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International Regulation of Diesel Engine Use Underground: A Country-by-Country Synopsis

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UNIT OF MEASURE ABBREVIATIONS USED IN TABLES 1 THROUGH 6 OF THIS REPORT

°C	degree Celsius	L/(s·hp)	liter per second per horsepower
cm	centimeter	m/min	meter per minute
dB(A)	decibel (A-weighted)	m/s	meter per second
dm ³ /s	cubic decimeter per second	m ³ /min	cubic meter per minute
ft ³	cubic foot	m ³ /(min·bhp)	cubic meter per minute per brake horsepower
ft ³ /bhp	cubic foot per brake horsepower	m ³ /(min·hp)	cubic meter per minute per horsepower
ft ³ /min	cubic foot per minute	m ³ (min·kW)	cubic meter per minute per kilowatt
ft ³ /(min·bhp)	cubic foot per minute per brake horsepower	m ³ /s	cubic meter per second
ft ³ /(min·hp)	cubic foot per minute per horsepower	m ³ /(s·kW)	cubic meter per second per kilowatt
h	hour	pct	percent
L/s	liter per second	ppm	part per million
L/(s·bhp)	liter per second per brake horsepower		

INTERNATIONAL REGULATION OF DIESEL ENGINE USE UNDERGROUND: A COUNTRY-BY-COUNTRY SYNOPSIS

By Robert W. Waytulonis¹ and Debra J. Johnson²

ABSTRACT

Mining regulations pertaining to the use of diesel engines were solicited from foreign countries with mining operations by the Bureau of Mines. Responses were received from 27 countries; the information received and U.S. regulations were reviewed, and those parts pertaining to the use of diesel engines in underground mining were synopsized according to the following subject categories: types of engines permitted, testing and certification procedures, fuel quality specifications, emission control requirements, procedures and frequency of testing exhaust gases, mine air quality and quantity (ventilation) requirements, procedures for testing mine air quality and quantity, and noise standards. All categories except the types of engines permitted and testing and certification procedures are summarized in tables. Contacts are provided for each country to facilitate inquiries concerning regulation revisions or interpretation.

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INTRODUCTION

Not long after Dr. Rudolph Diesel, a German mechanical engineer, patented his first engine in 1892, internal combustion engines began to be used to aid extraction of minerals from the Earth. Early in the search for suitable power sources, the diesel engine was chosen over the spark ignition (gasoline) engine for safety reasons. Diesel engines have lower CO emissions, diesel fuel is much less volatile than gasoline, and the explosion hazards associated with a spark ignition system are eliminated. In certain applications diesels have advantages over electric-powered mine equipment, but diesel engines are not without their drawbacks.

The diesel engines used underground are usually derated (governed to less than full power) to reduce production of certain pollutants, and each has its own dilution requirement with mine ventilation air. Contaminants such as particulate matter, oxides of nitrogen, unburned hydrocarbons, CO, and oxides of sulfur are of concern because these compounds are found in diesel exhaust. For many years the primary hazard and concern of using fuel burning engines in confined spaces such as mines and tunnels was exposure to CO emissions. Concern in the United States has since shifted to exposures to nitrogen and sulfur oxides emissions, and most recently diesel exhaust particulate matter emissions.

Health and safety standards for mines in the United States are found in Title 30, Mineral Resources, of the Code of Federal Regulations (1).³ Here, the threshold limit values (TLV's) of the American Conference of Governmental Industrial Hygienists (ACGIH) have been adopted to serve as standards for many chemical and physical agents found in mines. Title 30 also contains the criteria for safety certification, approval (permissibility), and some use guidelines for diesel-powered equipment. The safe use of diesel-powered mining equipment in underground mines promoted by the enforcement of these safety standards is primarily designed to prevent fire and explosion hazards.

Part 36 of title 30 (2) covers permissibility tests for equipment used in gassy noncoal mines. Safety and health standards for underground metal and nonmetal mines are given in part 57 of title 30 (3); part 57.5-1 specifically refers to TLV's. General regulations specific to diesel equipment in underground coal mines have not yet been established, but

the Mine Safety and Health Administration (MSHA) has applied part 36 with some modifications. Diesels in coal mines are also subject to other parts of title 30; e.g., portions of Part 18 (4), Electric Motor-Driven Mine Equipment and Accessories, and Part 75 (5), Mandatory Safety Standards—Underground Coal Mines. Part 75.301 specifically refers to TLV's. Part 31 (6) contains test descriptions and use recommendations for diesel locomotives in gassy coal mines; part 32 (7) regulates mobile diesel-powered equipment used in noncoal mines.

In 1938 (8), 1957 (9), and again in 1981 (10), the Bureau of Mines surveyed State regulations pertaining to the use of internal combustion engines (particularly diesel engines) underground. It was found that the States have a large variation in their regulations. Some States have regulations more stringent than Federal regulations, whereas some States have less stringent regulations or none at all, or they defer to Federal regulations. Because safety legislation is continuously being changed to suit experience, this international survey has sought to identify areas where regulations of other countries differ from Federal regulations of the United States, and to perhaps learn from foreign experience and provide enlightening technical information concerning safe utilization of diesels in mines.

Sections of the information contained within the text of this report have been summarized in tables 1 through 6 for purposes of comparing salient features of international regulations. Important criteria that were commonly expressed in the majority of countries were selected for these comparisons. Specifications pertaining to fuel quality, engine emission and temperature control, undiluted emissions measurement, air quality and noise, ventilation, and ambient air quality are given. Countries for which the available literature did not specify the aforementioned criteria were excluded from the appropriate tables. Regulations and specifications pertaining to the type of engines permitted underground and certification procedures are highly variable and many times vague; therefore, this information was not usually used (except for the United States) in the tabular comparisons.

Tables 1 through 6 also indicate the type of mines governed, i.e., coal, metal and/or nonmetal, gassy, or nongassy. If the regulations do not specify a mine type, the notation NS (not specified) is given. When a regulation is not specific about the mine type, it is unknown whether this is indicative of it applying to all mine types. It is possible

³Italic numbers in parentheses refer to items in the list of references at the end of this report.

that for these countries, only one specific mine type exists, but this information did not usually accompany the documents received. In any case, the columns marked in the tables are those specifically identified in the documents. The number designations used in the text for each country's regulations are those appearing in the original documents. Special information and unique features are footnoted throughout as appropriate.

It should be noted that it was sometimes difficult to summarize information into tables for comparison owing to variations in word meanings from that intended, after English translation, and the general vagueness of some documents received. It is therefore strongly suggested that the main text or the foreign contacts be consulted for seeming contradictions and/or clarification.

FUEL QUALITY REQUIREMENTS

Table 1 summarizes the fuel quality requirements for diesel engines. Each country regulating fuel quality is listed along with the mine type. Flashpoint, sulfur content, and cetane number are fuel properties most frequently specified. The highest flashpoint specified is 66° C in the Philippines, New South Wales, South Australia, and the Canadian Province of Nova Scotia. The lowest flashpoint is specified in the Yukon Territory at 48° C. Most countries specify a maximum sulfur content that ranges from 0.1 to 1.5 pct by weight. The only countries that specify a minimum cetane number for fuel are the Federal Republic of Germany, Canada, and Yugoslavia.

Table 1.—Fuel quality requirements

Country	Mine type	Min flashpoint, °C	Max S, pct	Min cetane number
Australia:				
New South Wales	NS	66	< 0.1	NS
Northern Territory	NS	61	.5	NS
South Australia	Metal-nonmetal	66	.5	NS
Tasmania	..do	61	.5	NS
Victoria	..do	61	.5	NS
Western Australia	..do	61	.5	NS
Canada:				
National	Coal	52	.2	40
British Columbia	Coal, metal-nonmetal	52	NS	NS
Manitoba	NS	52	.5	NS
Newfoundland	NS	52	0.25-.5	NS
Nova Scotia	Coal	66	NS	NS
Ontario	NS	52	.25	NS
Quebec	NS	NS	.25	NS
Saskatchewan	Metal-nonmetal	52	.5	NS
Yukon Territory	NS	48	NS	NS
Colombia	Coal	55	NS	NS
France	Gassy	50	NS	NS
Germany, Fed. Rep. of:				
Bavaria	Nongassy	55	NS	NS
Lower Saxony	..do	55	.3	45
North Rhine-Westphalia	Hard coal	55	.3	45
Saarland	..do	55	.3	45
India ¹	Coal	60	.5	NS
Mexico	NS	60	1.5	NS
New Zealand	Coal	65.5	.5	NS
Philippines	..NS	66	.12	NS
Sweden	..NS	NS	.1	NS
Switzerland	..NS	NS	.5	NS
U.S.S.R.	Coal	55	.2	NS
United States	Gassy (locomotives)	² 60	² .5	NS
Do	Noncoal, metal-nonmetal	60	.5	NS
Do	Gassy noncoal	60	.5	NS
Yugoslavia	Nongassy	60	.5	45

NS Not specified in available literature.

¹Guidelines, not enforced as regulations.

²Recommendations on the use of diesel locomotives underground.

EMISSION AND TEMPERATURE CONTROL REQUIREMENTS

Table 2 summarizes the regulations for diesel engine emission and surface temperature control. CO is universally regulated, although the maximum allowable concentration in the undiluted exhaust varies from country to country. Some of this difference may be due to the test conditions used and the type of mine. For example, in gassy noncoal mines in the United States, 3,000 ppm is specified with 1.5 pct CH₄ in the intake air and the engine operated at the condition where CO is greatest. In nongassy mines the value for CO is 2,500 ppm. Except for the U.S. regulations, it is not

known if the maximum allowable concentrations listed are for new engines, overhauled engines, or engines-in-use, unless this is otherwise noted. The information in this table concerning U.S. criteria is for new engine certification. Also, these pollutant levels, at least in the United States, are measured prior to the use of any control device. Control devices listed are generally those used to control safety hazards, i.e., excessive exhaust temperatures and engine backfires. Temperature regulations vary among countries for both exhaust gases and engine surfaces, even if temperature values are grouped according to mine type. Coal mine exhaust temperature limits range between 70° and 85.3° C. Surface temperature limits in coal mines vary between 150° and 200° C.

Table 2.—Emission and temperature control requirements

Country	Mine type	Max allowable conc in undiluted exhaust			Max allowable temperature, °C		Control devices specified
		CO, ppm	NO _x , ppm	Smoke ¹	Ex- haust	External surfaces	
Australia:							
New South Wales	Coal	1,500	1,000	(²)	77	150	Water-cooled.
Northern Territory	Metal-nonmetal	1,000	1,000	NS	NS	NS	Scrubber.
South Australia	do	1,500	1,000	NS	NS	NS	Do.
Tasmania	do	1,000	1,000	NS	NS	NS	Scrubber, diffuser.
Victoria	do	2,500	1,000	NS	NS	NS	Scrubber.
Western Australia	do	2,500	2,000	NS	93	NS	Do.
Belgium	NS	1,200	NS	NS	85	150	Flame trap, water bath.
Canada:							
British Columbia	Coal, metal-nonmetal	1,000	NS	NS	NS	NS	Flame trap (coal only).
Manitoba	NS	2,500	NS	NS	NS	NS	Flame trap, scrubber.
Newfoundland	NS	1,500	NS	NS	80	NS	Wet scrubber.
Ontario	NS	1,500	NS	NS	NS	NS	NS.
Quebec	NS	2,500	NS	(²)	83	NS	NS.
Saskatchewan	Metal-nonmetal	1,500	NS	NS	NS	NS	Scrubber.
Finland	NS	1,000	NS	3	NS	NS	Exhaust cleaner.
Germany, Fed. Rep. of:							
Baden-Wuerttemberg	NS	1,200	NS	NS	NS	NS	NS.
Bavaria	NS	500	³ 705	³ 3	NS	NS	Exhaust gas diffuser.
Lower Saxony	Nongassy	500	³ 750	³ 3	NS	NS	Do.
North Rhine- Westphalia	Coal	500	³ 750	³ NS	70	200	Injected water.
Saarland	NS	1,200	NS	NS	NS	200	Water spray.
Hungary	NS	2,000	500	NS	70	200	Scrubber.
India ⁴	Coal	2,000	1,000	NS	85.3	NS	Flame trap, scrubber.
Ireland	NS	2,000	1,000	NS	NS	NS	Scrubber, diluter.
Japan	Coal	1,200	1,000	NS	70	160	Flame trap, scrubber.
Mexico	NS	2,500	1,000	NS	82	NS	NS.
New Zealand	Coal	1,000	1,000	(²)	NS	NS	Water scrubber.
Philippines	NS	1,000	1,000	NS	NS	NS	NS.
Poland	NS	1,000	NS	NS	70	200	Flame trap, scrubber.
Romania	NS	1,200	NS	2.5	NS	NS	Water spray.
South Africa, Rep. of	NS	2,000	1,000	NS	76.7	204	Flame trap, water-cooled.
Spain	NS	1,500	NS	NS	NS	NS	NS.
Sweden	NS	800	NS	2	NS	NS	NS.
U.S.S.R.	Coal	⁵ 800	⁵ 700	NS	70	150	Injected water, jacket.
United Kingdom	NS	1,500	1,000	NS	70	150	Flame trap, water bath.
United States	Locomotives specified.	2,500	NS	NS	71	204	Flame arrestor.
Do	Noncoal	2,500	NS	NS	71	204	Do.
Do	Gassy noncoal	3,000	⁶ 2,000	NS	71	204	Do.
Yugoslavia	Nongassy	1,200	NS	NS	NS	NS	NS.

NS Not specified in available literature.

¹ Bosch units.

² Regulation specifies no black smoke.

³ Concentration specified for a new or overhauled engine.

⁴ Guidelines, not enforced as regulations.

⁵ After clean up of exhaust gases.

⁶ Specified as equivalent NO₂ with 1.5 pct CH₄ in intake air.

TESTING REQUIREMENTS FOR UNDILUTED EXHAUST EMISSIONS

Table 3 summarizes the test requirements for sampling undiluted diesel exhaust emissions; sampling is performed either during new engine certification or during specified periods during the engine service life. In the United States, the information presented pertains to new engine certification. Some countries test after a certain number of engine-hours; for example, Romania requires exhaust sample analysis to be performed once per 1,200 h of engine use.

Sweden, Finland, and the Province of Manitoba also have set similar "hours-in-service" criteria. Among the different countries, frequency of sampling varies from twice per shift to once per year. Specific pollutants, sampling frequency, sampling location, and test conditions are presented. All the countries that sample undiluted exhaust emissions specify CO; approximately half of these also specify NO₂ or NO_x. The sampling locations vary widely, and most of the time are not specified. The two engine test conditions that seem most prevalent are maximum power and idle. For soot determinations, the Bosch smoke number filter test is a widely accepted method.

Table 3.—Testing requirements for undiluted exhaust emissions

Country	Mine type	Exhaust sample type	Sampling		Method or test conditions
			Frequency	Location	
Australia:					
New South Wales	Coal	NS	Monthly	NS	Drager tube.
Do	Metal-nonmetal	NS	Annually	NS	Do.
Queensland	Coal	NS	Monthly	NS	NS.
South Australia	Metal-nonmetal	NS	do	NS	NS.
Tasmania	do	CO, NO _x	do	Near exhaust manifold.	Drager tube.
Victoria	do	CO, NO _x	Weekly	NS	NS.
Western Australia	do	CO, NO _x	do	NS	NS.
Canada:					
British Columbia	do	CO, NO _x	Twice per week	NS	NS.
Manitoba	NS	CO	Once per 80 h use	NS	NS.
Newfoundland	NS	CO	Once per shift	NS	NS.
Do	NS	Total analysis	Semiannually	Scrubber exhaust port.	NS.
Nova Scotia	Coal	CO	Monthly	NS	NS.
Ontario	NS	CO	Weekly	NS	NS.
Quebec	NS	CO	do	NS	NS.
Saskatchewan	Metal-nonmetal	NS	Monthly	Upstream of scrubber.	NS.
Finland	do	CO, soot	Once per 150 h use	NS	NS.
Germany, Fed. Rep. of:					
Baden-Wuerttemberg	NS	CO	do	NS	Test tube.
Bavaria	Nongassy	HC, CO, soot	NS	NS	Flame ionization detector, Bosch filter.
Lower Saxony	do	CO, spot	Once per 3 months	NS	Bosch filter, test at max idle.
North Rhine-Westphalia	Hard coal	CO, NO _x , NO ₂ , soot, HC.	do	Near exhaust manifold.	Bosch filter.
Saarland	NS	CO ₂	Once per 4 months	NS	Full load and idle, max rotational speed.
Hungary	NS	CO, NO _x	Once per 3 months	NS	NS.
India ¹	Coal	NS	Monthly	NS	Max power and idle.
Ireland	NS	General	Once per 3 months	NS	Max speed and load, normal idle.
Japan	Coal	CO, NO _x	NS	Exhaust gas line	4 conditions: CH ₄ intake specified.
Mexico	NS	NS	NS	30 cm from exhaust outlet.	NS.
New Zealand	NS	CO, NO ₂ , total analysis.	Monthly, semiannually	NS	Max power and idle, no load.
Poland	NS	CO	Biweekly	NS	Pipettes; test at max rotational speed.
Romania	NS	CO, soot	Once per 1,200 h use	NS	Drager tube, Bosch test, max rotational speed and idle.
South Africa, Rep. of	NS	CO, NO _x	Once per 3 months	NS	Max power and idle.
Sweden	NS	CO, soot	Once per 150 h use, or once per 2 months.	Near exhaust pipe.	Bosch filter, full load and rotational speed.
U.S.S.R.	Coal	CO, NO _x	Twice per shift	NS	Max idle, 75- and 100-pct load.
United Kingdom	NS	General	Once per 3 months	NS	Max power and idle.
United States	Noncoal, metal-nonmetal. ²	CO, CO ₂ , O ₂ , H ₂ , N ₂ , NO _x , CH ₄ , aldehydes.	NS	NS	Min and max speeds, 3 power outputs.
Yugoslavia	Nongassy	CO	Once per shift	Upstream of filters.	NS.

NS Not specified in available literature.

¹ Guidelines, not enforced as regulations.

² Includes gassy noncoal mines and regulations for locomotives in gassy mines.

MINE AIR QUALITY AND NOISE REQUIREMENTS

Table 4 summarizes the requirements for mine air quality and noise. The maximum allowable concentrations in the diluted exhaust or (mine air) for specific pollutants are listed for each country. In the United States, maximum allowable concentrations of NO₂ is listed but is actually calculated as "equivalent" NO₂ based on a conservative assumption that all oxides of nitrogen measured are in the form of more toxic NO₂. The maximum allowable concentrations for CO,

CO₂, NO₂, and minimum O₂ are regulated in most countries. The minimum O₂ level required in mine ambient air ranges from 19 to 20 pct. Concentrations of SO₂ and aldehydes are regulated in Australia, Canada, Federal Republic of Germany, Norway, Switzerland, and Yugoslavia. The regulation for maximum noise exposure does not exceed 95 dBA nor go lower than 75 dBA in any country for a standard 8-h workday. The noise standards are the most consistent of all topics associated with diesel regulation.

