed the Island Creek petition. On May 6, 1975, however, all parties agreed that the petition for modification should be granted contingent upon the installation of a prototype carbon monoxide (CO) monitoring system in the mine. Based upon this stipulation, the Administrative Law Judge granted the petition.

Following laboratory and in-mine studies at the VP No. 4 Mine, the Agency endorsed the use of CO monitors as an early fire detection system. This was based on the fact that fires, even in their initial stages before flame appears, will produce carbon monoxide gas. Detection of carbon monoxide therefore provides the potential for quicker and safer escape from fire areas and greater potential for fighting fires while they are still relatively small. These facts and the in-mine demonstrations convinced all parties that CO monitors were a desirable safeguard. [Reference 3]. To date, approximately 60 petitions have been granted by the Agency, all of which include the requirement for installation of a CO monitoring system.

In granting petitions for modification for the use of belt air in 1989, the Administrator for Coal Mine Safety and Health has made three significant changes. The first of these is that CO sensors are required to be installed every 1000 feet rather than the previous requirement of every 2000 feet. This change was based on a recent Bureau of Mines report addressing optimum warning times. [Reference 16].

The second change is the elimination of the 300 foot per minute (fpm) upper air velocity restriction previously included in 30 CFR 75.326 modifications. This restriction was originally included because the MSHA test procedure for flame resistant belting used only a 300 fpm air current. Recent Bureau of Mines tests have demonstrated that velocities above 300 fpm have no detrimental effect on belt flame propagation. The Administrator has also begun to receive requests from coal mine operators to amend previously issued decisions which include the 300 fpm maximum velocity.

The third new provision included in recently granted petitions has acknowledged the ongoing development of new conveyor belt flammability tests. These tests, when fully developed, will result in the identification of conveyor belt materials with improved flame resistance characteristics which will further reduce the likelihood of coal mine belt fires. Modifications granted in 1989 require operators to install the improved belt materials when replacing or extending belts in areas where belt air is being used to ventilate working places, as soon as the materials are identified by MSHA and become commercially available.

The UMWA has opposed most petitions for modification of 30 CFR 75.326 to allow the use of belt air in underground coal mines. In three cases, the UMWA requested and received a hearing to challenge the use of belt entries as intake aircourses. Of the three cases, the presiding administrative law judge issued a decision granting the modification in two, and upheld the UMWA challenge in the third. All three of these cases are currently on appeal before the Assistant Secretary.[2]

On January 27, 1988, MSHA published a proposed rule to revise its existing standards for ventilation of underground coal mines. Drawing upon the Agency's experience with belt air in ventilation plans and petitions for modification, the ventilation proposal includes a revision of 30 CFR 75.326 which would permit the belt entry to be used as an intake aircourse to ventilate working places in any coal mine installing a carbon monoxide detection system in compliance with the proposed rule. Industry commenters support the use of belt air, while the UMWA remains opposed.

BELT FIRE EXPERIENCE

The primary purpose of this historical review was to identify factors contributing to the occurrence of underground coal mine conveyor belt fires and to determine whether the use of belt air to ventilate working places had a significant impact on the outcome of each fire. A detailed summary was prepared by MSHA's Industrial Safety Division (ISD), Bruceton Safety Technology Center, so that a comparative analysis could be made of the underground coal mine conveyor belt fires that occurred and were investigated by MSHA from 1970 through 1988. To maximize the information in all necessary categories, the ISD reviewed each MSHA Accident Report and also contacted responsible Coal Mine Safety and Health personnel.

Under 30 CFR Part 50, a fire is required to be reported to MSHA if it is not extinguished within 30 minutes of discovery or if it involves a death or serious injury. Also, 30 CFR 50.11 provides MSHA with the latitude to decide whether or not to conduct an investigation. For this reason, it can be expected that additional underground coal mine conveyor belt fires have occurred without an MSHA accident report being prepared.

From 1970 to 1988, a total of 280 underground coal mine fires were reported to MSHA. Forty-two (15%) of the total involved conveyor belts and were investigated by MSHA. The percentage of reported underground conveyor belt fires to total fires, as shown below, has increased over the 19-year period.

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[2]These cases involve petitions filed by Emerald Mines Company, Quarto Mining Company, and Southern Ohio Coal Company

Conveyor Belt Fires, 1970 - 1988

Years Range	Total Fires	Number of Belt Fires	Percent of Total Fires
1970	36	2	5.5%
1971-1973	49	2	4.1%
1974-1976	37	5	13.5%
1977-1979	25	5	20.0%
1980-1982	47	7	14.9%
1983-1985	40	11	27.5%
1986-1988	46	10	21.7%
Total	280	42	15.0%

It is significant to note that while conveyor belt fires have accounted for 15% of the total fires that occurred during the period, only two resulted in harm to miners. Also notable is that both were heart attacks, one fatal and one non-fatal, sustained as a result of fire fighting activities.

Tables 1 and 2 in Appendix A, were prepared to identify any differences in fire experience related to the use of belt entries to ventilate working places. Although occurring in the belt entry, 3 of the original 42 fires were not considered in this analysis because they did not involve belt conveyors.

Of the 39 fires analyzed, 9 fires occurred in belt entries used to ventilate working places. Of the nine, two fires were detected first by fire sensors (one CO and one heat sensor), one was detected by sight at about the same time as the CO system gave a warning, and the other six were detected by sight or smell. Four of the belts were monitored with CO sensors. [References 7, 11, and 18]. Three of the fires involved idle sections and no escape was necessary. Of the remaining six, escape was completed before smoke reached the section in four cases, information was not available for one case, and escape was conducted through heavy smoke in one. Of particular interest is that friction caused the six fires where the source could be determined and that maintenance deficiencies were contributing factors.

Of the 30 fires where belt air was not used to ventilate working places, 19 fires were discovered by sight and 1 fire was detected by point-type heat sensors. Of the remaining ten, nine were discovered by smell, and one because the belt stopped. Sensors were installed above 29 of the belts; heat sensors were installed above 27 belts with 2 types unknown. Escape was not necessary in nine of these fires because the section or mine was idle; and information pertaining to escape was not available for another two fires. In four cases the crews encountered light smoke during escape; no smoke was encountered in the remaining 15. Maintenance was a contributing factor in about half of these fires. The ignition source could not be determined in 11 of the fires. Four were started electrically, three from welding or cutting, and twelve from friction.

These data support the contention that fire hazards are associated with belt entries. However, the data reflect similar experience in terms of injuries, source of ignition, maintenance deficiencies contributing to the fire, and the means by which the fire was detected, regardless of whether belt air was used to ventilate working places.

CONVEYOR BELT FLAMMABILITY

One of the more significant developments resulting from the Coal Act has been the increased flame resistance of conveyor belting. The Bureau of Mines developed a flame-resistance test for conveyor belts in 1955 that was made mandatory in 1970 by section 311(h) of the Coal Act. As a result, highly flammable rubber materials were replaced with flame-resistant, synthetic compounds such as polyvinyl chloride (PVC) and styrene-butadiene rubber (SBR).

Much has been learned over the past several years about the fire-resistant qualities of these synthetic belts. Conveyor belts accepted under the current test are highly resistant to ignition, but once ignited they may propagate flame along their length. Therefore, a revised test was developed by the Bureau of Mines at the request of MSHA's Approval and Certification Center to address the resistance of conveyor belting to both ignition and flame propagation. [Reference 13]. The test is designed to significantly reduce or eliminate the hazard of flame propagation along the belt. Conveyor belts passing the revised test will not only be resistant to ignition, but also highly resistant to flame propagation. This means that when the fire source is removed, the belt will self-extinguish.

MSHA presently intends to revise through rulemaking the current conveyor belt acceptance test, proposing the more stringent test which would, in the Agency's view, provide enhanced safety to miners. Concurrent with rulemaking, MSHA plans to implement a voluntary acceptance program which would permit conveyor belt manufacturers to submit belts for evaluation under the revised acceptance test. Belts passing the revised test would receive an MSHA acceptance number certifying the enhanced flame resistance of the belts. Once a belt is accepted under this program, it could be used underground in compliance with 30 CFR 75.1108. This would allow mine operators to use either conveyor belts approved under 30 CFR 18.65 or accepted under the voluntary program.

The primary hazard associated with the belt entry today is the existence of conveyor belting which can be ignited and propagate flame along its length. Belt fires when they reach the propagation stage produce more fire gases and spread faster than the surrounding coal surfaces. The committee believes that the elimination of this major fire source through the introduction of improved belting materials is the single greatest achievement that can be made in reducing the hazards associated with belt entries.

How do they [illegible] since they admitted they [illegible] [illegible]

EVALUATION OF BELT VENTILATION FACTORS

To evaluate the benefits and risks associated with the common methods of ventilating belt entries, the review committee examined and analyzed the safety goals of 30 CFR 75.326 as expressed in the standard and in the legislative history. The committee also identified other factors that influence the degree of protection provided to miners by the various methods of ventilating belt entries that should be considered when evaluating the suitability of a belt ventilation system. Our analysis is discussed below.

SEPARATION FROM INTAKE AND RETURN AIRCOURSES

The legislative history of 30 CFR 75.326 is silent with respect to the requirement for separating intake and return aircourses from belt haulage entries. However, Congress recognized that while it was important to keep belt fire contaminants from reaching the working places, separating the belt entry also served to protect the intake escapeway. The Senate Report of the bill that resulted in the Coal Act discussed this issue in the context of intake escapeways. It stated:

> This section requires that all new mines separate the escapeway which is on intake air from the belt or trolley haulageway because mine fires often originate in these haulageways and within a relatively short time the air current is completely filled with smoke, and harmful matter. [Reference 15, p. 84].

It is important that belt haulage entries be physically separated from intake escapeways. If they are not separated, a fire in the belt entry will quickly and directly contaminate the intake escapeway, the working places, and the return aircourses with the products of combustion. Miners working inby the fire would be required to travel in contaminated air to escape. In the committee's view, physical separation of belt haulage entries from intake escapeways is essential. To the extent possible, mine ventilation systems should be designed, installed, and maintained to enhance the integrity of intake escapeways from contamination by fires in belt entries.

When Congress enacted the provision which is now reflected in 30 CFR 75.326, it was their expectation that contaminants from any fire in the belt entry would be contained if that entry was physically separated from the other entries by permanent stoppings. Likewise, it was their belief that those fire contaminants could be coursed directly to the return. Accordingly, miners at the working places could be effectively protected from the products of any fire within the belt entry.

The results of our review illustrate that the objective of Congress to provide isolated aircourses is not achievable with reliable results in underground coal mines and that air leakage occurs between mine entries even when separated by substantially constructed permanent stoppings. This leakage occurs even when the pressure drop between the entries is very small. Leakage occurred in varying amounts on every section that was evaluated in our survey. Similarly, leakage between aircourses can be expected in all underground mines even when separated by well maintained, permanent stoppings.

This is supported by a recent study by Robert J. Timko, a physical scientist with the Bureau of Mines. He conducted an evaluation of the integrity of the escapeways in a three-entry underground mine. Timko found that:

> Air leakage occurs through stoppings or the coal seam when the entries have different atmospheric pressures. Air always flows from higher pressure to lower pressure. Intake entries have higher atmospheric pressures than return entries. Belt entries, because they are airflow restricted, typically have pressures somewhere between intakes and returns. [Reference 28, p. 1].

The study concluded that

> This research has shown that the permanent separation of entries does not guarantee safe egress from an escapeway fire. Stoppings in this mine were structurally and visually sound. Their construction method conformed to industry standards. In each test a significant portion of the simulated fire by-products flowed between entries... [Reference 28, p. 7].

Therefore, while Congress intended that the belt entry be isolated, this cannot be accomplished reliably. Air from entries having higher pressure will migrate to the belt entry. Likewise, if the atmospheric pressure in the belt entry is higher than other adjacent entries, the air from the belt will migrate toward them. The tendency for intermingling of separated intake air flows negates the notion of isolated entries with protected air quality. Therefore, the intent of Congress to maximize protection of face workers from the contaminants of a belt entry fire can best be achieved by strategically locating the intake escapeway so that the potential for leakage is from the escapeway to adjacent intake airways and then to the return. The intake escapeway should be provided with sufficient capacity to maintain this direction of leakage.

We recognize that encouraging leakage from the intake escapeway toward the return would foster contamination of all intake entries if a fire should occur in the intake escapeway. This finding was confirmed by Timko's study. [Reference 28]. A mine design that encourages flow from the intake escapeway to other intake entries and then to the return certainly would tend to contaminate all entries if the source of contamination were located in that entry. Accordingly, we recommend that the intake escapeway be maintained free of potential fire sources unless such sources are protected by fire suppression or other acceptable devices.

The importance of protecting the intake escapeway from leakage from the belt entry or any entry containing fire sources is illustrated by the belt fire at the Marianna Mine on March 17, 1988. At the time of the fire, belt air was being used to ventilate the working face. The fire originated in the mains at a belt drive. There were four intake entries in the area; the belt, track, a common entry with the track, and a designated intake escapeway.

Some stoppings had been partially or totally removed between the track entry and the belt entry, making these entries common. The intake escapeway, located between the belt entry and a return, was regulated by the mine layout and provided little ventilation to the working sections. Some of the air it delivered to the sections was leakage from the belt entry.

Smoke from the belt fire immediately entered the track entries just inby the fire through the open crosscuts. Smoke also filled the intake escapeway through leakage from the high pressure track and belt entries toward the return. In this fire, mine design contributed to the fact that all intake aircourses became contaminated in the early stages of the fire and necessitated the escape of inby crews through heavy smoke.

The Marianna Mine fire also leads us to conclude that training on mine evacuation under fire conditions must be stressed. The Bureau of Mines study of the evacuation during this fire showed that many of the miners were unprepared to travel through the smoke they encountered while exiting the mine. An emphasis should be placed on communications, evacuation procedures, and precautions for escape through smoke.

A mine design that protects the intake escapeway by encouraging leakage away from that entry and toward the return, early warning of a fire in the belt entry, and proper training on mine evacuation would better serve to protect face workers.

There also are valid reasons for separating return aircourses from belt haulage entries. Return air leaving a production face usually is contaminated with float dust, respirable dust, and methane. These contaminants are properly directed to return entries where activity is limited and ignition sources are not present. Accordingly, the review committee finds no reason to relax the requirement for separating belt haulage entries from return aircourses unless there are other compelling safety considerations.

LIMITING BELT ENTRY AIR VELOCITY

When the Coal Act was written, the prevailing sentiment was that the air velocity in belt haulage entries should be maintained at the lowest possible level that would provide an adequate supply of oxygen and ensure that the air would contain less than 1.0 percent methane. This was based on the belief that lower air velocities would lessen fire propagation, inhibit the rapid spread of contaminants to working places thereby increasing escape time, and reduce float coal dust levels in belt entries.

A minimum air velocity is required to ensure positive airflow in the belt entry and to prevent dead spots and air reversals. This minimum air velocity depends on the ventilating pressures and the cross sectional area of the entry involved and often exceeds the velocity required to supply oxygen and dilute methane. In several of the mines surveyed for this review, belt entry air velocities were limited to very low values. In a section in one of these mines, belt air was flowing opposite the intended direction.

Several variables affect methane dilution and layering, such as the source of methane, dip of the entry, airway area and air velocity. Research has shown that the ability of the air stream to dilute methane and prevent layering generally increases with air velocity and that while an entry air velocity of 100 fpm may help prevent layering, it is no assurance that layers will not occur in some areas. Air velocities should be established which are appropriate to the conditions of the mines to ensure methane dilution and removal of methane layers. [References 1, 2 and 4]. Finally, a belt entry air velocity of at least 50 fpm is required in mines that use carbon monoxide monitoring systems since these systems depend on the ventilating current to transport fire products to the sensors. [Reference 21].

Fire Propagation

In 1985, a conveyor belt fire test program was initiated by MSHA and the Bureau of Mines. The purpose of the program was to assess data from large and small scale belt flammability tests and to evaluate belts meeting the flame resistance standards of MSHA and agencies of other countries. As a part of this program, evaluation of the effect of entry air velocity on the burning properties of mine conveyor belts was initiated [References 13 and 30].

During testing of conveyor belts in the Bureau of Mines large-scale fire gallery, belt flame propagation rates were studied at air velocities ranging from 150 feet per minute (fpm) to 1200 fpm. The results of the initial belt fire tests in the gallery showed that, under the test conditions, the highest belt flame propagation rate occurred at gallery air velocities of 300 fpm. Flame propagation rates decreased, except in one case when it remained the same, when the entry air velocity was increased to 800 fpm. In the few tests with an entry air velocity of 150 fpm, belt flame propagation rates were also reduced when compared to the 300 fpm air velocity tests. Two tests were conducted to determine the flame propagation rates of styrene-butadiene rubber (SBR) belts. In the first test, flame spread rates were: 0.7, 3.0 and 1.3 fpm at velocities of 150, 300, and 800 fpm, respectively. In the second test, on a different SBR belt, flame spread rates were: 9.8, 18.0, and 2.0 fpm at the same respective velocities. These results indicate that 150 fpm air velocity does not always result in lower flame spread rates when compared with 800 fpm. [Reference 31]. The concept of reduced flame propagation rates with increased air velocity above some critical point is not new. [Reference 9].

Information from the Bureau of Mines, based on the results of more than 70 separate tests, indicates that increasing air velocities above 300 fpm does not enhance flame propagation along a conveyor belt. On the contrary, all test data indicate that the opposite is generally true and that under no test condition did the increased air velocity result in belt flame propagation rates greater than exhibited at a 300 fpm gallery air velocity. Available data show that as the gallery air velocity increased from 300 fpm to 800 fpm it became more difficult to ignite the conveyor belt and that, once ignited, lower concentrations of toxic contaminants and lower air temperatures were present downstream. The large-scale test results give no indication that belt flame propagation will increase with ventilating rates exceeding 800 fpm, however, test data at 1200 fpm is limited. In summary, test data do not support limiting belt entry air velocities on the basis of belt flame propagation. Appendix B contains a more complete discussion of these recent data.

Current Bureau of Mines tests use a coal bed fire to ignite the conveyor belt. They were designed to study fire growth rates, flame propagation, and fire warning times at air velocities of 150 to 1200 fpm. A series of tests with SBR belts have been completed. The Bureau plans to continue these tests with PVC belts at the same velocities. Based on data on PVC belts from earlier tests, the committee does not expect the PVC test results to affect the conclusions of this report.

Margaret R. Egan, a chemist with the Bureau of Mines, in her work, Coal Combustion in a Ventilated Tunnel, investigated the impact of air quantity and velocity in small-scale fire tests. In the tests the velocity ranged from 73.8 fpm to 135.2 fpm, and in this range she found that the fire size increased with velocity and the CO concentration decreased because of dilution. [Reference 10]. Similar results were reported in an earlier work, Wood Crib Fires in a Ventilated Tunnel, where a maximum velocity of 307.6 fpm was used. This work was done to provide knowledge about the combustion products emitted. These tests do not answer questions concerning the behavior of coal or wood fires with respect to increases in velocity. [Reference 9]. The recent belt flammability tests showed that the coal fire growth rate also increased with velocity from 150 fpm to 300 fpm. That growth rate, however, was slightly lower at velocities above 300 fpm. Additional research is necessary to provide information on the growth and spread of mine fires involving materials other than conveyor belts.

Traditionally, the mining industry has believed that higher entry air velocities will fan and propagate a fire to a greater extent than lower air velocities. Underground fire fighting techniques call for the reduction of air velocities passing through a fire area as a part of direct fire fighting methods. In light of the information now available, the committee recommends that further research be done to evaluate the impact of the recent data as applied to underground fire fighting.

Escape Time

Safe escape from inby a belt fire can best be ensured by providing an escapeway that is relatively free from fire contaminants, by providing early warning of the fire, and by responding immediately. As previously discussed, the maintenance of separation between the belt entry and the intake escapeway is very important. Equally important, is the early warning of a fire in the belt entry.

Congress addressed the issue of fire warning by requiring that all underground conveyor belts have devices installed which will automatically warn when a fire occurs on or near the belt. This requirement is found at section 311(g) of the Coal Act and at 30 CFR 75.1103 of Title 30. Sensors responding to a rise in temperature at a point (point-type heat sensors) have been installed in most belt entries to meet the requirements of this section. Point-type heat sensors, however, have significant limitations.

Point-type heat sensors are required by 30 CFR 75.1103-10 to be spaced not more than 125 feet apart when the average belt entry air velocity is equal to or less than 100 fpm and not more than 50 feet apart when the air velocity exceeds 100 fpm. However, these spacings do not permit detection of a belt fire in its early stages of development. For air velocities ranging from 40 to 320 fpm, Charles D. Litton, Supervisory Physical Scientist with the Bureau of Mines, reported that:

> The spacing requirements are in fact so severe for the range of ventilation velocities involved, that only continuous thermal sensors are of any practical value. [Reference 17, p. 13].

Fire data have shown that point-type heat sensors do not reliably detect fires in the early stages of development. Of the 39 belt fires that have been reported in the last 19 years, only 2, both on idle sections, were detected initially by point-type heat sensors.

The performance of point-type heat sensors is also impacted by higher belt entry air velocities. In the Bureau of Mines coal bed fire tests, point-type heat sensors installed 45 feet from the fire gave warning times before belt flame propagation as follows: 8.5, 5.3, and 0.0 minutes at velocities of 150, 300, and 800 fpm, respectively. These warning times were significantly less than those provided by CO sensors and smoke detectors in the same tests.

CO monitoring systems offer an improved means for early fire detection. They have proven to be more reliable and dependable indicators of belt entry fires than point-type heat sensors. CO monitoring systems have been installed in approximately 90 mines to satisfy the requirement for automatic fire warning devices and to provide additional safety precautions when belt entry air is used to ventilate the working places. Because of their sensitivity, these systems can provide increased fire warning times at far greater spacings than point-type heat sensors. Litton reports:

> For this application, a critical fire size is defined as that size of fire for which belt ignition and subsequent flame spread down the belt is assured. Detection and alarm, regardless of sensor type or sensing methodology, must be achieved at some point in time before the critical fire size is reached. Based on this approach, it is found that the horizontal spacing for Products-of-Combustion sensors is in the range of 300 to 600 meters, while the thermal sensor spacing is found to be about 4 meters or less. [Reference 17, p. 1].

The increased warning times provided by CO monitoring systems can improve the ability of miners to escape from inby a belt entry fire. For this reason, all petitions for modification granted by

MSHA to allow the use of belt air to ventilate active working places have required the installation of CO monitoring systems.

CO monitoring systems have limitations, however. Some belts will liberate only small amounts of carbon monoxide if they slip in the drive or rub against supporting structures. As a result, these occurrences may go undetected by the monitoring systems. Under these circumstances, flame and fire have not been generated. Also, where diesel machines are used, the CO monitoring system will indicate warnings and alarms if diesel exhaust sufficiently contaminates the air passing over the sensor. In addition, MSHA has received complaints about the number of false alarms throughout the industry where CO monitoring systems are in use. These complaints have been investigated, and in part, led to the development by MSHA of formal inspection procedures.

In October of 1988, MSHA began collecting field data about the performance of CO systems when a small fire or heating occurred, even though the time of the incident was less than the 30 minutes required for formal reporting under 30 CFR Part 50. Prior to collecting this data, MSHA only became aware of heatings or small fires of less than 30 minutes duration when complaints were received about the failure of a CO system. Thirteen heatings or small fires have been reported to MSHA where CO monitoring systems were installed. The CO systems gave a warning in 11 out of the 13 occurrences. In two of the eleven cases, employees smelled smoke at about the same time the CO systems alarmed. The tables in Appendix C summarize reports of CO system operation.

