U.S. Mine Ventilation Standards

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SYNOPSIS

State mine ventilation legal standards in the United States were first introduced in 1869 in Schuylkill County anthracite mines in Pennsylvania. Other coal mining states later expanded and used these standards as a basis for their own laws. Metal mine ventilation regulations have a parallel history, beginning in Colorado in 1876. The formation of the U.S. Bureau of Mines in 1910 began the Federal involvement in ventilation regulations for both coal and non-coal mines. Current laws involve State and Federal regulation. Projected Federal metal and non-metal mining standards primarily involve changing the present advisory standards to mandatory requirements. A Federal organization concerned with engineering applications of the ventilation standards is the Technical Support Center (TSC) in Denver, Colorado. The variety of units used by the TSC is a factor impelling the change-over from English to SI units.

INTRODUCTION

This paper, which provides an overview of mine ventilation standards in the United States, is not intended to be an exhaustive treatise on any particular aspect of statutory controls. The standards, falling into two broad categories, legal and engineering, are considered in that order. Legal standards, for both coal mines and non-coal mines, are viewed on the State and on the Federal levels in a past-and-present sequence. Mention is made of projected or future trends in Federal mine ventilation legal standards based on the Ventilation Standards Development Committee proposals. Details of legal standards are discussed and a review then given of present engineering standards used by Federal mine ventilation engineers; their application in the present organizational structure which is not familiar to many persons outside of the United States, is also discussed.

The difference between legal standards and engineering standards is well enough known, but the difference between a law and a standard does need defining. A law, within the meaning of this discussion, means a statute enacted by a legislative body; a standard is a specific requirement which may or may not be a law. For example, in the State of Colorado, the current statutory law in Section 92-33-28 says, 'The commissioner of mines shall have the power to make such rules and regulations as may be necessary for the carrying out of the provisions of this article . . .' Section 162(4) of the Colorado Mining Rules and Regulations, which is not statutory law but which is enforceable under that authority, states, 'Each employer shall provide at least one hundred (100) cubic feet per minute of free air for each employee underground. An air velocity of thirty (30) linear feet per minute shall be maintained in working places, after blasting.' The foregoing is a standard; it also happens to be an enforceable legal standard under present Colorado law.

LEGAL STANDARDS

Past and Present

In the United States the first state to enact a mine ventilation law was Pennsylvania on April 12, 1869. The General Assembly limited the coverage of this law to only anthracite coal mines in the county of Schuylkill. *Purdon's Pennsylvania Statutes Annotated* says 'Attempts to extend the coverage of this Act to all counties of the Commonwealth were defeated.'[1] Based on the English code then in existence, this law was a prototype of all mine ventilation standards in the United States, and some of its provisions can still be traced in the laws of other states. The Act specified:

'Sec. 1. That it shall be . . . the duty of all superintendents, . . . in the county of Schuylkill, to provide for . . . an adequate amount of ventilation and of circulation of pure air . . .

Sec. 2. That in providing for and establishing ventilation in the mines aforesaid, furnaces and suction fans, or other suitable apparatus, may be used therein; and if underground furnaces be used for such purposes, they shall be so erected as to prevent ignition of the coal in the mines; the fire of the same shall be fed with fresh air, and the vitiated air of the mine shall not be allowed to come in contact with the furnance (*sic*), but shall be made to pass into the up-cast air course, at a point far enough above the fire to insure against the ignition of the fire-damp which said return air current may contain; and if suction fans are used, they shall be substantially built, and be of such size, and the air courses shall be of such dimensions as to insure an abundant supply of fresh air in all the working places of the mine.

Sec. 4. . . . it shall be the duty of such mining boss . . . to provide that all doors used for assisting or in any way affecting the ventilation shall be so hung that they will close of their own accord; and the main doors in collieries . . . shall be provided with a boy, whose constant business shall be to guard them and prevent their being left open.

Sec. 6. It shall be the duty of the owner or operator, in all mines hereinafter opened, to start, continue and maintain good, substantial and reliable up-cast air-ways of a size sufficient to draw the necessary quantity of air through the workings of said mines at all times, and also the necessary distributing air-ways; which said air-ways shall be kept independent of each other until they terminate in the up-cast air-shaft; and upon their neglect or refusal so to do, they shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by imprisonment and fine at the discretion of the court trying the same.'