Table 4.—Mine air quality and noise requirements

Country	Mine type	Max allowable conc, ppm					Min O ₂ , pct	Max noise, ¹ dBA
		CO	CO ₂	NO ₂	SO ₂	Aldehydes		
Australia:								
New South Wales	Coal	50	NS	5	NS	NS	19	90
Queensland	Coal, metal-nonmetal	50	5,000	5	NS	NS	19	90
South Australia	Metal-nonmetal	50	5,000	5	NS	NS	20	90
Tasmania	do	50	5,000	5	5	5	20	85
Victoria	do	50	5,000	5	5	5	20	85
Western Australia	do	50	5,000	5	5	5	20	NS
Canada:								
Manitoba	NS	50	5,000	5	NS	5	20	² 85
Newfoundland	NS	50	NS	5	NS	2	20	² 85
Nova Scotia ²	Coal	50	5,000	3	2	³ 1	NS	85
Ontario ²	NS	50	5,000	3	2	³ 1	NS	85
Saskatchewan	Metal-nonmetal	25	5,000	2	NS	NS	19	NS
Yukon Territory ²	NS	20	5,000	3	2	³ 1	NS	90
Chile	NS	NS	NS	NS	NS	NS	NS	85
Colombia	Coal	100	5,000	5	5	NS	19.5	85
France	Gassy	20	NS	NS	NS	NS	NS	85
Germany, Fed. Rep. of:								
Baden-Wuerttemberg	NS	50	NS	NS	NS	NS	NS	NS
North Rhine-Westphalia	Hard coal	50	10,000	5	2	NS	NS	² 83
Do	Nonhard coal	30	5,000	5	2	³ 1	NS	² 75
Hungary	NS	50	10,000	5	5	NS	19	85
India ⁶	Coal	50	NS	⁷ 20	NS	NS	NS	NS
Ireland	NS	50	NS	NS	NS	NS	NS	NS
Korea, Rep. of	NS	NS	10,000	NS	NS	NS	19	NS
Mexico	Coal	100	5,000	5	5	NS	20	NS
New Zealand	NS	20	2,500	5	5	NS	NS	NS
Norway	NS	35	5,000	2	2	³ 1	19	85
Philippines	NS	100	5,000	⁷ 25	10	NS	NS	NS
Poland	Coal	20	10,000	2.5	7	NS	19	90
South Africa, Rep. of	NS	100	5,000	5	NS	NS	NS	NS
Spain	NS	50	NS	NS	NS	NS	NS	NS
Sweden	NS	25	5,000	2	NS	NS	20	85
Switzerland ⁶	NS	50	5,000	5	5	5	NS	⁹ 95, ⁹ 90
United Kingdom	NS	50	12,500	NS	NS	NS	19	90
United States								
Do	Gassy ¹⁰	100	5,000	¹¹ 2.5	NS	NS	20	90
Do	Noncoal	100	5,000	¹¹ 2.5	NS	NS	20	90
Do	Gassy noncoal	50	2,500	¹¹ 1.25	NS	NS	20	90
Yugoslavia	Nongassy	50	5,000	5	4	10	19	NS

NS Not specified in available literature.

¹ Noise exposures permissible for 8-h duration.

² Regulations reference ACGIH TLV, updated annually.

³ Formaldehyde.

⁴ Full run for diesel monorails.

⁵ Empty run for diesel monorails.

⁶ Guidelines, not enforced as regulations.

⁷ Specified as NO_x(NO₂ + NO).

⁸ Excavator.

⁹ Transporter.

¹⁰ Regulations specified for locomotives.

¹¹ Total oxides of nitrogen as NO₂.

AIR QUANTITY (VENTILATION) REQUIREMENTS

Table 5 summarizes the air quantity or ventilation requirements for areas where diesel engines are used. The table lists specific ventilation requirements in terms of air velocity over equipment, unit volume of air per unit of engine power, or flow based on a CO measurement. Romania, North-Rhine Westphalia, and Colombia list ventilation requirements based on dilution of measured ambient CO. The Republic of South Africa specifies ventilation in a unique way for noncoal mines; the average air velocity at working height must be greater than a given air volume flow rate, or it can be based on the volume of the working space multiplied by a constant. In South African coal mines, the volume flow ventilation rate must be at least that number calculated from multiplying the mass of coal mined

per shift times a constant, with a minimum velocity of 0.25 m/s. In the United States, ventilation rates are calculated during equipment certification and based on the amount of fresh air needed to dilute either CO, CO₂, or NO_x to one-half their TLV when the engine is operated at the condition where these pollutants are greatest. This is the quantity of fresh air required for a single diesel unit. If two units are operating in the same split of ventilation air, the ventilation quantity is equal to the sum of the rate for the higher horsepower unit plus 75 pct of the rate for the lower powered unit. If three or more engines are operating in the same split of air, the ventilation quantity is equal to the sum of the rate for the highest powered unit plus 75 pct of the rate for the next size unit plus 50 pct of the rate for each remaining lower powered unit.

Table 5.—Air quantity (ventilation) requirements

Country	Mine type	Minimum ventilation requirements
Australia:		
New South Wales	Coal	10,000 ft ³ /min; 100 ft ³ /(min·bhp) for locomotives.
Queensland	Metal-nonmetal	2.5 m ³ /s; 0.04 m ³ /(s·kW).
South Australia	..do	50 ft ³ /bhp; 5,000 ft ³ + 100 ft ³ /min per person.
Victoria	..do	141.5 m ³ /min; 1.4 m ³ /(min·bhp).
Western Australia	..do	1.9 m ³ /(min·kW); 3.8 m ³ /(min·kW).
Canada:		
Manitoba	NS	75 ft ³ /(min·hp).
Newfoundland	NS	0.05 m ³ /(s·kW).
Ontario	NS	0.06 m ³ /(s·kW).
Quebec	NS	5.5 m ³ /(min·kW), or flows from U.S. BuMines schedules 24 and 31.
Saskatchewan	Metal-nonmetal	3.8 m ³ /(min·kW).
Yukon Territory	NS	75 ft ³ /(min·hp).
Chile	NS	3 m ³ /min per person; max velocity, 150 m/min.
Colombia	Coal	CO < 0.12 pct, 6 m ³ /(min·hp); CO < 0.08 pct, 4 m ³ /(min·hp).
Germany, Fed. Rep. of:		
Lower Saxony	Nongassy	3.4 m ³ /(min·kW).
North Rhine-Westphalia	Hard coal	CO < 0.06 pct, 4.1 m ³ /(min·kW); CO < 0.08 pct, 5.4 m ³ /(min·kW); CO < 0.12 pct, 8.2 m ³ /(min·kW).
Do	Nonhard coal	2.7 m ³ /(min·kW).
Saarland	Hard coal	6 m ³ /(min·hp).
Do	Nonhard coal	3 m ³ /(min·hp).
India ¹	Coal	170 m ³ /min fresh air.
Ireland	NS	100 ft ³ /(min·hp).
Korea, Rep. of	Coal	3 m ³ /min per person; velocity < 450 m/s.
Mexico	..do	50 L/s per worker + 200 L/(s·hp).
Do	NS	2.121 m ³ /(min·hp), or 15.24 m/min velocity.
New Zealand	Coal	10,000 ft ³ /min in airway.
Norway	NS	Flow = 0.65 (load capacity) (conc/norm) + 17.2 (oil consumption).
Philippines	Coal	2 m ³ /min, or 75 ft ³ /min per rated horsepower at max.
Poland	..do	Flow = 62.5 (quantity CO) + 50 m ³ /min or 100 (quantity CO).
South Africa, Rep. of	Metal-nonmetal	Av air velocity > 0.25 m/s over working height, or > 150 dm ³ /s for each square meter of space.
Do	Coal	Flow > 25 dm ³ /s times metric tons coal mined per shift; velocity > 0.25 m/s.
Romania	..do	CO < 0.06 pct, 3 m ³ /min; CO < 0.08 pct, 4 m ³ /min; CO < 0.12 pct, 6 m ³ /min.
Spain	NS	180 L/(s·bhp).
Sweden	NS	Flow = 0.27 m ³ /s (power rating) (specific air requirement) (load factor)/3,600.
Switzerland	NS	4 m ³ /min.
United States	Noncoal	Determined in approval tests for each vehicle.
Do	Gassy noncoal	Do.
Do	Locomotives (for gassy mines)	Do.

NS Not specified in available literature.

¹ Guidelines, not enforced as regulations.

REQUIREMENTS FOR TESTING MINE (AMBIENT) AIR QUALITY AND QUANTITY

Table 6 summarizes the requirements for testing mine or ambient air quality and quantity. Although somewhat vague, the type of test, test frequency, and test location are listed. Some countries specify "general air quality," while others note specific pollutants. Testing frequency varies from once per shift to twice per year depending on the country and type of analysis. The location of air quality tests are specified in various ways. Some countries note "diesel use sites," while others are more specific with location; for example, New South Wales in Australia notes the test location to be 10 ft from the engine at a height of 5 ft. Still others specify "exhaust currents" as the location. The specific testing method and apparatus are specified by only a few countries.

The remainder of the report is a synopsis, by country, of available information on international regulations pertaining to the use of diesel engines underground. A general policy statement is given at the beginning of each section, as well as the source of the information. The available information is then presented for the following categories:

Types of engines permitted.

Testing and certification procedures of engine and auxiliary equipment.

Fuel quality specifications.

Engine emission control requirements.

Procedures and frequency of testing engine exhaust gases.

Mine air quality and quantity requirements.

Procedures and frequency of testing mine air quality and quantity.

Noise standards.

Table 6.—Requirements for testing mine (ambient) air quality and quantity

Country	Mine type	Test				Method
		Type	Frequency	Location		
Australia:						
New South Wales	Coal	CO, NO _x	Weekly	10 ft from engine, 5 ft. high.	Device capable of 10 ppm CO, 1 ppm NO _x .	
Northern Territory	Metal-nonmetal	General air quality	Monthly	Diesel use sites	NS.	
Queensland	Coal	..do	Daily	..do	NS.	
South Australia	Metal-nonmetal	..do	Monthly	Diesel use sites	NS.	
Tasmania	..do	CO, NO ₂ , NO _x	Weekly	..do	NS.	
Victoria	..do	General air quality	..do	..do	NS.	
Western Australia	..do	CO, CO ₂ , NO ₂	Daily	Return airways, engine exhaust side.	Drager tube.	
Canada:						
British Columbia	Coal, metal-nonmetal	CO, NO	..do	NS	NS.	
Do	Coal	Airflow	Weekly	300 ft from work site on ventilation split.	NS.	
Do	Metal-nonmetal	..do	..do	NS	NS.	
Manitoba	NS	CO	Once per 80 h use	Adjacent to engine	NS.	
Do	NS	Airflow	Weekly	NS	NS.	
Newfoundland	NS	CO, NO ₂	Once per shift	NS	NS.	
Do	NS	NO _x	Monthly	Adjacent to engine	NS.	
Do	NS	Aldehydes	Once per 3 months	..do	NS.	
Do	NS	Complete analysis	Once per 6 months	..do	Detector tubes.	
Do	NS	Airflow	Weekly	Near work face ventilation duct.	NS.	
Nova Scotia	Coal	Airflow, percent inflammable gas.	..do	Road endings, intermediate points.	NS.	
Ontario	NS	CO, NO _x , airflow	..do	NS	NS.	
Do	NS	Aldehydes	Once per 3 months	NS	NS.	
Quebec	NS	Airflow	Weekly	Vehicle work area	NS.	
Saskatchewan	Metal-nonmetal	General air quality	..do	NS	NS.	
Yukon Territory	NS	CO	Daily	Work area	NS.	
Do	NS	Airflow	Weekly	..do	NS.	
Chile	NS	..do	Monthly	Each section, intakes and fronts.	NS.	
Colombia	Coal	General air quality	Weekly	NS	NS.	
Germany, Fed. Rep. of:						
Lower Saxony	Nongassy	Airflow	Semiannually	NS	NS.	
North Rhine-Westphalia	Coal	General air quality	Once per 3 months	Diesel use sites	Test tubes, chemical analysis.	
Hungary	NS	CO, NO _x	Weekly	..do	Continuous CO monitor.	
India ¹	Coal	Airflow, CO, NO _x	..do	End of roadway use sites.	NS.	
Ireland	NS	General air quality	Monthly	NS	NS.	
Korea, Rep. of	Coal	Airflow	Weekly	Intakes, returns	NS.	
Do	..do	Volume of velocity	Monthly	All worksites	Anemometer.	
Mexico	Coal	Airflow	Twice a week	Entrances, exits	NS.	
New Zealand	..do	CO, NO _x	Daily	NS	NS.	
Norway	NS	CO, NO ₂ , oil mist	Semiannually	NS	NS.	
Poland	NS	CO, NO _x	Monthly	Excavations, exhaust currents.	NS.	
South Africa, Rep. of	Metal-nonmetal	Dust, gases	Once per 3 months	NS	NS.	
Do	Coal	Airflow, velocity	Monthly	NS	NS.	
Sweden	NS	CO, NO _x	Twice a week	Diesel work sites	NS.	
Switzerland ¹	NS	General air quality	Daily	NS	NS.	
United Kingdom	NS	CO	Monthly	NS	NS.	
United States	Gassy (locomotives).	CO, CO ₂ , NO _x	NS	Diesel use sites	NS.	
Do	Noncoal	CO, CO ₂ , NO _x	NS	..do	NS.	
Yugoslavia	Nongassy	Airflow	Twice a week	NS	NS.	
Do	..do	CO, CO ₂	Once per 15 days	Diesel use sites	NS.	
Do	..do	Soot, CO ₂	Once per 3 months	..do	NS.	

NS Not specified in available literature.

¹ Guidelines, not enforced as regulations.

The data and units of measure presented are those of the original sources; no attempt has been made at standardization of this information. Throughout the remainder of this publication, an asterisk (*) denotes that the information was not available. Other information is quoted directly from the sources identified by the italic numbers in parentheses.

The eight criteria (categories) for the United States have been summarized and presented in tables 1 through 6. The information presented in the tables for the United States was excerpted from references 1 through 7.

ACKNOWLEDGEMENTS

John N. Murphy, research director, Pittsburgh (PA) Research Center, Bureau of Mines, is gratefully acknowledged for his solicitations of the foreign mining regulations used in this report. By utilization of his official contacts as liaison to foreign mining organizations, and his personal acquaintances throughout the world, he has

assured that this document is comprehensive. Also, the assistance of Jean E. Small-Johnson (formerly industrial hygienist with the Bureau of Mines, now industrial hygienist with the Minnesota Pollution Control Agency) in the task of excerpting and categorizing information from the foreign documents is greatly appreciated.

AUSTRALIA

The Australian Mining Industry is subject to both national and State control, but in respect to safety and health the State is the responsible authority. The Federal Government has control over such matters as exports and through the Joint Coal Board has input with regard to granting of leases. Also, they have an opportunity to comment on safety regulations through this joint Coal Board (11).

The following statutory authorities are responsible for use of diesels below ground in Australia (12):

1. *N.S.W. Department of Industrial Relations.*—Has two separate administrations for coal mines and noncoal mines.
2. *Queensland Department of Mines.*—Has two separate administrations for coal mines and noncoal mines.
3. *Tasmanian Department of Mines.*—Has single administration for both coal and noncoal mines.
4. *Western Australian Department of Mines.*—Has single administration for both coal and noncoal mines.
5. *South Australian Department of Mines and Energy.*—Noncoal underground mines only.
6. *Department of Minerals and Energy, Victoria.*—Noncoal underground mines only.
7. *Northern Territory Department of Mines and Energy.*—Noncoal underground mines only.

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132 Londonderry Road
Londonderry, N.S.W., Australia 2753

NEW SOUTH WALES AND QUEENSLAND

The two States in Australia that are most concerned with coal mining are Queensland and New South Wales (11). The following information on these two States covers both coal and noncoal.

Types of Engines Permitted

In one way or another the only type of internal combustion engine permitted below ground in coal and noncoal mines in New South Wales and Queensland are diesel powered. For example this is specified in the N.S.W. Coal Mines Regulations which states that any internal combustion engine used underground must be of the

compression ignition type. Whereas in the Regulations for noncoal mines in New South Wales dependence is placed on the requirement regarding % CO from the exhaust. There is no requirement as to the type of diesel engine, either direct or indirect ignition are permitted, and turbo charging is allowed, provided that requirements regarding exhaust pollution and flameproofing, where appropriate, are met (12).

Types of Engines (13)

- Must be water cooled.
- Electrical or compressed air starting allowed.
- Electrical equipment to be less than 32 V.
- Belt drives non-flam and anti-static.
- Fan blades to be non ferrous, non-aluminum, non-flam, anti-static, and non-sparking.
- Air intakes, combustion and exhaust systems to withstand internal explosion (4 times explosion test pressure or 862 KPA whichever is greater).
- Hydraulic systems to be use non-flam fluids.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Procedures for N.S.W. and Queensland (12):

To summarise, flameproof testing is carried out on a prototype basis of components, i.e., scrubber and flametraps. Exhaust gas analysis is carried out on each individual engine before it is used and at the same time engine temperature is checked. Prototype approval is given in respect of flametraps and scrubbers, and then individual vehicle approval is given after the performance of the exhaust gas analysis. Individual vehicle approval is given in accordance with one of the "Special Rules and Conditions"⁴ as appropriate.

Ancilliary equipment, e.g., F.L.P. lighting, is also approved on a prototype basis by the Chief Inspector of Coal Mines. It is proposed to introduce full prototype vehicle approval but this is still in the discussion stage.

The regulations for N.S.W. noncoal mines required approval by the Chief Inspector. In practice this means that each diesel before it is used at a mine is examined by an Inspector and then individual

⁴New South Wales has rules and special conditions for each of the following diesel powered vehicles: tractors, scoop trams, shuttle cars, personnel carriers, locomotives, and rock dusters.

approval granted by the Chief Inspector. This examination includes exhaust gas testing.

At Queensland coal mines approval is given on a prototype basis, except that exhaust analysis tests are carried out on each individual vehicle. It is proposed to introduce prototype testing to cover the requirements for engine exhaust pollution but even then each individual engine will still be subject to exhaust analysis by the local district inspector.

Queensland noncoal mines have no approval procedure in respect to engines for use underground but imposes the statutory requirements through its Inspectorate.

Test and Certification (13):

Design approved by Department of Mineral Resources (NSW) and engine stamped with serial no. and approval no. (details of approval procedure not held: believed to be similar to United Kingdom's). For tractors, the manufacturers are to verify engine adjustments before the tractor is put into operation.

Fuel Quality Specifications

New South Wales (13):

Best quality fuel with sulphur less than 0.1 (0.3 for tractors) and flash point greater than 150 F to current British standard specification.

Fuel pumps to be locked or sealed to prevent tampering.

Tank capacity to be less than 4 hours at full load.

In the case of Queensland coal and noncoal mines, there is no requirement for the fuel-oil composition. However, the fuel in Queensland is supplied from local sources and has an extremely low sulphur content (12).

Engine Emission Control Requirements

Emission Control (13):

Undiluted exhaust gas to have less than 1,500 ppm CO and less than 1,000 ppm NO_x at idling and full load.

Black smoke prohibited.

Conditioner make up water level engine cut out to be provided.

Minimum water supply for 7-hour shift to be provided.

The exhaust system shall reduce the exhaust gas temperature so that it does not exceed 77° C at the point of discharge to the atmosphere. Exhaust manifold shall be water-cooled, capable of arresting flame; external surface temperature of exhaust system shall be kept below 150° C (12).