CO monitors were present in four of the fires reported to MSHA since 1970. The monitors in two of the fires were not properly maintained and did not provide warnings. [References 11 and 18]. The systems worked where the other two fires occurred, although one fire was discovered by the belt examiner at about the same time the warning was indicated by the system. In this case, water was not available to fight the fire and it spread out of control. In the second case, the monitor detected the fire before the smoke became visible. The smoldering coal was found before flame appeared and it was extinguished within ten minutes after it was located. [Reference 7].

The most recent tests by the Bureau of Mines have indicated that the increased air quantity associated with an air velocity above 300 fpm reduces the warning time provided by CO sensors. The warning time prior to belt flame propagation is about 16 to 20 minutes with the traditional CO sensor alarm setting of 15 ppm when the velocity is 300 fpm or under. This velocity equates to a quantity of approximately 24,000 cfm in the 81 square foot test gallery. At the 15 ppm threshold, the warning times decreased to 14.5 and 8.5 minutes at 800 and 1200 fpm, respectively. Warning times can be slightly improved by reducing the alert and alarm levels when the quantity of air used to ventilate belt entries exceeds 24,000 cfm.

The technology of CO monitoring systems has improved over the last few years. For example, moisture in the mine caused earlier sensors to falsely indicate CO. Sensors now on the market are not affected by the normal moisture levels encountered in underground mines. In addition, the Agency's experience at mines using monitoring systems is that maintenance improves as the mine technicians become more proficient with the systems.

We believe that CO system performance standards would have prevented some of the early problems of CO system failures and false alarms. Requiring that the sensor demonstrate stable performance in the mine environment would have prevented the necessity for post-installation product upgrades and modifications by manufacturers. Requiring minimum basic standards for system performance, such as loss-of-power alarms, protection from interference by mine power systems, and sensor stability in the mine environment would have prevented many of the early CO monitoring system problems. [Reference 25]. Performance standards for CO systems would ensure that manufacturers provide products of uniform basic quality to the industry.

Bureau of Mines tests have also shown the superiority of smoke detectors, especially when higher quantities of air are used. (See Table 1 in Appendix B.) Also smoke detectors offer a solution to the diesel and belt slippage problems. Accordingly, we recommend that MSHA initiate the development of performance standards for smoke detectors and encourage field tests. Performance standards for smoke detectors would prevent a possible recurrence of the CO system problems.

Systems ventilating inby through the belt entry and directing belt air to the return outby the loading point and systems ventilating outby through the belt entry offer the greatest potential for protecting face workers from contaminants from a belt fire. However, these systems allow for the use of point-type heat sensors which do not provide early fire detection. This could negatively impact safe escape. Accordingly, we recommend improvement or replacement of point-type heat sensors

Systems directing belt air to the face will always allow fire contaminants to reach the working face. Therefore, early fire detection is critical. It is essential that CO monitoring systems or other improved detection systems be installed in belt entries utilizing this method. It is equally important that MSHA continue to stress the maintenance of present systems and encourage development of improved systems.

Float Coal Dust

The effect of any ventilation system on potential generation, entrainment and disbursal of float coal dust was a major concern of Congress. Potential hazards associated with accumulations of float coal dust cannot be overstated. Any readily observable accumulation on mine roof, ribs, floor or belts can contribute to explosion propagation. [References 23 and 24]. In his study on explosion hazards in mining, John Nagy, a retired MSHA physical scientist, states:

> "... the accumulation of coal on the conveyor belt or mine cars is a necessary result of the mining operation, and under normal conditions will be transported out of the mine. Coal dust on the mine floor and ribs cannot be justified by the mining process." [Reference 22, p. 48].

Our review of the literature leads us to conclude that there is no direct relationship between coal dust ignitability and ventilation. Concerning the effects of ventilation on mine explosions, Nagy states:

> The mine ventilating air has no direct effect on explosion propagation; however, if the ventilation system is inadequate, the chance of a methane accumulation is increased. The amount of water vapor in the mine atmosphere is too small to affect explosion development.
>
> The velocity of a strong ventilating air current is very much less than that of the slowest explosion. For example, at a ventilation velocity of 800 fpm the air velocity is 13.5 feet per second or less than one-tenth of the velocity of the slowest explosion that propagates flame. Moreover, the static pressure developed by the slow explosion is at least 10 times greater than the highest ventilation pressures used. In actual explosion tests made with ventilating air velocities ranging from 0 to 850 fpm, no significant effect of the direction of the ventilating air was observed on explosion development.
>
> The idea that coal dust explosions "always go against the air" arises from the fact that in cold weather the intake air tends to dry the dust, whereas the return air is usually saturated and the dust is damp and less dispersible. [Reference 22, p. 46].

Generation of float coal dust (the making of float coal dust) is not expected to be an issue in the selection of a belt entry ventilation system. This is because the generation of float coal dust is a function of the mechanical action of the mining process and not a function of the air velocity in an entry.

Studies have established that air at a velocity of 800 fpm or greater will carry dust which is being generated and put into suspension by the mining or coal transportation process. [Reference 27]. In most mines, these velocities are not found at float coal dust generating points such as faces, dumping points, and transfer points.

The same studies also show that air velocities in excess of 1500 fpm will lift and carry away accumulations of coal dust from flat surfaces. The only regularly occurring potential for entrainment is where brattices, stoppings, or regulators are built in the belt entry. This is because the belt must pass through these structures causing high velocities of air to pass very close to the coal. Velocities of this magnitude also exist near the intake point of the belt entry in a relatively small number of mines using belt air to ventilate the faces. [References 22, 23, 24, and 26].

Disbursal of float coal dust (the depositing of airborne float coal dust) is expected at any air velocity. Once float coal dust is airborne any movement of air will transport it with the air flow. The area of disbursal or distance the airborne dust will travel is directly influenced by the air velocity. Therefore, the greater the air velocity the greater the distance over which float coal dust will be deposited. [References 22, 23, and 24].

Considering the above, we conclude air velocity will not introduce additional hazards associated with float coal dust generation, entrainment, or disbursal unless:

1 velocities above 1500 fpm are present at locations where float coal dust accumulations exist, or

2 velocities above 800 fpm are present at float coal dust generating points.

However, when such situations are encountered, technology exists to control dust in these areas. For example, application of water at dust generating points, clean up of accumulations, inerting with additional rock dust, and wet rock dusting of roof and ribs reduce the hazards associated with float coal dust.

OTHER FACTORS

The committee identified two factors related to belt entry ventilation that appear not to have been considered by Congress when it enacted the Coal Act. These factors are the impact of belt ventilation on respirable dust at the working faces and its impact on fighting a fire in the belt entry. The committee believes that these factors are important enough to warrant consideration when evaluating the overall effect of belt entry ventilation on miner health and safety.

Respirable Dust

The impact of belt entry ventilation on respirable dust has been given considerable attention by the UMWA as well as by MSHA. The concern is that significant levels of respirable dust are generated within the belt entry from such sources as crushers, transfer points, dump points, or the coal moving in the opposite direction from the air. It has been suggested that, if not controlled, the dust can be picked up by the airstream and, if allowed to be used to ventilate the working places, can contribute to face workers' exposure.

To address this concern, the review committee asked the Division of Health within Coal Mine Safety and Health to review the levels of respirable dust in belt entries and to determine the impact of utilizing the air from such entries at the working faces. The report is included as Appendix D. In addition, the committee reviewed existing studies conducted by Technical Support's Health Technology Center in Pittsburgh. [References 5 and 29]. This review led us to conclude that utilizing air from the belt entry to ventilate the working places should not adversely affect workers. The basis for these conclusions is outlined below.

Existing standards require that air in the belt entries be sampled on a regular basis to determine the concentration of respirable dust. At no time is the concentration of dust in these entries allowed to be above 2.0 mg/m^3. In addition, present standards require the concentration of any air used to ventilate the working section to be maintained below 1.0 mg/m^3 within 200 feet of the face. Lastly, if belt air is being used at the face under the terms of a petition for modification, the level of respirable dust within the belt entry outby the tailpiece cannot exceed 1.0 mg/m^3. These provisions are designed to ensure that any intake air reaching the working faces will not overexpose workers.

The Division of Health's examination of MSHA's respirable dust database confirms that samples of air taken within belt entries are within the level established by the standard. For example, the mean dust concentration in the belt entry for fiscal year 1988, as measured by operator and inspector samples, was 0.6 mg/m^3 and 0.5 mg/m^3, respectively. In addition, the study found no evidence to show that coursing belt air to the face adversely impacts respirable dust concentrations. (See Appendix D, pg. 3.)

Clearly there are sources within the belt entry that can generate dust; and the possibility of entraining dust is increased with higher velocities within that entry. However, existing technology can control the dust at those sources and the effect of dilution due to increased velocities more than compensates for any increases due to entrainment. (See Appendix D, pg. 7.)

An additional finding by the review committee is that the use of belt air to ventilate the working places may improve respirable dust levels for face workers. Because belt air (and any intake air) must be at or below a concentration of 1.0 mg/m^3 within 200 feet of the face, this additional quantity of air can be used to dilute dust generated in the face area, especially during longwall mining. This finding was also supported by the Division of Health study (Appendix D, pg. 7).

Fire Fighting

Fighting a fire in an underground coal mine is an inherently hazardous activity. Two miners have died in the last 4 years after fighting fires underground, one of which was a conveyor belt fire. According to a survey of the 39 conveyor belt fires that have been reported to MSHA since 1970, this is the only death attributable to a belt fire.

The ability to locate and effectively fight a fire is significantly influenced by the air velocity over the fire. At lower air velocities, smoke from a fire will back up against the ventilating current preventing fire fighters from approaching the flames. Smoke from a large fire has been known to travel at an estimated 150 feet per hour against a ventilation speed of 250 fpm. [Reference 6, p. 17]. The survey revealed that in the belt ventilation methods evaluated, the velocity of air in the belt entry would not have prevented rollback of smoke from a fire.

While fighting any fire is hazardous, the danger is magnified in entries with air moving outby. Fire fighting crews would have to work inby the fire. If the fire were to burn through into the intake, escape could be cut off. Waterlines that are installed in the belt entry would be exposed to the fire outby the area where water is needed. Heat from the fire could melt or otherwise damage the waterline necessitating the installation of a separate waterline around the fire. The delay in water availability for fire fighting could reduce the possibility of expediently extinguishing the fire and prolong the fire fighters exposure to the hazards of the fire. Accordingly, the committee recommends that where the belt is being ventilated with air moving outby, the waterlines should be located in an adjacent intake airway.

One alternative to fighting a fire from a location inby the flames is to reverse the air direction in the entry. Although this is sometimes done, it is in direct conflict with recognized fire fighting procedures. [Reference 6, p. 18]. Reversing the air, thus returning unburned distillates to the fire or forcing smoke and distillates that have backed up against the air current back over the flames, is hazardous.

The conveyor belt fire at the Shoemaker Mine illustrates the difficulties of fighting a fire in an entry with air traveling outby. In this instance, a roof fall in the fire area had broken the waterline before a fire hose could be connected and used. To provide water, a fire car was brought to the area in the adjacent track entry but heavy smoke entering the track entry through an overcast was moving against the 150 fpm air velocity and prevented the car from approaching the fire. Three different ventilation controls were adjusted, all inby the fire and in smoke, to increase the track entry velocity to clear the smoke. By this time, dense smoke and extreme heat prevented access to the belt entry. To gain sufficient air velocity in the belt entry to clear the smoke and gain access to the flames, several stoppings were removed between the belt entry and intake escapeway outby the fire and the air in the belt entry was reversed. Fortunately, the proximity of an intake shaft made sufficient air available and allowed fire hose to be lowered into the mine from a fire truck on the surface. Once water was applied to the fire, it was extinguished within a few hours. [Reference 12].

VENTILATION SYSTEM EVALUATIONS

The review committee identified three basic methods that are being used to ventilate the belt entry:

1 air directed inby and coursed into the return;

2 air directed outby from the working places; and

3 belt air used at the face and monitored for carbon monoxide.

As part of this review, the committee requested that Technical Support undertake an evaluation of section ventilation systems. Four mining engineers and one electronics technician from the Ventilation Division, Pittsburgh Health Technology Center, and four ventilation specialists from Coal Mine Safety and Health surveyed the ventilation systems of 17 mining sections in 10 mines to obtain a cross section of industry practice under varying conditions. The results of their survey were presented to the committee for review and analysis. A summary of their findings as well as section line drawings are in Appendix E.

The following is a description and evaluation of each of these methods.

AIR DIRECTED INBY AND COURSED INTO THE RETURN

This method, one of the most common means of belt entry ventilation, directs air inby along the belt entry to the section loading point. At this location the flow is interrupted by a ventilation check across the belt entry and the air is diverted into the section return. The velocity of the air flow in the belt entry is limited by the return opening. Three of the sections surveyed used this technique with air entering the return through a restricted opening and three others used a modified version, as discussed below.

The survey of section ventilation indicated that leakage of air between mine intake entries may happen even when separated by substantially constructed permanent stoppings with very low ventilation pressure differentials. For example, in one section, which was five crosscuts off the mains, approximately 7,000 cfm of air leaked from the mains belt entry into the section's intake escapeway. This leakage occurred between the previously developed section and the survey section. Total escapeway flow in the leakage area was approximately 20,000 cfm and the pressure differential across the stoppings was approximately 0.01 inches water gage (wg). Should a fire occur along the belt entry in the mains serving this section, contaminants would be delivered to the section escapeway.

The study also showed that installing a ventilation check at the belt loading point could have the effect of pressurizing the belt for some distance outby. This has the potential to increase the amount of leakage from the belt entry and was demonstrated in two of the sections surveyed.

It also should be noted that in the three cases using a restricted opening to the return, the air in the belt entry was not being directed to the return. Virtually all of the air in the belt entry was reaching the face by leakage through or around the belt entry check. This occurred even where the check outby the loading point was considered to be tight. This method of belt ventilation does not effectively prevent belt air from ventilating the face and contaminants from a fire in the belt entry would travel to the face. However, unlike mines which take belt air to the face under the terms of a petition for modification, there is no requirement to use a CO monitoring system to alert miners to a fire in the belt entry.

Belt entry air velocities in two of the sections of this group were quite low, ranging from 14 fpm to an estimated 35 fpm. In the third section, an improperly installed check permitted a greater air velocity of about 50 fpm. In the first two instances methane released in the belt entry would accumulate freely with little mixing. In the higher air velocity, methane mixing will take place but methane layering could occur.

In further evaluating this method, the review committee concluded that taking the air inby would aid in fighting fires that occur in the entry. However, with the velocity limited, smoke from a fire would be expected to roll back in the entry. This method also provides another potential intake escapeway from the section in the event of a fire in another separated intake entry. Because the air velocity in the belt entry is limited, this system should not contribute to the entrainment of float coal dust, however belt entry ventilation may be inadequate to prevent methane accumulations.

The three modified versions of this system delivered belt air to an area boxed in by a combination of checks and stoppings near the belt loading point. In a four-entry version, the belt was in the no. 3 entry. The belt air was diverted by checks to the return in the no. 2 entry through a regulator one crosscut outby the loading point and through a split check across the no. 2 entry adjacent to the loading point. Although 10,000 cfm of air flowed inby along the belt entry to the belt tailpiece area and 13,000 cfm of air entered the no. 2 entry return through the regulator and split check, tracer gas showed that a small quantity of belt air traveled to the working place.

In the two other four-entry systems, control of belt air was similar but less complicated. The belt air was diverted to the return by checks inby the tailpiece. In these versions, belt air was not indicated in the working places.

Belt entry ventilation with a regulator installed outby the section with belt air directed through another regulator with minimal restriction to the section return near the belt loading point was considered by the committee. However, none of the survey mines used this system. In this case, belt air may be delivered to the return with little, if any, leakage to the face. This method prevents contaminants from going to the face and, because of the intake regulator, promotes leakage into the belt entry. Because all of the belt air enters the return, there is little opportunity to see or smell smoke from a fire and no existing requirement for a CO monitoring system to detect the fire in its early stages. With this system, float dust could be entrained through belt entry regulation outby the section.

AIR DIRECTED OUTBY FROM THE WORKING PLACES

This method involves taking a split of intake air and directing it outby along the belt entry. The velocity and quantity of air entering the belt entry is generally controlled by a regulator near the mouth of the section where the belt air enters the return. With this method the belt entry functions in a manner similar to a return entry. Six sections which were surveyed were ventilated in this manner. Because airflow through the belt entry was restricted, air velocities in the belt entry outby the loading point were generally low. Only one section had an entry air velocity near the loading point in excess of 100 fpm (127 fpm). The other five had entry air velocities ranging downward from approximately 75 fpm to 33 fpm. Leakage from adjacent aircourses doubled or tripled the belt entry air quantity and velocity as it traveled to the return air course. Low air velocities in the area of the loading point may permit the accumulation and layering of methane in the affected areas. However, this problem would not exist along the outby areas of the belt entries where the velocities were higher.

In all instances, we would expect any contaminants from a fire in the belt entry to be directed to the return without entering the active workings of the section. In addition, since all leakage was into the belt entry, the intake escapeway was protected from any contamination from a belt entry fire.

In two additional sections the belt entry loading point was boxed into a neutral area by stoppings and checks and leakage ventilated the outby belt entry. Air velocities along the belt entries were very low. As in other systems, the low air velocities are less able to mix methane released in the area and accumulations and methane layers may occur.

A disadvantage of directing the air outby along the belt entry is that it reduces the number of potential escapeways available from the working section, since the belt functions like a return entry. In two of the four-entry sections, air leakage would cause smoke from a fire in the track entry to enter both the belt entry and the intake escapeway by leakage. The seriousness of this leakage depends on the quality of the stoppings and conditions in the entries.

This method of belt entry ventilation also results in the air flowing in the wrong direction for fire fighting purposes. A fire in the belt entry would have to be approached from the inby side, or the air on the belt would have to be reversed over the fire. Reversing air over a fire is hazardous and creates the potential for an ignition of unburned combustibles when the air is stopped and reversed. The low air quantities in the belt entries near the working faces also could result in a portion of the belt entry being inadequately ventilated to control methane or respirable dust. In one section surveyed, with a belt entry air velocity of about 33 fpm, a respirable dust concentration of 3.09 mg/m^3 was found outby the belt loading point. However, the increased quantities of air resulting from air leakage to the belt entry usually precludes similar problems outby.

This method of ventilating the belt is susceptible to being easily short-circuited. For example, whenever a man door is opened to the belt from an adjoining intake entry, the air flow inby the door would be reduced or even reversed.

The low velocity in the belt entry in the area where dust may be generated should preclude any problem with entrainment of float coal dust unless a regulator is installed across the belt entry. If this occurs, float dust may be entrained by air passing through the regulator.

BELT AIR USED AT THE FACE

This method of ventilation involves directing a split of intake air inby in the belt entry and using the air to ventilate the working places. Where permitted under a petition for modification, the use of a CO monitoring system is required. Three of the sections surveyed used belt air to ventilate the working places. Two of these were four-entry systems with the intake escapeway in the no. 2 entry which was adjacent to the return aircourse. The track entry, in the no. 3 entry, was between the escapeway and the belt entry in no. 4 entry. Air leakage or the potential for leakage was from the track to the belt and from the track to the intake escapeway in both sections. As in many of the other sections, a fire in the track entry of either section would leak contaminants into both the belt and escapeway entries But, contaminants from a fire in the section belt entry would be confined to the belt entry.

In the deepest of the three sections, about 40 percent of the belt airflow was leakage from the track. Airflow in the escapeway was restricted by a check one crosscut outby the face and the escapeway was pressurized for a short distance. Leakage into the escapeway was less than 2,000 cfm. However, outby the escapeway check 7,000 cfm leaked from the escapeway, of which 3,000 cfm passed to the track entry. The escapeway would be protected from belt entry contaminants during the early stages of a fire by the higher pressure track entry. Pressure differentials between the intake airways was low, generally less than 0.02 inches wg. The airflow quantity in the belt entry ranged from 35 to 53 percent of that in the track entry. In the newly started four-entry development, the belt entry air flow quantity was 88 percent of that in the track entry.

The five-entry section was developed with only four crosscuts and leakage patterns had not yet developed. However, because of the section layout, with the intake escapeway adjacent to the no. 1 entry return and the belt entry adjacent to the no. 5 entry return, significant leakage between the escapeway and the belt entry should not occur.

With these three sections, contaminants from a belt entry fire would be carried to the working faces, however the smoke would be confined to the belt entry or the belt entry and return because of the indicated pressure differentials, leakage paths, and location of the respective entries. On the other hand, a fire in the track entry would leak contaminants into both the belt entry and intake escapeway in two of the three sections. The effect of the intake escapeway check curtain on air leakage between parallel intake aircourses clearly shows the impact of local artificial resistance on air leakage in mine airways. In these systems, leaving the belt entry unrestricted at the face improves the potential for containing fire gasses in the belt entry.

Using the belt entry as an intake aircourse separated from all others also provides an additional escapeway that can be used in event of an emergency. An additional advantage of using belt air to ventilate the working places is that the increased air quantity provides a positive and sometimes critical improvement in methane control at the face and in the belt entry. Also, respirable dust control on longwall sections may be improved by the use of belt air. The increased air quantity will aid in diluting respirable dust generated on the section.

Since the air is coursed inby, a fire occurring in the belt entry can be fought from outby the fire. Fire fighting equipment could be brought to the fire area and miners would not be required to enter smoke-filled areas to effect ventilation changes or for fire fighting purposes.

Air velocities of 800 fpm or greater will carry float coal dust being generated and put into suspension by the coal transportation process. In most mines these velocities are not normally found at float coal dust generating points along the belt entry. Where such velocities exist, technology is available to control float dust at these locations.

CONCLUSIONS AND RECOMMENDATIONS

Recognizing that the use of conveyor belts continues to present the potential for fires in underground coal mines, we have arrived at the following conclusions and recommendations. They cover the topics of fire prevention, separation and leakage, belt ventilation, intake escapeways, training, warning times, air velocity, and research.

Fire Prevention

Use of conveyor belts meeting the new and more stringent flammability tests developed by the Bureau of Mines would significantly reduce the hazards to miners from conveyor belt fires. The experience with conveyor belt fires suggests that increased emphasis should be placed on belt maintenance, belt entry clean-up, and rock dusting.

Separation and Leakage

Physical separation of the belt haulage entry from the intake escapeway is essential to provide miners with an escapeway to the surface in the event of a fire in the belt entry. Accordingly, the belt entry should be separated from the entry designated as the intake escapeway with substantially constructed and well maintained permanent stoppings as required by present regulations.

However, atmospheric isolation of adjacent aircourses is not achievable with reliable results in the mine environment. Even at low ventilation differential pressures, leakage between entries occurs. Therefore, the intent of Congress to maximize protection of face workers from the contaminants of a belt entry fire can best be achieved by strategically locating the intake escapeway so that the potential for leakage is from the escapeway to adjacent intake airways and then to the return. The intake escapeway should be provided with sufficient capacity to maintain this direction of leakage.

Belt Ventilation

There are three basic methods used to ventilate belt entries

1 In the first method, belt air is directed to the return immediately outby the section loading point. This method can be accomplished in two ways:

   a Belt air is directed to the return without significant restriction and the belt entry is immediately adjacent to the return. Air flow in the belt entry is regulated outby the section. This method of ventilating the belt entry complies with 30 CFR 75.326.

b Belt air is intended to be directed to the return through a restrictive regulator or pipe overcast. This alternative does not comply with 30 CFR 75.326 and should be discontinued for the following reasons:

1) Virtually all of the air in the belt entry will travel to the face rather than being directed to the return and this air is not required to be monitored for carbon monoxide.

2) Placing a ventilation check across the belt entry and attempting to direct the air into the return through a restricted opening will pressurize the belt entry for a distance outby thereby fostering leakage.