On September 6, 1869, in Luzerne County, Pennsylvania, a ventilating furnace at the foot of the single, 327 ft.-deep shaft of an anthracite mine erupted; the resulting mine fire killed 108 men and boys, all overcome by mine gases. Rescuers found the victims two days later behind a makeshift

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barrier near the foot of the shaft. This disaster precipitated further legislation; subsequently the Act of March 3, 1870, was applied to all anthracite coal mines in Pennsylvania, and ventilation was dealt with in more detail in this Act than in the original law. That it was not easy for the state mine inspector was exemplified by the injunction that was brought by the mine inspector of Luzerne County against one of the coal mining companies and fought through the courts. In *Purdon's Pennsylvania Statutes Annotated,* it states that the country was entering a post-Civil War depression, a circumstance used to colour the attack on the law. ' "Millions of capital, it is urged, invested here in good faith under former laws must remain unproductive for months, and thousands of laborers must suffer in idleness with hunger and want across their very hearthstones already, if the sole attention of the operators must be given to strict compliance with said Act." The Court was not persuaded: "The Act as we view it, is nothing more nor less than a mandate to the operators of coal mines, that they shall so work them as not to injure the health, nor endanger the lives of persons employed in and about them." . . . a subsequent attack upon the Act was repulsed by the same Judge.'

For only the bituminous coal fields in Mercer County, Pennsylvania, special safety legislation was passed on April 22, 1870. The extension of this law to all the bituminous coal mines of the state required more time than it took for the anthracite mines; the Act covering all bituminous mines was not passed until April 18, 1877. This 1877 law specified in Sec. 2: '. . . and in case of furnace ventilation being used before the second opening is reached, the furnace shall not be placed within forty feet of the foot of the shaft, and shall be well secured from danger from fire by brick or stone walls of sufficient thickness . . .' Also, Sec. 4 required a minimum of 100 cfm of air to be provided for every person in the mine.

Pennsylvania remained in the forefront of mining health and safety legislation for their coal miners with the Act of June 30, 1885, which outlawed ventilation furnaces in gassy mines, specified an air quantity of 200 cfm per man but not more than 450 ft./min. velocity, and prohibited more than 75 men from working on one split of air. Legislative activity continued with the Acts of May 9, 1889; June 2, 1891; June 9, 1911; and more recently in 1943, 1961, and 1965.

The first state to follow Pennsylvania's lead in coal-mining legislation appears to be Illinois, which on March 27, 1872, specified in Sec. 4 of their Act that: 'The owner or agent of . . . every coal mine . . . shall provide therefor an adequate amount of ventilation . . . The ventilation required by this section may be produced by any suitable appliances, but in case a furnace shall be used for ventilating purposes, it shall be built in such a manner as to prevent the communication of fire to any part of the works, by lining the up-cast with incombustible material for a sufficient distance up from the said furnace.' A sidelight of the 1872 Illinois Act is that it deputizes the county surveyors to be mine inspectors.

Ohio, in 1874, on following the Pennsylvania law, provided for inspection and a code for bituminous coal mining. The Missouri law of March 23, 1881, was modelled on the prior Illinois law; a minor change in Sec. 4 on ventilation states that the 100 cfm of air per man be 'measured at the foot of the downcast'.

In West Virginia detailed ventilation regulations date, in part, from 1883. The state of Kansas, starting in 1883, used the Illinois code as a basis for its law adding that the ventilation furnace be not less than 40 ft. from the foot of the shaft and the flue composed of incombustible material for not less than 30 ft. Interestingly, the current Kansas law retains this provision (there are no operating coal mines in Kansas), although Tennessee specifically prohibited the use of furnaces for ventilation in 1881.

The preceding regulations are all primarily for coal mines. Other states with principally metal mining had slightly different regulations. Apparently Colorado was unique in that the 1876 State Constitution itself provided in Article XVI, Sec. 2 that:

'Sec. 2. The General Assembly shall provide by law for the proper ventilation of mines, the construction of escapement shafts, and such other appliances as may be necessary to protect the health and secure the safety of the workmen therein; and shall prohibit the employment in the mines of children under twelve years of age.'