Procedures and Frequency of Testing Engine Exhaust Gases

N.S.W. coal mining regulations require monthly testing of each engine exhaust vehicle, and this is also the case in Queensland. For N.S.W. noncoal mines the Inspectorate requires this to be done annually. No frequency is specified for Queensland noncoal mines (12).

Exhaust testing (13):

Once every four weeks and after any fuel pump or injector maintenance, undiluted exhaust gases to be tested by Dräger tube.

Once every six months, undiluted exhaust gases to be tested by laboratory sample.

Conditioner to be drained and refilled with clean water at least once per shift.

Exhaust flame trap to be replaced once every 24 hours.

Periodic measurements to be made of positive pressure in the exhaust system to indicated cleanliness of exhaust flame trap.

Mine Air Quality and Quantity Requirements

Queensland mines (12):

Coal: Oxygen, 19%; CO, 50 ppm; CO₂, 5,000 ppm; oxides of nitrogen (as NO₂) 5 ppm.

In the case of Queensland noncoal mines, general body mine air requirements are the same as for coal mines but for the exhaust gas there is only a requirement for carbon monoxide which shall not exceed 1,500 ppm.

In respect of Queensland coal mines for each engine, the District Inspector has to assure himself that there is sufficient ventilation to achieve mine air general body figures for CO, etc., in the regulations. Queensland noncoal mines specify a quantity of 0.04 m³/sec/kW or 2.5 m³/sec, whichever is greater.

NSW coal mines (13):

Working prohibited if concentrations in general body of air exceed: CO greater than 50 ppm, NO_x greater than 5 ppm, CH₄ greater than 1.25.

(Locomotives) airflow to be 10,000 cfm or 100 cfm per bhp whichever is greatest.

(Tractors) no more than two to be operated in the same ventilation split.

(Tractors) minimum quantity of air to be individually specified for each installation.

Procedures and Frequency of Testing Mine Air Quality and Quantity

In the case of Queensland coal mines the general body is required to be tested daily, and in the case of Queensland noncoal mines no test frequencies are specified at present (12).

Testing of ventilation (13):

Once per week (tractors, once per shift) atmosphere on return of machine to be tested approximately 10 ft from it at a height of 5 ft by an apparatus capable of recording 10 ppm CO and 1 ppm NO_x (and for tractors, 0.5 = CH₄); and recorded.

(Tractors) twice per shift in general body by locked flame safety lamp.

Noise Standards

Noise limit in respect of New South Wales coal mines and Queensland coal mines is specified at 90 dBA, although it is admitted that in practice this is rarely achieved. In the case of New South Wales non coal mines the requirement is that the noise may be 90 dBA for eight hours and the working time is halved for every 3 dBA above this figure. For Queensland noncoal mines no noise requirements are stipulated (12).

NORTHERN TERRITORY

The following regulations for Northern Territory were excerpted from the Northern Territory Regulations - Mines Safety Control (14).

Types of Engines Permitted

138. APPROVAL OF ENGINES (1) An internal combustion engine, other than a compression ignition engine, shall not be installed or used underground in a mine without the written approval of the Chief Government Mining Engineer.

Testing and Certification Procedures of Engine and Auxiliary Equipment

138. APPROVAL OF ENGINES (2) The power of the Chief Government Mining Engineer under sub-regulation (1) to approve the installation or use of an internal combustion engine includes the power to direct that specified tests of the engine be carried out before the approval is given.

141. SAFETY CHECKS (1) A compression ignition engine used underground in a mine shall be examined – (a) not less than once a day by a competent person other than the driver or operator of the vehicle; and (b) not less than once a week – (i) by a competent driver or operator; and (ii) by a competent compression ignition engineer or mechanic.

(2) The results of the weekly inspections referred to in sub-regulation (1) and the actions taken to remedy defects, if any, shall be recorded in the Machine Record Book.

(3) A compression ignition engine which is not in a vehicle shall be examined not less than once a week by a competent compression ignition engineer or mechanic.

Fuel Quality Specifications

126. TYPE OF FUEL OIL which – (a) has a closed cup flash point of less than 61° C; (b) contains more than 0.5% by weight of sulphur; or (c) contains an additive which has not been approved in writing by the Chief Government Mining Engineer, shall not be used underground in a mine for fueling diesel-engined vehicles.

Engine Emission Control Requirements

136. EXHAUST CLEANERS (1) Each compression ignition unit exhaust in a mine shall be equipped – (a) with a water scrubber; or (b) with an approved diluting and diffusing apparatus.

(2) Where a scrubber required by sub-regulation (1) is used on a compression ignition unit – (a) the water shall be changed not less than twice in each working shift; and (b) the scrubber tank shall be cleaned not less than once a day.

137. EXHAUST DISCHARGE The exhaust fumes from the operation of a compression ignition engine underground in a mine shall be discharged at a point remote from the engine operator or driver.

145. AIR QUALITY Compression ignition operated equipment shall not be used underground in a mine if the undiluted exhaust gases of that equipment contain – (a) more than 1,000 parts per million of carbon monoxide; or (b) more than 1,000 parts per million of combined oxides of nitrogen calculated as nitrogen dioxide.

Procedures and Frequency of Testing Engine Exhaust Gases

See regulation 141 in “Testing and Certification Procedures of Engine and Auxiliary Equipment” section.

Mine Air Quality and Quantity Requirements

96. CLEAN AIR TO BE PROVIDED Subject to this Part, a working, and each part of a working, in a mine shall be kept ventilated to the extent that – (a) it is a fit place to pass through or in which to work; and (b) the air in that working or part of that working – (i) contains not less than 19% by volume of oxygen; and (ii) contains no more aldehydes (as formaldehyde), carbon dioxide, carbon monoxide, nitrogen dioxide, or dust (nuisance or containing hazardous substances) that is specified by the Chief Government Mining Engineer by notice in the *Gazette* or, if no such notice has been published in the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores or the Journal of Atmospheric Contaminants, November 1980, published by the Australian Health and Medical Research Council.

Procedures and Frequency of Testing Mine Air Quality and Quantity

98. TESTING FOR CLEAN AIR (1) A competent person appointed by the manager of a mine shall, at approved regular intervals, make tests in the working face and airways of the mine to establish whether regulation 96 has been complied with.

(2) The results of the tests carried out in a mine pursuant to sub-regulation (1) shall be entered in the Record Book for the mine.

(3) The methods and apparatus used to carry out the tests required by this regulation shall be such methods and apparatus as are approved.

Noise Standards

47. PROTECTIVE HEARING EQUIPMENT The manager of a mine shall supply protective hearing equipment to a person at the mine who is or who is likely to be exposed to noise with a pressure level exceeding –

(a) the level fixed by the Chief Government Mining Engineer in relation to the mine; or

(b) if no level is fixed under paragraph (a), a maximum of 85 decibels measured in accordance with standard reference curve A referred to in Australian Standard 1259, Part 1-1976*.

SOUTH AUSTRALIA

Only about 10 diesel units are operated underground in South Australia. The requirements for these are under review (15).

Types of Engines Permitted

DIVISION 8 – INTERNAL-COMBUSTION ENGINES UNDERGROUND (16).

Permission to Use Engines Underground

145. (1) Before an internal-combustion engine is installed underground in a mine, permission in writing shall be obtained from the Chief Inspector of Mines for the engine to be used underground.

(2) The Chief Inspector shall not give such permission unless he is satisfied that the engine complies with these regulations and can be used in the mine without danger to the men working therein.

(3) The Chief Inspector shall not give permission for the use underground in a mine of an internal combustion engine forming the prime mover of a locomotive or vehicle, unless it is a diesel engine.

(4) Any permission so given may be subject to any conditions which the Chief Inspector considers necessary as to the place where the engine may be used, inspection, and any other matters relative to the safety of those working in the mine.

(5) A person installing or using an internal combustion engine underground in a mine shall comply with every condition specified in the permission given by the Chief Inspector.

(6) Upon giving permission for the use of an engine underground the Chief Inspector shall assign a number to the engine and keep a record of such number in his office.

(7) The number assigned by the Chief Inspector to each engine shall be clearly painted on such engine.

Testing and Certification Procedures of Engine and Auxiliary Equipment

DIVISION 4 – SAFETY AND PROTECTION (16)
Machinery to be in Good Condition

52. (1) All machinery which is in use in or at a mine shall be kept at all times in good order and in safe condition.

(2) In this regulation "machinery" includes engines, plant, gear, and equipment of all kinds.

53. (1) All material and equipment installed or used in or at a mine shall be sound and of adequate strength for the purpose for which it is to be used.

(2) Every working part of a mine and every structure and item of equipment which is in use in or at the mine shall be maintained in good order and in a safe condition.

DIVISION 8—INTERNAL-COMBUSTION ENGINES UNDERGROUND (16).

Examination of Internal Combustion Engines

146. (1) All internal combustion engines used underground shall be examined daily by a competent person and at least once a week by a competent diesel engineer or mechanic, and the result of such weekly examination and the action taken to remedy defects (if any) shall be recorded in the Machinery Record Book.

(2) No person shall use an internal-combustion engine underground in a mine if the engine has any defect.

An "Application for Permission to Use a Diesel Engine Underground" is submitted by the Mine Manager to the Chief Inspector of Mines for approval. This application is to include information on the following items: diesel engine specifications, engine exhaust data, starter, transmission, steering, operating speeds, brakes, payload, lights, horn, fire extinguisher, safety belts, electric system, and overhead protection.

Fuel Quality Specifications

DIVISION 8—INTERNAL-COMBUSTION ENGINES UNDERGROUND (16).

Fuel for Underground Diesel Engines

147. (1) No person shall use in a diesel engine underground any fuel-oil having a flash-point of less than 150 degrees Fahrenheit, as determined by the Abel Apparatus or the Pensky-Martens closed cup method, or having more than 0.5 pct sulphur by weight.

Engine Emission Control Requirements

DIVISION 8—INTERNAL-COMBUSTION ENGINES UNDERGROUND (16).

Exhaust Gas

150. (1) Every diesel engine used underground in a mine shall be fitted with exhaust-gas scrubbers or other apparatus to render toxic exhaust-gases harmless, or reduce the toxic content of such gases to the extent required by these regulations.

(2) All such scrubbers or other apparatus shall be kept clean and efficient, and the tanks of any such scrubbers shall be cleaned and filled with the fresh water daily.

(3) The following requirements shall be complied with in relation to every diesel engine used underground in a mine:

(a) The exhaust gases shall be discharged at a place remote from the operator.

(b) The exhaust-gases shall contain not more than 1,500 parts per million of carbon monoxide nor more than 1,000 parts per million of oxides of nitrogen.

Procedures and Frequency of Testing Engine Exhaust Gases

DIVISION 8—INTERNAL-COMBUSTION ENGINES UNDERGROUND (16).

Exhaust-Gas

150. (4) At intervals not exceeding four weeks, samples of the air in places where diesel engines are used underground, and of the

exhaust-gases of such engines, shall be taken and such samples shall forthwith be analysed and the results of the analyses entered in the Machinery Record Book.

Mine Air Quality and Quantity Requirements

150. (3)(c) The quantity of air passing each minute through the place where the engine is being used shall not be less than fifty cubic feet per brake-horsepower or 5,000 cubic feet whichever is the greater. The brake-horsepower to be taken into account in computing the amount of air shall be the total horsepower of all the engines working in the said place at the same time.

The said quantity of air shall be in addition to the quantity prescribed by these regulations for any other purpose.

DIVISION 3—VENTILATION AND CONTROL OF DUST AND FUMES (16).

Standards of Ventilation

37. (1) The mine shall be ventilated so that at all times the air in every part of the mine where men are working shall comply with the following requirements:—

(a) It shall contain at least 20 per cent by volume of oxygen.

(b) It shall not contain more than 0.5 per cent of carbon dioxide or more than 0.005 per cent of carbon monoxide or more than 0.0005 per cent of the higher oxides of nitrogen, or more than 0.002 per cent of sulphuretted hydrogen; all such percentages being calculated by volume.

(c) It shall not contain more than 300 particles per cubic centimetre of dust which is five microns or less in diameter.

(d) It shall not have a temperature of more than 83 degrees Fahrenheit, by wet-bulb thermometer.

(e) At least one hundred cubic feet of fresh air per minute for every man and horse working in any place shall be circulated through that place.

Procedures and Frequency of Testing Mine Air Quality and Quantity

DIVISION 3—VENTILATION AND CONTROL OF DUST AND FUMES (16).

Standards of Ventilation

37. (2) For the purpose of this regulation 37, the number of dust particles per cubic centimetre shall be determined:

(a) by an efficient konimeter, taking the average of the numbers ascertained by six tests made at intervals of one minute; or

(b) by any other efficient instruments to the satisfaction of the Chief Inspector of Mines.

In either case, the number of such particles shall be counted under dark field illumination.

Noise Standards

HEARING CONSERVATION (17).

3. Where the noise level ascertained in respect of an employee's place of employment and in respect of the period for which the employee is at work in that employment during any day, exceeds an equivalent continuous noise level of 90 decibels calculated in accordance with these regulations or the noise level in respect of any period of employment exceeds 115 decibels the employee is exposed to excessive noise and the employer shall, where practicable, take action to reduce the equivalent continuous noise level to the allowable limit by means of either—

(a) engineering noise reduction, or

(b) administrative noise control or a combination of both.

4. The equivalent continuous noise level shall be derived from the measurement of noise levels and the actual duration of exposure of an employee to those noise levels.

TASMANIA

The following information for Tasmania was excerpted from information provided by M. R. Lloyd, Director, Londonerry Industrial Safety Centre (15).

Types of Engines Permitted

Engine types other than hydraulic and electric are confined to 4-cycle diesel carrying approval and certification.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Approval testing is carried out after a suitable initial running-in period which may be permitted underground on a temporary certification. This latter is only granted where the engine is a known type in a modified application and it is possible to arrive at a reasoned approval. Totally unknown engines are confined to surface operations for a period of 500 to 700 engine hours with regular exhaust testing recorded by the operator and submitted to the Department for assessment. Approval testing is carried out on site under near as possible operating conditions.

Fuel Quality Specifications

Fuel quality specifications are:

- (a) closed cup flashpoint above 61° C; and
- (b) contains less than 0.5% sulphur.

Engine Emission Control Requirements

Emission controls are:

- (a) approved means of preventing adjustment of fuel rate at maximum governed speed.
- (b) a 6 NB plug for gas sampling on the exhaust system.
- (c) the fitting of a water scrubber or an approved diluting and diffusing apparatus of adequate capacity.
- (d) total CO or NO_x in undiluted exhaust does not exceed 1,000 ppm.
- (e) ventilating air supplied must at least equal the ventilating quantity required by the approval.

Procedures and Frequency of Testing Engine Exhaust Gases

All exhaust gas must be sampled and analysed by approved methods at four weekly intervals and the results recorded. The method approved is the use of Drager gas test tube with the sample taken as close to the exhaust manifold as is reasonable.

Mine Air Quality and Quantity Requirements

In general, mine air must not contain less than 20% by volume of oxygen or more than 5,000 ppm carbon dioxide, 50 ppm carbon monoxide, 25 ppm total oxides of nitrogen, and 5 ppm aldehydes.

All diesel exhausts must be diluted with fresh air to meet the above requirements except that in the case of CO₂ the dilution standard is 2,500 ppm and for nitrous fumes it is 12.5 ppm. The maximum dilution factor required from testing is the criterion for establishing the ventilation requirement stipulated on the subsequent approval certificate.

In addition, regulations limit NO₂ to 5 ppm and SO₂ to 5 ppm while calling in the limits imposed by the NHMRC "Atmospheric Contaminants"*. Konimeter limits are 300 particles of 5 or less per millilitre and temperature is limited to 25° C wet-bulb.

The quantity of pure air supplied must be sufficient to meet the requirement specified for each engine approved underground, i.e., cumulative.

Procedures and Frequency of Testing Mine Air Quality and Quantity

The general body of the air must be sampled and recorded at least weekly in addition to the exhaust sampling requirements. In areas where engines are in use the tests shall be for carbon monoxide and the total oxides of nitrogen, in the case of other areas for carbon monoxide and nitrogen dioxide. If ventilation is interrupted, or falls below total requirement all engines are required to be stopped.

Noise Standards

Hearing conservation equipment is required to be supplied and used where the noise level exceeds 85 dbA.

VICTORIA

The following regulations are for the metal and nonmetal mines of Victoria. They were excerpted from the Mines (Gold and Minerals) Underground Mining General Regulations (18).

Types of Engines Permitted

Permission Required to Install Diesel Engines Underground

601. (a) An internal combustion engine other than a diesel engine of approved type shall not be used underground.

(b) All engines shall be tested in an approved manner before they are put into service.

(c) The results of tests shall be recorded in the record book kept pursuant to sub-regulation (3) of Regulation 604.

Registration of Engine Number

602. Every diesel engine used underground shall have an official number, such number to be recorded in the record book, pursuant to sub-regulation (3) of Regulation 604.

Use of Defective Engines Forbidden Underground

603. A diesel engine shall not be used underground if it has any defect that may affect its safe operation.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Inspection of Diesel Engined Vehicles and Engines Required

604. (1) Diesel engined vehicles used underground shall be examined daily by a competent person appointed by the manager other than the driver and at least once a week by a competent diesel engineer or mechanic appointed by the manager.

(2) Diesel engines other than those in vehicles shall be examined once a week by a competent diesel engineer or other than the driver and at least once a week by a competent mechanic appointed by the manager.

(3) The results of such inspections and the actions taken to remedy defects if any shall be recorded in a record book to be kept for that purpose by the manager and such record book shall be available for inspection at any reasonable time by an inspector.

Fuel Quality Specifications

Specifications for Fuel Oil

607. (1) Oil used for fuelling diesel engined vehicles and stationary engines underground shall have a closed cup flash point of not less than 61 degrees Celsius.

- (2) The sulphur content of the fuel oil shall not exceed 0.5 percent by weight.
- (3) No substance shall be added to fuel oil without the written permission of the Chief Inspector.

Engine Emission Control Requirements

612. (3) No diesel operated equipment shall be permitted to be used underground if the undiluted exhaust gases contain more than 1,000 parts per million combined oxides of nitrogen.

Exhaust Gas Scrubbers to be Provided

613. (1) Diesel engines used underground shall be fitted with water scrubbers or apparatus suitable for reducing the toxic content of exhaust gases to comply with these Regulations.

(2) The tanks of water scrubbers shall be cleaned and filled with fresh water not less than once per working shift or more frequently if an inspector directs.

(3) The competent person appointed by the manager under sub-regulation (1) of Regulation 604 shall ensure that other apparatus shall be examined and cleaned as often as is necessary to maintain efficient operation or as directed by an inspector.

Engines Not to Run While Stationary

614. Diesel engines of vehicles used underground shall not be left running while the vehicles are stationary except for short periods when necessary.

Procedures and Frequency of Testing Engine Exhaust Gases

612. (2) Accurate analyses of the carbon monoxide and nitrogen dioxide content of the undiluted exhaust gases shall be made by a competent person appointed by the manager at the diesel engine at weekly intervals or more frequently if directed by an inspector.

Mine Air Quality and Quantity Requirements

503. (1) The air in any working place shall be deemed adequate if
 (a) it contains not less than 20 per cent by volume of oxygen;
 (b) it contains not more than the following amounts of impurities:

carbon dioxide	5,000 ppm.
carbon monoxide	50 ppm.
nitrogen dioxide	5 ppm.
hydrogen sulphide	10 ppm.
sulphur dioxide	5 ppm.
aldehydes (as formaldehyde)	5 ppm.