2 In the second method, belt air is directed outby from the section. While this method of belt ventilation complies with 30 CFR 75.326, there are problems associated with fire fighting and the inability to use the belt entry as a secondary intake escapeway. To mitigate the fire fighting problems, waterlines should be relocated from the belt entry to a separate intake entry.

3 In the third method, belt air is directed to the face. Under current petitions for modification, a CO monitoring system in the belt entry is required when this method is used. This method of ventilating the belt entry provides protection equivalent to complying with 30 CFR 75.326.

Intake Escapeways

Intake escapeways should be maintained free of potential fire sources unless such sources are protected by fire suppression or other acceptable devices.

Training

Training in proper evacuation procedures is critical to the safe escape of miners from inby a developing fire. This training should include instruction and drills in communication and evacuation techniques and instruction in precautions to be taken for escape through smoke.

Warning Times

Warning times provided by carbon monoxide monitoring systems to miners in the event of a belt entry fire are superior to that provided by point-type heat sensors. However, recent tests by the Bureau of Mines indicate that the dilution of contaminants provided by increased air quantities in the belt entry decreases the warning time provided by carbon monoxide systems. Smoke detectors can provide even greater warning times to miners due to greater sensitivity. We recommend that:

1 Mine operators use carbon monoxide or other improved monitoring systems to monitor belt air used to ventilate active working places.

2 MSHA and the Bureau of Mines encourage the development and testing of smoke detectors suitable for use in underground coal mines.

3. MSHA initiate the development of performance standards for CO monitors and smoke detectors, and that MSHA continue to stress the maintenance of CO monitoring systems.

4. MSHA consider requiring improvements to or replacement of point-type heat sensors to enhance early fire detection.

Air Velocity

The quantity of air needed to ventilate a coal mine depends primarily on the volume of methane produced and the level of respirable dust generated in the mine. If methane is present in the belt entry, a sufficient volume of air should be provided to ventilate the entry and prevent methane layering. Belt entry ventilation should discourage the leakage of fire contaminants from the belt entry into the intake escapeway. The primary concern should be to encourage air leakage away from the intake escapeway to the belt entry. Strategically locating the belt entry with respect to the intake escapeway and return may achieve this objective.

Test data do not support limiting belt entry air velocity on the basis of belt flame propagation. Normally, air velocity will have no impact on float coal dust generation or entrainment. In those few instances where high velocities exist or where dispersal occurs, technology for control is available. Accordingly, there is no reason to limit the velocity of air in the belt entry provided that the belt entry does not become the primary intake aircourse.

Additional Research

Further research should be conducted to evaluate the impact of air velocities on underground fire fighting and to provide information on the growth and spread of mine fires involving materials other than conveyor belts.

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APPENDIX A - CONVEYOR BELT FIRE TABLES

TABLE 1
CONVEYOR BELT FIRES, 1970 - 1988
BELT AIR USED AT THE FACE

DATE OF FIRE	HOW FIRE DETECTED	TYPE OF SENSOR	MAINTENANCE CONTRIBUTING FACTOR	IGNITION SOURCE	DURATION OF FIRE (HRS)	BELT BURNED (FT)	ESCAPE THRU SMOKE
77-07-13	SIGHT	HEAT	YES	FRICTION	2.50	UNKNOWN	IDLE
81-11-25	SIGHT	HEAT	YES	FRICTION	SEALED	UNKNOWN	NO
83-03-15	SENSOR	CO	NO	UNKNOWN	.75	0	NO
85-05-04	SIGHT	CO	NO	UNKNOWN	1.75	275	UNKNOWN
86-11-27	SENSOR	HEAT	YES	FRICTION	20.50	1200	IDLE
87-04-01	SIGHT	CO	YES	FRICTION	288.00	1200	IDLE
87-10-20	SIGHT	HEAT	YES	FRICTION	2.00	15	NO
88-03-07	SENSOR & SIGHT*	CO	YES	UNKNOWN	SEALED	UNKNOWN	YES
88-05-09	SMELL	HEAT	YES	FRICTION	1.25	1	NO
TOTALS: 9 FIRES	5-SIGHT 2-SENSOR 1-SENSOR& SIGHT 1-SMELL	5-HEAT 4-CO	7-YES 2-NO	6-FRICTION 3-UNKNOWN			4-NO 3-IDLE 1-YES 1-UNKNOWN

*FIRE DETECTED BY BELT EXAMINER ABOUT SAME TIME AS CO SYSTEM GAVE WARNING

TABLE 2
CONVEYOR BELT FIRES, 1970 - 1988
BELT AIR NOT USED AT THE FACE

DATE OF FIRE	HOW FIRE DETECTED	TYPE OF SENSOR	MAINTENANCE CONTRIBUTING FACTOR	IGNITION SOURCE	DURATION OF FIRE (HRS)	BELT BURNED (FT)	ESCAPE THRU SMOKE
70-01-12	SIGHT	NONE	YES	FRICTION	1.00	10	NO
70-08-07	SIGHT	UNKNOWN	NO	FRICTION	264.00	800	IDLE
73-11-20	SMELL	HEAT	YES	FRICTION	10.50	335	UNKNOWN
74-11-11	SIGHT	HEAT	NO	UNKNOWN	SEALED	0	IDLE
76-12-09	SMELL	HEAT	YES	FRICTION	3.00	UNKNOWN	NO
76-12-10	SIGHT	HEAT	YES	ELECTRIC	9.50	UNKNOWN	IDLE
77-03-20	SMELL	HEAT	YES	ELECTRIC	0.50	0	NO
77-09-23	SIGHT	UNKNOWN	NO	UNKNOWN	6.00	UNKNOWN	UNKNOWN
79-03-14	SIGHT	HEAT	NO	UNKNOWN	SEALED	UNKNOWN	IDLE
79-11-22	SIGHT	HEAT	YES	UNKNOWN	7.00	UNKNOWN	IDLE
80-09-07	SIGHT	HEAT	YES	FRICTION	4.00	0	NO
80-11-01	SENSOR	HEAT	NO	WELD/CUT	4.75	0	IDLE
80-12-15	SIGHT	HEAT	UNKNOWN	FRICTION	0.75	0	NO
81-11-07	SIGHT	HEAT	UNKNOWN	FRICTION	2.00	0	IDLE
82-02-03	SMELL	HEAT	YES	ELECTRIC	7.50	138	NO
82-03-26	SIGHT	HEAT	YES	FRICTION	19.50	800	YES
83-12-19	SMELL	HEAT	NO	FRICTION	2.00	35	NO
84-01-18	SIGHT	HEAT	NO	WELD/CUT	0.75	0	NO
84-04-16	SMELL	HEAT	YES	UNKNOWN	10.00	12	IDLE
84-08-08	SIGHT	HEAT	YES	FRICTION	2.50	0	NO
85-01-30	SIGHT	HEAT	NO	UNKNOWN	1.50	240	YES
85-02-24	SIGHT	HEAT	NO	UNKNOWN	5.00	67	IDLE
85-05-06	SIGHT	HEAT	YES	FRICTION	8.30	90	NO
85-08-18	SIGHT	HEAT	NO	UNKNOWN	20.50	UNKNOWN	YES
85-08-23	SIGHT	HEAT	NO	FRICTION	3.00	100	NO
86-01-04	SMELL	HEAT	NO	ELECTRIC	5.50	180	NO
87-12-09	BELT STOP	HEAT	NO	UNKNOWN	2.25	70	NO
88-05-13	SIGHT	HEAT	NO	UNKNOWN	1.75	20	NO
88-08-20	SMELL	HEAT	NO	WELD/CUT	2.70	178	NO
88-11-15	SMELL	HEAT	YES	UNKNOWN	2.00	UNKNOWN	YES
TOTALS:							
30 FIRES	19-SIGHT 9-SMELL 1-SENSOR 1-BELT STOP	27-HEAT 2-UNKNOWN 1-NONE	15-NO 13-YES 2-UNKNOWN	12-FRICTION 11-UNKNOWN 4-ELECTRICAL 3-WELD/CUT			15-NO 9-IDLE 4-YES 2-UNKNOWN

APPENDIX B - CONVEYOR BELT FLAME TESTS

During testing of conveyor belts in the Bureau of Mines (BOM) large-scale fire gallery at Lake Lynn, Pennsylvania, belt flame propagation rates were studied at air velocities ranging from 150 feet per minute (fpm) to 1200 fpm. Not all air velocities were considered in all tests. Both double and single strands of belting were tested when supported on a commercial belt structure installed in a fire gallery 90 feet long and 81 square feet in cross-section. In some tests double strands of conveyor belt with coal on the top belt were burned. Summaries of much of this work have been made available to the industry. [References 7 and 20].

The results of the initial belt fire tests in the Bureau of Mines Lake Lynn fire gallery showed that, under the conditions of test, the highest belt flame propagation rate occurred at gallery air velocities of 300 fpm. Belt flame propagation rates decreased, except in one case when it remained the same, when the entry air velocity was increased to 800 fpm. [Reference 14]. In the few tests with an entry air velocity of 150 fpm, belt flame propagation rates were also reduced when compared to the 300 fpm air velocity tests.

Subsequent tests at the Lake Lynn facility using conveyor belt similar to that involved in the Beth Energy Mines, Inc., Marianna Mine fire with coal placed on the top belt strand also showed that belt flame propagation decreased as the gallery air velocity increased from 300 fpm to 800 fpm. In these tests flame propagation rates were two to three times higher at 300 fpm than at 800 fpm. These tests also showed that the maximum temperatures downstream of the fire were 63% higher at the lower gallery air velocity (2,192°F versus 1,346°F) and that the gallery exit temperatures were 117% higher than those at the higher air velocity (806°F versus 388°F).

Current BOM tests use a coal bed as the conveyor belt igniting source instead of the liquid fuel of earlier studies. The coal bed source is ignited by electric strip heaters imbedded in the coal pile to provide a more realistic fire source which may occur underground. These tests are designed to investigate growth rates of the coal fire and subsequent belt fire, flame propagation of the belt, and fire detection capability in various air velocities. The test used a single strand of belting suspended about 3 inches above the coal bed. Preliminary results obtained with belting similar to the Marianna belt, support previous findings of belt flame propagation relative to gallery air velocity. The tests show that, under the conditions of test, at air velocities ranging from 150 fpm to 1200 fpm:

1 The interval between coal pile ignition and belt ignition increased with air velocity: The time between coal pile ignition and conveyor belt ignition increased from approximately 9 minutes at an air velocity of 150 fpm to about 25 minutes at an air velocity of 1200 fpm.

2 The interval between coal ignition and flame propagation on the belt increased from approximately 24 minutes to 37 minutes as the air velocity increased from 150 fpm to 1200 fpm.

3 Both the coal fire growth rate and the belt fire growth rate in kilowatts/minute increased dramatically from an air velocity of 150 fpm to 300 fpm and then decreased at air velocities of 800 fpm. (Data for 1200 fpm were not obtained due to equipment failure.)

4 The rate of carbon monoxide production from 15 TO 200 ppm decreased when the air velocity was increased to 300 fpm, and further decreased at an air velocity of 800 fpm.

5 The time from a 15 ppm carbon monoxide roof alarm near the fire until the average concentration of carbon monoxide reached 200 ppm was approximately 10.5 minutes at a test air velocity of 150 fpm, approximately 16 minutes at 300 fpm, and 17 minutes at 800 fpm. The peak CO concentrations were: 350, 580, and 372 ppm at velocities of 150, 300, and 800 fpm respectively.

6 The intensity (kilowatts) of the coal fire required to ignite the conveyor belt increased linearly with gallery air velocity. Initial tests indicate that it requires a coal fire with more than five times the strength, in kilowatts, to ignite the belt at a gallery air velocity of 800 fpm when compared to a coal igniting fire at an entry air velocity of 150 fpm, and 2.5 times the strength of an igniting coal fire at a gallery air velocity of 300 fpm.

The tables and graphs on the following pages summarize the test data.

TABLES 1 AND 2
BUREAU OF MINES BELT FIRE TESTS
COAL BED IGNITED

68 ft person fire service

TABLE 1

TIMES FOR VARIOUS EVENTS FROM HEAT TURN-ON (MINUTES)
BELT PASSES 2G TEST

TEST NO	AIR VELOCITY (FPM)	VISIBLE COAL SMOKE	VISIBLE COAL FLAME	BELT IGNITION	BELT FLAME PROPA-GATION	BEACON ROOF SMOKE ALARM	15 PPM ROOF CO ALARM	5 PPM ROOF CO ALARM
GAC-81-A	150	11.5	22.0	30.5	46.0	17.5	29.6	19.3
GAC-78/85	300	13.0	22.5	38.5	56.3	18.4	35.8	22.8
GAC-80	800	14.0	24.0	44.0	59.5	29.5	45.0	42.5
GAC-83	1200	16.0	24.4	49.0	61.0	34.0	52.5	----

SOURCE BUREAU OF MINES

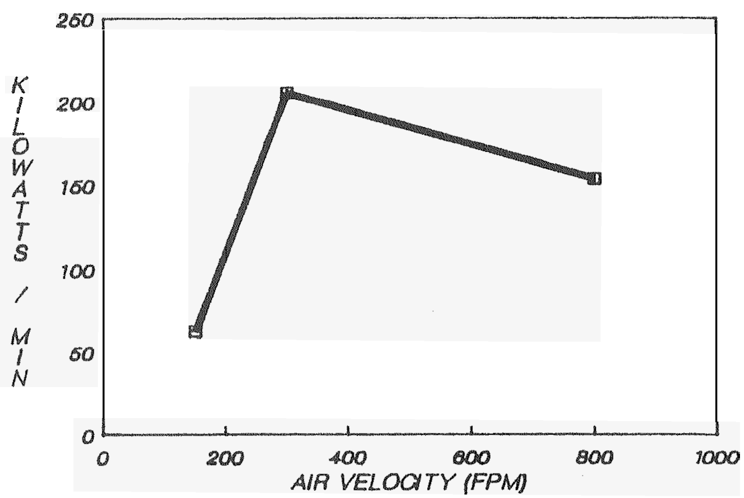
TABLE 2

TEST NO	AIR VELOCITY (FPM)	AIR QUANTITY (CFM)	TIMES FROM ROOF SMOKE ALARM TO: BELT IGNITION (MINUTES)	BELT FLAME PROPAGATION (MINUTES)	TIME (MINUTES) FROM CO ROOF ALARM TO: BELT IGNITION (15 PPM)	BELT FLAME PROPAGATION (15 PPM)	BELT IGNITION (5 PPM)	BELT FLAME PROPAGATION (5 PPM)	15 PPM ROOF ALARM TO 200 PPM AT FIRE (MIN)	PEAK CO LEVEL (PPM)
GAC-81-A	150	12,150	13.0	28.5	0.9	16.4	11.2	26.7	10.5	350
GAC-78/85	300	24,000	20.1	37.9	2.7	20.5	15.8	33.5	16.3	580
GAC-80	800	64,000	14.5	30.0	-1.0	14.5	1.5	17.0	16.8	372
GAC-83	1200	96,000	18.0	30.0	3.5	8.5	----	----	N/A	N/A

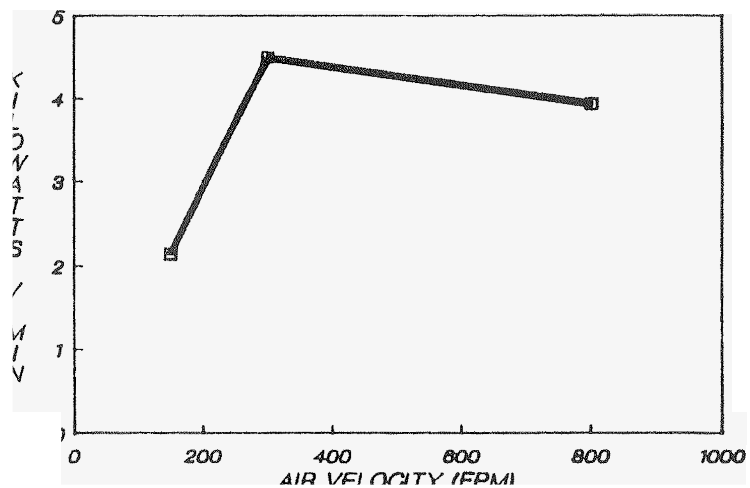
SOURCE: BUREAU OF MINES

BUREAU OF MINES BELT FIRE TESTS
COAL BED IGNITED

BELT FIRE GROWTH RATES

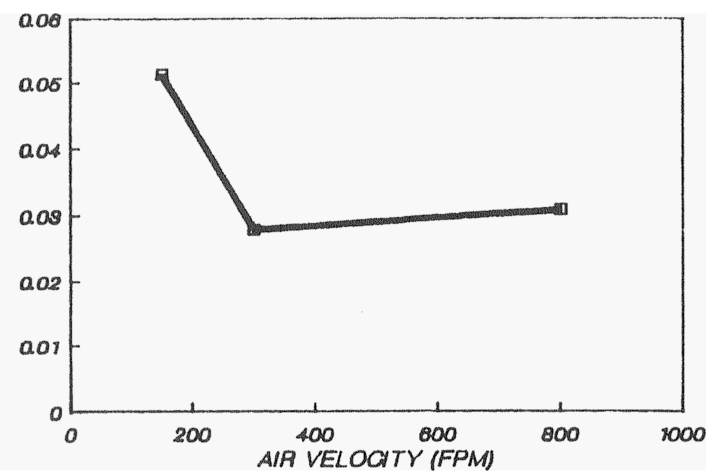


COAL FIRE GROWTH RATES

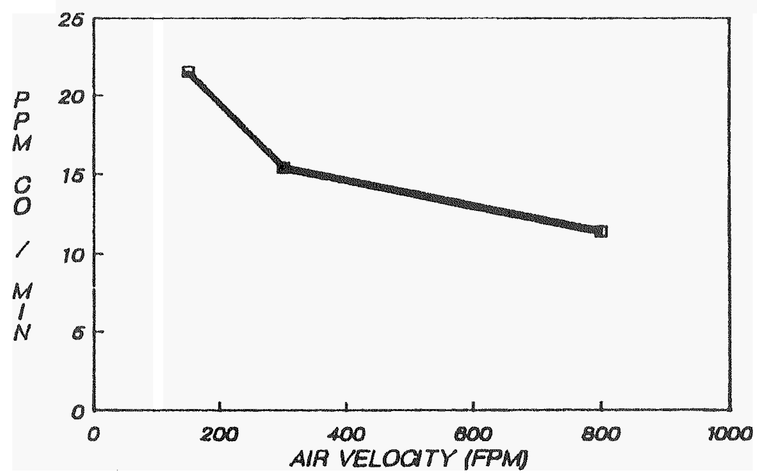


BUREAU OF MINES BELT FIRE TESTS
COAL BED IGNITED

RATE OF SMOKE PRODUCTION
(0.1 TO 0.5 PER METER OPTICAL DENSITY)

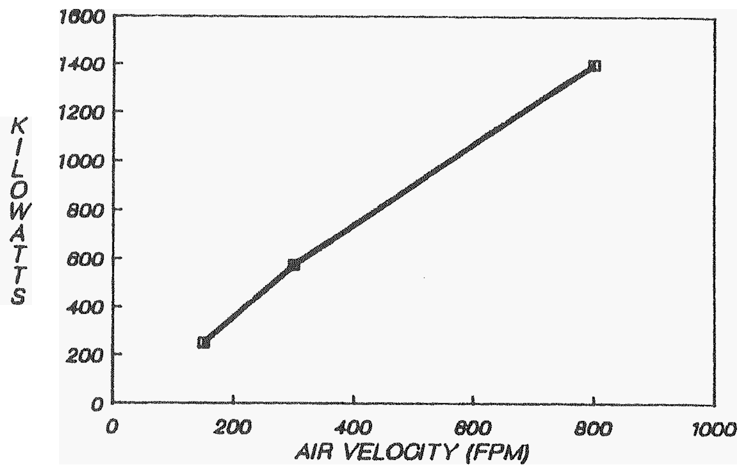


RATE OF CO PRODUCTION
(15 TO 200 PPM CO)

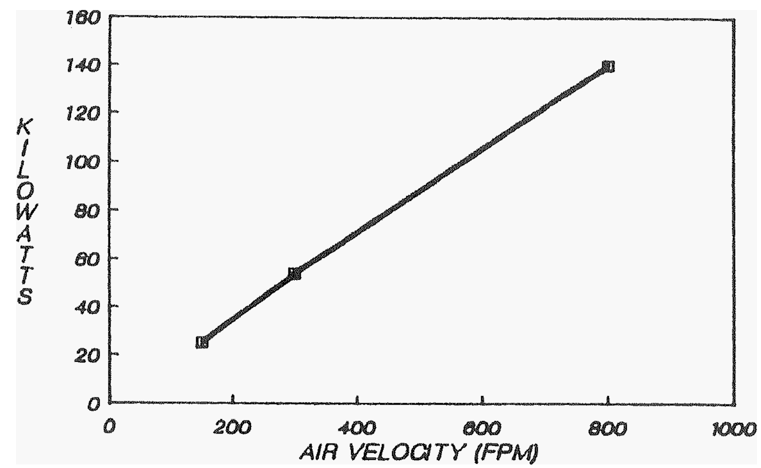


BUREAU OF MINES BELT FIRE TESTS
COAL BED IGNITED

TOTAL FIRE INTENSITY AT ONSET OF BELT FLAME SPREAD



COAL FIRE INTENSITY AT BELT IGNITION



APPENDIX C - SMALL FIRES AND BELT HEATINGS

TABLE 1
SMALL BELT FIRES AND HEATINGS, OCT 1988 - MAY 1989 WHEN CO MONITORING SYSTEMS ARE BEING USED

DATE OF FIRE	SOURCE OF FIRE	DURATION OF FIRE	HOW FIRE WAS DETECTED	BELT AIR USED	SENSOR LEVEL WARN/ALARM (PPM)	
05-24-89	FAILED TROLLEY WIRE INSULATOR MELTED PLASTIC TROLLEY WIRE GUARDING MATERIAL	5 MIN	SENSOR AT BELT DRIVE +/-800 FT FROM SOURCE OBSERVED AT 6 PPM	YES D.M. APPROVAL	10	15
04-31-89	BELT RUBBING FRAME BELT SHAVINGS & GREASE BURNED	10 MIN	CO SYSTEM SOUNDED WARNING AND ALARM	NO	6	10.5
03-21-89	FINE COAL AND GREASE HEATING (SOURCE UNKNOWN)	10 MIN	1ST WARNING FROM CO SYSTEM 2 MINERS SMELLED SMOKE SHORTLY BEFORE ALARM	NO	5.5	10.5
03-02-89	GEAR DRIVE GUARD RUBBING SHAFT CAUSING SPARKS AND FRICTION, FLAMES DEVELOPED	10 MIN	CO SYSTEM ALARMED AND 2 MINERS SMELLED SMOKE	NO	5.5	10.5
02-25-89	BELT TAKE-UP ROLLER BEARING WAS SMOKING	N/A	CO SYSTEM DETECTED	NO (PETITION PENDING)	13.5	18.5
02-09-89	CONVEYOR BEARING FAILED 2 CROSSCUTS OUTBY TAIL SENSOR CAUSING SMOKE	10 MIN	CO SYSTEM ALARMED ON SECTION	NO	12	17
02-07-89	BELT WAS SLIPPING IN DRIVE (ESTIMATED FOR 45 MIN)	N/A	CO WASN'T RELEASED; SMOKE AND SLIPPING FOUND BY SUPER INVESTIGATING BELT STOPPAGE	NO	N/A	14
02-06-89	OVERHEATED BEARING IN SPEED REDUCER IGNITED GEAR OIL	5 MIN	FIRE DISC. BY BELT EXAMINER; SENSOR WAS IMPROPERLY LOCATED OUT OF AIR STREAM FROM DRIVE	YES BY PETITION	10	15
01-11-89	HOT ROLLER BEARING CAUSED A SMALL PILE OF COAL TO SMOKE IN CONTACT WITH BEARING	5 MIN	CO SYSTEM DETECTED; REQ'D 2 SEARCHES TO FIND SOURCE	NO (PETITION PENDING)	13.5	18.5