Ventilation requirements in Colorado mines before statehood on August 1, 1876, are unknown. The 1873 Colorado Mining Laws state: 'Prior to the organization of Colorado as a Territory, in 1861, and the session of its first Legislature, there were no general laws affecting the whole Territory in force.' Each mining district made its own laws. The Colorado Territorial Mining Act passed on February 9, 1866, made no specific mention of ventilation requirements; however as a sidelight, it was quite specific in Sec. 18 in providing for disabled miners 'including necessary medical attendance' (a provision and fund which did not carry on into statehood). In common with most of the other metal-mining states, Colorado left detailed metal mine health and safety rules and regulations to the discretion of the State Commissioner of Mines. This policy differed from that of the Colorado Coal Mining Law of 1883 which was quite detailed but similar to the earlier state laws of that type; even today, coal and metal mines come under two different laws in Colorado.

In the Act of May 21, 1890, New York State also included a provision that the state mining inspector examine the adequacy of ventilation of all mines. Similarly, Idaho in 1893, specified that the Inspector of Mines was 'to promulgate reasonable rules and regulations for safety and health of employees in mines, after consultation with the state mine safety advisory board'. North Carolina in 1897 had a provision for coal mine ventilation of 100 cfm per person and also required that 'all mines governed by this chapter shall be provided with artificial means of producing ventilation, such as forcing or suction fans, exhaust steam furnaces, or other contrivances of such capacity and power as to produce and maintain an abundant supply of air'. This is also the current law in North Carolina. Likewise in Iowa in the Code of 1897, 100 cfm of air per person was required plus not less than 500 cfm of air for each animal. Also, 'exhaust steam, fans, furnaces, or other contrivances of sufficient capacity shall be kept in operation to supply air current but if a furnace is used it shall be so constructed by lining the upcast for a distance of not less than fifty feet or for such greater distance as in special cases may be required by the mine inspector, with incombustible material'; again this is current law. Michigan, in its Act of May 2, 1899, specified in Sec. 8 that 'Every mine owner or agent operating a coal mine shall furnish means and devices that will supply a sufficient amount of fresh air when necessary, or when required by said inspector of mines.'

Nevada, in 1901, required that 'The operator of every mine, whether operated by shaft, stope or drift, shall provide and maintain for every such mine a good and sufficient amount of ventilation for such men and animals as may be employed therein and shall cause an adequate amount of pure air to circulate through and into all shafts, winzes, levels and all working places of such mine.' This provision is also the current

statute. It is suspected that local regulations for ventilation were made in the silver mines of the Comstock Lode at Virginia City in the 1860's and thereafter. The high temperatures reputedly required one ton of ice per man per shift from the Sierras for cooling on the lower levels, but no written regulations have survived as far as is known. Smith[2], in his *History of the Comstock Lode*, gives some sidelights including the fact that Root blowers were introduced in 1865 to combat the bad ventilation which reputedly killed more men than any other cause in the early years. He also mentions that Burleigh compressed-air drills indirectly helped with the ventilation by requiring compressed-air lines which also ran blowers and small underground hoists after 1874 in the Yellow Jacket Mine; the exhaust air was not only uncontaminated but cool. The highest water temperature recorded was 170°F. in a flood on the 3 000-foot level of the Yellow Jacket shaft in November, 1880.

Missouri, in the Law of 1905, permitted either 'natural or mechanical' ventilation, an allowance not noted in most of the other states' regulations. In both its Civil Code and Penal Code, Texas, in 1907, specified fresh air and that 'a furnace shall not be used' in a gassy mine.