(c) it shows a count not in excess of 300 particles of dust per cubic centimetre of 5 micrometers or less in diameter, or a count not in excess of such lower number of particles as the inspector may require. Such count shall be the average of not less than six tests caused to be taken by the inspector, using a konimeter and counted under dark field illumination or, a maximum allowable concentration of respirable dust based on mass measurement if required by or approved in writing by the Chief Inspector. The method of sampling dust shall be laid down by the Chief Inspector. The maximum allowable concentration of respirable dust shall be that recommended by the Australian National Health and Medical Research Council.

(2) The temperature of the air shall not exceed 28 degrees Celsius, wet bulb, unless otherwise approved by the Chief Inspector.

Ventilation Standards for Diesel Engines

611. (1) Diesel engines shall be used underground only in places where the ventilation is adequate within the meaning of paragraphs (a) and (b) of sub-regulation (1) of Regulation 503.

(2) The quality of air passing through such places shall be based on gas analyses of the vehicle exhausts; and the appropriate dilution factor shall be sufficient to comply with the standards set out in paragraphs (a) and (b) of sub-regulation (1) of Regulation 503.

Procedures and Frequency of Testing Mine Air Quality and Quantity

503. (3) At intervals approved by an inspector a competent person appointed by the manager shall make tests of the air at the working faces and in the airways of the mine and shall enter the results of such tests in the record book.

(4) Standards shall be measured by approved methods and apparatus.

Noise Standards

PERMISSIBLE NOISE EXPOSURE

<i>Duration per day, hours</i>	<i>Noise level, dB (A)</i>
8	90
6	92
4	93
2	96
1	99
1/2	102
1/4 or less	105

WESTERN AUSTRALIA

The following regulations for Western Australia were excerpted from the Mines Regulations for 1946-74 (19).

Types of Engines Permitted

14.1 No internal combustion engine, other than a compression ignition diesel engine which uses low volatile fuel, shall be used underground in a mine.

Testing and Certification Procedures of Engine and Auxiliary Equipment

14.4 (1) The Senior Inspector shall, before issuing a permit for a diesel engine to be installed or used underground, have tests made to ensure that the diesel engine is safe for use underground, and the cost of those tests shall be borne by the applicant.

(2) Applications for a permit shall be accompanied by complete engine identification data, full specification of the engine, and an analysis of its undiluted exhaust gas composition with respect to carbon monoxide, oxides of nitrogen and carbon dioxide.

(3) The determination of the analyses of exhaust gas composition required by this regulation shall be made when the engine is operating— (a) at normal operating temperature minimum rated power output; and (b) at maximum rated speed and maximum rated power output.

New and overhauled spare and replacement engines are tested on dynamometers to ensure that their exhaust gas complies with emission standards.

Fuel Quality Specifications

14.15 (1) Diesel engine fuel for use underground shall have a flash point of not less than 61° C. as determined in the manner prescribed in regulation 6 of the Flammable Liquid Regulations, 1967, under Explosives and Dangerous Goods Act, 1961*.

(2) The sulphur content of such diesel fuel shall not exceed 0.5%.

Engine Emission Control Requirements

14.4 (4) The undiluted exhaust gas produced by a diesel engine intended for use underground shall not contain more than 1,500 parts per million of carbon monoxide or more than 2,000 parts per million of oxides of nitrogen under any condition of engine operation.

14.6 (1) Unless exempted by the Senior Inspector in writing, every diesel engine used underground shall be fitted with an exhaust gas cooling device capable of reducing the temperature of the undiluted exhaust gases under any condition of operation to less than 93° C. at the point of discharge from the device.

(2) Any proposed change or modification to an approved exhaust cooling device, and any proposed modification to a diesel engine, which could affect the characteristics of the exhaust gas emission shall be made known to the Senior Inspector.

Procedures and Frequency of Testing Engine Exhaust Gases

14.9 (1) The undiluted exhaust gas produced by a diesel engine underground shall be sampled and analyzed at intervals of not more than one week, or at such lesser intervals as the Inspector may require.

(2) If when sampling the undiluted exhaust gas produced by a diesel engine it is found that the exhaust gas contains more than 2,500 parts per million of carbon monoxide or more than 2,000 parts per million of the oxides of nitrogen the diesel engine shall be immediately withdrawn from service and shall not be used until the fault has been remedied.

Air Quality and Quantity Requirements

14.5 (1) A diesel engine shall not be taken or used underground in any part of a mine unless the air for the ventilation of that part of the mine is drawn from the purest possible source.

(2) The quantity of air supplied to ventilate any part of a mine underground in which a diesel engine is used shall be sufficient to dilute the final exhaust gases so that the concentration of any of the following constituents in the diluted mixture shall not be more than –

- (a) 5,000 parts per million of carbon dioxide;
- (b) 50 parts per million of carbon monoxide;
- (c) 10 parts per million of hydrogen sulphide;
- (d) 5 parts per million of nitrogen dioxide;
- (e) 5 parts per million of sulphur dioxide;
- (f) 5 parts per million of aldehyde (as formaldehyde).

(3) The oxygen content of the diluted mixture shall be not less than 20% by volume.

(4) Each diesel engine permit shall specify the minimum quantity of air per minute which shall be supplied to dilute the engine exhaust gases to the standard required by subregulation (2).

(5) In calculating the quantity of air required to dilute the exhaust gases, 3.8 cubic metres of air per minute shall be supplied per kilowatt engine output, based on the manufacturer's maximum rating but – (a) the figure may be reduced by the Senior Inspector for a particular diesel engine if it can be established that, because of special design features, a lesser quantity of air will dilute the exhaust gases to the acceptable standard; and (b) in no case shall less than 1.9 cubic metres per minute per kilowatt be supplied.

(6) Where more than one diesel engine is operating in an underground working place at the same time the volume of ventilating air required to be supplied shall be the aggregate of the volumes shown on the respective permits issued by the Senior Inspector with regard to those engines.

Procedures and Frequency of Testing Mine Air Quality and Quantity

14.8 (1) The Manager shall be responsible for testing the composition of the exhaust atmosphere in any place underground where a diesel engine or diesel engines are working.

(2) The tests shall be taken in the return airway and on the exhaust side of the engine or engines, and may be taken at the primary or secondary ventilation exhaust outlets or at both.

(3) The tests shall be made daily to determine the quantity of carbon monoxide (CO), carbon dioxide (CO₂) and nitrogen dioxide (NO₂).

(4) If as a result of the test the concentrations of the components in the diluted exhaust gas do not conform with the requirements of this Part further operation of that diesel engine or engines in the working place so tested shall be suspended until the cause of the high gas concentration has been discovered and remedied.

Noise

There are no standards for noise (14).

BELGIUM

Types of Engines Permitted

The Royal Decree of May 19, 1952 regulating the use of internal combustion engines in the underground works of mines prescribes in Article 14:

The only mobile internal combustion engines permitted to travel in the underground works of mines, surface mines and underground quarries are diesel locomotives of a type satisfying the conditions established by the Ministry and approved by the director general of Mines (20).

No ignition system allowed apart from starting mechanism. Both manual and automatic provision to be made to prevent "racing" (speed in excess of 120% normal) (21).

Testing and Certification Procedures of Engine and Auxiliary Equipment

I. Conditions of Approval for Diesel Engines (20).

Art. 1 – Diesel engines must be able to be supplied in any mine containing firedamp (mine gas) without racing, without undergoing dangerous overheating nor any deterioration which endangers general safety, and without igniting the ambient atmosphere. These engines do not contain any device for ignition except possibly

a glow plug or other device intended solely to facilitate starting in the cold.

Art. 2 – The National Institute of Mining Industries is the only organization competent to verify whether a diesel motor conforms to the specifications of this circular and to carry out the required tests or any other test which it determines to be necessary for the purpose of insuring safety.

Art. 6 – All parts of the air admission and exhaust systems included between the stacks and cylinder head must resist, without experiencing dangerous deformation, a static pressure of at least 8 kg/cm².

Art. 7 – The motor must be furnished with a manual and automatic emergency stopping device in case of motor runaway in a gassy atmosphere. These devices can keep the inlet valves raised or can close a damper placed in the inlet tube or can employ any other effective means for stopping the motor when it is in a gassy flammable mixture. The automatic device intervenes as soon as the normal speed is exceeded by 20% or more; its correct functioning must be verifiable at all times.

Art. 9 – The motor will be equipped with an automatic device which will stop it when the cooling water of the engine-gearbox assembly reaches a temperature of 100° C.

Fuel Quality Specifications

Not specified in available literature.

Engine Emission Control Requirements

I. Conditions of Approval for Diesel Engines (20)

Art. 11—The design and control of the motor must be such that the concentration of CO of the undiluted exhaust gases is less than 0.05% by volume for a new motor, ready for use and regardless of the load. During the course of its use, this concentration must not exceed 0.12% by volume.

Art. 4 (a) A stack of thin plates or any other apparatus of equivalent safety is to be located at the entrance or exit of the splash water bath. If the system is located upstream of the splashing tank, its construction must not be affected by the gas temperatures which cannot exceed 300° C.

(b) An apparatus for injecting water into the exhaust collector or in the pipe which follows it if the collector is furnished with a jacket of circulating cooling water in order to cool the gases so that the external surface temperature of the motor and the air admission and exhaust systems do not exceed 150° C regardless of the motor load.

(c) A muffler with a water bath, fed by injection into the exhaust system, and provided with interior baffles which force the gas to bubble through the water before exiting. The temperature of the gases at the discharge must not exceed 85° C.

The water reservoir must allow the motor to operate at one-third load for eight hours.

The cooling must remain satisfactory for road slopes up to 15%. The injection water reservoir will be equipped with a level indicator located in the engineers cabin.

The engine must be provided with a device to stop the engine in case of loss of injection water or when the temperature of the exhaust gases at the discharge exceed 85°C.

II. Tests (20)

Art. 1—The intake exhaust systems will resist an internal explosion of a gassy flammable mixture without deformation and without igniting the gassy ambient atmosphere.

Art 2.—The engine is started and adjusted to a fast idle. It is tested with an empty exhaust canister, no water injection, the automatic emergency shutdown device disabled (replaced by a manual control), and the intake and exhaust stacks installed.

It is placed in a tank supplied with air-gas mixture. Barring any running operating incident, it is left there running for a half hour during which time the gas content is made to vary between 3 and 9%. It is then removed and examined.

It is subjected to a series of eight similar tests during which it must not race or suffer any serious deterioration, nor dangerous overheating, nor ignite the gassy atmosphere in which it is operating.

Art. 3—Test of the automatic emergency shutoff device. The operation of the automatic emergency shutoff device is verified either by accelerating the engine during a supplementary test in a gassy atmosphere, or by changing the adjustment of the regulator.

Art. 4—Test with the object of the approval of a stack of 0.8 mm spacing. An analogous stack except with a spacing of 1 mm is installed on one side on a case approximately of the volume of a muffler and on the other side on a pipe 5 cm in diameter and 1.5 m in length. Inside the casing or the tube is introduced a flammable mixture of gas and air in the proportion for which the flame will most easily travel through a space between two metal walls. This mixture is lit by means of a spark plug set on the wall opposite the wall upon which the stack is attached. Tested in a test chamber, the inside ignition must not be transmitted to the inflammable environment of the chamber. Stacks with a spacing of 5 mm are tested in an identical way except that the spacing is held at 8 mm for the tests.

Procedures and Frequency of Testing Engine Exhaust Gases

Not specified in available literature.

Mine Air Quality and Quantity Requirements

Not specified in available literature.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Not specified in available literature.

Noise Standards

Not specified in available literature.

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CANADA

The Canadian Explosive Atmospheres Laboratory (CEAL) is presently certifying coal mine diesels in accordance with the preliminary draft code (22) for British Columbia, Alberta and Nova Scotia; where most underground coal in Canada is mined. The certification service has no regulatory authority, but, if equipment bears the federal certification mark, the provincial authorities permit its use underground in their jurisdiction. The Canadian constitutional arrangement has, with some exceptions, placed regulatory responsibility for mining operations in the domain of the provincial governments (the trend seems to be to place the inspectorates within the Provincial Ministries of Labour (23).

The following information on Canada was excerpted from reference 22.

Types of Engines Permitted

3.3.5 Engine Requirements

3.3.5.1 The engine shall be liquid cooled and manufactured in accordance with the provisions of clause 3.3.5.2 below.

3.3.5.2 Normal diesel engine design, the design of fastenings associated with the joints in this clause, and normal manufacturing

tolerances and wear limits provide acceptable flameproof barriers for the joint clearances between:

- (a) pistons and piston rings
- (b) pistons and cylinder walls
- (c) piston rings and cylinder walls
- (d) cylinder head to cylinder block
- (e) valve stem to valve guide
- (f) injector body to cylinder head

Any joint other than those listed above which directly or indirectly connect the combustion chamber to the surrounding atmosphere must be flameproof.

3.3.5.3 The engine crankcase breather shall not contain incendive material and shall not be connected to the air intake system of the engine. The discharge from the breather shall be directed away from hot surfaces and in such a way as to ensure that the external surfaces of the engine and exhaust system do not become fouled with oil.

3.3.5.4 The oil filter and oil dipstick shall be secured in position by positive means which do not rely solely on friction and which prevent loss of oil from the interior of the engine.

3.3.5.5. The engine flywheel, clutch and starter ring gear housing must be flameproof unless clutch and starter impact energies are below the maximum values stated herein.

Testing and Certification Procedures of Engine and Auxiliary Equipment

3.2.5.7 The engine shall be tested on a dynamometer as described in clause 4.9 and shall conform to the requirements described therein.

3.2.3.4. Each fuel tank shall be tested by the manufacturer to be water-tight at 30 kPa gauge (4.35 psig).

4. VEHICLE PERFORMANCE TESTS

4.1 Exhaust System Cooling Capacity Evaluation

Tests shall be undertaken to determine directly by dynamometer tests or indirectly by engineering calculations, the capacity of the exhaust system to continuously cool the exhaust gases to 77° C (170° F) for a half-shift period (3 hours of vehicle operation).

(2) Vehicle load factor studies have been reported (1983) in Canada, Sweden, and the U.S.A. A maximum vehicle load factor of 0.85 relative to full load, full speed operation is reported for a heavily-loaded Load-Haul-Dump machine. Some haulage trucks exhibit a load factor of 0.70, whereas, utility vehicles and personnel carriers may operate at a 0.50 level load factor. These rules of thumb shall be used to evaluate the cooling capacity of scrubbing systems and may be used by the appropriate regulatory authority to reduce ventilation rates (see clause 4.9.2) according to vehicle type, assuming individual concentrations of toxic constituents remain below their respective TLV (see clause 3.5.4.3).

4.2 Safety Shutdown System Operation Confirmation

The operation of all safety shutdown devices on a completed vehicle shall be checked against the performance requirements of this standard during factory or field inspection.

METHANOMETER TESTS

4.2.1 The performance of the methanometer system shall be tested according to the provisions of CSA Standard C22.2 No. 152-1976 "Combustible Gas Detection Instruments."*

4.6 PREVENTION TESTS ON ENGINE SYSTEMS

4.6.1 Explosion Proof Enclosure Tests

Refer to CSA Standard C22.2 No. 30 "Explosion Proof Enclosures for Use in Class I Hazardous Locations,"* and IEC

Publication 79-1 "Electrical Apparatus for Explosive Gas Atmospheres,"* as applicable, for flameproofness and overpressure tests and for structural adequacy of explosion proof enclosures. Explosion tests shall be required in accordance with the appropriate document. Flameproof electrical/mechanical equipment shall be subjected to the following pressure tests as applicable. All intake and exhaust system castings and weldments shall be **leak tested** to pressure of 3.5 atmospheres hydrostatically on a routine basis at the factory, in order to ensure leakproof fabrication. This factory test requirement shall be noted on all appropriate assembly drawings and listed on the Factory Inspection form as a routine inspection requirement. In addition, the **maximum explosion pressure test**, the **routine hydrostatic test**, the **hydrostatic type test**, and the **flameproof test**, as applicable shall be undertaken in accordance with the above quoted standards.

4.6.2 Impact Tests on Coated Aluminum Alloy Parts

External parts made from coated aluminum alloy materials shall be evaluated from frictional impact hazard on the basis of results obtained from drop tests and judgments made with respect to their intended application.

4.6.3 ANTI-STATIC MATERIALS TESTS

4.6.3.1 Anti-Static Rubber V-belt Test

The method of ISO Standard 1813-1976 (E) "Anti-Static Endless V-Belts (sections Y, Z, A, B, C, D, E)—Electrical Conductivity—Characteristic and Method of Test"* shall be used to "ensure that the belt is sufficiently conductive to dissipate charges of electricity which may form in it in service." This standard pertains to new belts intended to be used in an explosive atmosphere or in situations where there is a fire risk. This test shall be performed if no adequately documented tests in accordance with the standard have been previously performed, and show the material to be acceptable. The test values of resistance thus determined shall be less than the specified maxima as determined by the following relation:

$$R_{\max} \text{ (ohms)} = 6 \times 10^5 \times (L/I),$$

where L is the distance between the inner edges of the two electrodes and where I is the sum of the heights of the two sidewalls of the belt.

4.6.3.2 Anti-Static Plastic Engine Cooling

Fans CSA Standard C22.2 No. 145 "Explosion Proof Motors and Generators for Use in Class I and Class II Hazardous Locations,"* clause 2.3.3 states— "External rotating parts of non-metallic material shall be investigated for the generation of electrostatic charges if the resistance between the extreme ends of the part exceeds 10 megohm." The tip-to-tip and tip-to-hub resistances of the fan shall be determined. If the resistance exceeds 10 megohms the fan shall not be acceptable.

4.6.3.3 Conveyor belts shall be tested to CSA Standard M422, "Fire Retardant and Anti-Static Conveyor Belts" (under preparation).*

4.7 FIRE PREVENTION TESTS

4.7.1 Fire Resistant Fluid Tests

Refer to CSA Standard M423, "Fire Resistant Hydraulic Fluids."*

4.7.2 Surface Temperature Checks

Tests shall be carried out at various engine load/speed combinations with up to 1.25 pct methane in the intake air to determine the maximum external surface temperatures of the various vehicle

components. The testing sequence shall also ensure that the vehicle safety devices prevent excessive surface temperatures in the event of:

- (a) Shortage of water in the cooling circuits.
- (b) Pneumatic or hydraulic system malfunctions, including hydraulic relief valves.
- (c) Heat build-up in components upon application such as in service, emergency and parking brake systems, in torque converters particularly in a stalled condition, and in retarders.

(d) Any other malfunctions which could produce elevated external surface temperatures on one or more of the vehicle components.

The temperature test may be made at any room temperature between 10° C and 40° C. The 40° C value is assumed to be the maximum possible ambient temperature for which the corresponding surface temperatures must not exceed 150° C. The ambient temperature differential below 40° C shall be added to the observed surface temperatures before comparing with the values in clause 3.4.1.

4.7.3 FIRE RESISTANT MATERIALS TESTS

4.7.3.1 Conveyor Belt Tests

The conveyor belts tests and specifications are described in CSA Standard M422 "Fire-Retardant and Anti-Static Conveyor Belts" (under preparation).

4.7.3.2 Hose Tests

The hose tests and specifications shall be similar to the tests described in CANMET, Division Report ERP/MRL 80-21 (TR),* clauses 4.1 to 4.5, except for test purposes only 4 specimens of the hose (each 6 inches long by ½ inch wide by the specimen thickness) shall be required.