TABLE 1 (Cont.)
SMALL BELT FIRES AND HEATINGS, OCT 1988 - MAY 1989
WHEN CO MONITORING SYSTEMS ARE BEING USED

DATE OF FIRE	SOURCE OF FIRE	DURATION OF FIRE	HOW FIRE WAS DETECTED	BELT AIR USED	SENSOR LEVEL WARN/ALARM (PPM)	
12-21-88	HOT METAL SLAG FROM CUTTING OPERATIONS ON BELT DRIVE IGNITED COAL DUST ON FLOOR	28 MIN	CO SYSTEM DETECTED AFTER WELDER LEFT SCENE	YES D.M. APPROVAL	5	14
12-03-88	TRANSPORTING CONTINUOUS MINER ON TRACK; HOSE FITTING CONTACTED TROLLEY WIRE	5 MIN	CO SYSTEM DETECTED	YES BY PETIKION	10	15
11-26-88	HOT METAL FROM CUTTING TORCH	25 MIN	CO SYSTEM DETECTED	NO	N/A	14
11-22-88	OVERHEATED FLUID COUPLING ON BELT BOOSTER DRIVE; SMOKE AND SOME FLAME	N/A	ENTERING CREW FOUND SMOKE; CO SYSTEM SHOWED HIGH READINGS UNNOTICED AT SURFACE	YES D.M. APPROVAL	10	15

TABLE 2
BELT FIRES AND HEATINGS PRIOR TO OCT 1988
CONCERNING COMPLAINTS ABOUT CO MONITORING SYSTEMS

DATE OF FIRE	SOURCE OF FIRE	DURATION OF FIRE	HOW FIRE WAS DETECTED	BELT AIR USED	SENSOR LEVEL WARN/ALARM (PPM)	
04-24-88	REPORTED SMOKE FROM HOT TAIL ROLLER; FOUND AND EXTINGUISHED BY EMPLOYEES	N/A	SYSTEM CHECKED 4/25; SENSORS OK; HIGHEST LEVEL OF 11 PPM RECORDED 4/24 AT 5:10 AM	NO	N/A	14
07-16-87	BELT TAKE-UP MISALIGNED; BELT RUBBED AGAINST FRAME & BROKE; SMOKE, NO FLAME	N/A	APPARENTLY CO NOT GENERATED; MSHA TEST IMMED. AFTER FIRE SHOWED SENSORS OK	YES BY PETITION	10	15
04-01-87	CONVEYOR BELT RUBBING AGAINST FLOOR/CRIBS; IGNITED COAL OR FLOAT COAL DUST	13 DYS	CO SYSTEM PRINTER HAD BEEN INADVERTENTLY UNPLUGGED; NO ALARM OR DISPLAY	YES BY PETITION	10	15
03-17-87	LOCATED IN BELT ENTRY JUST INBY ISOLATION STOPPING; FRICTION HEAT ON STRUCK ROLLER	24 MIN	CO SENSORS NOT EXPOSED TO CO; SMOKE & GASES VENTED DIRECTLY TO RETURN	NO	N/A	N/A
FALL 84	BELT SLIPPED IN DRIVE; RUBBED AND SEPARATED GENERATING SMOKE BUT NO FLAME	N/A	CO NOT DETECTED; SENSORS CALIBRATED OK	YES BY PETITION	N/A	N/A

APPENDIX D - EFFECT OF USING BELT AIR ON AIRBORNE RESPIRABLE DUST LEVELS

PURPOSE

The purpose of this study was to determine whether

1. Increasing the air velocity in the belt entry, due to the increase in the quantity of air coursed through it, and the presence of outby or secondary dust sources will increase the concentration of airborne respirable dust in the belt air; and

2. Coursing belt air to the working faces will increase the face workers' dust exposure.

INTRODUCTION

As of the April 1989, approximately 53 coal mines, involving some 213 mechanized mining units (MMUs), were using belt air to ventilate the working face. Its use, however, has been and continues to be opposed by the United Mine Workers of America (UMWA) because of their concern about the increased problem with respirable dust when ventilating working places with belt air. Specifically, their main argument is that significant levels of respirable dust can be and are generated by outby dust sources (i.e., transfer points, dump points, tail piece, coal moving in opposite direction from air, etc.) associated with belt haulage which, if not controlled, are picked up by the airstream and carried directly to the working faces. It is their contention that these outby dust sources in the belt haulageway can contribute significantly to face workers' dust exposure.

Recognizing the need to maintain respirable dust levels in the environment of all areas of the active workings of a mine, especially those identified by the UMWA, to which miners could be exposed during the course of a working shift, current regulations require each operator to maintain average dust concentrations at or below the applicable dust standard of 2.0 mg/m^3. Compliance is being monitored through the establishment and sampling of designated areas (DAs) at dust generating sources in active working by both the operator and Mine Safety and Health Administration (MSHA) inspectors. Additional DA sampling locations can and are established based on the results of inspector samples.

The general practice is to sample along the belt lines so that each measurement represents up to, but not more than, four dust generating sources (transfer points). Guidelines for selecting and approving designated sampling areas have been in place since August, 1980.

The operator's approved ventilation system and methane and dust control plan, as required under 30 CFR 75.316, show the specific location in each underground mine where DA samples will be collected, the specific location of each sampling device, and the types of dust controls to be used.

Furthermore, to assure the availability and delivery of quality intake air, regulations require each operator to continuously maintain the average dust concentration within 200 feet outby the working faces of each section in intake airways at or below 1.0 mg/m^3. This also applies to other entries that may be used as intakes, such as belt haulageways. The 2.0 mg/m^3 dust standard is applied to the remaining parts of the intake airways except at mines required to comply with the provisions of the Petition for Modification. In those instances, the 1.0 mg/m^3 dust standard may apply to belt haulageways used as intakes some distance beyond 200 feet from the face. Specifically, compliance with the intake air standard must be determined within 15 feet outby the working section belt tailpiece or just outby any air split point introduced into the belt entry.

The quality of this air, especially belt air, is monitored on a routine basis by the operator through bimonthly sampling and by MSHA inspectors during annual respirable dust technical inspections. Additionally, during nonsampling inspections the effectiveness of the mine operator's respirable dust control measures in use are monitored by MSHA inspectors.

In summary, the regulatory requirements currently in place along with established enforcement procedures adequately protect the health of miners at all times as intended by the Mine Act of 1977. This is accomplished by requiring the operator to continually maintain dust concentrations in the environment of all areas of the mine where men work or travel at or below the applicable dust standard. The continued enforcement of these safeguards will ensure that the health of the miners are not compromised under any circumstances, including those identified by the UMWA.

As part of an overall re-examination of the belt air issue, the compliance sampling data and the results of Technical Support field surveys were analyzed to determine what effect does supplementing intake air with belt air has on respirable dust concentrations in the intake airway and at the face.

DATA SOURCES

The respirable dust data analyzed in this study was obtained from the operator and inspector subsystems of the Management Information System (MIS). Only the FY '88 - '89 data was used because it included both operator and inspector belt intake

DA sampling results. Prior to that period, MSHA was not routinely establishing belt intake DAs and requiring these areas to be sampled by mine operators and inspectors. Also, since the limited number of samples taken by inspectors were either of the primary intake air or of the blended air stream, these could not be used in this study either.

It should be emphasized at the outset that, while a standard inferential technique (independent measure "t" statistic) was used as a basis to draw conclusions about mean differences in dust concentrations between operations using belt air and those that are not, the original dust data was analyzed in the absence of key information on the location of belt air and intake air sampling in relation to the designated occupation, on the quantities and velocities of each air stream, and on the operating conditions and engineering dust control parameters in effect at time of sampling. Such information would enhance ones understanding of what else may be occurring as the belt air travels to the working face.

RESULTS AND DISCUSSION

The results and accompanying discussion are presented in two parts. The first focuses on the effects of our coursing increased quantities of air in the belt haulageway on respirable dust concentrations in the belt entry within 200 feet outby of the working face, followed by the discussion on the effects of belt air usage on the face workers' (DO) dust exposure.

Effects of Coursing Increased Quantities of Air in Belt Haulageways on the Level of Respirable Dust in Belt Air

As summerized in Table 1, some 970 operator and 468 inspector intake DA samples were taken in mines using belt air at the face since October 1, 1987. Figures 1 and 2 show the range of intake DA dust concentrations by individual districts. According to the data, 36 percent of all operator samples and 37 percent of the inspector samples were taken in Districts 7 and 9, respectively. Eleven percent of the operator and 18 percent of the inspector samples exceeded 1.0 mg/m^3, the maximum level allowed by 30 CFR Part 70.100(b). A total of 25 citations were issued during this period for exceeding the intake air standard.

Although significantly below the 1.0 mg/m^3 dust standard, the sampling data shows that the air coursed through the belt haulageway contains more respirable dust than the primary intake air. The mean dust concentration of primary intake air as measured by inspectors during FY '88 was 0.2 mg/m^3 compared to 0.5 mg/m^3 for belt intake air. On a National level, the operator mean intake DA dust concentration (includes non-belt air samples) was 0.3 mg/m^3 versus 0.6 mg/m^3 for belt air only. Similar dust concentrations have been reported by Pittsburgh Technical Support.

In the districts where belt air is used to ventilate longwall faces, the dust concentration of the intake air ranged from 0.3 to 0.8 mg/m^3 as illustrated by Table 2. As a comparison, in District 3 mines, where belt air is not used, the dust concentration in the intake air delivered either to longwall or continuous miner sections averaged 0.2 mg/m^3.

Since the dust concentrations in the environment of outby dust sources, especially those associated with belt haulage, are being monitored, the results of FY '88 operator and inspector sampling were examined and are summarized in Table 3. On a National level, the dust concentrations at outby dust sources (i.e., transfer points and section dump points) in mines using belt air ranged from 0.5 to 0.9 mg/m^3 compared to 0.4 to 0.6 mg/m^3, for all mines. While there is a difference of 0.1 to 0.3 mg/m^3, the the measured dust concentrations are still significantly below the 2.0 mg/m^3 dust standard applicable to these outby areas. Given the magnitude of these dust levels, it would appear that the contribution of these sources to the overall dust concentration in the environment immediately outby the belt tailpiece would be minimal.

In certain instances, these differences are more pronounced when examined on a district level as Figures 3 and 4 illustrate. With mean dust concentrations ranging from 1.1 mg/m^3 in District 2 to 1.7 mg/m^3 in District 7 (District 9 data was not considered because of the small sample size), one would assume a similar increase in the belt air dust concentration. Instead, the concentration means ranged from 0.3 to 0.6 mg/m^3, well below the allowable standard, suggesting that, among other factors, dilution may be effecting the quality of the air before it reaches the particular sampling location. This is not unexpected as current regulations permit the dust concentration in intake air to reach 2.0 mg/m^3 outby 200 feet from the working faces. However, once within 200 feet of the face, this air must be treated to comply with the 1.0 mg/m^3 dust standard. This is usually accomplished by blending the belt air with the main intake air stream.

This effect appears to more evident when one examines individual paired inspector DA respirable dust samples taken on the same day at section dump points and at the intake (belt entry) DA sampling location in several District 7 mines. Table 4 shows that, in most but a few of the instances, the dust concentration in belt air was lower than in the environment of associated outby section dump points.

While these data may imply that dilution is having a direct impact, the extent of its effect could not be quantified in the absence of physical data on air quantities and velocities in belt and intake entries and on dust concentrations in other strategic locations. According to Pittsburgh Technical Support, the level of dilution can be accurately calculated and is dependent on the respirable dust concentration of the nonbelt air and on the ratio of belt air to nonbelt air being mixed. The following example illustrates the significance of the above relationship. In one of Technical Support's respirable studies at the Lucerne No. 6 Mine, in District 2, where 51 percent of the intake air was coursed through the entries common to the belt, it was determined that, if the respirable dust concentration at the section dump point was maintained at or below 2.0 mg/m^3, the respirable dust concentration of the intake air to the working faces should be below 1.0 mg/m^3[(1)]. To assure that the dust concentration of the blended air mixture is consistently below the standard, it is vital that adequate dust controls be implemented and properly maintained to minimize dust generation and liberation at the section belt tailpiece, at other outby dust sources associated with belt haulage, and in intake entries (i.e., used as roadways, etc.).

With regard to the question, "What effect does the increase in belt air velocity, due to an increase in the quantity of air coursed through the belt haulageway, have on the respirable dust concentration of the belt airstream?," studies conducted by Pittsburgh Technical Support show that the effect of dilution on the dust concentration more than compensates for increases in dust concentration due to entrainment[(2)]. In one such study the air velocity on the belt entry was approximately 600 fpm with the belt moving at 400 fpm in the opposite direction to air flow, resulting in a relative velocityof 1,000 fpm. With 60,000 cfm of air in the entry, comparative measurements over a 3,000-foot distance of belt entry showed no increase in dust levels, indicating that, under the conditions existing, dust was not being entrained from the belt[(2)].

In another respirable dust survey at the Lucerne No. 6 Mine where the relatively velocity in the slope belt entry was 1600 fpm, the dust concentration increased only 0.26 mg/m^3 over a 2000-foot length of belt. Assuming that no entrainment of dust would occur at a relative velocity of 700 fpm, it was determined that based on the relationship mentioned earlier, there would be a 90 percent reduction in the belt entry dust concentration due to dilution. While in this particular case entrainment of dust did occur, the effect of dilution compensated for it[(2)].

Relative to the sampling data analyzed, the amount of the respirable dust that was being entrained, especially where longwall mining is employed, could not be determined since the required comparative measurements over a given distance are not routinely made. Nevertheless, in light of what is known about the effect of dilution on dust levels, the quantities of water currently used at the face, and the level of health protection afforded by current dust standards, the concerns that are being raised regarding the effects of increasing belt air velocity on dust concentrations are unwarranted. The focus, instead, should be directed to assuring that the concentration of respirable dust in intake air within 200 feet of the working face is continually maintained at or below 1.0 mg/m^3.

The Effect of Belt Air Usage on the Face Workers' (DO) Dust Exposure

With regard to the second issue concerning the effect that coursing belt air to the working faces has on the face workers' dust exposure, 165 matched pairs of inspector intake (belt entry) DA and DO samples taken the same day on longwall and continuous miner MMUs were retrieved and analyzed. The results are summarized in Table 5. The concentration of the matched pairs of inspector DA and DO samples by districts is shown in Figures 5 and 6. Some individual dust concentrations from selected mines in District 7 are shown in Table 4. In no case, whether on a mine or on a district level, did the data indicate a significant linear relationship. In fact, the standard of the DO (2.0 mg/m^3) was exceeded more often when the dust concentration of the intake air was equal to or less than 1.0 mg/m^3 than when intake air exceeded its standard.

In addition, although based on a much smaller data set, the analysis of 38 matched pairs of operator intake air (belt entry) DA and longwall DO samples, and of 13 pairs of samples from several District 3 mines not using belt air, also failed to show a direct relationship between the respirable dust concentration of belt air and of the DO. As in the previous comparison, the 2.0 mg/m^3 dust standard of the DO was exceeded some 30 percent of the time when the intake DA dust concentration was equal to or less than 1.0 mg/m^3. According to District 3's matched samples, this occurred 36 percent of the time. These findings suggest that dust sources at the face continue to have an overwhelming effect on the DO's dust exposure.

Finally, since belt air usage is most often associated with longwall mining because of the need to provide as much air as possible for dust and methane control, the mean DO dust concentration of MMUs using belt air was compared against MMUs not using belt air. The FY '89 operator data for the two groups are presented in Table 2 and displayed by district in Figure 7. The distribution of samples exceeding 2.0 mg/m^3 and equal to or less than 0.2 mg/m^3 is as shown in Table 6. Excluding District 5 data because of the small number of samples from MMUs without belt air, these data show that the differences in the mean DO dust concentration before truncation range from 0.10 mg/m^3 in District 4 to 0.48 mg/m^3 in District 6. At the National level, the difference was only 0.27 mg/m^3. To determine whether longwalls using belt air are dustier than those not using it, or in statistical terms are the mean dust concentrations the same or different, the independent measures "t" statistic was calculated by district and Nation for the two groups. The results indicate that for Districts 2, 4, 6 and 7 and on a National level there is no statistical difference between the mean dust concentrations. Only District 9 had a mean difference that turned out to be significant ($t=3.06$, $p<.05$). In other words, the longwalls using belt air are less dusty than those that do not use it at the face. This suggests that the additional air being brought up the belt is helping to dilute the dust generated in the face area, which may account for the smaller number of individual samples that were found exceeding the 2.0 mg/m^3 dust standard.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are drawn from the analysis of operator and MSHA inspector dust data.

1. Given the magnitude of the dust concentrations measured in the vicinity of the outby dust sources associated with belt haulage (excluding the section belt tailpiece), which were found to be well below the applicable standard of 2.0 mg/m^3, their contribution to the total dust loading of the air coursed through belt haulageways is expected to be minimal. Even after including the contribution of the section belt tailpiece, the resulting dust concentration is still expected to be significantly below the allowable standard for intake air, providing adequate controls are in place. Since such controls are readily available, there is no reason why the dust at these sources cannot be controlled effectively at all times.

2 Intake air that is coursed through belt haulageways is twice as dusty as the primary intake air (0.2 mg/m^3 vs 0.5 mg/m^3) according to MSHA inspector dust samples. Because it is significantly below the 1.0 mg/m^3 intake air dust standard, coursing belt air to the face will not adversely impact the face workers' dust exposure.

3 Based on the data analyzed, there appears to be no direct relationship between the level of dust measured in the vicinity of secondary dust sources outby the belt tailpiece and in the belt air within 200 feet of the working face. Given this finding, it should not be assumed that elevated dust levels in these areas will cause the concentration in belt air to increase similarly.

4 According to studies conducted by Pittsburgh Technical Support, the effect of dilution due to the increased

quantities of air coursed through belt haulageways more than compensates for any increase in dust concentration due to entrainment.

5 Based on sampling results, there is no evidence to suggest that using belt air at the face, especially at longwalls, will adversely impact the face workers' dust exposure. A comparison of the mean DO dust concentrations at longwalls with and without belt air, revealed the differences in the means to be insignificant. Only District 9's mean difference proved to be statistically significant, indicating that the partiuclar longwalls using belt air are less dusty. This suggests that the additional air being delivered to the face is helping to dilute the dust being generated at the face. The key to effectively controlling the face workers' dust exposure at longwalls, is to control the face sources by providing as much air as is feasible to dilute the generated dust, confine it against the face to prevent its migration in the walkway, and direct the contaminated air stream to the return.

6 To ensure the continuous delivery of quality intake air to the working face(s), it must be monitored on a routine basis. Furthermore, the ventilation, methane and dust control plans must detail the location of the intake and other outby DAs, and describe the dust control measures being applied and maintained at outby belt transfer points, dump points, intake roadways, etc..

7. Finally, since existing health standards are designed to effectively protect all miners where they work and travel, their continued enforcement will ensure that, whether belt air is used or not, the health of the miner will not be compromised.

REFERENCES

1 Chiz, D. and Atchison, D. Environmental Dust Survey, PHTC-DD-88-25C: Lucerne No. 6 Mine, Helvetia Coal Company, Mine ID No. 36-00197, April 19 and 20, 1988

2 Tomb, T. PHTC Memorandum for William H. Sutherland, Dated July 8, 1988, Subject: Effect of Air Velocity on Dust Levels in Coal Mines.

TABLE 1. SUMMARY TABLE OF INTAKE AIR SAMPLING

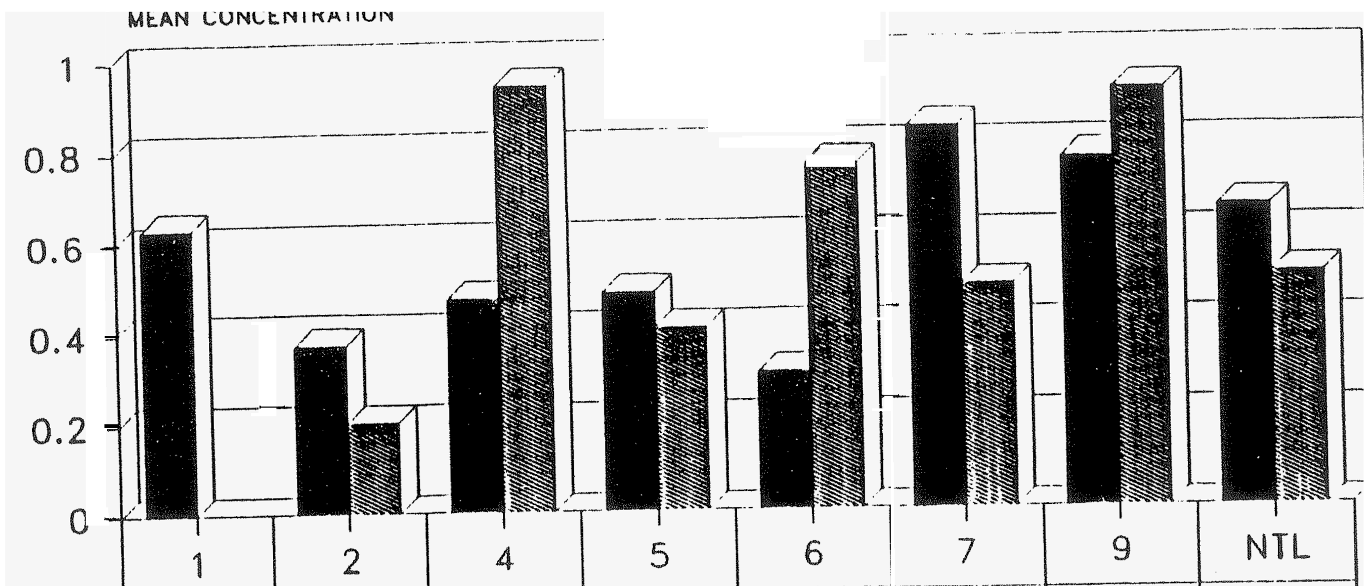
MINES AUTHORIZED TO USE BELT AIR TO VENTILATE THE WORKING FACE(S)*

DISTRICT /FY	# OF MINES	# OF MMUs* AFFECTED	AUTHORITY: 101 (c) PETITION	AUTHORITY: VARIANCE DM	SAMPLED # MINES: OPR	SAMPLED # MINES: INSP	SAMPLED # DA ENTITIES: OPR	SAMPLED # DA ENTITIES: INSP	# INTAKE SAMPLES: OPR	# INTAKE SAMPLES: INSP	# > 1.0: OPR	# > 1.0: INSP	# = 0.1: OPR	# = 0.1: INSP	ARITHMETIC MEAN: OPR	ARITHMETIC MEAN: INSP	ARITHMETIC STD. DEV.: OPR	ARITHMETIC STD. DEV.: INSP
1/FY '88	1	1	1	-	1	2	0	0	16	0	2	0	7	0	0.63	0	1.09	0
1/FY '89					1	2	0	0	2	0	0	0	1	0	0.25	0	0.15	0
3/FY '88	14	64	3	11	5	15	9	57	19	62	1	1	4	46	0.37	0.20	0.27	0.23
3/FY '89					11	49	12	39	132	26	4	0	41	11	0.37	0.26	0.31	0.15
4/FY '88	11	35	6	5	5	11	3	8	24	16	2	7	7	3	0.47	0.94	0.46	0.72
4/FY '89					8	37	4	6	95	16	7	3	27	1	0.44	0.81	0.50	0.42
5/FY '88	13	44	11	2	10	39	6	17	44	23	3	0	11	7	0.48	0.40	0.43	0.27
5/FY '89					12	49	9	29	180	46	16	9	33	1	0.53	0.74	0.50	0.56
6/FY '88	2	3	2	-	1	4	1	4	17	15	0	4	3	0	0.30	0.76**	0.16	0.39
6/FY '89					1	3	1	3	9	5	0	1	2	0	0.23	0.56	0.12	0.30
7/FY '88	8	61	6	2	6	32	5	27	121	54	23	5	15	12	0.84	0.49	1.02	0.39
7/FY '89					7	47	6	20	232	30	34	2	72	7	0.64	0.47	0.95	0.32
8/FY '88	4	5	2	2	3	5	2	8	25	30	5	6	3	5	0.77	0.92	0.61	1.42
8/FY '89					4	11	3	9	54	145	10	49	6	15	0.72	1.10	0.57	1.19
NTL/'88	53	213	31	22	33	26	108	121	266	200	40	23	50	73	0.66	0.51	0.82	0.70
NTL/'89					44	35	198	106	704	268	71	64	182	35	0.53	0.66	0.67	0.97

* ACCORDING TO 1988 SURVEY CONDUCTED BY DOS.