In the history of mining health and safety legislation in the United States, July 1, 1910, is a landmark – the day the U.S. Bureau of Mines (USBM) was officially formed. In Public Law No. 179, passed by the 61st Congress, which created the Bureau, Sec. 5 specifically stated that the USBM had no enforcement power whatsoever: 'That nothing in this Act shall be construed as in any way granting to any officer or employee of the Bureau of Mines any right or authority in connection with the inspection or supervision of mines or metallurgical plants in any State.' The formation of the USBM was not the first attempt at Federal legislation; the first, unsuccessful, attempt to establish a Federal Mining Bureau appears to have been made in 1865. Similar to the first statewide coal mining law in Pennsylvania in 1870, precipitated by the disaster mentioned previously, the formation of the USBM was precipitated by four major coal-mine disasters: on December 6, 1907, in Monongah, West Virginia, 361 men died; 13 days later 239 men were killed at the Darr Mine in Jacobs Creek, Pennsylvania; on November 28, 1908, at the Rachel and Agnes Mine in Marianna, Pennsylvania, 154 men died in an explosion; and on November 13, 1909, at the St. Paul No. 2 Mine in Cherry, Illinois, 259 men died in a mine fire.[3] In coal mine disasters involving more than five men killed in the years 1906 through 1910, according to USBM Bulletin 481, 2 492 men died. 'The adage is . . . that "dead miners have always been the most powerful influence in securing passage of mining legislation." '[4]

Similarly in metal mining legislation, the numbers of fatalities pressured the American Mining Congress in its November 1906 meeting at Denver, Colorado, to appoint a committee to draft a model law for metal mine safety. In 1909 the committee became a joint committee not only for the American Mining Congress but also for the American Institute of Mining Engineers and the Mining and Metallurgical Society of America. Ingalls *et al*[5] mention, 'in April, 1911, Dr. Joseph A. Holmes, Director of the United States Bureau of Mines, invited the committee to serve as a committee of that bureau' which it did. The committee's proposal in Sec. 44 for ventilation states: 'The operator of every mine, whether operated by shaft, slope, tunnel, adit, level, or drift, shall provide and maintain for every such mine a good and sufficient amount of ventilation for such men and animals as may be employed therein, and shall cause an adequate quantity of pure air to circulate through and into all the shafts, winzes, levels, and all the working places of such mine.' The committee felt that each state should include specific requirements according to its own particular circumstances.

The additional state ventilation legislation passed between 1906 and 1915, while the committee was functioning, included that of Michigan in 1909 which required 'one hundred cubic feet of air per minute for each person employed and three hundred cubic feet for each animal used'; in 1913 this requirement was amended to double the quantities in gassy mines, similar to the Illinois requirement except that Illinois required only 500 cfm per animal. Immediately after statehood, in 1912, New Mexico required 100 cfm for each miner and 300 cfm for 'each mule, horse, or burro'. No prior regulations from Spanish colonial times, the Mexican period, or territorial days are known to have survived in writing. Also, as in the 1872 Illinois law, fine and imprisonment were prescribed for 'any person who shall wilfully obstruct or do any act which may interfere with the free passage of air through any ventilation circuit, or who shall wilfully remove, break, destroy or damage any apparatus or equipment in or about any mine used for ventilation purposes'.

Iowa, in 1913, in Sec. 82.39, directed that escapeways be ventilated and also kept free of ice from any cause. Colorado also in 1913 revised its coal mining laws, which were printed in eight foreign languages for the miners' use, and specified ventilation requirements in detail. These are still the basic requirements. Later, in 1916, Colorado revised its metal mine regulations which were printed in Colorado Bureau of Mines Bulletin No. 7. Before 1915, as mentioned in USBM Bulletin No. 75, Arizona and Montana required 'an adequate amount of pure air' and 'a suitable and practicable method for ventilation', respectively.

In Vol. LXXIV of the Transactions of the American Institute of Mining and Metallurgical Engineers, Mr John A. Garcia gives an excellent comparison of *State Coal Mine Laws Concerning Ventilation* up to 1926. The paper and tables as given show the variations in state requirements. Air requirements vary from 100 to 200 cfm of air per man; four states require reversible fans; and varying numbers of men are allowed per split of air (from 45 to 100 men).