4.7.3.3. Other Tests

Other fire-resistant materials, such as V-belts, will be tested in a manner similar to the tests described above.

4.8 ELECTRICAL SYSTEMS TESTS

4.8.1 Explosion-Proof Enclosures Tests

All tests of flameproof electrical enclosures shall conform to the provisions of Section 6—"tests" of CSA Standard C22.2 No. 30-1970, "Explosion-Proof Enclosures for use in Class I Hazardous Locations."*

This document describes:

- (a) the maximum explosion pressure test,
- (b) overpressure tests,
- (c) temperature tests,
- (d) impact tests (including glass lenses) and,
- (e) materials flammability tests.

4.8.2 Intrinsically Safe Systems Tests

All tests of intrinsically safe electrical systems shall conform to the provisions of Section 6—"Tests" of CSA Standard C22.2 No. 157-M1979 "Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations."*

4.8.3 Lighting System Lens Strength Test

See clause 4.8.1 item d.

4.8.4 Electric Motor and Generator Tests

Electric motors and generators intended for hazardous location applications will be tested to CSA Standard C22.2 No. 145, "Explosion Proof Motors and Generators for Use in Class I and Class II Hazardous Locations."*

Fuel Quality Specifications

3.2.5.5 The fuel employed in certification tests shall conform to the appropriate CGSB (Canadian General Specification Board) Specification CAN 2-3.16-M84, "Mines Diesel Fuel."*

Engine Emission Control Requirements

3.5 EXHAUST EMISSIONS REQUIREMENTS

3.5.1 Fuel Rate Setting

The liquid fuel supply to the new engine shall be adjusted, fixed and sealed so that the undiluted exhaust gas shall contain not more than 2,500 ppm of carbon monoxide, not more than 1,500 ppm of oxides of nitrogen (NO_x) and not more than 150 mg/m³ of particulate (as measured by a centre line sampling probe), within the full design range of engine output, when the intake air mixture to the engine is either 100 pct air, or 1.25 pct methane by volume in air. Reduction in the maximum allowable fuel injection rate for increases in altitude above 300 metres (approximately 1,000 feet) shall be made.

3.5.2 Fuel Alteration System

Innovations which alter the fuel and which beneficially affect the emissions, provided that they are practicable and that the emissions tests of clause 3.5.3 reflect their beneficial effects, shall be permitted.

3.5.3 Exhaust Treatment Devices

Exhaust treatment may be accomplished by a number of devices; for example, filters and water scrubbers, applied singly or in combination. Where evidence can be furnished that treatment performance does not deteriorate with use and that suitable procedures can be instituted to maintain the device(s), their application shall result in reduced ventilation assessments as defined in clause 3.5.4.2. The emissions reduction performance of all such devices shall be assessed during dynamometer exhaust emissions tests as described in clause 4.9.1.

Mine Air Quality and Quantity Requirements

3.5.4 EMISSIONS TOXICITY CRITERION

3.5.4.1 In order to establish the Exhaust Quality Index (EQI) for undiluted exhaust emitted from the diesel engine or the last treatment device, the concentration of the various pollutants contained in the exhaust shall be the considered additive in accordance with the following expression:

$$EQI = (CO/50) + (NO/25) + (RCD/2) + 1.5 [(SO_2/3) + (RCD/2)] + 1.2 [(NO_2/3) + (RCD/2)],$$

where EQI = exhaust quality index,

CO = carbon monoxide concentration, ppm,

NO = nitric oxide concentration, ppm,

RCD = respirable combustion dust concentration, mg/m³,

SO₂ = sulphur dioxide concentration, ppm,

and NO₂ = nitrogen dioxide concentration, ppm.

3.5.4.2 Ventilation air requirement shall be based on a dilution ratio of (EQI/3) where 3 is the maximum value of the ambient mine air Air Quality Index (AQI) in accordance with the calculation prescribed in clause 4.9.2.

Note: AQI max = 3 and dilution ratio = EQI/AQI max.

3.5.4.3 In circumstances where unusually low amounts of diesel particulates are emitted from the machine, it may be that the concentration of one or more of the gaseous emissions will exceed the

current ACGIH-TLV. In such cases, sufficient ventilating air shall be provided to ensure that the concentration of each toxic constituent, taken separately, does not exceed its ACGIH-TLV at its maximum rate of generation.

3.5.5 Exhaust Dilution System

A dilution system shall reduce the undiluted toxic exhaust constituents emitted from the last treatment device, such as a water scrubber, to levels equivalent to an AQI of 6 for engine operating conditions producing the maximum combined toxicity of the emitted constituents. Exhaust dilution may be accomplished by a number of devices such as exhaust flow induced air entrainment, injection into radiator ejection air flow, mechanical baffling etc. The final diluted exhaust mixture shall be discharged from the vehicle in such a manner that it is directed away from the operator's compartment, passengers if applicable, and also away from the breathing zones of persons required to be along side the equipment. No exhaust constituent designated as having a "C" (Ceiling) rating should exceed that rating at the operator's breathing zone.

Procedures and Frequency of Testing Mine Air Quality and Quantity

4.9.1 Dynamometer Emissions Tests

One series of dynamometer emission tests on a single example of the specified power package shall be performed in an approved laboratory or test facility. The power package shall include all those systems which affect the levels of emitted toxic constituents.

Such tests shall include but not necessarily be limited to:

- (a) confirmation of the maximum fuel rate setting.
- (b) fuel alteration system performance evaluation if applicable,
- (c) determination of untreated engine emissions,
- (d) exhaust treatment device(s) performance evaluation if applicable,
- (e) exhaust dilution system performance evaluation.

Variations due to the addition of methane (CH₄) in the intake air shall be determined for items (b), (c), and (d). The engine submitted for test shall be pre-run to the extent required to allow it to be operated immediately at full load and speed in an approved laboratory or test facility. Couplings or adapters for attachment of the engine to the testing laboratory dynamometer shall be furnished by the applicant. Clutches, transmissions or torque converters, are not generally required in the coupling train. The fuel employed for engine dynamometer emission tests shall conform to CGSB Specification CAN 2-3.16-M84, "Mines Diesel Fuel."*

4.9.2 Assessed Ventilation Recommendations

The results of tests at the engine operating conditions which produce the greatest toxicity hazard, and as specified in clause 4.9.1 shall be employed in the following equation to assess the ventilation recommendation for the exhaust leaving the last exhaust treatment device prior to exhaust dilution and emission into the environment:

$$Q_{dva} = [M_{dxg} \times (EQI/3) + (9H_2\%/100) - 1 M_p]/3,600 p,$$

where Q_{dva} = flow rate of dry ventilating air for the diesel machine, m³/sec,

M_{dxg} = dry exhaust gas rate produced by combustion of the fuel consumption rate, kg/hr,

EQI = exhaust quality index defined by clause 3.5.4.1,

H_2 = percent by weight of hydrogen in the fuel,

M_f = fuel consumption rate, kg/hr,

and p = dry ventilating air density, kg/m³.

This level of ventilation will apply to all applications of the power package so tested. The above recommended ventilation rate pertains to the worst engine operating conditions from an emissions

toxicity point of view, and therefore represents a maximum. Local conditions of altitude, methane concentration, vehicle loading cycle, multiple machine density, mine layout, etc., may reduce this ventilation recommendation. See note 2 of clause 4.1 for ventilation reduction factors for various types of vehicle loading cycle.

Noise Standards

3.2.11 Noise Control (to be developed).

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ALBERTA

According to T. Smith (24), Alberta's status is as follows:

"We are presently rewording the Alberta Regulations. The regulations for the use of diesel equipment are incomplete and require updating, we expect this to be completed in 1982.

For the past two years we have agreed the operation and approval of diesel equipment to the certification requirements of the Energy Mines and Resources Explosive Laboratories,⁵ in addition that the complete machine be approved within the principles of the Testing Memorandum No. 12⁶ prepared by the U.K. Inspectorate this until such time as the C.S.A. Standard is complete and in use."

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BRITISH COLUMBIA

In British Columbia, the regulations for coal mines are separate from the regulations for metal and nonmetal mines. However, all standards pertaining to diesel engines underground, which are listed in the Mining Regulation Act (25) (for metal and nonmetal mines) are identical to those in the Coal Mine Regulation Act (26). The only difference is that the Coal Mine Regulation Act has some additional standards.

Types of Engines Permitted

No internal combustion engine other than a diesel engine shall be used underground and no diesel powered equipment shall be used unless it has been specifically approved for underground use by a recognized authority acceptable to the chief inspector and a permit has been issued by the chief inspector (25-26).

Testing and Certification Procedures of Engine and Auxiliary Equipment

The diesel engines used in British Columbia's coal mines are certified by the Canadian Explosives Atmospheres Laboratory according to its preliminary draft proposal (27).

⁵See section on Canada.

⁶See section on United Kingdom.

Fuel Quality Specifications

Fuel oil and lubricants shall be stored in quantities and in fuel rooms approved by the inspector. The minimum closed flash point of fuel shall not be less than 125° F (25-26).

Engine Emission Control Requirements

No diesel engine shall be used underground if it has any defect which may affect its safe operation. All mobile diesel powered equipment shall be equipped with suitable lights, sound warning devices, fire extinguishers, [flame traps], and exhaust conditioners, and all shall be kept in working order. [The flame traps fitted to the diesel engine shall be detached and replaced by traps in clean condition at least once in every 24 hours] (26).

Note.—The Mining Regulation Act (25) for metal and nonmetal mines contains this same regulation, except the requirements for flame traps have been omitted.

No diesel engine shall be operated if the exhaust gas contains more than 1,000 parts per million of carbon monoxide (25-26).

Procedures and Frequency of Testing Engine Exhaust Gases

The exhaust gases shall be sampled at least twice a week for carbon monoxide, oxides of nitrogen, and other gases the inspector directs; and the results recorded (25).

Mine Air Quality and Quantity Requirements

Standards of ventilating air (25-26)

The ventilation in every mine shall be such that the air in all of its workings that are in use or are to be used by workers or others shall be free from injurious amounts of impurities and shall contain sufficient oxygen to obviate danger to the health of anyone in the mine. The chief inspector may declare in writing the standards for permissible mine air which in the chief inspector's judgment are in the interest of the workers employed in the mine, and air not meeting these standards may be classed as injurious.

No work in dusty places (25-26)

No person shall work or remain, or be permitted or caused to work or remain, in or about any place in a mine if the air contains dust and fumes in injurious quantities, except under emergent or temporary conditions and only if protective equipment is provided and worn.

Diesel engines shall be operated where the volume of ventilating air being supplied is at all times more than that specified by a testing laboratory satisfactory to the chief inspector. Mobile diesel powered equipment shall not be operated in such a manner that the exhaust gases produced are travelling with and enveloping the vehicle (25-26).

Procedures and Frequency of Testing Mine Air Quality and Quantity

Tests for CO, NO, and other gases as the inspector directs, shall be conducted in the general body of the air at least once each day, and the results recorded (25-26).

Air measurements shall be taken and recorded at least once a week where diesel engines are operating (25-26).

Coal mines only:

Ventilation quantities, splits and measurements (26)

146. (1) Where necessary for efficient and effective ventilation, every mine shall be divided into separate ventilating splits.

(2) Air measurements to determine the quantity of air circulating shall be taken within 300 feet from the first normal working place in each split intake, and the intake and return airways of each ventilating split, and at the main intake and return airways of the mine, and the measurements shall be taken at time intervals the inspector may prescribe, and the results shall be entered in a book to be kept at the mine.

(3) If an inspector is of the opinion that the ventilation of all or part of a mine is adequate in the interests of the health or safety of the persons employed, the inspector may serve notice in writing to the manager requiring improvement to certain minimum standards within a specified time, and it shall be the duty of the manager to comply with the notice.

Noise Standards

Noise Control (25-26)

164. (1) The manager shall take all reasonable measures to ensure that noise levels do not exceed suitable standards.

(2) Where noise levels exceed suitable standards, the manager shall provide suitable protective equipment, and no person shall work in areas with excessive noise levels without wearing the equipment.

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MANITOBA

Types of Engines Permitted

Internal combustion engines underground (28)

8.10 Where an internal combustion engine is operated underground

(a) written permission of the chief mining engineer shall be obtained before the engine is operated:

(b) the equipment shall be operated in accordance with the conditions stated in the written permission mentioned in clause (a):

(c) there shall be maintained a Diesel Record Book, in which shall be recorded all information as required in the letter of permission.

Requirements for the Operation of Diesel Equipment Underground (29)

No internal combustion engine shall be installed or operated underground in any mine unless the permission in writing of the Director be first obtained.

Permission may be given for specified equipment to be operated according to the following requirements, under conditions and in locations as are outlined in an application to the Director of Mines.

GENERAL REQUIREMENTS

Engine

1. The engine shall be of a type which is suitable for use underground in mines as determined from the information required by Clause 17.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Application (29)

17. An application for permission to use diesel equipment underground shall be sent to the Mines Branch, Department of

Mines, Resources and Environmental Management, Winnipeg, and shall include the following information:

(a) The type of construction, complete identification data and specifications of the engine with an analysis of the undiluted exhaust gas from an approved laboratory.

Samples of exhaust gas (after the scrubber) shall be taken for each engine under varied conditions of engine speed and load and analyzed for carbon monoxide, oxides of nitrogen and aldehydes.

(b) The type of equipment and number of units to be used.

(c) Drawings showing the location and extent of the operating area, the location and design of the fuelling stations and diesel repair shops, details of the ventilation of the area, and the method of transport and storage of the fuel.

Fuel Quality Specifications

Fuel (29)

10. The fuel shall have a flash point of not less than 125° F (closed-cup) and a sulphur content not greater than 0.5% by weight. Fuels with a heavy asphalt base shall not be used.

Engine Emission Control Requirements

Engine (29)

2. The engine exhaust system shall be fitted with a suitable scrubber and, in gassy mines, with a flame trap.

3. The exhaust system shall be arranged or fitted in a suitable manner to provide diffusion of the gas with the atmosphere so that persons alongside will not encounter the undiluted exhaust from the scrubber.

Procedures and Frequency of Testing Engine Exhaust Gases

Engine (29)

4. The exhaust shall be fitted with a plug or petcock, after the scrubber, to provide a suitable means for taking samples of the undiluted exhaust gas.

Operation (29)

28. At least once in every eight hours the exhaust system and scrubber shall be inspected. The level of the scrubbing fluid shall be checked at intervals on each shift as may be required.

29. Tests for carbon monoxide concentration for each engine shall be carried out at least after every eighty hours of operation . . . in the undiluted engine exhaust gas.

32. An analysis of the undiluted engine gas may be required from time to time, for carbon monoxide, oxides of nitrogen and aldehydes, and shall be made for each new engine and after each major engine overhaul. Results shall be recorded in the Underground Diesel Equipment Record Book and a copy of the analysis sent to the Mineral Resources Division.

Mine Air Quality and Quantity Requirements

Ventilation Requirements (28)

Ventilation of working places.

4.22 (1) All places in or at mines where persons are required to work or travel shall be ventilated, to maintain safe and healthy environmental conditions; and the ventilating air shall contain sufficient oxygen to obviate danger to health.

Safe atmosphere in work places.

4.22 (2) In any travelway or regular working place, the oxygen content in the atmosphere shall be not less than eighteen per cent by volume and the concentration of contaminants in the atmosphere shall not exceed the Threshold Limit Values recommend-

ed by the American Conference of Governmental Industrial Hygienists, and published in its updated pamphlet, "Threshold Limit Values for Chemical Substances in Workroom Air as Adopted by the American Conference of Governmental Industrial Hygienists (ACGIH)," as amended from time to time.

Ventilation (29)

6. Where diesel powered equipment is operated underground the ventilation shall be by mechanical means with auxiliary fans when required. A visible warning signal shall be so arranged as to indicate to the operator when the mechanical ventilation system serving the area is not operating.

7. The ventilating air supplied to the area shall contain not less than 20% by volume of oxygen and not more than 0.5% carbon dioxide.

8. The volume of air supplied for ventilation shall be such as to maintain the atmosphere in accordance with the requirements of Clause 9, and in any case shall be not less than 75 cubic feet per minute per maximum brake horsepower for the total of the engines to be operated in the area.

9. No diesel engine shall be operated when the carbon monoxide content of the undiluted exhaust gas exceeds 2,500 ppm or when the quality of the atmosphere at any location does not conform to the following:

(a) Carbon Monoxide, in the area immediately adjacent to a diesel engine, to be not greater than 50 parts per million (0.005%).

(b) Carbon Monoxide, in the general atmosphere of the operating area, to be not greater than 20 parts per million (0.002%).

(c) Carbon Dioxide to be not greater than 5,000 parts per million (0.5%).

(d) Nitrogen Dioxide to be not greater than 5 parts per million (0.0005%).

(e) Aldehydes to be not greater than 5 parts per million (0.0005%).

Procedures and Frequency of Testing Mine Air Quality and Quantity

Operation (29)

29. The following tests for carbon monoxide concentration for each engine shall be carried out at least after every eighty hours of operation and recorded in the Underground Diesel Equipment Record Book.

(a) In the atmosphere adjacent to the engine while it is running.

31. Suitable locations shall be selected as check points for the following measurements:

(a) The carbon monoxide content in the general atmosphere shall be tested daily and recorded, together with the locations checked and units operating at the time, in the Underground Diesel Equipment Record Book.

(Note: In general, when the engine exhaust is not smoky or strongly irritating, a concentration of carbon monoxide in the atmosphere not exceeding 0.002 per cent will indicate that the oxides of nitrogen and aldehydes do not exceed safe limits.)

(b) At least weekly, measurements shall be made of the ventilating current and recorded for each location in the Underground Diesel Equipment Record Book.

(c) An analysis of the atmosphere in the operating area may be required from time to time, for carbon monoxide, oxides of nitrogen and aldehydes. The results shall be recorded, together with the units operating and the locations sampled in the Underground Diesel Equipment Record Book. A copy of the entry shall be sent to the Mineral Resources Division.

Noise Standards

Control of exposure to noise (28).

4.24 Employees shall not be exposed to noise in excess of the Threshold Limit Values recommended by the American Conference of Governmental Industrial Hygienists and published in its updated

pamphlet, "Threshold Limit Values of Physical Agents for 1972," as amended from time to time.

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NEW BRUNSWICK

New Brunswick has phased out underground mining, but coal is still being produced from surface locations (30).

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NEWFOUNDLAND

Types of Engines Permitted

No internal combustion engine may be operated underground unless approval has first been obtained in writing from the Chief Inspector for each and every engine (31).

These engines must be of an approved type directed for mine use (32).

Testing and Certification Procedures of Engine and Auxiliary Equipment

Engines are deemed to be approved if a prototype has been tested by CANMET or MSHA (USBM) or any other recognized government testing laboratory (32).

Fuel Quality Specifications

(1) No substance shall be used in any mine as fuel in or for an internal combustion engine of the compression-ignition type unless it conforms to the specification 3-GP-6⁷ made or set by Canadian Government Specifications Board and any modifications or revisions thereof from time to time for the place or region designated in the specification (31).

(2) Fuel with a heavy asphalt base shall not be used in any underground operations (31).