** COMPARED TO PURE INTAKE AIR OF 0.36 (SD = .27)

FIGURE 1. FY 88 INTAKE AIR SAMPLING
MINES USING BELT AIR

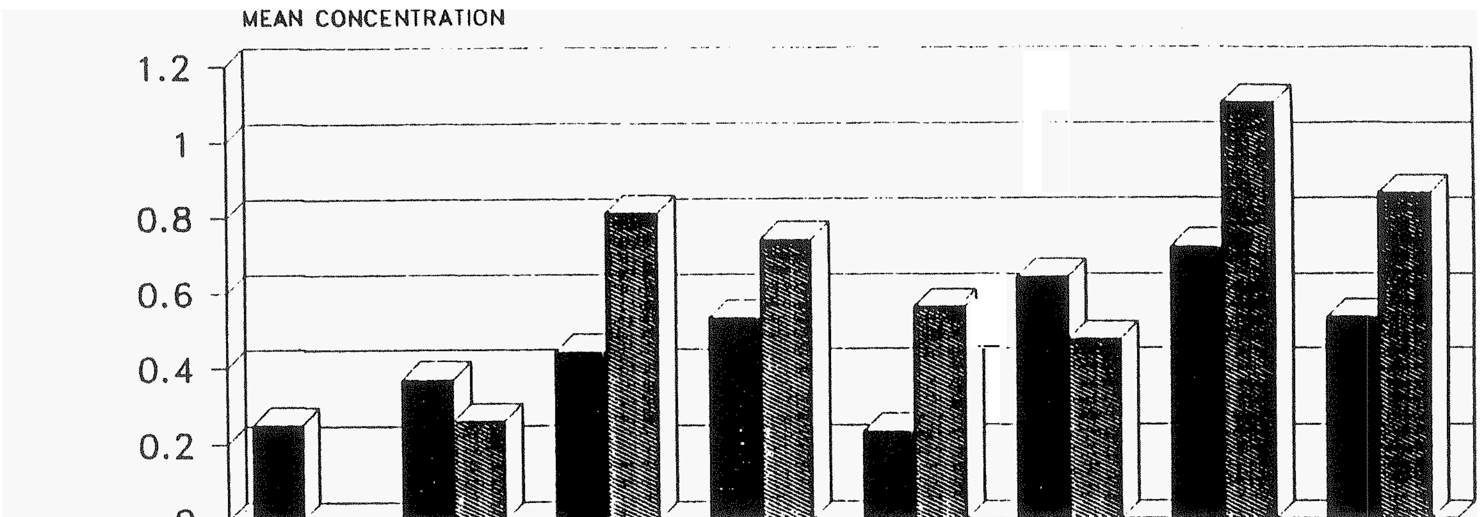


	1	2	4	5	6	7	9	NTL
OPERATOR	0.63	0.37	0.47	0.48	0.3	0.84	0.77	0.66
INSPECTOR		0.2	0.94	0.4	0.76	0.49	0.92	0.51

DISTRICT

OPERATOR INSPECTOR

FIGURE 2. FY 89 INTAKE AIR SAMPLING
MINES USING BELT AIR



	1	2	4	5	6	7	9	NTL
OPERATOR	0.25	0.37	0.44	0.53	0.23	0.64	0.72	0.53
INSPECTOR		0.26	0.81	0.74	0.56	0.47	1.1	0.86

DISTRICT

TABLE 2. OPERATOR MEAN FY '89 LONGWALL DO CONCENTRATIONS
(OCT. 1 - APR. 30)

	MMUs USING BELT AIR				MMUs NOT USING BELT AIR	
			INTAKE AIR			
DISTRICT	SAMPLES/ MEAN	STANDARD DEVIATION	SAMPLES/ MEAN	STANDARD DEVIATION	SAMPLES/ MEAN	STANDARD DEVIATION
2	84/1.31	0.89	15/0.41	0.27	133/1.13	0.64
3	--	--	--	--	482/1.41	1.47
4	102/1.39	1.39	21/0.61	0.79	62/1.49	1.65
5	309/1.93	1.28	52/0.54	0.62	5/0.92	0.32
6	15/1.22	1.35	3/0.37	0.15	50/1.70	1.57
7	174/2.08	1.46	64/0.69	0.66	31/1.81	0.87
8	--	--	--	--	125/1.54	1.23
9	88/1.55	0.93	35/0.87	0.65	184/1.98	1.15
10	--	--	--	--	18/1.65	0.59
NATIONAL	780/1.78	1.26	187/0.65	0.65	1070/1.51	1.33

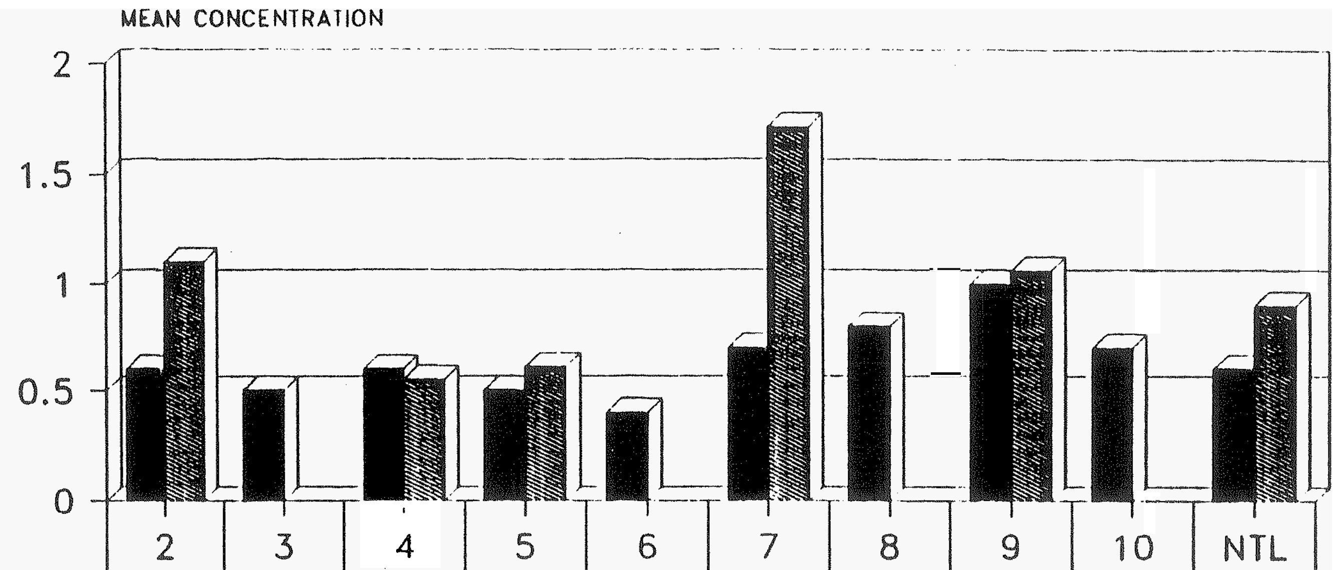
TABLE 3 FY 1988 RESULTS OF OPERATOR AND INSPECTOR SAMPLING OF OUTBY DUST SOURCE

	OTHER BELT AREA (200-299) SAMPLES				OTHER SECTION DUMP POINTS (500-599			
	# SAMPLES		CONCENTRATION		# SAMPLES		CONCENTRATION	
DISTRICT	OPR	INSP	OPR	INSP	OPR	INSP	OPR	INSP
1	--	--	--	--	--	--	--	--
2	1349 371*	87 14*	0.60 1.1*	0.50 0.50*	73 47*	2 --	0.40 0.51*	0.10 --
3	901	88	0.50	0.40	297	25	0.60	0.40
4	1886 180*	247 14*	0.60 0.55*	0.50 0.44*				
5	1693 358*	25 8*	0.50 0.61*	0.40 0.66*				
6	1322	153	0.40	0.80				
7	1153 137*	153 21*	0.70 1.71*	0.50 0.62*	171 171*	23 23*	0.80 0.81*	0.50 0.56*
8	735	75	0.8	0.90				
9	521 96*	28 3*	1.00 1.06*	1.80 4.30*				
10	403	70	0.7	0.60				
NATIONAL	9963 1142*	926 60*	0.60 0.93*	0.60 0.74*	541 218*	50 23*	0.60 0.75*	0.40 0.56*

* WHEN BELT AIR IS USED TO VENTILATE FACE(S)

FIGURE 3. FY 88 OPR SAMPLING RESULTS

OUTBY BELT AREAS



	2	3	4	5	6	7	8	9	10	NTL
SITUATION 1	0.6	0.5	0.6	0.5	0.4	0.7	0.8	1	0.7	0.6
SITUATION 2	1.1		0.55	0.61		1.71		1.06		0.9

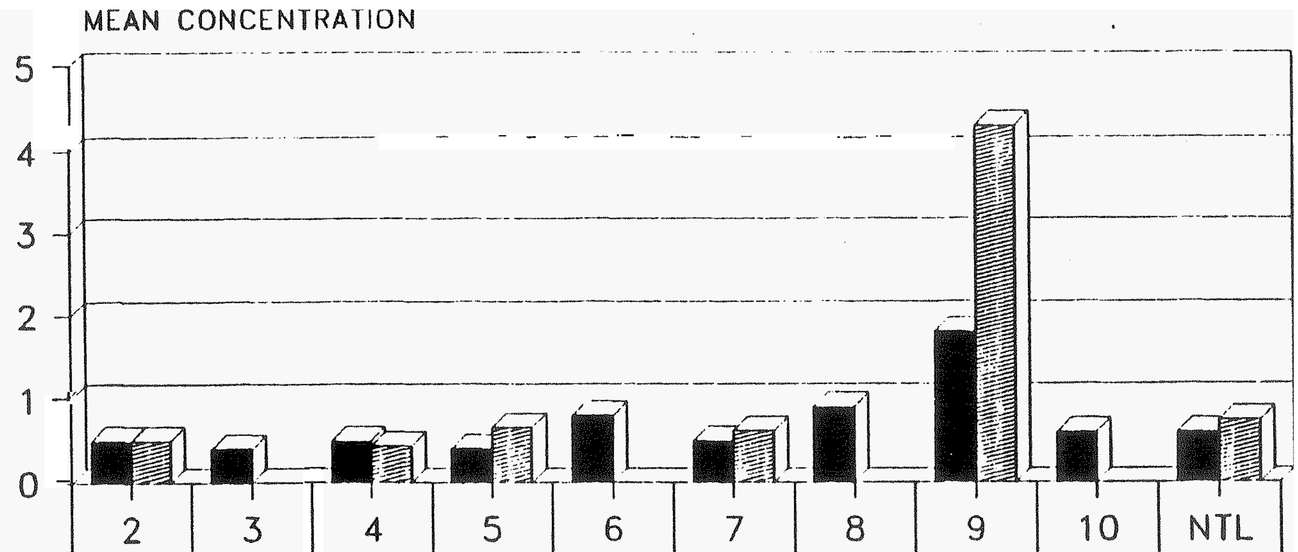
DISTRICT

SITUATION 1　SITUATION 2

1 WHETHER OR NOT USING BELT AIR
2 WHEN USING BELT AIR

FIGURE 4. FY 88 INSP SAMPLING RESULTS

OUTBY BELT AREAS



	2	3	4	5	6	7	8	9	10	NTL
SITUATION 1	0.5	0.4	0.5	0.4	0.8	0.5	0.9	1.8	0.6	0.6
SITUATION 2	0.5		0.44	0.66		0.62		4.3		0.74

DISTRICT

SITUATION 1 SITUATION 2

1 WHETHER OR NOT USING BELT AIR
2 WHEN USING BELT AIR

TABLE 4. COMPARISON OF SELECTED INSPECTOR OUTBY DA
(SECTION DUMP POINTS - 500 SERIES), BELT AIR AND DO
INSPECTOR SAMPLES TAKEN SAME DAY

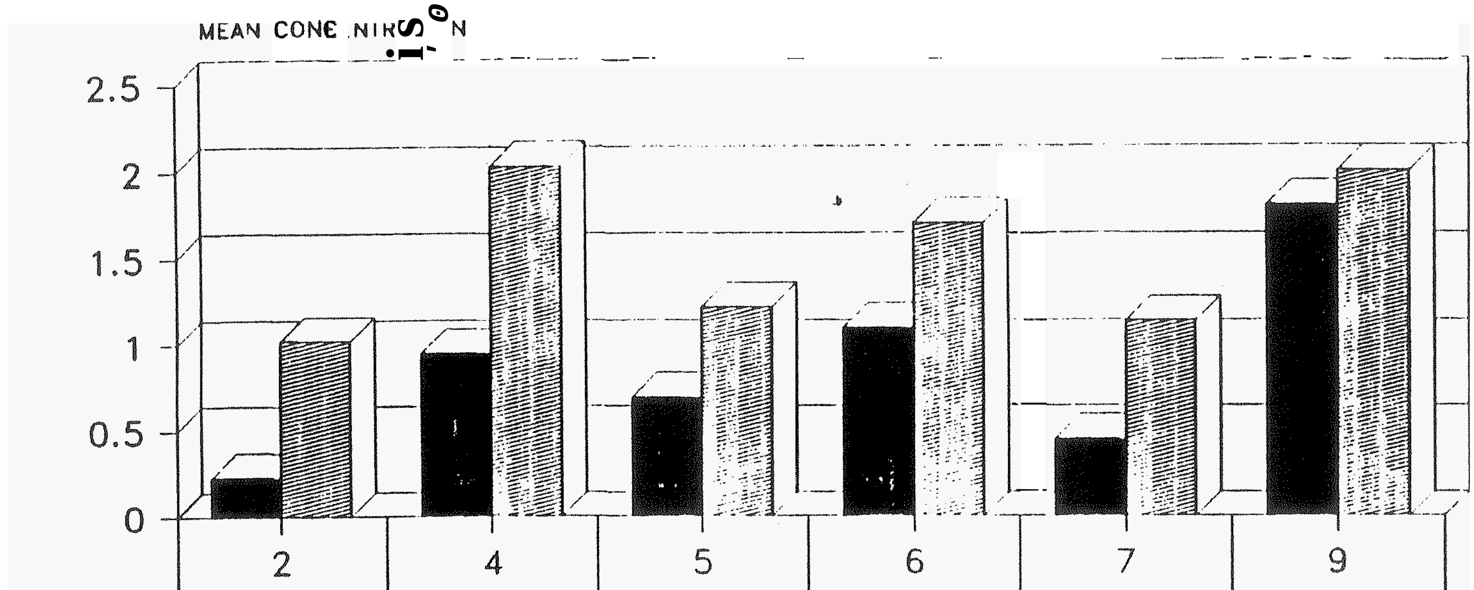
MINE ID	OUTBY SECTION DUMP POINTS ON 2.0 STANDARD	BELT AIR ON 1.0 STANDARD	DO
01-00758	0.4	0.2	0.7
	1.2	0.7	1.1
	0.7	0.4	
	1.5	1.2	0.5
	0.8	0.8	
	0.5	0.1	0.5
01-00328	1.4		2.1
	0.4		1.2
01-00851	0.2	0.1	0.8
	0.4	1	1.2
	0.5	0.4	0.7
	0.5	0.1	
	0.2	0.1	1.1
		0.5	2.7(044)
		0.5	2.2(044)
01-01247	0.2	0.2	0.5
	0.2	0.1	0.4
	0.2	0.1	0.5
	0.5		1.1
	0.4		0.5
		0.2	1.4(044)
		1.8	3.7(044)
		0.8	2.4(044)
		0.8	3.7(044)
		0.7	2.7(044)
		0.4	3.4(044)
		0.8	1.2(044)
01-01322	1.2	0.4	0.8
		0.2	1.2(044)
01-01401	0.5		0.5
	0.4	0.5	1.0
	0.1	0.1	1.0
	0.4	0.1	1.4(044)
		0.1	2.8(044)
40-00520		0.1	0.4
		0.4	1.2
		0.2	0.8
		0.2	1.1
		0.2	1.2

TABLE 5. MATCHED PAIRS OF INSPECTOR DA AND DO SAMPLES TAKEN SAME DAY IN FY '88/'89*

		INSTANCES WHEN DA <1.0 AND DO >2.0		INSTANCES WHEN DA >1.0 AND DO <2.0		# SAMPLES/ARITHMETIC MEAN				STANDARD DEVIATION			
DIST.	N	CM	LW	CM	LW	DA(CM)	DO(CM)	DA(LW)	DO(LW)	DA(CM)	DO(CM)	DA(LW)	DO(LW)
2	44	4	0	0	0	39/.23	1.02	5/.54	1.34	0.19	0.63	0.51	0.70
4	12	1	4	1	1	6/.95	2.03	6/.57	2.03	0.90	1.42	0.31	0.80
5	24	2	3	5	0	14/.69	1.22	10/.55	2.19	0.32	0.50	0.31	1.45
6	2	0	0	1	0	1/1.1	1.70	1/.6	0.70	0.00	0.00	0.00	0.00
7	32	4	2	1	0	31/.45	1.14	3/.6	1.60	0.37	0.72	0.10	0.78
9	51	0	15	1	6	4/1.8	2.00	47/1.13	2.14	1.09	1.17	1.51	1.18
NTL	165	11	24	9	7								

* THE DA AND DO CONCENTRATION OF MATCHED PAIRS CORRELATES POORLY.
IN NO CASE DID THE CORRELATION COEFFICIENT PROVED TO BE SIGNIFICANT

FIGURE 5 FY '88–'89 CONCENTRATION OF MATCHED INSPECTOR DA AND CM DO SAMPLES



	2	4	5	6	7	9
DA (CM)	0.23	0.95	0.69	1.1	0.45	1.8
DO (CM)	1.02	2.03	1.22	1.7	1.14	2

DISTRICT

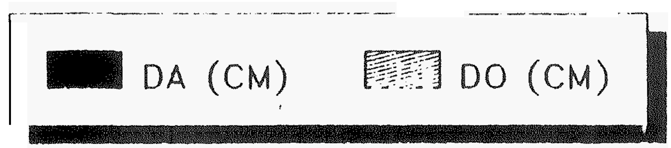
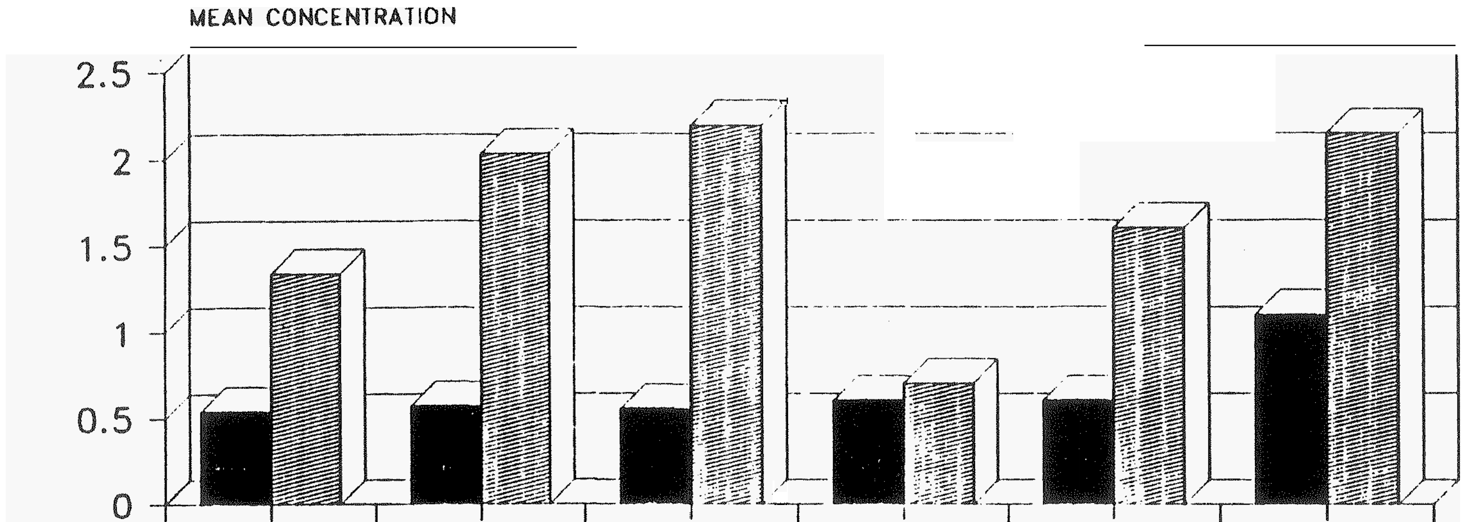


FIGURE 6. FY '88–'89 CONCENTRATION OF MATCHED INSPECTOR DA AND LW DO SAMPLES



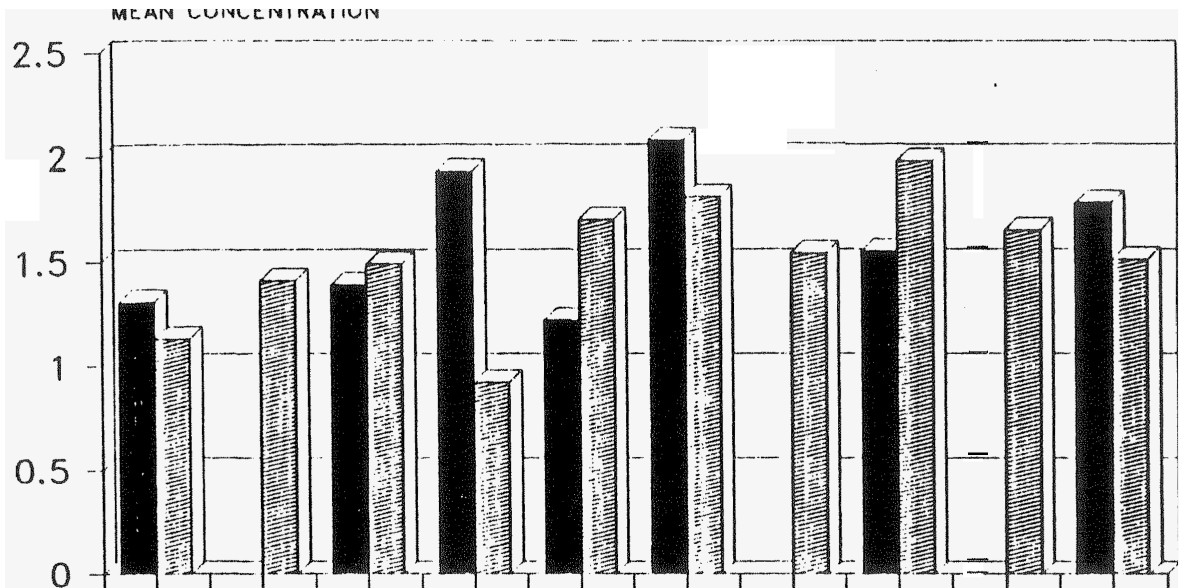
	2	4	5	6	7	9
DA (LW)	0.54	0.57	0.55	0.6	0.6	1.1
DO (LW)	1.34	2.03	2.19	0.7	1.6	2.14

DISTRICT

TABLE 6. DISTRIBUTION OF FY 1989 OPERATOR LONGWALL DO SAMPLES FOR MMUs WITH AND WITHOUT BELT AIR

DISTRICT	MMUs WITH BELT AIR				MMUs WITHOUT BELT AIR			
	N	# > 2.0	%	# < 0.2	N	# > 2.0	%	# < 0.2
2	84	25	30	16(19%)	133	11	8	12(9%)
3	--	--	--	---	482	81	17	25(5%)
4	102	22	22	15(14.7%)	62	13	21	9(14.5%)
5	309	127	41	4	51	0	0	0
6	15	2	13	1	50	21	42	11(22%)
7	174	75	43	8	31	10	32	0
8	--	--	--	---	125	33	26	13(10%)
9	88	21	24	1	169	69	41	1
10	--	--	--	---	18	5	28	0
NATIONAL	772	272	35	45(6%)	1075	243	23	71(7%)

FIGURE 7 FY 89 OPR LW MMU RESULTS



	2	3	4	5	6	7	8	9	10	NTL
USING BELT AIR	1.31		1.39	1.93	1.22	2.08		1.55		1.78
NOT USING BELT AIR	1.13	1.41	1.49	0.92	1.7	1.81	1.54	1.98	1.65	1.51

DISTRICT

USING BELT AIR NOT USING BELT AIR

APPENDIX E - VENTILATION SURVEYS

Section surveys were taken in 10 mines. In some of these mines multiple sections were reviewed. Respirable dust samples were obtained in one section in each mine. Although not always noted, entries with low air velocities have the potential for poor methane dilution or methane layering if methane is present. Line drawings for each section discussed, identified by the section number, are included at the end of this Appendix.