New Mexico revised its state laws in 1933 and made detailed requirements in Sec. 63-26 for non-coal mine ventilation. In Sec. 63-26-1 the law did allow natural ventilation in non-coal mines where it was sufficient and where approval had been given by the state mine inspector in writing. Also, in Sec. 63-14-7, the law specifically prohibited the use of ventilation furnaces in any coal mine in the state. Indiana in 1935 prohibited the use of ventilation furnaces 'unless such furnace is used in a shaft other than the hoisting shaft and not near or connected therewith'. The 1941 Ohio requirements in Sec. 4157.09 to 4157.15 went into considerable detail on the ventilation requirements, including percentages of methane and fan requirements.

Most of the present state requirements for coal mines are similar, with variation in details. The newer ones usually make some reference to the Federal standards. The current state ventilation requirements for metal mines vary considerably, Colorado being the only state at present that cross-references the state requirements to the Federal requirements.

There was a long delay after 1910, when the Bureau of Mines was established, before the Federal requirements became enforceable. In Public Law 49 of the 77th Congress, May 7, 1941, some inspection power was given but no enforceable standards were specified. On August 4, 1947, the 80th Congress in Public Law 328 specified that the standards of the Federal Mine Safety Code were to be

followed but only for a period of one year after the date of the Act. An amendment to Public Law 49, July 16, 1952, entitled Public Law 552 of the 82nd Congress, went into much more detail on requirements. Sec. 202 required at least annual inspections, plus special inspections of coal mines and specified co-operation with the state inspectors within an agreed-upon *State Plan*. Sec. 209 required compliance with specified provisions subject to fines, set out in detail in Sec. 210, if these were not complied with. The ventilation section, in Sec. 209, specified not less than 19,5 per cent oxygen, not more than 0,5 per cent carbon dioxide, and no harmful quantities of other noxious or poisonous gases, and in coal mines the quantity of air reaching the last open crosscut shall not be less than 6 000 cfm. Sections (2) through (11) go into detail on the methane requirements, up to 1,0 per cent being allowed and 1,5 per cent being the limit above which the men must be withdrawn and the power shut off.

In Public Law 376 passed by the 89th Congress on March 26, 1966, the exemption of coal mines employing 14 men or less in the July 16, 1952, Act was repealed so that effectively all coal mines now came under Federal regulations. On September 16, 1966, the 89th Congress passed 'an act to promote health and safety in metal and non-metallic mineral industries'. This law took an approach similar to the various state regulations, in that the statute law did not specify the standards as such. Sec. 6 says that 'The Secretary shall develop . . . and promulgate health and safety standards for the purpose of the protection of life, the promotion of health and safety, and the prevention of accidents in mines.' This Act also allows for *State Plans*. This is now the current Federal law for metal mines (non-coal mines). The standards promulgated under the above-stated authority for non-coal mine ventilation, Sec. 57.5 complete, are given in full in the Appendix.

The last major Federal legislation is the *Federal Coal Mine Health and Safety Act of 1969*. The ventilation section of the statute states in Sec. 303:

> 'All coal mines shall be ventilated by mechanical ventilation equipment installed and operated in a manner approved by an authorized representative of the Secretary and such equipment shall be examined daily and a record shall be kept of such examination.'

Sec. 303 also sets out in great detail the allowable percentages of methane under certain conditions and the requirements for inspecting for methane.

The statute law, of which Sec. 303 is a part, is amplified in the Mandatory Coal Mine Health and Safety Standards, Sections 75.300 through 75.330. Coal Mine Health and Safety District Managers have the authority to require detailed ventilation plans on an individual-mine basis; the Standards give criteria for fans, air quantity and velocity, air quality, auxiliary ventilation, and dust, among others.

Projections

Turning now from past and present toward the future, the term *projected* standards is used in preference to *future* standards because no one can guarantee what the future standards will be. This paper limits projections to Federal standards only and does not include projected state standards. The philosophy of the Ventilation Standards Development Committee appears to be to make more of the present advisory standards mandatory and to define, more closely, some of the current provisions. For example, the change from July 1971 to August 1974 in the ventilation section of the Metal and Non-metal Mine Safety Standards shows only in Sections 57.5-1 and 57.5-5. The insertion of a new section on asbestos after 57.5-1(a) detailed the allowable exposure to asbestos dust, and the respiratory protective equipment requirements were set out in greater detail in Sec. 57.5-5 as given in the Appendix.