Engine Emission Control Requirements

Internal Combustion Engines (31)

85. The chief inspector may suspend or revoke the approval given under the provisions of these regulations for an internal combustion engine if the engine, in test operation or regular operation, produces noxious exhaust gases in excess of the amounts stated as follows:—

(a) carbon monoxide content in undiluted exhaust of 0.15 per centum by volume;

(b) carbon monoxide content of the atmosphere adjacent to the engine of 0.005 per centum by volume;

(c) oxides of nitrogen content at the atmosphere adjacent to the engine of 0.0005 per centum by volume;

(d) aldehyde content of the atmosphere adjacent to the engine by 0.0002 per centum by volume (measured as formaldehyde).

89. Every internal combustion engine operated underground shall be equipped with an approved type of scrubber, and except

with the permission of the chief inspector in writing the scrubber shall be of the wet type, and shall contain only plain fresh water which shall be changed at least once in each eight hour shift or as often as may be required to maintain the temperature of the exhaust gases below 80 degrees Celcius (80° C).

Diesel Engines (33)

(iii) When Diesel engines are used:

(A) they shall be in a state of repair that will give performance approximated to that of new engines.

(B) they shall be checked regularly and shall be maintained in good operating condition.

(C) they shall be equipped with suitable exhaust-gas conditioners approved by the Director, which are properly maintained, and regularly serviced.

(D) they shall not be permitted to idle unnecessarily, and operating time shall be kept to a minimum.

Procedures and Frequency of Testing Engine Exhaust Gases

Maintenance and Records (31)

90. For each internal combustion engine operating underground the manager shall cause a log book to be kept in which the following shall be recorded—

(a) at once in an eight hour shift;

(ii) the CO content of the exhaust gases at the scrubber.

50.4 Diesel engines (33)

(c) When diesel equipment is being operated underground

(i) tests shall be made by a competent person for carbon monoxide and nitrogen dioxide, at least every eight hours, and

(ii) an instrument acceptable to the Director shall be provided for this purpose.

Mine Air Quality and Quantity Requirements

50.4 Diesel engines (33)

(a) (i) When diesel engines are used underground, mechanical ventilation shall be used to effectively ventilate all work areas.

(ii) The volume of ventilating air shall not be less than that required to limit the contamination of the general atmosphere to those levels established in the current ACGIH publication.

Oxygen Content of Atmosphere (31)

86. The chief inspector may withhold, suspend, or revoke, the approval for operation of an internal combustion engine underground if the oxygen content of the general atmosphere of the mine is less than 20 per centum by volume.

88. No approval for the operation of an internal combustion engine underground may be given unless positive mechanical ventilation of the mine is employed, and the volume of air supplied by the ventilation system to every area where the engine may be operated shall not be less than the greater of—

(a) 0.5 cubic metres per second for each brake kilowatt (.05m³/sec/kw) of the internal combustion engine or engines in operation plus the normal requirements for all other purposes; or

(b) an amount required to maintain at all times the atmospheric conditions set forth in regulations 85 and 86.

Procedures and Frequency of Testing Mine Air Quality and Quantity

50.2 Diesel engines (33)

(a) (iv) Measurements of the air volume of the mechanical ventilation system shall be made at suitable intervals to ensure compliance with the minimum air volume requirements. Measurements shall be

⁷ See "Fuel Quality Specifications" in Canada section.

made at the end of the ventilation duct near the working face. Records shall be maintained of all air-volume measurements.

Maintenance and Records (31)

90. For each internal combustion engine operated underground the manager shall cause a log book to be kept in which the following shall be recorded –

- (a) at least once in each eight hour shift;
 - (i) the carbon monoxide content of the atmosphere taken adjacent to the engine.
- (b) at least once in each week;
- (iii) the volume of air supplied by the ventilation system to the most remote point where the engine is operated.
- (c) at least once in six months:
 - (i) the results of a complete analysis of the atmosphere at the exhaust port of the scrubber, the atmosphere adjacent to the engine, a remote point in the area of operation of the engine.

Precautions Against Accumulation of Carbon Monoxide (31)

93. At least once in every six months and as often as may be considered necessary by an inspector, three samples of air shall be taken from the uppermost recesses of the workings where the internal combustion engine is operating; and, once in each year three samples shall be taken from the uppermost and accessible underground recesses of the mine where the internal combustion engine is operating; and, in both cases the samples shall be sent to the chief inspector.

(The Schedule of Mandatory Test required by Reg's 90(c) and 93 shall be considered to be met if the following procedures are followed: Representative samples are to be taken, in areas to be specified by an inspector, and sent to a Laboratory, approved by the chief inspector, for analysis to determine the percentages by volume of the following components: carbon monoxide, carbon dioxide, oxygen, hydrocarbons, and nitrogen. In addition to these tests the oxides of nitrogen (measured as NO₂) and aldehyde (measured as formaldehyde) content of the atmosphere, adjacent to each engine, shall be measured by detector tubes when the engine is first used in underground workings and thereafter, once each month for oxides of nitrogen and once each three months for aldehydes. A copy of the laboratory analysis shall be sent to the chief inspector and the analysis record and tube measurements shall be recorded in the log book(s) of the engines.)

Noise Standards

31.5 Noise Hazards (33)

(a) When workers are required to work in areas in which noise levels exceed the criteria for permissible noise exposure:

- (i) the employer shall first take appropriate measures to reduce the noise intensity to approved levels, or
- (ii) if it is not practicable to reduce the noise to approved noise levels, or isolate the workers from the noise the workers shall wear personal protective equipment which will effectively protect their hearing.

(b) Criteria for Permissible Noise shall be as established by ACGIH.

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NOVA SCOTIA

Nova Scotia has separate regulations for coal mines and metalliferous mines. In the regulations for metal mines, only three regulations pertain to diesel engines underground. These are included and referenced.

Types of Engines Permitted

Diesel Locomotives (34)

83. Rule (6) No diesel locomotive shall be used unless it is a type which has been approved by the Minister; and all parts of the locomotive and its accessories shall be properly maintained in their designed condition.

Ventilation (35)

15. (d) No internal combustion engine shall be installed or operated underground in any mine without the written permission of an inspector.

Testing and Certification Procedures of Engine and Auxiliary Equipment

The Canadian Explosives Atmospheres Laboratory (CEAL) certifies coal mine diesels in accordance with the draft code: "Flameproof Diesel-Powered Vehicles for Use in Gassy Underground Coal Mines" (22). See section on Canada (national regulations) for specifications.

Diesel Locomotives (34)

83. Rule (2) The Minister may permit the operations of diesel locomotives in coal mines on any roadway, either on the intake or return side of any ventilation district, such as may be specified in the application by the mine's manager.

Rule (3) An Application for a permit to operate a diesel locomotive in a coal mine shall be made to the Minister and shall contain the following information;

- (a) the type of construction of the diesel locomotive;
- (b) the district or section of the mine in which the diesel locomotive will be operated;
- (c) The quantity of air passing and the percentage of inflammable gas present in the general body of the air determined on each shift, over a period of not less than six consecutive working days, at each end of a road, or part of a road, on which the diesel locomotive is proposed to be used, and at every intermediate point where air from a split enters the road; provided that with respect to any main intake airway commencing at a shaft or outlet to the surface, the percentage of inflammable gas shall not be required to be determined except within three hundred yards of the face.

Fuel Quality Specifications

Diesel Locomotives (34)

83. Rule (22) The oil used as fuel in any diesel locomotive underground;

- (a) shall have a flashpoint of not less than one hundred and fifty degrees Fahrenheit as determined in the manner indicated in the current British Standard Specifications (no. 209) and shall not have a heavy asphalt base.

Engine Emission Control Requirements

Diesel Locomotives (34)

83. Rule (7) The exhaust from the engine of every diesel locomotive shall be fitted with a flameproof trap to prevent the emission of sparks and flames, and the emission of smoke or pungent fumes.

Procedures and Frequency of Testing Engine Exhaust Gases

Diesel Locomotives (34)

83. Rule (21) A sample of exhaust gas from every locomotive shall be analyzed once at least in every month, and the locomotive shall

be deemed to be defective if the exhaust gas at any times contains more than two parts per thousand of carbon monoxide.

Mine Air Quality and Quantity Requirements

Metal/Nonmetal Mines (35)

(17) (a) The ventilation in every mine shall be such that the air in all of its workings that are in use or are to be used by workmen (workers) or others shall be free from dangerous amount (amounts) of noxious impurities and shall contain sufficient oxygen to obviate danger to the health of anyone employed in any such mine.

(243) No person shall work or remain, or be permitted or required to work or remain, in any place in any mine if the air contains dust, fumes or smoke perceptible (perceptible) to the senses.

Coal Mines (30)

The Occupational Health Standards relating to gases and dusts are those listed in the *Threshold Limit Values for Chemical Substances and Physical Agents* for 1975, published by ACGIH and its subsequent amendments or revisions.

Ventilation (34)

69.9 No dust of a kind that is prohibited by the Minister on the ground that it would be injurious to the health of the persons working in the mine shall be used for the purpose of complying with this Section.

70 (1) Every mine while being worked shall be thoroughly ventilated and furnished with an adequate supply of pure air to dilute and render harmless inflammable and noxious gases to such an extent that all underground places, except places sealed or properly fenced off according to law, shall be in safe and healthy condition for the persons passing and working therein.

(2) An adequate supply of pure air shall mean such volume of air circulating in a mine and working places thereof as may be deemed necessary by the deputy inspector for the district in which the mine is situated.

83.5 (d) if the percentage of inflammable gas present in the general body of the air is found to exceed 1.25 per cent,

(i) the official in charge of the district, the manager and an inspector shall immediately be informed and the use of such locomotive shall be discontinued forthwith and shall not be recommended except on the approval of an inspector and on the instructions of the manager after steps have been taken to improve the ventilation and it has been ascertained by analysis that the percentage of inflammable gas present in the general body of the air does not exceed one per cent;

(ii) the owner, agent or manager shall without delay report to the Chief Inspector any instance in which the use of diesel locomotives is discontinued because of inflammable gas.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Precautions Against Coal Dust (34)

69.7 (7) For the purpose of testing the composition of the dust mixture in any part of a road, the following procedure shall be adopted,

(a) Representative samples of the dust shall be collected from the floor, roof and sides, respectively, over an area of road not less than fifty yards in length, and shall comprise the dust collected on the roof and sides and to a depth not exceeding one quarter of an inch on the floor.

(b) Each sample collected shall be well mixed and a portion of the mixture shall be sieved through a piece of metallic gauze, having a mesh of twenty-eight to the lineal inch.

(c) A weighed quantity of the dust which has passed through the sieve shall be dried at two hundred and twelve degrees Fahrenheit, and the weight lost shall be reckoned as moisture. The sample shall then be brought to red heat in an open vessel until it no longer loses weight. The weight so lost shall be reckoned as combustible matter for the purpose of the test.

(d) In dust mixtures which contain carbonates:

(i) a weight quantity of the dried dust shall be heated in an open vessel to a temperature high enough to ensure complete decomposition of the carbonates (the high temperature of a blowpipe flame is required, and heating continued for about an hour) and until it no longer loses weight; and the percentage loss of weight shall be determined;

(ii) a weighed quantity of the dried dust shall be treated with dilute acid in a suitable apparatus and the percentage loss of weight due to the evolution of carbonic gas shall be determined;

(iii) the difference between the two percentage losses of weight so determined shall be reckoned as the percentage of combustible matter for the purpose of the test.

(8) Tests of samples of dust, so taken as to be representative of the normal composition of the dust throughout the roads of the mine on the floor, roof and sides, respectively, shall be made as often as the inspector deems necessary, and the result of these tests shall be recorded and a copy sent to the deputy inspector of the district.

70. (15) The owner, agent or manager of every mine, shall, once a year, or oftener if required by the Chief Inspector, send to him a plan and a return of facts relating to the mode and description of means of ventilation, a description of the upcast and downcast shafts, of the length and sectional area of airways, the number of splits and quantity of fresh air in cubic feet per minute, and the average total quantity of air in cubic feet per minute in the mine.

83. Rule (5) In every road or part of a road on which a diesel locomotive is operated,

(a) the quantity of air passing and the percentage of inflammable gas present in the general body of the air shall, except as hereinafter provided, be determined at least once in every week, and in addition, whenever any alteration is made in the quantity of air circulating,

(i) at each end of the road or part of a road;

(ii) at such intermediate points as may be fixed by the manager, with the approval of an inspector; provided that with respect to any main intake airway commencing at a shaft or outlet to the surface, the percentage of inflammable gas shall not be required to be determined except within three hundred yards of the face;

(b) if the percentage of inflammable gas in any sample exceeds 0.75 percent determinations shall be made at intervals not exceeding twenty-four hours for so long as the percentage continues to exceed 0.75 per cent and for at least six working days thereafter;

(c) the samples shall be taken by a competent person appointed by the manager in writing for the purpose, and at times when experience shows that the percentage of inflammable gas is likely to be greatest, and a written record of the results shall be made to the manager and an inspector within seven days.

Noise Standards

Not specified in available literature.

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ONTARIO

Types of Engines Permitted

Part VIII—Mechanical (36)

175. (1) Before first using a diesel engine in an underground mine,

- (a) an engineer of the Ministry shall be advised in writing; and
- (b) a log book approved by the Ministry shall be obtained to record information prescribed to be kept therein.

PREAMBLE (37)

1.0 Section 213, sub-section (9), of Requirements Governing the Operation of Mines states:

No internal combustion engine shall be installed or operated in a shaft or adit or in any working in connection with a shaft or adit unless permission in writing from the chief engineer is first obtained.

NOTE: The responsibility for the written permission referred to has been delegated to the region and this permission must be first obtained from the Regional Engineer.

Testing and Certification Procedures of Engine and Auxiliary Equipment

1.2 The written permission referred to in section 1.0, may be given for specified diesel equipment which shall be operated according to the Mining Act and the following additional requirements, under the conditions and in the locations as are outlined in the application to the engineer. The engineer is empowered to order the immediate cessation of operations and the departure of personnel from any area of a mine until the standards of this code are met. Failure to comply with the requirements may result in cancellation of the diesel permit.

APPLICATION (37)

2.0 An application for permission to use diesel equipment underground shall be made in duplicate to the engineer and shall include the following information:

2.1 Pertinent identification data including the model number of the equipment, specifications of the engine (manufacturer, model number, brake horsepower, nominal rpm and fuel injection rate) and information as to the primary use of the equipment and any exception of this proposed usage.

2.2 Details of the braking systems.

2.3 Details of the emission control system.

2.4 Details of the fire suppression system.

2.5 The specific equipment unit number designated and marked on the machine by the applicant.

2.6 Drawings providing the following information.

2.6.1 the location and extent of the area of operation for the diesel unit.

2.6.2 the type of diesel equipment and the number of units to be used in the air split.

2.6.3 details of the ventilation of the area of operation.

2.7 The engineer may require details relating to:

2.7.1 the design and location of fueling stations and repair shops, and

2.7.2 the method of transport and storage of fuel.

2.8 Applications for duplicate type equipment may be made with referral to prior applications.

2.9 It is understood that an application is not required when a unit having prior approval is to be relocated to another area of the mine which has been approved for the operation of diesel equip-

ment, providing that the ventilation requirements are met, and that notification of such move is made to the engineer.

Engine (37)

3.0 The engine shall be of a type which is suitable for use underground as determined from the information provided in the application.

3.1 The engineer may require an analysis of the undiluted exhaust gas (after the emission control system) for carbon monoxide, oxides of nitrogen and aldehydes, while the engine is idling and operating at full load.

3.2 The engine shall be equipped with an approved starting system, and no starting engine using gasoline or other volatile fuel shall be used.

Fuel Quality Specifications

Part VIII—Mechanical (36)

175. (3) The fuel for a diesel engine shall have,
- (a) a flash point greater than 52° Celsius when tested by a closed cup method, and
 - (b) a sulphur content less than 0.25 per cent by weight.

Engine Emission Control Requirements

Part VIII—Mechanical (36)

175. (4) The undiluted exhaust gases from a diesel engine shall have less than 1,500 parts per million by volume of carbon monoxide.

Procedures and Frequency of Testing Engine Exhaust Gases

Part VIII—Mechanical (36)

176. (4) Tests shall be made to determine,
- (b) the carbon monoxide content of the undiluted exhaust discharging to atmosphere,
 - (i) at least weekly, and
 - (ii) immediately following repairs to the engine which may have altered its combustion characteristics.

Mine Air Quality and Quantity Requirements

Part VIII—Mechanical (36)

176. (2) A positive flow of air to the work place where a diesel unit or units are operating shall be provided by a mechanical ventilation system.

(3) The flow of air prescribed in subsection (2) shall

- (a) be at least 0.06 cubic metres per second for each brake kilowatt of the diesel unit or units operating in the work place; and

- (b) reduce the concentration of toxic substances in diesel exhaust emissions to prevent the exposure of a worker to such toxic substances in excess of the values adopted as criteria or guides under section 279.

Part XI—Working Environment (36)

279. As a factor to be considered under clause 20 (8) (f) of the Act, the "TLV's Threshold Limit Values for Chemical Substances and

Physical Agents in the Workroom Environment with Intended Changes for 1979," of the American Conference of Governmental Industrial Hygienists, are adopted as criteria or guides.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Part VIII—Mechanical (36)

176. (4) Tests shall be made to determine,

(a) the volume of air flowing in underground haulageways and workings where diesel equipment is working, at least weekly;

(b) the carbon monoxide content of the atmosphere at the operator's position,

(i) at least weekly, and

(ii) upon a request of the operator for cause.

(c) the nitrogen dioxide content of the atmosphere at the operator's position, at least weekly; and

(d) the aldehyde content of the atmosphere at the operator's position, at least every three months.

Noise Standards

Part IV—Toxic Substance (36)

(8) In making a decision or order, a Director, the Minister, or, where a person has been appointed under subsection (5), the person so appointed, shall consider as relevant factors,

(f) any criteria⁸ or guide with respect to the exposure of a worker to a biological, chemical or physical agent or combination of such agents that are adopted by a regulation.

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QUEBEC

Types of Engines Permitted

It is forbidden to install and use internal combustion engines underground in a mine without prior approval of each engine from the chief mining inspector (38).

Testing and Certification Procedures of Engine and Auxiliary Equipment

Not specified in available literature.

Fuel Quality Specifications

Sulphur content

All hydrocarbon fuels used for diesel equipment or any vehicle whatsoever in underground construction or underground mines should have a sulphur content of less than 0.25% (39).

⁸For criteria (noise standards) use ACGIH-TLV's. See section 279 in "Mine Air Quality and Quantity Requirements."

Engine Emission Control Requirements

Vehicles with internal combustion engines (39)

In an underground mine or an underground construction site, all vehicles run by internal combustion engines must, except in the case mentioned in article 31:

(a) be provided with a diesel type motor

(b) must abstain from emitting in the air non diluted escaping gas containing more than 0.25% carbon monoxide.

(c) must abstain from emitting continually black smoke in the air.

All vehicles must be furnished with a cooling device for the exhaust gas which permits one to maintain the latter at 83 Celsius (181F) no matter what the working condition of the motor.

Procedures and Frequency of Testing Engine Exhaust Gases

The operator of all mining establishments regulated by the present article should keep a vehicle log in which to note at least once a week the concentration of carbon monoxide in the non diluted exhaust gas of each vehicle used in the mine (39).