Mine A, Section 1 is a three-entry system. Ventilating air is directed through the belt entry toward the face. The belt entry airflow is controlled by a check installed outby the loading point and the belt air is directed to the section return aircourse by a 4" diameter pipe installed in a stopping outby the check.

Comments

1 The check across the belt entry outby the section loading point coupled with the regulation provided by the 4" diameter pipe leading to the return, raises the ventilating pressure in the belt entry above that of the section intake escapeway. This results in air leakage from the belt entry to the intake escapeway.

2 From the previous section off the mains to the mouth of the Section 1, approximately 7,000 cfm of air is leaked from the belt entry to the intake escapeway. Smoke in the belt haulageway within the survey area would contaminate the intake escapeway.

3. The total intake air quantity to the section is 21,700 cfm. The ventilation pressure differential between the belt entry and intake escapeway is approximately 0.01 inches of water gage (wg).

4 Because of the low ventilating pressure differentials the belt entry and intake escapeway could be considered to be "balanced". However, the potential for leakage is consistently from the belt entry to the intake escapeway.

5 Although the check across the belt entry outby the loading point was reported to be tight, virtually all of the belt entry airflow (3,500 cfm) passed through the belt check and traveled to the working places. This air flow was confirmed by tracer gas distribution. Airflow through the 4" pipe was negligible.

7 Section respirable dust samples in the intake airstream to the working places was 0.18 mg/m^3; outby the belt entry check, 0.75 mg/m^3; inby the belt entry check, 0.69 mg/m^3; and in the immediate return, 1.10 mg/m^3.

8 Point type heat sensors were installed in belt entry

Mine B, Section 2 is a three-entry system. Ventilating air is directed through the belt entry (#3 entry) toward the face and the primary escapeway (#2 entry). For practical purposes the belt entry is neutral with indicated air flow velocities ranging from 14 fpm to 26 fpm. The belt entry airflow is controlled by a check installed across the belt entry immediately outby the loading point. Belt entry airflow was directed to the return air course (# 1 entry) through a 3" diameter steel pipe in the first crosscut outby the belt entry check which extends from the #3 entry to the #1 entry.

Comments

1 The check across the belt entry outby the section loading point coupled with the regulation provided by the 3" diameter pipe raises the ventilating pressure in the belt entry above that of the primary intake escapeway in the inby portion of the section. This results in air leakage from the belt entry to the primary intake escapeway.

2 Approximately 1,000 cfm of air leaked from the belt entry to the face area through the belt entry check. Airflow to the face was confirmed by tracer gas. Total airflow in the belt entry outby the 3" diameter pipe crosscut was 1,200 cfm. Airflow through the 3" diameter pipe was negligible and approximately 1,000 cfm of belt entry air leaked to the intake escapeway outby the 3" pipe crosscut.

3 The total intake air quantity to the section is 21,400 cfm. Ventilating pressure differentials on the section between the belt entry and the escapeway are only a few hundredths of an inch wg.

4 The ventilation scheme is similar to that of Section 1 of the study. Except for the outby portion of Section 2, the air leakage potential was from the belt entry to the intake escapeway. The survey area extended from the face of Section 2 to points about 500 feet along the mains on both sides of Section 2.

5 Belt entry air velocities on the section range from about 14 fpm to 26 fpm and are inadequate to dilute methane layers.

6 Point-type heat sensors were installed in the belt entry.

Mine C, Section 3 is a five-entry section. This section operated under a section 75.326 petition for modification and belt entry air is taken to the face. In this system the #1 entry is a return air course, #2 & #3 entries are interconnected with the belt conveyor in the #3 entry, #4 entry is the intake escapeway, and #5 entry is a return air course. With this system the absolute ventilating pressures in the intake escapeway and the belt air courses are nearly balanced. All measured leakage from the intake air shaft to the section is from the intake escapeway to the belt air courses. The total air intake to the section was approximately 41,000 cfm with approximately 40 percent delivered by the belt entries.

Comments:

1. Because of the ventilating pressure distribution in the belt entries and the intake escapeway, smoke from the initial stages of a fire in the belt entry would probably be confined to that entry. Although the products of combustion would be delivered to the #1, 2, & 3 entry faces, the intake escapeway would remain smoke-free.

2. The ventilating pressures between the belt entries and the intake escapeway are within a few hundredths of an inch water gage. However, in contrast to Sections 1 & 2, the belt entry has a slightly lower pressure and leakage is consistently from the intake escapeway to the belt entry.

3 Airflow into the intake escapeway is controlled by an intake escapeway regulator located near the shaft bottom.

4 The average entry air velocity in the belt entries on the section is approximately 80 fpm. This velocity is adequate for methane mixing in the entry, however some layering could occur. The air velocities in the #1 and #5 entries of the section are approximately 198 fpm and 208 fpm respectively.

5 Point-type heat sensors and a CO detection system were installed in the belt entry.

Mine D, Section 4 is a four-entry system. The entries are separated by three lines of stoppings. The #1 entry is a return entry, #2 entry is the intake escapeway, #3 entry is the track entry, and #4 entry is the belt haulageway. All entries are separated by stoppings and airflow is directed into the belt entry at the loading point and travels outby through the belt entry to the return through a regulator near the section mouth

Comments:

1 Because the belt entry air is routed to the return from the mouth of the section after traveling inby along the intake escapeway and the track entry, the belt entry functions in a manner similar to a return entry and all air leakage is into the belt entry. Any smoke from a fire starting in the belt entry would be directed into the return without entering the active workings of the section.

2 The velocity of the airstream in all section entries exceeded 100 fpm. Methane layering or accumulation would not normally be expected in these entries.

3. Ventilation pressure differentials between the track and intake escapeway are from the track to the escapeway. On the section approximately 7,000 cfm of air leaks from the track entry to the intake escapeway. Thirty percent of the ventilating air delivered to the section faces by the intake escapeway is track entry air which has entered the escapeway on the section.

4 It is unlikely that a fire in the belt entry would contaminate any intake air courses during its initial stages.

5 The location of the belt entry regulator did not increase float dust in the belt entry. The system diverts approximately 23,000 cfm from the face areas. However, the section is ventilated with 67,000 cfm as measured at the mouth of the section.

6 Respirable dust concentrations were: at the last permanent stopping in the intake escapeway, 0.27 mg/m^3; in the belt entry outby the dumping point, 0.37 mg/m^3; inby the belt entry regulator to the return, 0.03 mg/m^3

7 Point-type heat sensors and a CO detection system were installed in the belt entry.

Mine D, Section 5 is a section adjacent to Section 4 above. The ventilation system is similar except that the ventilation pressures are more closely balanced between the track entry and the intake escapeway and no intermingling of air is indicated.

Comments

1 As in Section 4, the belt entry is routed to the return as a separate split. Air leakage is from the track to the belt entry.

2 Although the ventilating pressure potential is from the track to the escapeway at the entrance to the section, leakage is not indicated.

3 The air velocity at the entrance to the belt entry near the section face was about 76 fpm.

4 It is unlikely that smoke in the section belt entry would contaminate any section air courses.

5. Point-type heat sensors and a CO detection system were installed in the belt entry.

Mine D, Section 6 is an eight-entry section with five rows of stoppings. Nos. 1 & 2 entries are interconnected return airways, #3 is a "neutral" entry, #4 is the belt haulageway, #5 is the track entry, #6 is the intake escapeway and #7 & 8 are return airways. The section is ventilated by approximately 40,000 cfm of air. Of this, approximately 33,000 cfm is available for face ventilation and 7,000 cfm flows outby from the belt loading point to ventilate the belt entry. Ventilation here is different than that in Sections 4 & 5 by virtue of the location of the belt entry and the number of entries involved. The intake escapeway is well protected from a belt fire and the #3 entry, provides an additional means for escape.

Comments

1 In Section 6 the ventilating pressure differential between the track entry and the intake escapeway is balanced. No air leakage is indicated.

2 The ventilating pressure differential of 0.03 inches wg is from the track entry to the belt entry. However, no air leakage is indicated.

3 It is unlikely that smoke in the section belt entry would contaminate the adjacent section air courses.

4 Point-type heat sensors and a CO detection system were installed in the belt entry.

Mine E, Section 7 is operating under a 101(c) petition for modification of section 75.326 and uses a CO detection system. It is a four-entry section with three rows of stoppings: #1 is the return air course, #2 is a separated intake escapeway, #3 is the track entry, and #4 is the separated belt haulageway.

Comments

1 The section is ventilated by approximately 36,000 cfm of air. Approximately 15,000 cfm is supplied by the belt entry, 17,000 cfm is from the track entry, and 4,000 cfm is from the intake escapeway.

2 Smoke from a fire in the belt entry would contaminate all working places on the section, however the intake escapeway is protected from a fire in the belt entry by the higher pressure track entry.

3 Respirable dust concentrations were: at the last permanent stopping in the track entry, 0.89 mg/m^3; at the last permanent stopping in the intake escapeway, 0.33 mg/m^3; belt entry outby loading point, 0.60 mg/m^3; belt entry inby loading point, not available.

4 A CO detection system was installed in the belt entry

Mine E, Section 8 displays the same characteristics as Section 7. The Section is a four-entry development with three rows of stoppings. The return is in #1, the intake escapeway in #2, the track in #3, and the belt in #4. The section is ventilated by approximately 45,000 cfm of air at the mouth with approximately 33,000 cfm reaching the faces. Approximately 11,000 is delivered by the belt entry, 21,000 by the track entry, and 600 cfm by the intake escapeway. The primary difference between this section and Section 7 is that a check was installed across the intake escapeway one crosscut outby the face of #2 entry. It appears that the purpose of this check was to raise the ventilating pressure of the escapeway above that of the adjacent entries and prevent leakage into the escapeway. The check accomplishes this goal for the inby portion of the escapeway, however leakage is from the track entry to the escapeway for most of the development.

Comments

1 Smoke from the initial stages of a fire in the belt entry will be confined to the belt entry by the ventilation pressure distribution, however the products of combustion will contaminate all working places.

2 The intake escapeway is well protected from the belt entry, however leakage is from the track entry to the escapeway for the major portion of the section.

3 A CO detection system was installed in the belt entry

Mine F, Section 9 is a four entry section: #1 is the return air course, #2 is the intake escapeway, #3 is the track entry, and #4 is the belt entry. Air is coursed to the face through the #2 & #3 air courses and is split to the belt entry, #4, about 4 crosscuts outby the face. Air travels outby along the belt and is regulated to the return at the mouth of the section.

Comments

1 Air leakage is from the track to the belt entry.

2 Although the ventilating pressures in the escapeway and track entry are nearly the same, leakage is from the track to the escapeway from the mains onto the section.

3 Air velocities at the inby end of the belt are approximately 60 fpm and reach approximately 200 fpm near the regulator.

4 Approximately 100,000 cfm of air enters the section and 55,000 is delivered to the face area where 6,800 is split into the belt entry outby the faces.

5 The intake escapeway appears well protected from the products of combustion originating in the belt entry, and is reasonably well protected from the initial phases of a fire in the track entry. Leakage to the escapeway from the track is minimal and should not impede escape in the outby portions of the escapeway, however significant leakage occurs near the inby end.

6 Respirable dust concentrations were: at last permanent stopping in intake escapeway, 0.13 mg/m^3; in belt entry outby loading point, 0.48 mg/m^3.

7. Point-type heat sensors were installed in the belt entry.

Mine G, Section 10 is a four-entry development for a short distance and then becomes 3 entries. The #1 entry is the return, #2 is the intake escapeway, and #3 is the belt entry. Air is coursed to the face area through the intake escapeway. About 2 crosscuts outby the face the air is split with approximately 4000 cfm directed outby through the belt entry, and approximately 24,000 cfm flowing across the faces to the return, #1 entry. All leakage is from the intake escapeway.

Comments

1 The four-entry portion of the system contains an electric trolley wire in the #3 entry. The #3 entry

later becomes the #2 entry, the intake escapeway. The intake escapeway is routed around the electric trolley portion of the entry into the #2 entry of the four-entry development and is protected by doors. Airflow from the electric trolley portion is directed to the return across an overcast. Door leakage is from the escapeway to the electric trolley entry.

2 Ventilating pressure differentials were from the track to the belt entry.

3 Respirable dust concentrations were: at the last permanent stopping in the track entry, 0.44 mg/m^3; in the belt entry outby the loading point, 3.09 mg/m^3; in the return from the belt entry inby the regulator, 1.08 mg/m^3.

4 The respirable dust concentration in the belt entry, 3.09 mg/m^3, was in excess of the allowable concentration and additional dust control measures are required. Low entry air velocities in the vicinity of the loading point may contribute to the high respirable dust concentration in this area.

5 A CO detection system and point-type heat sensors were installed in the belt entry.

Mine H, Section 11. Section 11 was initially developed with 3 entries but was expanded to four entries one crosscut outby the belt tailpiece. Belt entry air was intended to be diverted to the return by a 16" diameter pipe in the first crosscut outby the loading point. However, an improperly located check permitted 6,000 cfm of belt airflow to go directly to the face without restriction. An additional 3,500 cfm of air leaked through the belt entry check to the working places.

Comments

1 About 28,000 cfm of intake air was delivered to the faces of which 34 percent was belt entry air.

2 Air that had ventilated the belt entry was used to ventilate the working places without restriction.

3 Belt entry air flow to the section was limited by belt entry checks on the mains outby the mouth of the section.

4 Section air leakage was from the intake escapeway to the belt entry and from the intake escapeway to the return entry.

later becomes the #2 entry, the intake escapeway. The intake escapeway is routed around the electric trolley portion of the entry into the #2 entry of the four-entry development and is protected by doors. Airflow from the electric trolley portion is directed to the return across an overcast. Door leakage is from the escapeway to the electric trolley entry.

2. Ventilating pressure differentials were from the track to the belt entry.

3. Respirable dust concentrations were: at the last permanent stopping in the track entry, 0.44 mg/m^3; in the belt entry outby the loading point, 3.09 mg/m^3; in the return from the belt entry inby the regulator, 1.08 mg/m^3.

4. The respirable dust concentration in the belt entry, 3.09 mg/m^3, was in excess of the allowable concentration and additional dust control measures are required. Low entry air velocities in the vicinity of the loading point may contribute to the high respirable dust concentration in this area.

5. A CO detection system and point-type heat sensors were installed in the belt entry.

Mine H, Section 11. Section 11 was initially developed with 3 entries but was expanded to four entries one crosscut outby the belt tailpiece. Belt entry air was intended to be diverted to the return by a 16" diameter pipe in the first crosscut outby the loading point. However, an improperly located check permitted 6,000 cfm of belt airflow to go directly to the face without restriction. An additional 3,500 cfm of air leaked through the belt entry check to the working places.

Comments

1 About 28,000 cfm of intake air was delivered to the faces of which 34 percent was belt entry air.

2 Air that had ventilated the belt entry was used to ventilate the working places without restriction.

3 Belt entry air flow to the section was limited by belt entry checks on the mains outby the mouth of the section.

4 Section air leakage was from the intake escapeway to the belt entry and from the intake escapeway to the return entry.

5 Belt entry air velocity was about 86 fpm

6 Smoke in the section belt entry would not enter the intake escapeway on the section.

7 A CO monitoring system was used to replace the point-type heat sensors along the belt entry.

Mine H, Section 12. Air that ventilated the belt entry of Section 12 is directed to the return near the belt tailpiece. This is a four-entry section. The #1 entry is the main section return, the #2 entry 3 crosscuts outby the face is a secondary return for air that has ventilated the belt entry, #3 entry is the belt entry, and #4 entry is the intake escapeway. The #2 entry return air flow enters the #1 air course through a crosscut bordering a gas well barrier pillar where the #2 air course is interrupted.

Comments:

1 Belt airflow near the loading point was controlled by a complex arrangement of checks and regulators. Tracer gas indicated that a small amount of belt air arrived at the face.

2 Ventilation pressure differentials between the intake escapeway and the belt entry were only a few hundredths of an inch wg, however leakage was consistently from the escapeway to the belt entry.

3 Belt entry airflow to the section was limited by belt entry checks on the mains outby the mouth of the section.

4 Approximately three times the airflow was present in the intake escapeway as compared to the belt entry

5 A CO monitoring system was used to replace point type heat sensors in the belt entry.

6 The respirable dust concentrations were: in the intake escapeway at the last permanent stopping, 0.04 mg/m^3; in the belt entry outby the loading point, 0.11 mg/m^3; in the belt entry inby the loading point, 0.09 mg/m^3.

Mine H, Section 13. In Section 13 the conveyor belt outby the loading point was ventilated by a separate split of air directed to the belt entry one crosscut outby the tailpiece and coursed to the main return. This is a three-entry section 5 crosscuts deep. The #1 entry is the Section return air course, The #2 entry is the intake escapeway, and the #3 entry is the belt entry which is on a separate split to the return. Total air delivered by the #2 entry was approximately 31,000 cfm; of this, 5,000 cfm was directed to the belt entry and 26,000 cfm was used to ventilate the working places.

Comments

1 Ventilating pressure differentials were from the intake escapeway to the belt entry in the mains approaching the section and on the section. The potential for leakage was from the escapeway to the belt entry.

2 It is unlikely that smoke in the belt entry would contaminate the intake escapeway.

3 The air velocity in the belt entry was approximately 45 fpm. This velocity is inadequate for dilution of methane layering.

4 A CO detection system was installed to replace point-type heat sensors in the belt entry.

Mine I, Section 14. This section includes rooms off the 3rd panel. It is a five-room development with blind cross cuts to the left off #1 room. The intake escapeway in #5 room is separated by stoppings from the adjacent #2, #3, and #4 rooms which house the belt conveyor system. The stoppings extend from the mouth of the section to the 3rd crosscut outby the face. The separation of the intake escapeway from the belt entries is extended by additional stoppings installed across #3 and #4 rooms between the 2nd and 3rd crosscuts outby the face.

Comments

1 The section conveyor belt is installed in the #3 room with the tailpiece in the 3rd crosscut outby the face Number 3 room is interconnected with #2 and #4 rooms.

2 The belt conveyor is enclosed in a three room by four crosscut area separated from the #5 room by stoppings, from the last open crosscut by stoppings in #3 & #4 rooms and a drive-through check in #2 room, from the return air course in #1 room by checks and from the main return air course by checks.

3 The belt area is ventilated by leakage entering through the run-through check in #2 room and from the intake escapeway. Ventilating air exits the area through an open crosscut in the third crosscut outby the face between #1 & #3 rooms and leaks through the checks to the main return. All ventilation readings into or out of the belt area were less than 1,000 cfm.

4 Intake air enters the section through the intake escapeway, #1 room; sweeps across the faces; and exits the section to the main return through #1 room. A tracer gas study showed that none of the air ventilating the belt haulageway was used to ventilate the faces.

5 Although ventilating pressure differentials between the intake escapeway and the belt entries from the 2nd Panel area were very low, generally less than 0.04 inches wg, air leakage was consistently from the intake escapeway to the belt haulage entries and then to the return.

6 Point type heat sensors were installed in the belt entry.

7. Section dust samples in the intake escapeway at the last permanent stopping was 0.08 mg/m^3; inby the loading point 0.15 mg/m^3; and outby the loading point, 0.16 mg/m^3.

Mine J, Section 15 is a five-entry development including rooms right off 2nd Panel East. Ventilating air is introduced into the belt entry at the tailpiece and is directed outby along the belt haulageway. Air that has ventilated the face is not used to ventilate working places.

Comments:

1 The section conveyor belt is installed in the #3 entry in line with #3 room.

2 The conveyor belt haulageway, #3 entry of 2nd Panel East, is interconnected with the #2 & #4 entries and the #2, 3 & 4 rooms.

3 The intake escapeway in #5 entry of 2nd Panel East and #5 room east is separated from the belt haulage area (#2, #3, and #4 entries of 2nd Panel East and #2, #3, and #4 rooms) by stoppings extending to the 2nd crosscut outby the face of #5 room.

4 Approximately 9,000 cfm of intake air was split into the #2, #3, and #4 rooms outby the last open crosscut and flowed outby to the belt haulageway in the 2nd Panel. Air flow outby along the belt was checked to less than 1,000 cfm outby the belt tailpiece and the remaining 8,000 cfm was directed to abandoned rooms on the left side of the panel. Belt haulage airflow was increased to approximately 4,000 cfm by leakage from the intake escapeway prior to reaching the mouth of the panel.

5. Ventilating pressure differentials between the intake escapeway and the belt haulage area was very low, less than .03 inches wg, however, air leakage was consistently from the intake escapeway to the belt area.

6. Point type heat sensors were installed in the belt entry.

Mine K, Section 16 is developed by four entries off the mains with 3 short rooms to the left, 1 crosscut outby the advancing faces. The #1 entry was the section return; the #2 entry was interconnected with the #3 entry (the belt entry), and the #4 entry was the intake escapeway. Air traveling inby along the belt was directed to the return outby the last open crosscut. Field measurements indicate that approximately 3,000 cfm of belt air passed to the return through the inby control check between #1 and #2 entries.

Comments:

1. Approximately 20,000 cfm of intake air entered the mouth of the section through the intake escapeway (#4 entry) and 15,000 cfm was delivered to the face. Approximately 5,000 cfm leaked from the intake escapeway to the belt haulage entry.

2. Although section absolute ventilation pressures were in excess of -6.5 inches wg, pressure differentials between the intake escapeway and the belt entries were very low, generally less than .02 inches wg.

3. Air traveled inby along the belt (#3 entry) and the interconnected #2 entry to the face area where approximately 5,000 cfm was routed to the return through an open man door; an additional 3,000 cfm of air entered the return through the inby control checks.

4. Ventilating pressure differentials between the belt entries and the section return inby the return regulator were also low at 0.04 inches wg or less. Leakage from the belt entry to the return was approximately 1,000 cfm outby the belt return man door near the face of the section.