Some of the proposed mandatory metal and non-metal mine ventilation safety standards by the committee have involved:

1. Ventilation plans to be approved by the Federal District Manager.
2. All mines to be ventilated by mechanical ventilation equipment.
3. Detailed requirements for main fans including non-combustible housing, remote controls, and a completely separate electrical power supply.
4. Booster fan requirements.
5. Auxiliary ventilation specifications.
6. Fire door requirements.
7. Non-combustible door and bulkhead details.
8. Requirements for surface air heaters.
9. Air-lock specifications.
10. Material requirements for ventilation tubing and brattice cloth.
11. Elimination of combustible material near fire doors.

Specific examples of proposed standards by the committee are the following:

Mandatory. All new main fans installed on the surface shall be in non-combustible housings and connected to the mine openings with non-combustible ducts.

Mandatory. Main fans shall be located so that the exhaust air cannot be recirculated into the mine intake air.

ENGINEERING STANDARDS

The legal standards have been detailed above; the organizational structure of the sub-group within the U.S. Government which is concerned with mine ventilation engineering standards may be of interest. The major governmental divisions under the President are the Departments, such as the Department of the Interior, Department of Defense, Department of the Treasury, etc. Within the Department of the Interior currently are nine Bureaus, including the Bureau of Mines. On July 1, 1973, what had been the mine inspection division of the U.S. Bureau of Mines became a new Bureau-level group, leaving the research and resources divisions to comprise the present Bureau of Mines. This new Bureau-level group is referred to by the acronym MESA, standing for Mining Enforcement and Safety Administration.

MESA is now composed of five major divisions: Coal Mine Health and Safety; Metal and Non-metal Mine Health and Safety; Education and Training; Plans, Assessment and Management; and Technical Support plus an administrative staff. The Technical Support Division is divided further into the Denver Health and Safety Analysis Center, the Pittsburgh Technical Support Center (primarily for coal mining problems), and the Denver Technical Support Center (primarily for metal mining problems). The organization within the Denver Technical Support Center (DTSC) is as follows:

1. Ventilation Group
2. Ground Support Group
3. Radiation Group
4. Industrial Safety Group
5. Industrial Health Group.

The Ventilation Group of DTSC, MESA, is currently staffed with a Chief, who is also a mine ventilation engineer; a secretary; a draftswoman; a technician; and six mine

ventilation engineers. The equipment used by the Ventilation Group for the actual field work includes both Wallace and Tiernan altimeters and Baromec barometers together with a Paulin recording microbarograph for pressure surveys; both Davis and Taylor Biram-type anemometers, swinging-vane velometers, and recording anemometers for airflow measurement; many different types of psychrometers, both manual and electronic, mercury and thermocouple-type thermometers, and humidity recorders; Magnehelic pressure gauges, inclined and U-type manometers, and gas detection kits; together with pitot tubes, tapes, recorders, etc.* Available in the laboratory is an Airflow Developments Ltd. wind tunnel for velocity calibration of anemometers and an environmental pressure chamber with a Hass A-1 precision mercury barometer for pressure calibration.

The field work is primarily done in terms of English units, cubic feet per minute of airflow and feet of air-column pressure. The Baromec barometers are read in millibars of pressure; the manometers and Magnehelic gauges are read in inches of water-gauge pressure. This variation of units is compounded by the Hass barometer reading in inches of mercury. The older work in mine ventilation of the USBM done by Harrington, McElroy, and Kingery is still the basis for present practice. Kingery's *Introduction to Mine Ventilating Principles and Practices*, USBM Bulletin 589, and *Making Ventilation – Pressure Surveys with Altimeters*, USBM Information Circular 7809, are used as the bases for computation.

Just as there is a world-wide changeover to the SI system, the Denver Technical Support Ventilation Section is also changing slowly. It is hoped that in the near future it will be possible, by means of an analogue computer, to simulate a mine ventilation network in SI units. It can be foreseen that to educate the mining industry in the use of this system will be difficult until the United States officially adopts SI units. In this area the leadership of the Mine Ventilation Society of South Africa is acknowledged.