Mine Air Quality and Quantity Requirements

Flow of air in underground workings (39)

All underground construction and underground mines must be supplied with fresh air at the rate of a minimum flow of air equivalent to the greatest of the following requirements:

(a) 5.50 cubic meters per minute of fresh air for each worker underground or

(b) 15 cubic meters per minute for each square meter of section in the case of a tunnel: or

(c) in the case in which diesel equipment is used, all flows of air prescribed for diesel equipment enumerated in Schedule 24 and Schedule 31 of the U.S. Bureau of Mines or 5.50 cubic meters per minute per kilowatt in the shaft for equipment not enumerated in the said documents.

When one uses simultaneously in the same ventilation circuit several diesel motors, the total quantity of fresh air ought to be 100% of the flow calculated for the motor with the highest fresh air flow requirement from the point of view of ventilation, 75% of the flow given for the second unit and 50% given for all supplementary units.

Procedures and Frequency of Testing Mine Air Quality and Quantity

The operators of all mining establishments should keep a log in which to note at least once a week the flow of ventilation air that circulates in the area in which each vehicle is used (39).

Noise Standards

22. Noise Protection (39)

(a) A mine operator must take all appropriate measures to assure that employees are not subjected to noise levels whose intensity exceeds agreed upon norms as accepted by the chief mining inspector.

(b) When the noise level exceeds conventional norms, the operator must furnish appropriate protective devices that employees may conveniently carry for self-protection.

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SASKATCHEWAN

Saskatchewan does not have any underground coal mines nor legislation covering coal mines (30).

Types of Engines Permitted

Part XXII: Use of Diesel Engines Underground (40)

444. (1) The mine employer shall not use or permit any internal combustion engine to be used underground at a mine other than a diesel engine approved by the chief inspector.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Part XXII: Use of Diesel Engines Underground (40)

444. (2) The chief inspector may require the mine employer to provide all necessary specifications and performance data of the diesel engine including an analysis of the exhaust gases under relevant conditions.

Fuel Quality Specifications

Part XXII: Use of Diesel Engines Underground (40)

444.14 (1) The employer at a mine shall ensure that the oil used as fuel in a diesel engine underground,

- (a) has a flash point of not less than fifty-two degrees Celsius (closed cup);
- (b) has a sulphur content not greater than one-half of one percent by mass;
- (c) does not have a heavy asphalt base.

Engine Emission Control Requirements

Part XXII: Use of Diesel Engines Underground (40)

444.02 The mine employer shall ensure that,

(a) every diesel engine used underground is equipped with an exhaust gas scrubber of a type and size approved by the chief inspector.

444.12 The employer at a mine shall not permit the operator of a diesel engine vehicle used underground to keep the engine running,

- (a) while the vehicle is unattended;
- (b) while the vehicle is stationary for other than a short period;
- (c) while the vehicle is being refuelled.

Procedures and Frequency of Testing Engine Exhaust Gases

Part XXII: Use of Diesel Engines Underground (40)

444.06 (3) The employer at a mine shall take effective steps to ensure that all diesel engine equipment is adequately maintained and where any unsafe condition may occur on any equipment this equipment is withdrawn from use forthwith.

444.08 The mine employer shall institute an adequate program

(1)(b) to test the undiluted exhaust gases of all diesel engines at regular intervals not exceeding one month and this test shall be made before the exhaust gases pass through any exhaust gas scrubber.

(2) Every test required by this section shall be made by a competent person appointed by the mine employer and the method of testing shall be approved.

Mine Air Quality and Quantity Requirements

Part XXII: Use of Diesel Engines Underground (40)

444.04 Notwithstanding and in addition to the requirements of any other regulations under the Act, the mine employer shall not use or permit the use of any diesel engine underground at a mine unless the following conditions are maintained,

- (a) the ventilation of the mine is by mechanical means;
- (b) the concentration of gases does not exceed in the operator's position of the diesel engine equipment or at any point in the vicinity of the equipment where workers work or pass in any work place or travelway in the mine,
 - (i) in the case of carbon monoxide twenty-five parts per million;
 - (ii) in the case of carbon dioxide five thousand parts per million;
 - (iii) in the case of nitrogen dioxide two parts per million;
- (c) the percentage of oxygen in the air shall not be less than nineteen by volume;

Procedures and Frequency of Testing Mine Air Quality and Quantity

Part XXII: Use of Diesel Engines Underground (40)

444.08 (1) Where diesel engines are used underground the mine employer shall institute an adequate program,

- (a) to determine the effect on the mine air of the exhaust gases and tests shall be made,
 - (i) at suitable places which will be representative of the exposure of workers to those gases;
 - (ii) at intervals of not more than one week at a time when the concentration of the exhaust gases is most likely to be highest.

Noise Standards

No person is permitted to work in excessive noise without wearing suitable hearing protection. The manager is required to take all steps practicable to prevent injury to the hearing of a person by reducing or eliminating noise from any machine and to designate the areas where protective hearing equipment shall be worn (30).

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YUKON TERRITORY

Types of Engines Permitted

No internal combustion engine may be operated underground without authority in writing from an inspector and under the conditions he may specify (41).

Appendix A (41)

An applicant for authority to operate equipment powered by internal combustion engines in mines shall submit to an inspector:

- (a) an application in duplicate showing the type of construction, complete identification data and specifications of the equipment,
- (b) the approval number issued by an approved testing laboratory or other acceptable agency.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Not specified in available literature.

Fuel Quality Specifications

Appendix A (41)

- 5. (1) Where diesel equipment is operated underground
 - (a) diesel fuel oil having a closed flash-point lower than 117 degrees Fahrenheit determined by the Pensky-Marten method shall not be used.

Engine Emission Control Requirements

The locomotive or equipment is equipped with an efficient scrubber for exhaust gases (41).

Procedures and Frequency of Testing Engine Exhaust Gases

Not specified in available literature.

Mine Air Quality and Quantity Requirements

Appendix A (41)

2. (1) No inspector shall authorize the operation of equipment powered by internal combustion engines in any mine unless he is satisfied from information submitted to him or as the result of a personal inspection made by him,

(c) that the ventilation system is mechanically controlled, and is capable of supplying to the operating area an air current of sufficient volume to dilute the exhaust gases of the equipment to a concentration of not more than

(i) 0.01 per cent of carbon monoxide by volume in the atmosphere adjacent to the equipment, and

(ii) 0.0020 per cent of carbon monoxide by volume in the general atmosphere, but the volume of the air current shall not be less than 75 cubic feet per minute for each maximum brake horsepower of the equipment in addition to the normal requirements of the mine.

3. (1) No diesel equipment shall be operated underground in any mine where

(a) the carbon dioxide content of the air in the operating area exceeds 0.75 per cent by volume,

(b) the percentage of methane or other flammable gases in the air in the operating area exceeds 1.25 per cent by volume.

For other gases we use the ACGIH-TLV's as guidelines (42).

The use of diesel equipment underground is not specifically covered, but it is not prohibited, provided the contaminants of the exhaust gases are maintained below the fixed maximum allowable concentrations (MAC) in the ventilation air (43).

Types of Engines Permitted

Not specified in available literature.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Not specified in available literature.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Appendix A (41)

Where diesel equipment is operated underground

(a) the air in the operating area shall be tested for carbon monoxide every day,

(b) the volume of air supplied to the operating area shall be measured every week.

3. (2) Where methane or other flammable gases are found to exist in percentages exceeding 0.75 per cent by volume in the operating area of any mine, the air in the operating area shall be tested at least once a week.

4. (1) Before diesel equipment is put into regular service underground a test shall be made to ensure that the ventilating air current is sufficient and that the concentration of noxious gases in the operating area does not exceed the percentages permitted, and the results of the tests shall be forthwith sent to an inspector.

Noise Standards

48. (3) Permissible Noise Exposure (42)

(a) The manager shall take all reasonable measures to ensure that no workman will be exposed to noises in excess of the levels shown in the table below.

(b) Where noise levels exceed the levels shown in the table below, the manager shall provide protective equipment.

(c) No person shall work without protective equipment if noise levels exceed the levels shown in the table below:

<i>Time per day, hours</i>	<i>Sound level, dB(A)</i>
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	100
¼ or less	115

NOTE.—Ruling value: No exposure in excess of 115 dBA.

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CHILE

Fuel Quality Specifications

Not specified in available literature.

Engine Emission Control Requirements

Article 48. Motor vehicles will not be permitted in transit if they have a defective horn, steering gear, brakes, lights and/or emission control (44).

Procedures and Frequency of Testing Engine Exhaust Gases

Not specified in available literature.

Mine Air Quality and Quantity Requirements

1. Ventilation (44)

Article 272. The work fronts, access roads or communication passages will not be considered safe, if the air indicates more than 50 parts per million carbon monoxide, or more than 5 parts per million nitrogen oxides or more than 2 percent methane is allowed and there must be at least 19.5 percent oxygen. If these minimums are exceeded, it will be mandatory that workers leave the mine.

Article 273. Polluted air which is unhealthy or hazardous to workers will be carefully diverted from the work areas and passages in use by the miners.

When polluted air is present the work day will be reduced or the number of workers will be limited.

Article 268. The atmosphere will be purified with a flow of fresh air at least 3 cubic meters (3m³) equivalent to 100 cubic feet of air per minute for every person working in any spot of the mine's interior, and at each location of the underground mine where workers will be in order to perform their tasks. This flow will be regulated, taking into consideration the number of workers, labor extent, the mine's natural emanations and gallery sections. By no means will it be permitted to have more than 75 workers in each circuit, nor speed over 150 meters per minute.

Supreme Decree No. 19 (45)

Article 1—Maximum permissible environmental concentrations, abbreviated as MPEC, of environmental pollutants in any place where people work, shall be as indicated by or resulting from Articles 5, 7 and 8. They shall be understood to apply for an 8 hour working day and a total of 48 hours per week, and they may only be surpassed momentarily if the daily weighted average concentration does not exceed the maximum permissible amount except as specified in Article 2. For shifts of 44 and 40 hours per week such concentrations will be increased by 10% and 20%, respectively.

Article 4—In the case of high altitude workplaces, the maximum permissible environmental concentrations should be modified according to the following equation:

$$\text{MPEC at high altitude} = \text{MPEC at sea level} \times \frac{\text{Local atmospheric pressure (mm Hg)}}{760 \text{ (mm Hg)}}$$

Article 7—Maximum permissible environmental concentrations for particles that are toxic to the lungs, inorganic or of plant origin, are indicated below.

INORGANIC PARTICLES

SILICA (SiO₂):

Crystalline silica (quarz): Two methods can be used for these particles; they can be counted or weighed (gravimetric method).

Particle Counting: The MPEC is expressed in particles per liter of air (p.p.l.) and can be determined according to the following equation:

$$\text{MPEC} = \frac{8\,500\,000}{\% \text{ quartz} + 10} \text{ p.p.l.}$$

The above equation is valid for samples taken with an air sampler near the respiratory system, and read with a common microscope.

Gravimetric System: the MPEC is expressed in milligrams per cubic meter of air (mg/m³), and is determined according to the following equation:

$$\text{Breathable dust: MPEC} = \frac{8}{\% \text{ breathable quartz} + 2} \text{ mg/m}^3.$$

This equation is applied to the proportion of the dust sample that can go through a filter that selects particles according to size, with the following characteristics:

Aerodynamic diameter (microns)	% crossing the selector
up to 2	90
2.5	75
3.5	50
5.0	25
10.0	0

Total dust (breathable and not breathable):

$$\text{MPEC} = \frac{24}{\% \text{ quartz} + 3} \text{ mg/m}^3.$$

Amorphous silica: 560 000 p.p.l.

Molten silica: Apply the equations for quartz.

Chrystobalite and Tridimite: Use one half of the figure calculated for quartz (by particle count or by gravimetric methods).

SILICATES (less than 1% quartz):

Asbestos (all types): 5 fibers per milliliter of air, measuring more than 5 microns (5 fibers larger than 5 μml). This method is valid using a membrane filter, a dark field microscope and 400 to 450 X magnification.

Steatite: 560 000 p.p.l.

Portland Cement: 850 000 p.p.l.

Mica: 560 000 p.p.l.

Talc (non asbestos): 560 000 p.p.l.

Talc (fibrous): Use the MPEC for asbestos.

Tremolite: Use the MPEC for asbestos.

Natural diatom powder: 560 000 p.p.l.

CARBON

Bituminous coal

Breathable dust

with less than 5% quartz: 2 mg/m³.

with 5% quartz or more: Use equations for quartz.

Natural graphite: 420 000 p.p.l.

PLANT DUST

Cotton, raw, breathable: 0.16 mg/m³ (lint free and measured with a vertical elutriator).

Procedures and Frequency of Testing Mine Air Quality and Quantity

1. Ventilation (44)

Article 269.—Effective ventilation will be used to avoid hazards to workers and it should avoid as much as possible the auxiliary airing of the works. At least once a month, there must be an appraisal of the air flow at the principal air intake of each work area. An appraisal must also be made at each section of the mine, and as close as possible to the air intake of the section fronts, with losses not to exceed 15 percent.

Article 272—Acceptable detection methods are: a methane detector or other types of chemical analysis. The tests should be done in an environment free of humidity.

Noise Standards

Supreme Decree No. 19 (45)

Article 13—Noise exposure can be differentiated according to whether the noise is continuous or explosive.

Continuous noise. The permissible level of sound, measured in decibels (slow dB(a)), is related to the time of exposure, according to the following table:

Noise level, slow dB(a)	Duration of exposure hours/day	Noise level, slow dB(a)	Duration of exposure hours/day
85	8.00	101	0.87
86	6.97	102	.76
87	6.06	103	.66
88	5.28	104	.57
89	4.60	105	.50
90	4.00	106	.44
91	3.48	107	.38
92	3.03	108	.33
93	2.64	109	.29
94	2.30	110	.25
95	2.00	111	.22
96	1.74	112	.19
97	1.52	113	.17
98	1.32	114	.14
99	1.14	115	.125
100	1.00		

The various levels of noise and the permissible duration of exposure have been tabulated for equivalent continuous exposures in which the daily dose of noise (d) was equal to 1.

When there is intermittent exposure to continuous sound, the combined effect of the noise levels or greater than 85 dB(A) should be considered. For that purpose, the Daily Dosis of Noise (D) is

calculated according to the following equation, and should not be greater than 1.

$$D = (C_1/T_1) + (C_2/T_2) + \dots + (C_n/T_n),$$

where C = total time of exposure to a specific level of sound and T = total time allowed at that level of sound.

In no case will the noise level be allowed to exceed 115 dB(A), whatever type of work is involved.

2. Regarding "Impact Noise," the present terms are maintained.

Impact noise. Impact noise is considered to have a frequency below 1 impact per second and any sound having a greater frequency will be considered continuous.

The maximum levels of sound pressure per 8-hour work day will depend on the total number of impacts within that period, according to the following table:

Impacts per 8-hour working day	Max sound pressure level, DB
100	140
500	135
1,000	130
5,000	125
10,000	120

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CHINA

No diesel engine regulations are available since diesel engines are not in use in underground coal mines in China (46).

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COLOMBIA

The following information on Colombia was extracted from its Resolution No. 02400, indicating regulations on mining safety for underground coal mining (47).

Types of Engines Permitted

Not specified in available literature.

Testing and Certification Procedures of Engine and Auxilliary Equipment

Not specified in available literature.

Fuel Quality Specifications

Article 50—Engine fuel must have an ignition point above 55° C. The fuel tank should be protected against mechanical damage, should be properly closed, and should not leak.

Article 174—Fuel should be transported in containers that are safe, properly closed, fire-proof, leak-proof, and shatter-proof.

Engine Emission Control Requirements

Not specified in available literature.

Procedures and Frequency of Testing Engine Exhaust Gases

Article 50—In Class III and Class IV Mines, which generate firedamp, the engines will carry methane detectors, preferably of the continuous monitoring kind. If methane levels in ambient air exceed 1% along the galleries traversed by the engine, the following precautions shall be observed:

- The motor of the engine must be shut off immediately.
- The immediate supervisor must be advised.
- The motor must not be started again until the driver is sure that ambient methane levels are below 1%.

Mine Air Quality and Quantity Requirements

Article 1—All workplaces in underground mining work should be swept by an air flow sufficient for maintaining a breathable environment, within the permissible limits for environmental pollution with gas, fumes, dust, vapors or any other toxic agent that could cause work-related illness or accidents (fire, explosions, etc.)

Article 2—Air dumped into the mine should be free from gases, fumes, dust vapors or any other toxic agent.

Article 3—Maximum permissible environmental concentrations of various pollutants in the mine during an 8 hour working day, also called maximum permissible values, will be as follows:

Contaminant	Formula	v/v, %	Parts per million
Carbon dioxide	CO ₂	0.5	5,000
Carbon monoxide	CO	.01	100
Hydrogen sulfide	H ₂ S	.002	20
Sulfur dioxide	SO ₂	.0005	5
Nitrous vapors	NO + NO ₂	.0005	5

Parts per million is the number of parts of the contaminant contained in one million parts of the air-contaminant mixture. For other pollutants, the maximum permissible values determined by the appropriately qualified body should be considered.

Firedamp or Methane (CH₄). The maximum permissible concentrations of this pollutant will be the following:

Firedamp or Methane		
%	Parts per million	Locations
1.5	15,000	At the cutting face and mine face.
1.5	15,000	Air returning from the cutting face.
1.5	15,000	Air returning from the preparation and development face.
1.0	10,000	In the main air return ducts.

Greater concentrations are allowed in the areas of development and preparation, as long as preventive measures are taken to protect the worker from the surrounding air and as long as methane levels do not exceed 1.9%.

Article 4—Areas containing 2% firedamp (20,000 ppm) or more should immediately be evacuated by mining personnel. Employees will not be allowed to return to the working areas until the concentration of firedamp has decreased and reached the permissible levels established in Article 3. If methane concentrations remain equal to or greater than 2% despite maximum ventilation, work should be suspended until the situation returns to normal.

Article 5—The minimum concentration of oxygen in the ventilation air of the mine should be 19.5% per volume, or 20,000 parts per million. In areas where the concentration of oxygen is less than 19.5% per volume, breathable air should be supplied to the workers.

Article 6—The minimum amounts of air underground for mines at up to 1,500 meters above sea level, shall be the following:

Description	Amount
Per worker	3 cubic meters per minute and per worker.
Per draft animal	15 cubic meters per minute and per draft animal.

Minimum amounts of air shall be increased for conditions above sea level, according to the following scale:

- At 1,501 to 3,000 meters Increase by 40%.
- At 3,001 to 4,000 meters Increase by 70%.
- Above 4,001 meters Increase by 100%.

Galleries used for transporting Diesel machinery should have the following air volume:

- 6 cubic meters per minute per horsepower at all levels, if the content of CO is less than 0.12%.
- 4 cubic meters per minute per horsepower at all levels, if the content of CO is less than 0.08%.

In order to calculate the amount of air required at the mine face, calculations should consider the maximum number of men, machines and animals that can work simultaneously during one shift.

The minimum amounts of air are valid when none of the permissible levels for the various contaminants, for temperature or explosives has been surpassed, according to this Resolution. When any of these maximum levels are exceeded, the volume of air should be increased as required to reduce contaminants to at least their maximum permissible levels.

Article 7—The minimum air flow for ventilation is that required for compliance with Articles 3 and 5 of this Resolution.