5. Respirable dust concentrations were: 0.15 mg/m^3 in the intake at the last permanent stopping, 0.22 mg/m^3 inby the belt loading point, and 0.18 mg/m^3 outby the belt loading point.

6. A heat-sensitive pneumatic fire-detection system was installed in the belt entry.

Mine K, Section 17 is a four-entry development off the mains adjacent to Section 16. This section differs from Section 16 only in the depth to which it has been driven. The #1 entry is the section return, #2 entry is interconnected with #3 entry, the belt entry, and #4 entry is the intake escapeway. Field measurements indicated that approximately 3,000 cfm of belt air passed to the return through the inby control checks between the #1 and #2 entries.

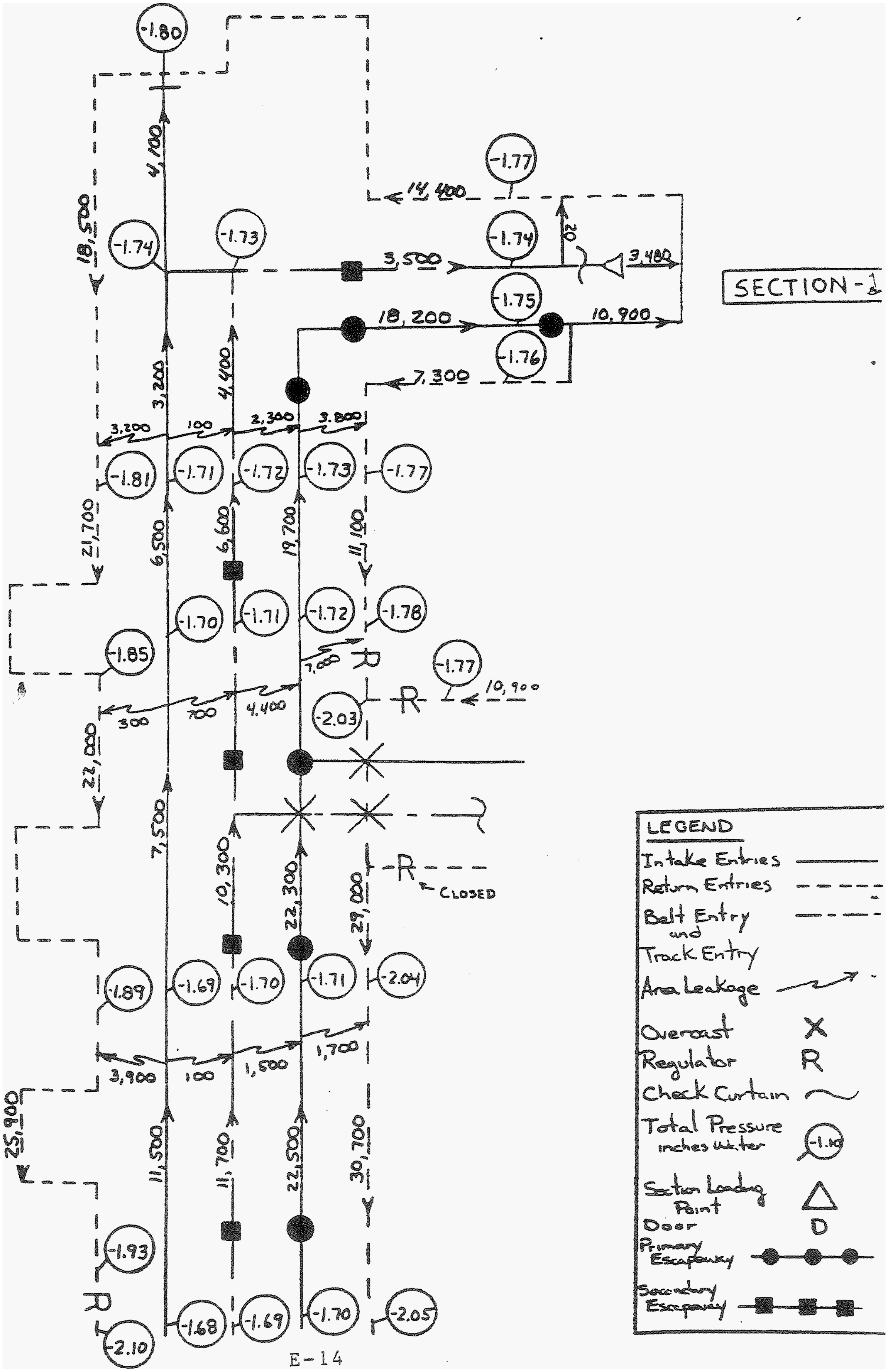
Comments

1. Approximately 22,000 cfm of intake air entered the intake escapeway at the mouth of the section and of this approximately 14,000 cfm was delivered to the face. The difference, 8,000 cfm leaked from the escapeway to the belt entry.

2. Section absolute ventilating pressures were in excess of -6.5 inches wg. However pressure differentials on the section were very low; generally, less than 0.02 inches wg.

3. Air traveled inby along the belt and the interconnected #2 entry to the face area where approximately 8,000 cfm was directed to the return and 3,000 cfm entered the return through the inby control check.

4 A heat-sensitive pneumatic fire-detection system was installed in the belt entry.


SECTION-1
LEGEND
Intake Entries
Return Entries
Belt Entry and Track Entry
Area Leakage
Overcast
Regulator
R
Check Curtain
Total Pressure inches Water
Section Loading Point
Door
D
Primary Escapeway
Secondary Escapeway
CLOSED
-1.80
-1.77
-1.74
-1.73
-1.75
-1.76
-1.81
-1.71
-1.72
-1.78
-1.85
-1.70
-2.03
-1.89
-1.69
-2.04
-1.93
-2.10
-1.68
-2.05
4,100
18,500
14,400
3,500
3,480
18,200
10,900
7,300
3,200
4,400
2,300
3,800
100
21,700
6,500
6,600
19,700
11,100
7,000
10,900
300
700
22,800
7,500
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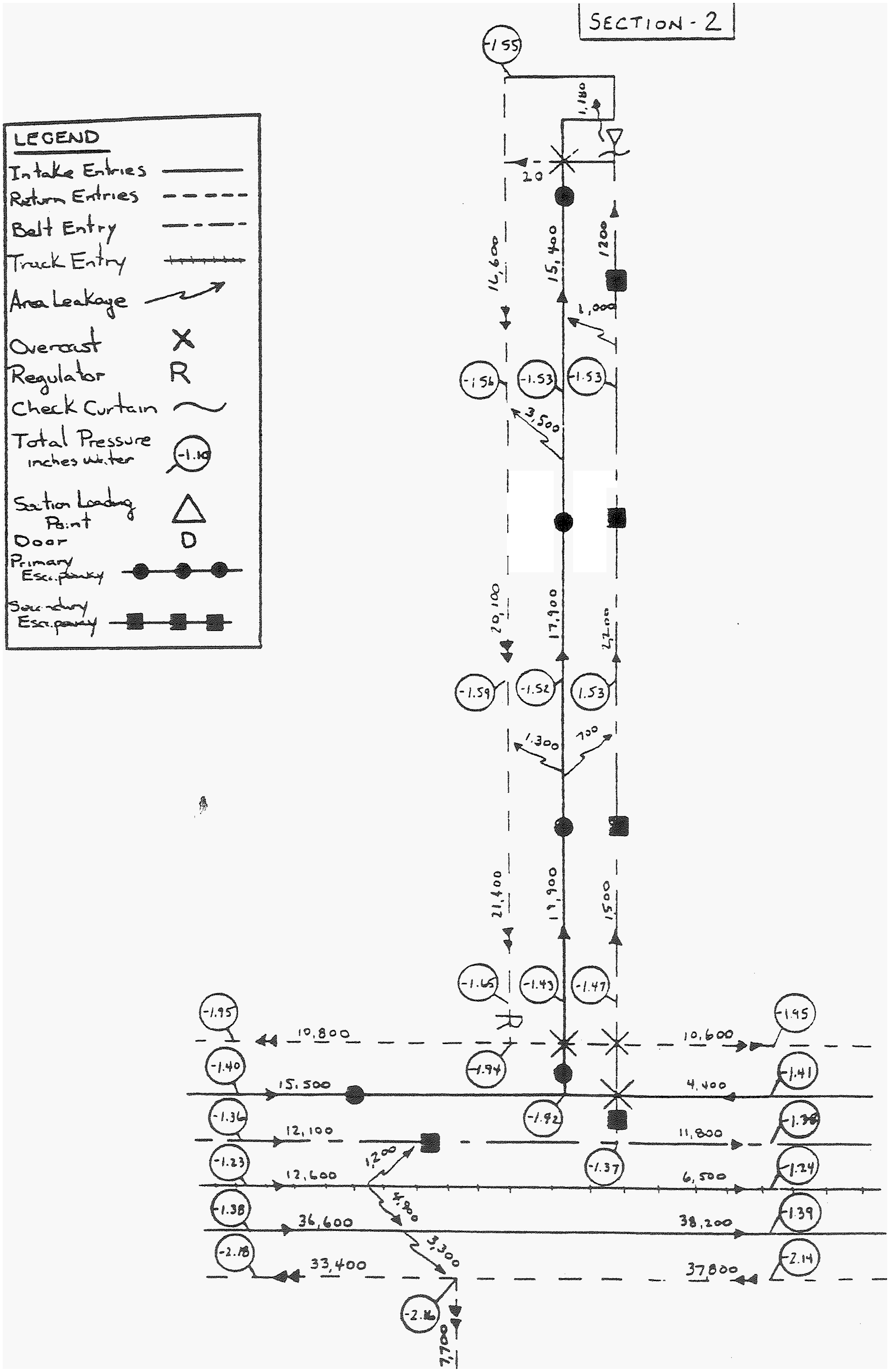
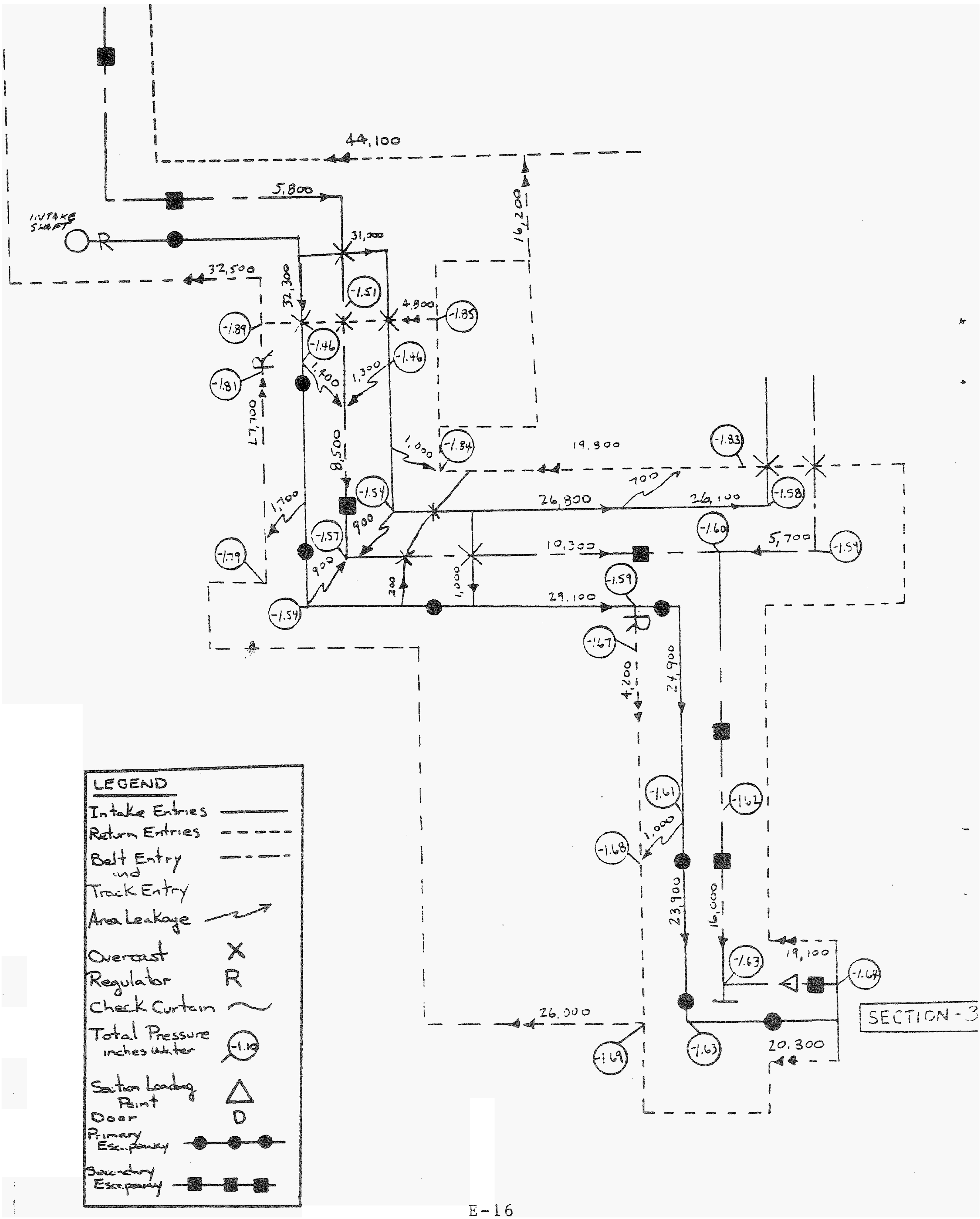
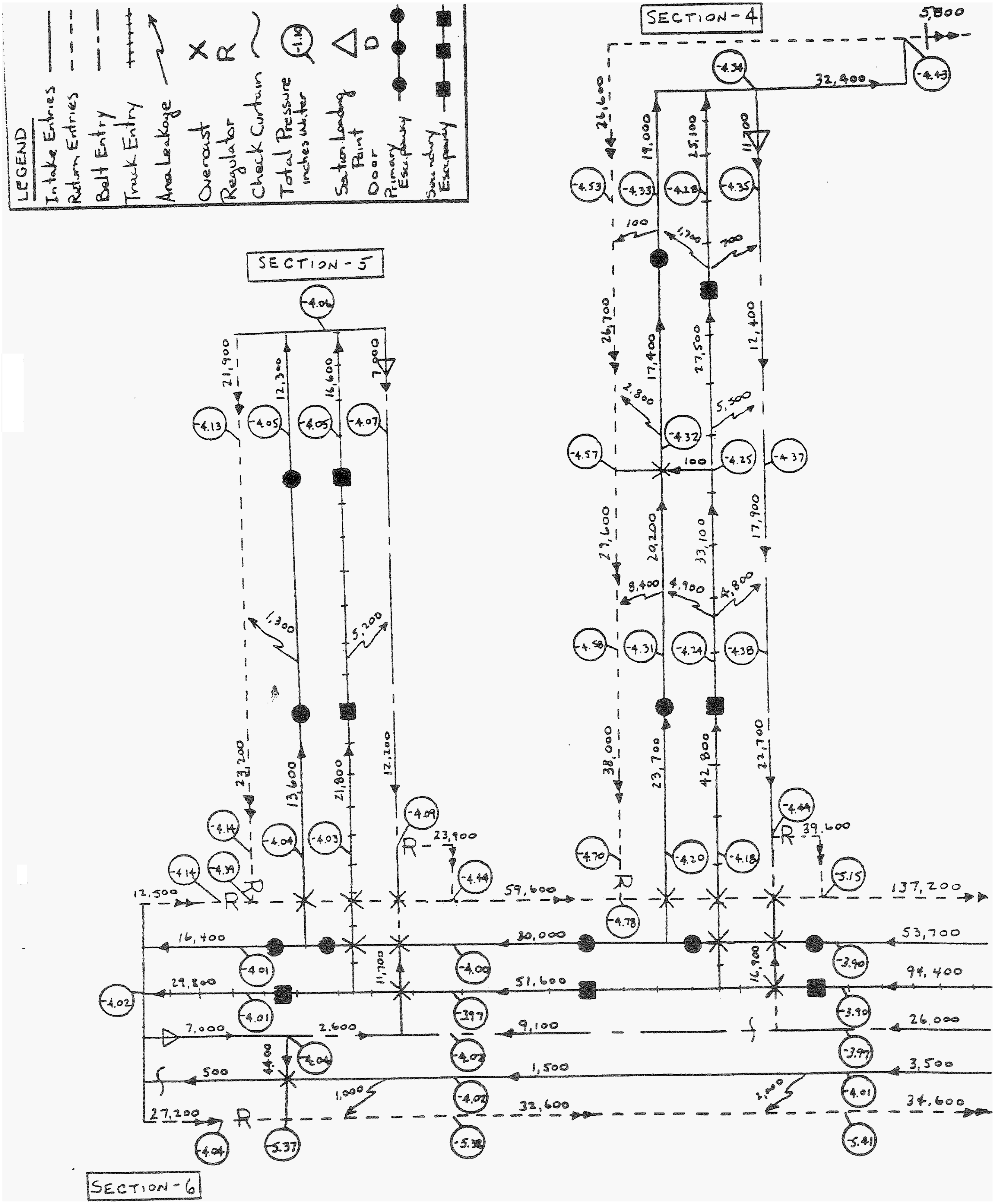
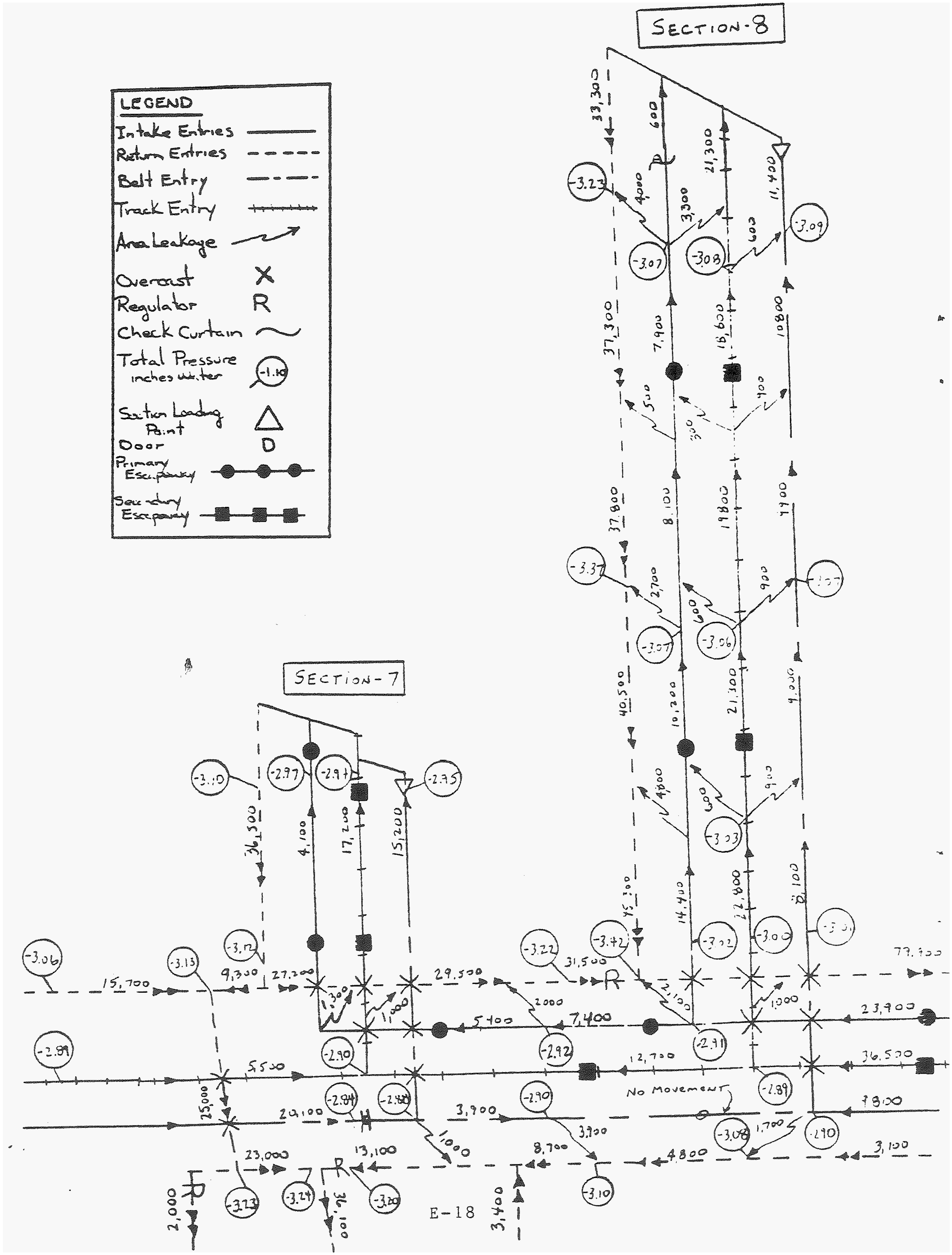
11,500
11,700
22,500
30,700