CONCLUSION

The significance of the various state and Federal mine ventilation regulations of the past lies in their relation to the present standards; otherwise these regulations would have intrinsic value only to an historian. With regard to the growing world-wide shortages in minerals and energy, projected mine ventilation standards, being part of overall health and safety legislation, are a pertinent factor in economic productivity. The increase in costs arising out of the adoption of legal standards in the United States would be balanced against the probable saving of lives and reduction in the number of accidents in the mines. Just as we are now able to assess the relevance and value of early mining laws and regulations, future generations will be able to judge the virtues and efficacy of our projected laws formed in the context of a world-wide energy and minerals crisis.

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*Reference to specific brands is made only for identification and does not imply endorsement by the Mining Enforcement and Safety Administration.

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APPENDIX

57.5 Air quality, ventilation, and radiation and physical agents.

General – surface and underground

57.5-1 *Mandatory.* Except as permitted by standard 57.5-5; (a) Except as provided in paragraph (b), the exposure to airborne contaminants shall not exceed, on the basis of a time weighted average, the threshold limit values adopted by the American Conference of Governmental Industrial Hygienists, as set forth and explained in the 1973 edition of the Conference's publication, entitled "TLV's Threshold Limit Values for Chemical Substances in Workroom Air Adopted by ACGIH for 1973", pages 1 through 54, which are hereby incorporated by reference and made a part hereof. This publication may be obtained from the American Conference of Governmental Industrial Hygienists by writing to the Secretary-Treasurer, P.O. Box 1937, Cincinnati, Ohio 45201, or may be examined in any Metal and Non-metal Mine Health and Safety District or Sub-district Office of the Mining Enforcement and Safety Administration. Excursions above the listed thresholds shall not be of a greater magnitude than is characterized as permissible by the Conference.

(b) The 8-hour time weighted average airborne concentration of asbestos dust to which employees are exposed shall not exceed 5 fibres per milliliter greater than 5 micrometres in length, as determined by the membrane filter method at 400-450 magnification (4 millimeter objective) phase contrast illumination. No employee shall be exposed at any time to airborne concentrations of asbestos fibers in excess of 10 fibers longer than 5 micrometers, per milliliter of air, as determined by the membrane filter method over a minimum sampling time of 15 minutes. Asbestos is a generic term for a member of hydrated silicates that, when crushed or processed, separate into flexible fibers made up of fibrils. Although there are many asbestos minerals, the term 'asbestos' as used herein is limited to the following minerals: chrysotile, amosite, crocidolite anthophylite asbestos, tremolite asbestos, and actinolite asbestos.

(c) Employees shall be withdrawn from areas where there is present an airborne contaminant given a 'C' designation by the Conference and the concentration exceeds the threshold limit value listed for that contaminant.

57.5-2 *Mandatory.* Dust, gas, mist, and fume surveys shall be conducted as frequently as necessary to determine the adequacy of control measures.

57.5-3 *Mandatory.* Holes shall be collared and drilled wet, or other efficient dust-control measures shall be used when drilling non-water-soluble material. Efficient dust-control measures shall be used when drilling water-soluble materials.

57.5-4 Muckpiles, haulage roads, rock transfer points, crushers, and other points where dust is produced in amounts sufficient to cause a health or safety hazard should be wetted down as often as necessary, unless the dust is controlled adequately by other methods.

57.5-5 *Mandatory.* Control of employee exposure to harmful airborne contaminants shall be, insofar as feasible, by prevention of contamination, removal by exhaust ventilation, or by dilution with uncontaminated air. However, where accepted engineering control measures have not been developed or when necessary by the nature of work involved (for example, while establishing controls or occasional entry into hazardous atmospheres to perform maintenance or investigation), employees may work for reasonable periods of time in concentration of airborne contaminants exceeding permissible levels if they are protected by appropriate respiratory protective equipment. Whenever respiratory protective equipment is used a program for selection, maintenance, training, fitting, supervision, cleaning, and use shall meet the following minimum requirements:

(a) Mining Enforcement and Safety Administration approved respirators which are applicable and suitable for the purpose intended shall be furnished, and employees shall use the protective equipment in accordance with training and instruction.

(b) A respirator program consistent with the requirements of ANSI Z88.2-1969, published by the American National Standards Institute and entitled 'American National Standards Practices for Respiratory Protection ANSI Z88.2-1969, approved August 11, 1969, which is hereby incorporated by reference and made a part hereof. This publication may be obtained from the American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018, or may be examined in any Metal and Non-metal Mine Health and Safety District or Sub-district Office of the Mining Enforcement and Safety Administration.

(c) When respiratory protection is used in atmospheres immediately harmful to life, the presence of at least one other person with backup equipment and rescue capability shall be required in the event of failure of the respiratory equipment.

Underground only

57.5-15 Atmospheres in all active areas should contain at least 20 per cent oxygen.

Ventilation: Underground only

57.5-21 Main fans should be installed on the surface; if it is necessary to locate them underground, they should be in fire-resistant areas and should be provided with remote controls.

57.5-22 *Mandatory.* Fan housings and air ducts connecting main fans to underground openings shall be fire-resistant.

57.5-23 Separate mine openings should be provided for main intake- and return-air currents except during early stages of development. A multiple compartment shaft is a single opening for the purpose of this standard.

57.5-25 Main fans should be inspected and maintained properly.

57.5-26 Instruments should be provided to test the mine atmosphere quantitatively for carbon monoxide, nitrogen dioxide, and other gases that occur in the mine. Tests should be conducted as frequently as necessary to assure that the required quality of air is maintained.

57.5-27 Flame safety lamps or other suitable devices should be used to test for acute oxygen deficiency.

57.5-28 *Mandatory.* Unventilated areas shall be sealed, or barricaded and posted against entry.

57.5-29 When used, ventilation tubing should be installed so that the air current sweeps the face areas effectively. Maximum distance of the end of the tubing from the face generally should be 30 feet for blowing and 6 feet for exhausting.

57.5-30 Ventilation doors not operated mechanically should be designed and installed so that they are self-closing and will remain closed regardless of the direction of the air movement.

Radiation

In those standards in 57.5 which relate to radiation, a 'working level' (WL) means any combination of the short-lived radon daughters in one liter of air that will result in the ultimate emission of $1{,}3 \times 10^5$MeV (million electron volts) of potential alpha energy, and exposure to these radon daughters over a period of time is expressed in terms of 'working level months' (WLM). Inhalation of air containing a radon daughter concentration of 1 WL for 170 hours results in an exposure of 1 WLM.

Underground only

57.5-37 *Mandatory.* Mine atmospheres shall be sampled to determine if hazardous concentrations of radon daughters are present. Where potentially hazardous concentrations are found, or known sources of radon exist, each active work area shall be sampled as often as necessary by a qualified person.

57.5-38 *Mandatory.* No employee shall be permitted to receive an exposure of more than 6 WLM (working level months) in any consecutive 3-month period and no more than 12 WLM in any consecutive 12-month period. Superseded.*

57.5-39 *Mandatory.* If samples show an atmospheric concentration of radon daughters of more than 1,0 working level, but less than 2,0 working levels, immediate corrective action shall be taken or the men shall be withdrawn. When concentrations higher than 2,0 working levels are found, the men shall be withdrawn from the area until corrective action is taken and the radon daughter atmospheric concentrations are reduced to 1,0 working level or less.

57.5-40 *Mandatory.* (a) Where uranium is mined, if measurements in areas indicate exposure to concentrations of radon daughters in excess of 0,3 working level, complete individual exposure records shall be kept for all employees entering these areas.

(b) ***

57.5-41 *Mandatory.* Smoking shall be prohibited where uranium is mined.

57.5-42 *Mandatory.* If levels of permissible exposures to concentrations of radon daughters different from those prescribed in 57.5-38 are recommended by the Environmental Protection Agency and approved by the President, no employee shall be permitted to receive exposures in excess of those levels after the effective dates established by the Agency.

*As provided in 57.5-42, permissible annual radiation-exposure levels of no more than 4 WLM were recommended by the Environmental Protection Agency and approved by the President, effective July 1, 1971.)