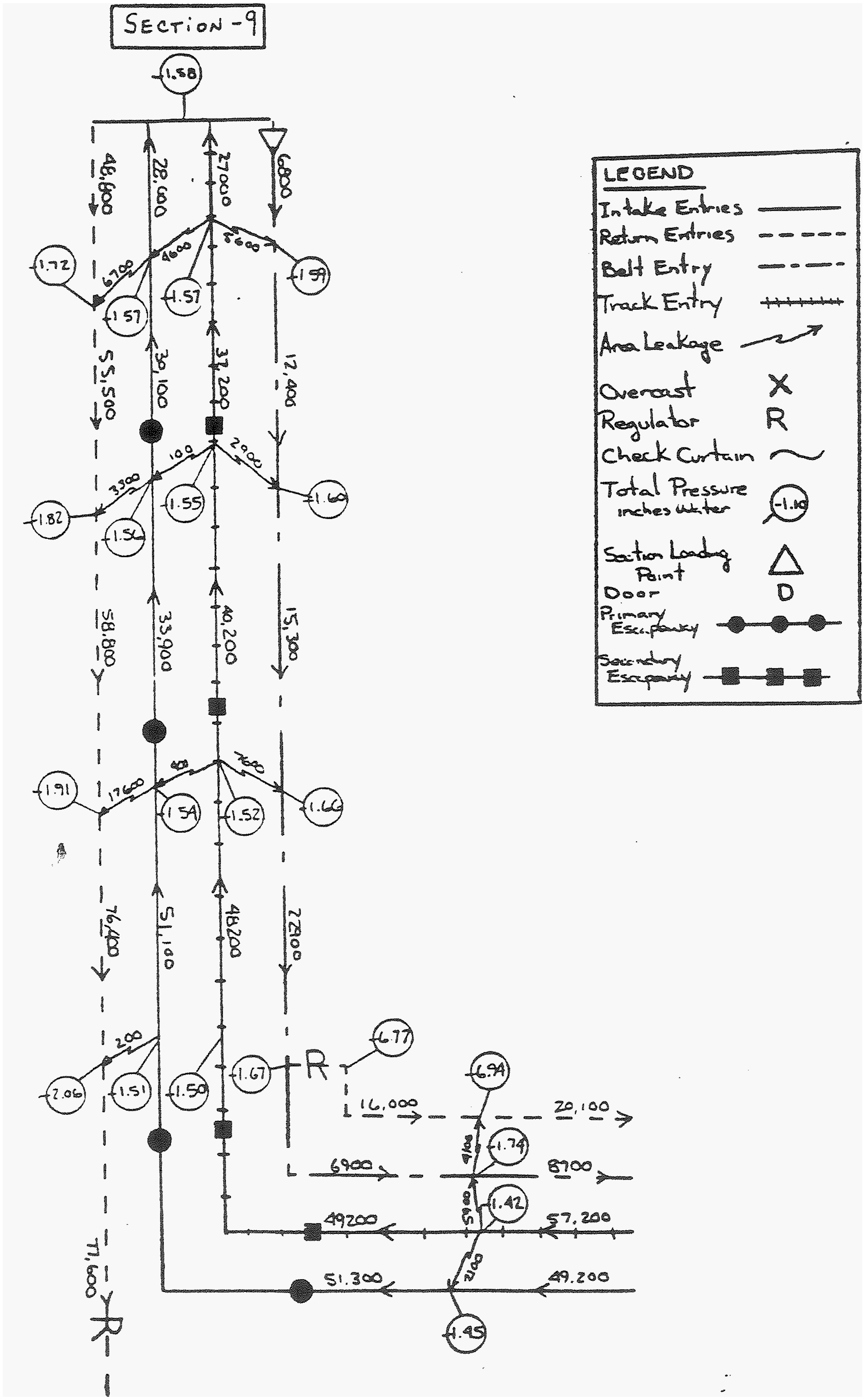


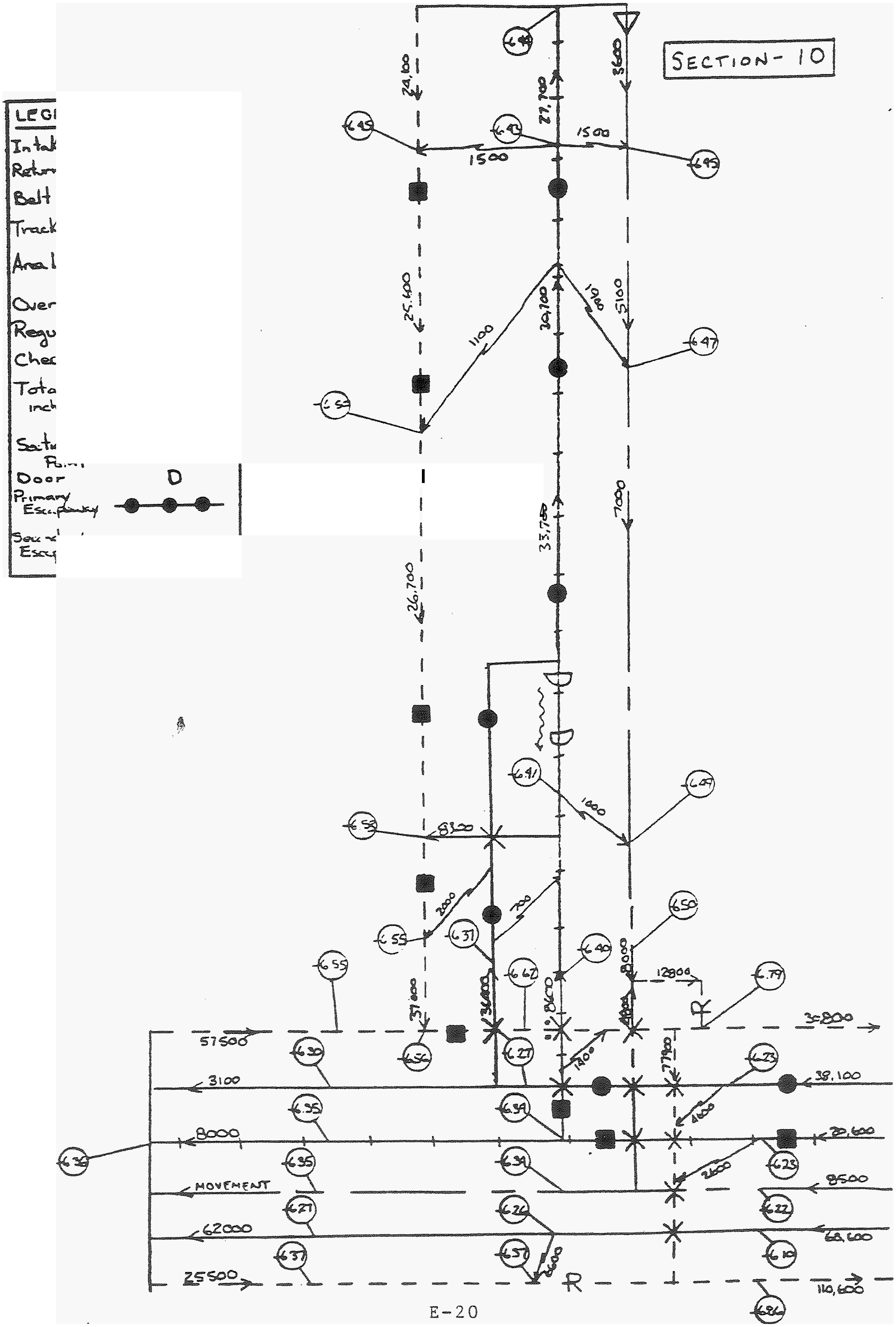
SECTION - 2
LEGEND
Intake Entries
Return Entries
Belt Entry
Track Entry
Area Leakage
Overcast
X
Regulator
R
Check Curtain
Total Pressure
inches water
-1.10
Section Loading Point
Door
D
Primary Escapeway
Secondary Escapeway
-1.55
1,180
20
16,600
15,400
1200
1,000
-1.56
-1.53
-1.53
3,500
20,100
17,900
2200
-1.59
-1.52
1.53
1,300
700
21,400
19,900
1500
-1.65
-1.43
-1.47
R
-1.95
10,800
10,600
-1.95
-1.94
-1.40
15,500
4,400
-1.41
-1.36
12,100
-1.92
11,800
1200
-1.37
-1.23
12,600
6,500
-1.24
4,800
-1.38
36,600
38,200
-1.39
3,300
-2.18
33,400
37800
-2.14
7,700


44,100
5,800
INTAKE SHAFT
R
31,000
16,200
32,500
32,300
-1.51
4,800
-1.85
-1.89
-1.46
-1.46
-1.81
1,400
1,300
27,700
8,500
1,000
-1.84
19,900
-1.83
700
26,800
26,100
-1.58
-1.54
1,700
-1.57
900
900
-1.60
5,700
-1.59
-1.79
10,300
200
1,000
-1.59
29,100
-1.54
-1.67
4,200
24,900
-1.61
-1.62
1,000
-1.68
23,900
16,000
-1.63
19,100
-1.64
26,000
-1.69
-1.63
20,300
SECTION-3
LEGEND
Intake Entries
Return Entries
Belt Entry and Track Entry
Area Leakage
Overcast X
Regulator R
Check Curtain
Total Pressure inches Water -1.10
Section Loading Point
Door D
Primary Escapeway
Secondary Escapeway

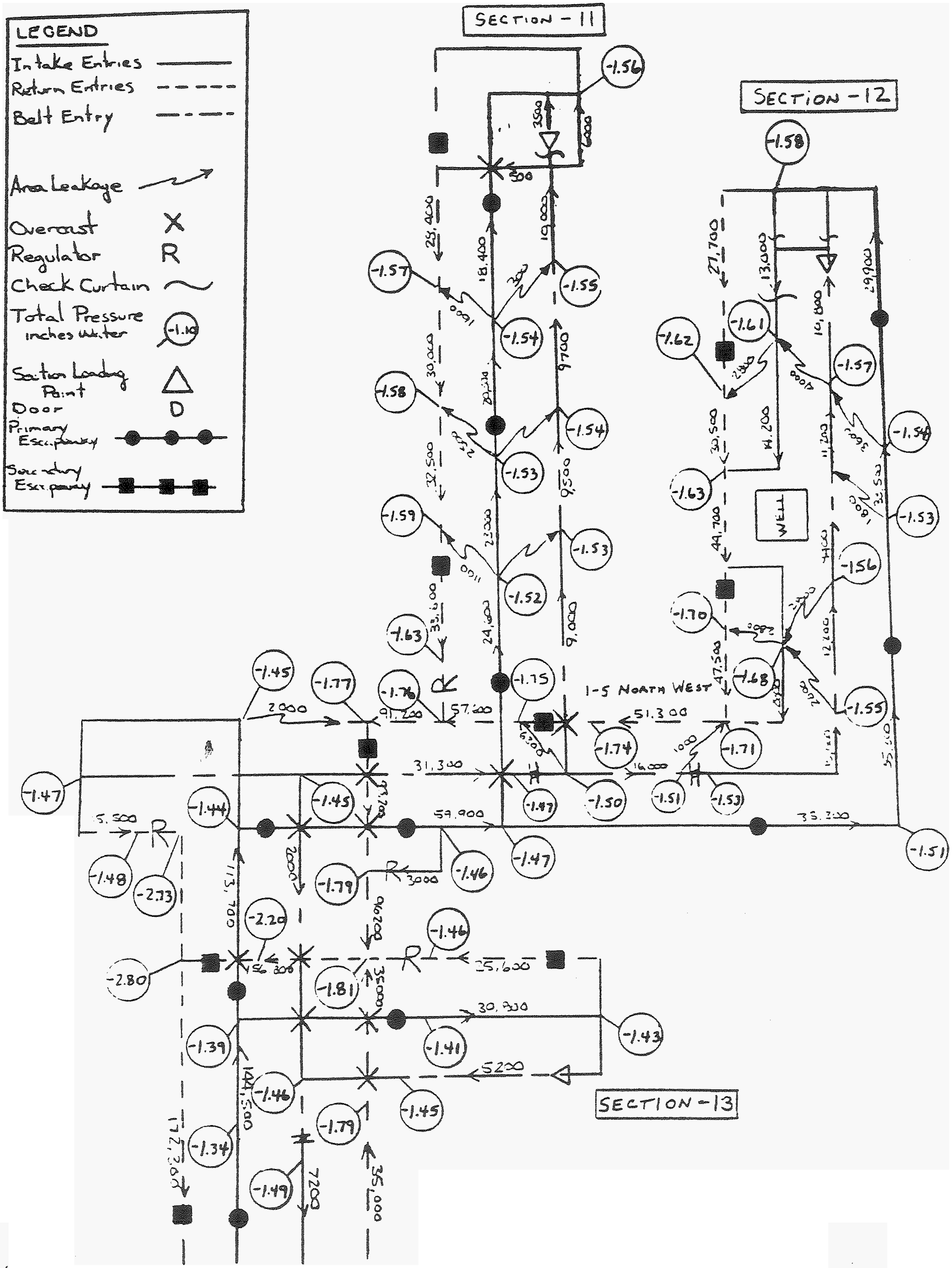

LEGEND
Intake Entries
Return Entries
Belt Entry
Truck Entry
Air Leakage
Overcast
Regulator
Check Curtain
Total Pressure inches Water
Section Loading Point
Door
Primary Escapeway
Secondary Escapeway
SECTION-4
SECTION-5
SECTION-6
5,800
32,400
26,600
19,000
25,100
11,700
26,700
17,400
27,500
12,400
27,600
20,200
33,100
17,900
38,000
23,700
42,800
22,700
21,900
12,300
16,600
7,000
23,200
13,600
21,800
12,200
23,900
59,600
39,600
137,200
12,500
16,400
30,000
53,700
29,800
51,600
94,400
7,000
2,600
9,100
26,000
500
1,500
3,500
27,200
32,600
34,600
11,700
16,900
4400
1,000
100
1,700
700
2,800
5,300
8,400
4,900
4,800
1,300
5,200
-4.34
-4.43
-4.53
-4.33
-4.28
-4.35
-4.32
-4.57
-4.25
-4.37
-4.58
-4.31
-4.24
-4.38
-4.44
-4.70
-4.20
-4.18
-5.15
-4.78
-4.06
-4.13
-4.05
-4.07
-4.14
-4.39
-4.04
-4.03
-4.09
-4.02
-4.01
-4.00
-3.97
-3.90
-3.99
-5.37
-5.38
-5.41


SECTION-8
SECTION-7
LEGEND
Intake Entries
Return Entries
Belt Entry
Track Entry
Area Leakage
Overcast X
Regulator R
Check Curtain
Total Pressure inches water
-1.10
Section Loading Point
Door D
Primary Escapeway
Secondary Escapeway
33,300
600
21,300
11,400
-3.23
4000
3300
603
-3.09
-3.07
-3.08
37,300
7,900
16,600
10800
500
300
400
37,800
8,100
19800
7700
-3.37
2,700
600
900
-3.07
-3.06
40,500
10,200
21,300
9,000
4,800
600
900
-3.03
45,300
14,400
22,800
21,100
-3.42
-3.02
-3.00
-3.10
36,500
4,100
17,200
15,200
-2.97
-2.97
-2.75
-3.06
-3.13
-3.12
-3.22
15,700
9,300
27,200
29,500
31,500
77,700
1,300
1,000
2000
2,100
1,000
5400
7,400
23,900
-2.89
-2.90
-2.92
-2.91
5,500
12,700
36,500
-2.89
25,000
-2.84
-2.80
-2.90
No Movement
7900
20,100
3,900
3,900
1,000
8,700
4800
1,700
-3.08
-2.90
3,100
23,000
13,100
-3.23
-3.24
-3.20
-3.10
2,000
36,100
3,400


SECTION-9
LEGEND
Intake Entries
Return Entries
Belt Entry
Track Entry
Area Leakage
Overcast X
Regulator R
Check Curtain
Total Pressure inches Water
Section Loading Point
Door D
Primary Escapeway
Secondary Escapeway
1.58
48,800
28,600
27000
6800
1.72
6700
4600
3600
1.57
1.57
1.59
55,500
30,100
37,200
12,400
3300
100
2900
1.82
1.56
1.55
1.60
58,800
33,900
40,200
15,300
1.91
17600
400
7600
1.54
1.52
1.66
76,400
51,100
48200
22800
200
2.06
1.51
1.50
1.67
R
6.77
6.94
16,000
20,100
1.74
6900
8700
1.42
49200
57,200
51,300
49,200
1.45
71,600
R



SECTION-10
LEGEND
Door
D
Primary Escapeway


LEGEND
Intake Entries
Return Entries
Belt Entry
Area Leakage
Overcast X
Regulator R
Check Curtain
Total Pressure inches Water
-1.10
Section Loading Point
Door D
Primary Escapeway
Secondary Escapeway
SECTION - 11
SECTION - 12
SECTION - 13
1-5 NORTH WEST
WELL
-1.56
-1.58
-1.57
-1.55
-1.54
-1.62
-1.61
-1.53
-1.52
-1.63
-1.70
-1.68
-1.45
-1.77
-1.76
-1.75
-1.74
-1.71
-1.47
-1.44
-1.50
-1.51
-1.48
-2.73
-1.79
-1.46
-2.20
-2.80
-1.81
-1.43
-1.39
-1.41
-1.34
-1.49
-1.59
28,400
18,400
19,000
30,000
9700
32,500
9500
22,000
33,600
24,000
9,000
27,700
13,000
29,900
10,800
32,500
14,200
44,700
47,500
12,200
51,300
57,600
91,200
31,300
59,900
35,300
35,500
2000
3000
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25,600
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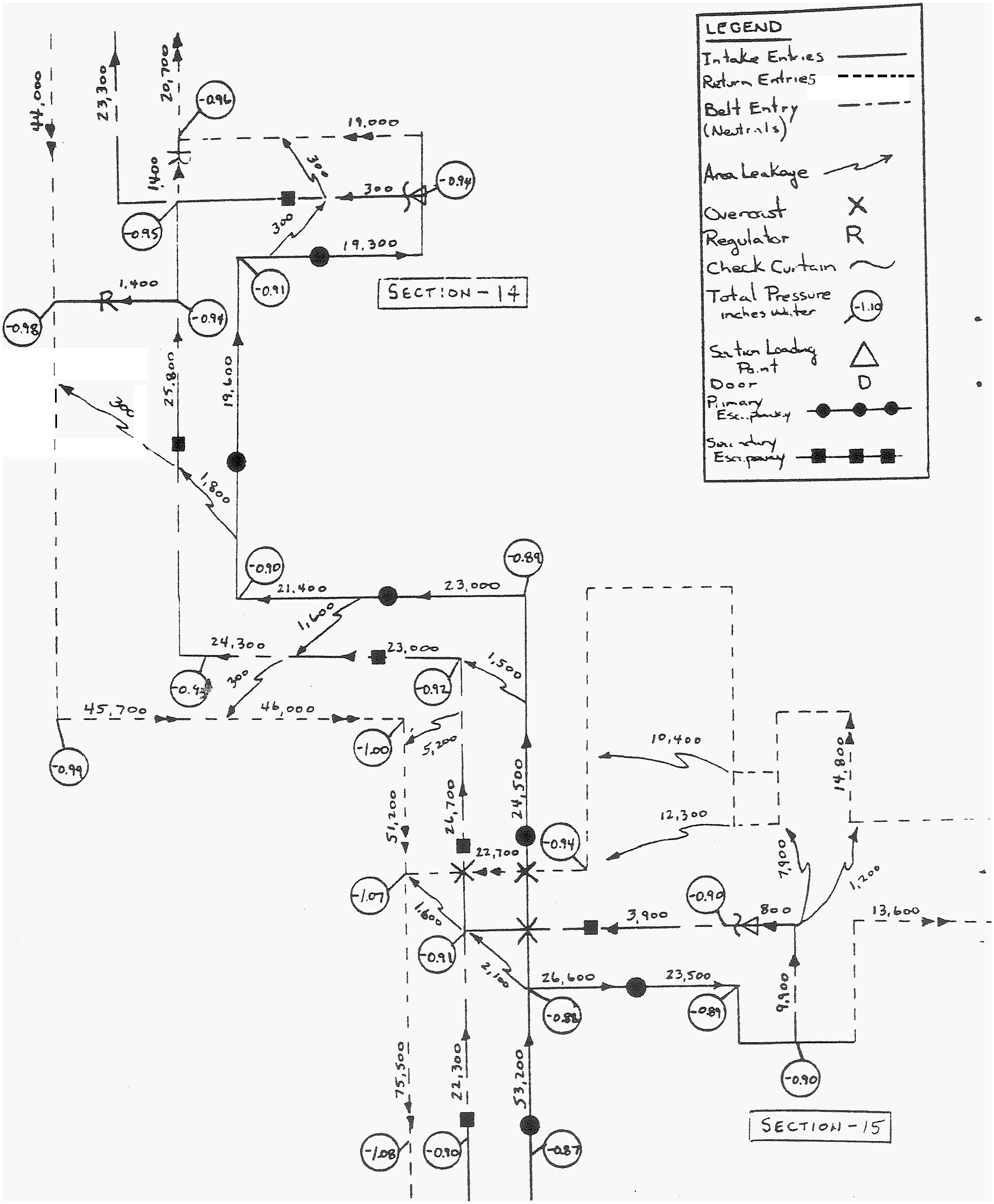
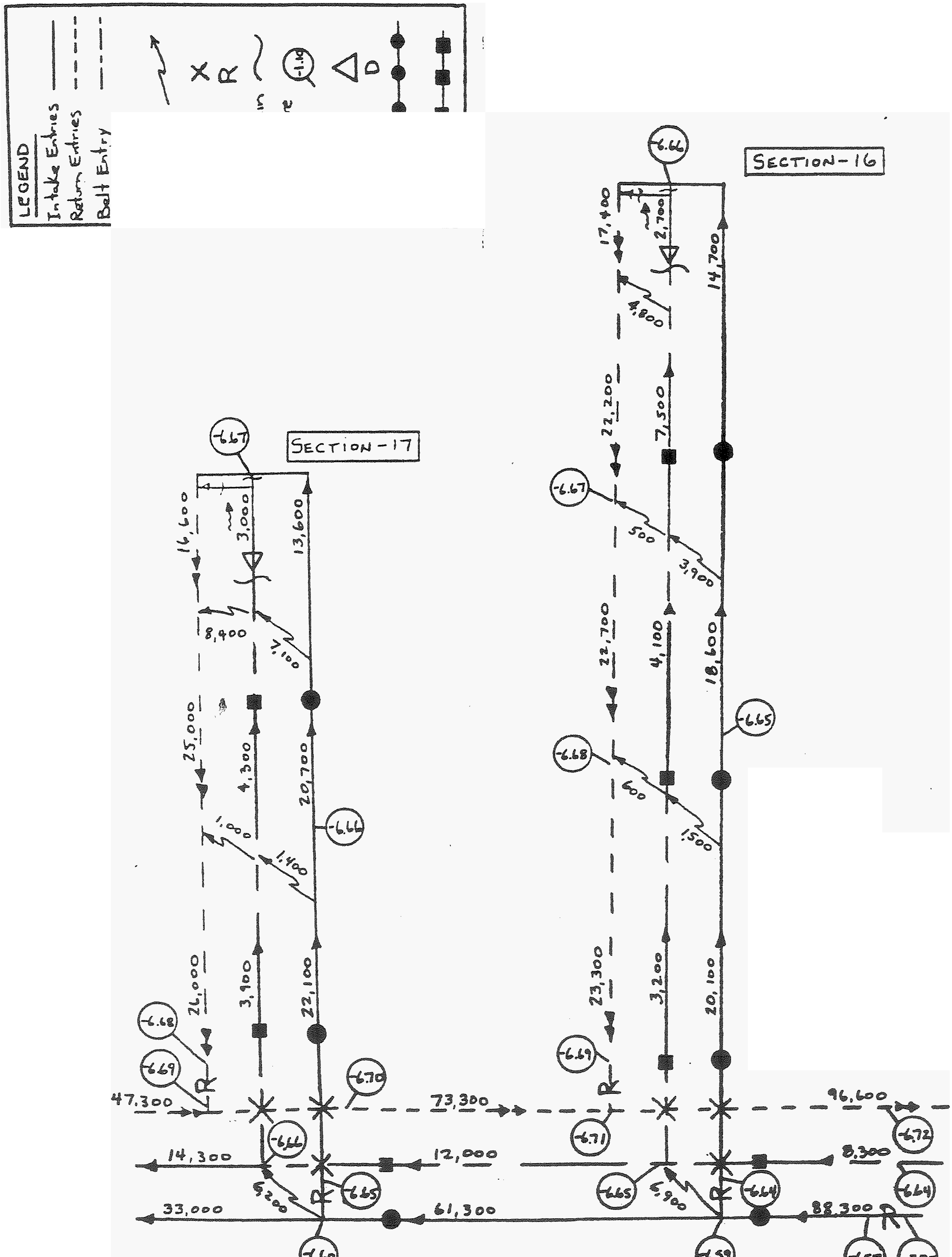
5200
35000
7200
35,000
113,700
144,500
172,200
156,300


LEGEND
Intake Entries
Return Entries
Belt Entry (Neutrals)
Area Leakage
Overcast
Regulator
R
Check Curtain
Total Pressure inches water
-1.10
Section Loading Point
Door
D
Primary Escapeway
Secondary Escapeway
SECTION - 14
SECTION - 15
44,000
23,300
20,700
19,000
19,300
1,400
25,800
19,600
1,800
21,400
23,000
24,300
1,600
1,500
45,700
46,000
5,200
51,200
26,700
24,500
10,400
12,300
14,800
22,700
7,900
1,200
3,900
800
13,600
26,600
23,500
9,900
75,500
22,300
53,200
-0.96
-0.94
-0.95
-0.91
-0.98
-0.90
-0.89
-0.92
-0.99
-1.00
-1.07
-0.88
-0.87
-1.08


LEGEND
Intake Entries
Return Entries
Belt Entry
SECTION-16
SECTION-17
-6.66
17,400
2,700
14,700
4,800
22,200
7,500
-6.67
500
3,900
22,700
4,100
18,600
-6.65
-6.68
600
1,500
23,300
3,200
20,100
-6.69
96,600
-6.72
8,300
-6.64
88,300
-6.57
-2.87
-6.59
6,900
-6.65
-6.71
73,300
-6.67
16,600
3,000
13,600
8,400
7,100
25,000
4,300
20,700
-6.66
1,000
1,400
26,000
3,900
22,100
-6.68
-6.69
47,300
-6.70
-6.66
14,300
12,000
6,200
-6.65
33,000
61,300
-6.60