Article 8—Maximum air flow: Ventilation air should not exceed the following air flow:

- 4 m/sec at the work face and preparation headings.
- 8 m/sec in the transportation galleries and ventilation shafts.
- 6 m/sec in the other underground headings.
- 10 m/sec in ventilation ducts.
- 8 m/sec in shafts for employees and cargo.
- 12 m/sec in shafts for cargo only.
- 15 m/sec in ventilation shafts without transportation facilities or ventilation ducts.

Article 25—Outlet air should not be drawn towards other work faces if its gas and dust content exceeds the permissible limits defined in this regulation.

CHAPTER XVI—Other work-related hazards—rock dust

Article 220—Necessary measures must be taken in mines to avoid hazardous levels, amounts or concentrations of chemical or biological agents that could be a risk to the health and well being of the workers.

Article 221—Maximum permissible values (MPV) for dust containing silica (SiO₂) are the following:

- (a) MPV, millions of particles per cubic foot, = (300 mmp/%SiO₂ + 10).
- (b) MPV for breathable dust, mg/m³ = (10 mg/m³/%SiO₂ breathable + 2).
- (c) MPV for breathable dust, mg/m³ = (30 mg/m³/%SiO₂ + 3).
- (d) MPV for coaldust = 12 mg/m³ if the fraction of breathable dust is equal to or less than 5% in SiO₂. Equation (a) is used when the proportion of silica is equal to or less than 5% SiO₂. When the percentage is greater, equations (b) and (c) are used.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Article 34—Measurements should be carried out in all the ventilation ducts under normal working conditions and when changes are made in the main ventilation system of the mine.

Article 35—In mines where there is a hazard of explosions, fire or toxic gas, risk should be evaluated at least once a week. If the values found exceed the maximum permissible levels, measurements should be carried out more frequently, as necessary. Mines generating firedamp should have methane levels checked at the beginning of each shift, and at the mine face. Measurements should be carried out before and after firing.

Article 36—Panels showing ventilation measurements and gas concentrations should be posted in all the main ventilation galleries and in all sections; these will show the figures obtained from measurements.

Article 37—The results of all ventilation, toxic gas and explosive substances measurements will be written in a book that is entitled main ventilation book.

Article 38—All mines will possess a drawing that is updated at least every two (2) months, showing all important data for the control of ventilation, toxic gases, explosive substances, dust, etc., using the authorized symbols according to mining standards. Any changes or major variations in the ventilation circuit within a two-month period should be immediately drawn into the original ventilation blueprint.

Article 39—All underground coal mines are obliged to keep at least two methane detectors, an airflow gauge, a general gas detector, and an oxygen analyzer; these must constantly be maintained in working order. These instruments will be kept by the regional Safety and Rescue Stations for small mines operating with electric power.

Article 40—The staff in charge of evaluating ventilation flow, gas, toxic substances or explosive materials, should be trained in the use and care of their instruments, be aware of the danger levels for various toxic gases and explosive gases, and understand the safety measurements to be taken in each case.

Article 41 – When work has been suspended during one or more shifts due to holidays or special tasks, the employees in charge of gas monitoring should, after the holiday is over and the ventilation system has started up again, carry out measurements at all work faces before the workers arrive.

Article 42 – When the employee in charge of monitoring gas levels and ventilation has to carry out measurements outside working hours, he should be accompanied by another mine worker, preferably by a supervisor or foreman, who can use this time to evaluate other safety conditions. He will write down his observations in a notebook, as well as write down observations as defined in Articles 36 and 37: whatever data he considers of interest will be copied in the book for gas monitoring.

Article 43 – In areas where explosives are fired, gas levels should be monitored where ventilation has been shut down or when it is necessary to enter before the safety waiting period has elapsed, according to the ventilation and gas levels found.

Noise Standards

Article 224 – Every workplace should have a continuous noise level below 85 decibels for 8 hours of exposure.

Article 225 – Maximum permissible values for partial exposure to continuous sound should be the following:

Exposure per day, hours	MPV for sound, decibels
4	90
2	95
1	100
1/2	105
1/4	110
1/8	115

Article 226 – In operations involving exposure to vibrations, necessary precautions should be taken to prevent danger to employee health.

Article 227 – The governing entities shall determine the measurement of noise levels at each mine face and decide which precautions should be taken by the employer in order to reduce the hazard of dangerous sound intensities to a minimum.

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FEDERAL REPUBLIC OF GERMANY

Germany is a major coal mining country with an industrial development comparable to that of the United States. Likewise, as a federated state, Germany also encounters the problem of occupational health legislation being split up between the federal government and its constituent states, in this case the Laender. Both bituminous or hard coal and lignite are mined in the Federal Republic; hard coal mostly in North Rhine-Westphalia and Saarland; lignite in Bavaria, Hesse, Lower Saxony, North Rhine-Westphalia, and Saarland. Of these Laender, North Rhine-Westphalia is the leading jurisdiction for all coal mining legislation. The rules of the other Laender are very similar both in structure and content, but North Rhine-Westphalia has the best documented body of rules. (48).

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The following information on Baden-Wuerttemberg, Bavaria, Lower Saxony, North Rhine-Westphalia, and Saarland was extracted from the "Regulations Concerning Diesel Motor Equipment in the Mines of West Germany (49)."

BADEN-WUERTEMBERG

Types of Engines Permitted

53. (1) Operation of internal combustion engines underground shall require the permission of the State Mines Inspectorate.

(2) Paragraph (1) shall not apply to internal combustion engines of vehicles and other machines if their design is allowed for use underground.

163. (4) Use of vehicles with four-cycle engines in underground areas is forbidden.

Testing and Certification Procedures of Engine and Auxilliary Equipment

180. (1) The State Mines Inspectorate shall be responsible for granting design acceptances, to the extent that design acceptances

are prescribed in this regulation or in other regulations by mine authorities. The design acceptances of the State Mines Inspectorate shall be the same as design acceptances of the mine authorities in other German federal states as well as other places which use different guidelines for design acceptances.

Fuel Quality Specifications

Not specified in available literature.

Engine Emission Control Requirements

163. (2) Vehicles with a content of more than 0.12 vol. % CO in the exhaust gas shall not be used underground.

Procedure and Frequency of Testing Engine Exhaust Gases

143. (3) Vehicles with selfcontained engines shall be checked and tested at time intervals established by the contractor, and must be examined at least once a year. The time interval shall not be more than 15 months.

163. (1) Vehicles and machines with selfcontained engines (diesel engines) prior to their first use in the underground areas of the construction site, and at monthly intervals thereafter, shall have the content of carbon monoxide (CO) in the exhaust fumes determined by the test tube method.

Mine Air Quality and Quantity Requirements

163. (3) Regulations 163. (1) and (2) shall not apply to vehicles which enter underground areas only occasionally if suitable measures are provided in the ventilation system to ensure that the CO level in the air at no time amounts to more than 0.005 vol. % in the ventilation shafts.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Not specified in available literature.

Noise Standards

Not specified in available literature.

BAVARIA

Types of Engines Permitted

1. General

According to 148, Para. 1 of the General Mine Regulations of December 7, 1978*, only those vehicles whose design has been approved for underground use may be used underground.

4. Basic Requirements

4.1 The design and equipment of vehicles for use underground must conform to the law on technical tools (Equipment Safety Law) to the extent that these regulations do not contain additional requirements.

Testing and Certification Procedures of Engine and Auxiliary Equipment

3. Administrative Procedures for Design Acceptance

3.1 For each vehicle design, an application for vehicle acceptance shall be filed in duplicate with the Bavarian Regional Mines Inspectorate. A data sheet and the documents designated in the data sheet shall accompany the application.

3.2 Design acceptance may be denied by the Bavarian Regional Mines Inspectorate if the vehicle in question has already been approved by another regional mines inspectorate.

In this case, the Regional Mines Inspectorate must be sent the essential data of the vehicle (e.g., exhaust gas figures), a brief description, and an overall diagram.

3.3 For each vehicle design, the Bavarian Regional Mines Inspectorate with participation of a technical monitoring organization, e.g., the Technische Ueberwachungs-Verein, or another organization or person authorized by the Bavarian Regional Mines Inspectorate, shall carry out a design inspection procedure. The design inspection shall consist of preliminary examination of the application documents and an acceptance test. The application documents shall be provided to the Bavarian Regional Mines Inspectorate with sufficient time to permit changes to be made.

3.4 An exhaust gas test shall be conducted in the "high-speed idle" position on each new vehicle entering operation, and the CO content shall be analyzed by a technical monitoring organization or another organization to be named by the Bavarian Regional Mines Inspectorate. At the same time, the soot value (blackness) shall be determined at "maximum idle" using the Bosch filter pump method.

In addition, every vehicle of a given design (except the first, on which the Regional Mines Inspectorate has performed the acceptance procedure) shall be subjected to acceptance prior to starting operation by the responsible mines inspectorate, to determine the correspondence of the vehicle to the design acceptance documents. The results of the test shall be submitted to the Regional Mines Inspectorate.

6. Motor and Exhaust

6.2 The responsible authority for the test stand trials is the Rheinisch-Westfaelische Technische Ueberwachungs-Verein e.V. (Rhine-Westphalia Technical Monitoring Association) in Essen as the central test facility for exhaust gases of motor vehicles, designated by the Federal Minister of Transport for the territory of the Federal Republic of Germany, or, in special cases, another facility named by the Regional Mines Inspectorate.

Fuel Quality Specifications

6. Motor and Exhaust

6.1 Only diesel engines operated on fuel whose flash point is not below 55° C (diesel fuel), may be used as motors.

Engine Emission Control Requirements

6.2 The exhaust gas composition shall be determined on a test stand for each type of engine.

The following emission limits must be maintained for the engine design in question:

Carbon monoxide (CO) ppm	500
Oxides of nitrogen (NO + NO ₂) ppm	750
Hydrocarbons (HC) ppm	220
Soot, blackness	3

6.3 The exhaust must be equipped with a device that will produce good mixing of the exhaust gases with the ambient air (exhaust gas diffusor). The exhaust opening must not be directed upward. Hot parts of the exhaust must be protected against persons coming accidentally in contact with them.

Procedures and Frequency of Testing Engine Exhaust Gases

6.2 (1) The hydrocarbons are measured with a flame ionization detector as ppm C, (carbon equivalent).

(b) The soot blackness is determined by the Bosch filter pump method.

Mine Air Quality and Quantity Requirements

Not specified in available literature.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Not specified in available literature.

Noise Standards

5. Cab and Seats

5.9 The noise emission from a vehicle shall not exceed the values attainable by the state of the art.

LOWER SAXONY

Types of Engines Permitted

1. Scope

These Design Regulations shall apply to the design and equipment of non-rail-bound vehicles with selfcontained engines, as well as the vehicular portions of machines for use underground in mines not endangered by mine gas.

These vehicles may only be used underground if a design acceptance has been granted for the corresponding vehicle design.

These conditions shall apply to the design testing of diesel engines to be used in the territory of the Regional Mines Inspectorate of Clausthal-Zellerfeld in vehicles to be operated in mines not endangered by mine gas.

Testing and Certification Procedures of Engine and Auxiliary Equipment

2. Administrative Procedure for Design Acceptance

2.1 For each vehicle design, an application for vehicle acceptance shall be filed in quadruplicate with the Regional Mines Inspectorate. A data sheet and the documents designated in the data sheet shall accompany the application.

2.2 For each vehicle design, the Regional Mines Inspectorate shall carry out a design inspection procedure with involvement of

the Technische Ueberwachungs-Verein e.V. or another organization named by the Regional Mines Inspectorate. The design inspection shall consist of a preliminary examination of the documents and an acceptance inspection under operating conditions.

An exhaust gas test shall be conducted in the "maximum idle" position on each new vehicle entering operation, and the CO content shall be analyzed by a technical monitoring organization or another organization to be named by the Regional Mines Inspectorate. At the same time, the soot value (blackness) shall be determined at "maximum idle" using the Bosch filter pump method. The results of the analysis as well as the carbon value shall be presented in a certificate. If significant differences from the measured values in the engine design test are found, the measurements shall be repeated after no more than 300 hours' operation. If the discrepancies are still present, the engine shall be taken out of service. With a blackness value of less than 1.5, this figure will suffice on the certificate.

3. Motor and Exhaust

3.2 The responsible authority for the test stand trials is the Rheinisch-Westfaelische Technische Ueberwachungs-Verein e.V. (Rhine-Westphalia Technical Monitoring Association) in Essen as the central test facility for exhaust gases of motor vehicles, designated by the Federal Minister of Transport for the territory of the Federal Republic of Germany, or, in special cases, another facility named by the Regional Mines Inspectorate.

7. Performance of Tests

7.2 Test procedure beginning with one type of engine (definition according to Number 3.2) the engine with the greatest horsepower and the highest rated rpm shall be measured under the following operating conditions:

1. At minimum and maximum idle;
2. At 5%, 20%, 40%, 80% and 100% horsepower at rated rpm.
3. Along the full-load characteristic in the range from the beginning of regulation up to 45% of the rated rpm or up to 1,000 min^{-1} , whichever value is greater.

In the measurements under Number 3, the rpm range shall be divided into at least 5 uniform rpm intervals, so that at least 6 measurement points are provided with these limits. If rpm intervals of more than 275 rpm result, their number must be increased accordingly. In addition, measurements must be made at maximum torque if the corresponding rpm is more than 50 rpm away from a measurement point.

For each operating state, the following operating parameters must be determined:

1. Engine rpm
2. Braking force or torque
3. Fuel volume or weight
4. Sampling rpm and/or sampling time
5. Fuel temperature:
 - at measuring device
 - upstream of injection pump
6. Temperature, pressure, and relative humidity of intake air, downstream of an intermediate cooler if any
7. Vacuum in intake manifold and boost pressure (if any)
8. Exhaust temperature
9. Exhaust backpressure
10. Coolant temperatures at engine intake and exhaust
11. Lubricating oil temperature and pressure
12. Intake air volume
13. Volume content of exhaust gas for:
 - oxygen
 - carbon monoxide (CO)
 - carbon dioxide (CO_2)
 - oxides of nitrogen as a total ($\text{NO} + \text{NO}_2$)
 - total number of organic compounds (NO and NO_2)
 - total number of organic compounds (HC)
 - solids content (The solids determination shall be performed as a measurement of the blackness using the Bosch filter pump method.)

Fuel Quality Specifications

The diesel fuel used in the design testing must conform to the following requirements:

Characteristics	Limiting values
Flashpoint	Over 55° C.
Density at 15° C	0.82 to 0.84 g/cm^3 .
Viscosity at 20° C	1.8 to 10 cSt (1.1 to 1.8 E).
Filterability	In summer, up to 0° C; in winter, down to -12° C.
Coking tendency	Not above 0.05% coke (mass content) Conradson test.
Ignition performance	Cetane number minimum 45.
Sulphur content	Up to 0.3% (mass content).
Water content according to Karl Fischer.	Maximum 500 mg/kg.
Up to 350° C, including evaporated volume.	85% (volume content).

The fuel must not contain additives that affect pollution emissions.

3. Motor and Exhaust

3.1 Only diesel engines, operated on fuel whose flashpoint is not below 55° C (diesel fuel), may be used as motors.

9.1.1 Additives to the fuel shall require the permission of the Regional Mines Inspectorate.

Engine Emission Control Requirements

3. Motor and Exhaust

3.2 The exhaust gas composition shall be determined on a test stand for each type of engine.

The following emission limits must be maintained for the engine design in question:

Carbon monoxide (CO)	ppm ..	500
Oxides of nitrogen ($\text{NO} + \text{NO}_2$)	ppm ..	750
Hydrocarbons (HC)	ppm ..	200
Soot, blackness		3

Values are valid for new engines following completion of the running-in time.

3.3 The exhaust must be equipped with a device that will produce good mixing of the exhaust gases with the ambient air (exhaust gas diffusor). The exhaust opening must not be directed upward. Hot parts of the exhaust must be protected against persons coming accidentally in contact with them.

12. Monitoring

12.3.1 If the CO content in the exhaust samples collected according to Nos. 12.1 or 12.2 exceeds 0.12 volume percent, the vehicle in question shall be taken out of service. If the CO content differs more than 200 PPM from the value established in the design inspection at "maximum idle", or if the soot level exceeds a blackness number of 3, the adjustment dates of the fuel-injection system shall be checked immediately and corrected if necessary.

Procedures and Frequency of Testing Engine Exhaust Gases

7.4 Determination of Pollutant Limits in Exhaust Fumes

7.4.1 Exhaust samples must be collected undiluted, immediately downstream of the exhaust manifold. Collection of exhaust samples in the gas exhaust manifold and their examination using analytical chemical measurement methods shall be limited to exceptional cases. The method parameters of the measurement methods employed must be known.

7.4.2 To determine the individual exhaust gas components, only those measuring devices shall be used which are capable of collecting a partial stream of exhaust gases from the exhaust manifold

without affecting the exhaust gas composition, and to prepare and analyze it. To study the exhaust gases in terms of their volume content of carbon dioxide, oxygen, carbon monoxide, oxides of nitrogen, and organic compounds, measuring devices which record continuously shall be used preferentially.

The operating and maintenance guidelines of the instrument manufacturer shall be observed.

7.4.3 The following requirements shall be imposed on the measuring devices used to measure exhaust gas components:

Exhaust gas components, volume content of—	Recommended measurement range	Detection limit	Lower safety limit
Carbon dioxide	0 to 16%	0.2%	± 0.4%.
Carbon monoxide	0 to 2,000 ppm	12 ppm	± 40 ppm.
Oxides of nitrogen	0 to 1,500 ppm	10 ppm	± 50 ppm.
Organic compounds	0 to 400 ppm.		

7.4.4 Carbon monoxide must be measured with measuring devices which operate by the non-dispersive infrared absorption method (NDIR).

7.4.5 Oxides of nitrogen (NO + NO₂) shall be determined by the chemiluminescence method or an equivalent method as a total and the NO portion shall be given.

7.4.6 Organic compounds (termed HC) shall be determined as a total and given as carbon equivalent (C₁). A flame-ionization detector (FID) shall be used for this measurement.

7.4.7 Solids (soot) shall be determined relatively as blackness by the Bosch filter pump method.

12. Monitoring

12.1 Every 3 months, the undiluted engine exhaust fumes shall be tested at "maximum idle" by a responsible person, using the test tube method to determine CO content. At the same time, the soot value (blackness) shall be determined by the Bosch filter-pump method. The results shall be entered in the log.

12.2 During the annual test, the experts shall sample the undiluted engine exhaust at "maximum idle" and analyze its content of CO at the Technische Ueberwachungs-Verein or another organization designated by the Regional Mines Inspectorate. At the same time, the soot (blackness) shall be determined at "maximum idle" by the Bosch filter-pump method.

Mine Air Quality and Quantity Requirements

5. Ventilation.

3.1 The ventilation supplied to a mine must correspond at least to the total of the fresh air flows which the Regional Mines Inspectorate has established for vehicles operating therein with diesel engines in the design acceptance. Unless otherwise specified in the design acceptance, 3.4 m³/min of fresh air per kW installed power shall be delivered. If no (or insufficient) fresh air is available, previous contamination of the air with diesel fumes shall be taken into account and the air flow increased to the point where all of the harmful substances in the exhaust fumes are diluted below the corresponding MAC value.

10. Vehicle Maintenance and Repair

10.1.6 When idling engines up to a maximum of 1/3 of their fixed power, it is sufficient if at least half the fresh-air flow specified in the design acceptance is available.

Procedures and Frequency of Testing Mine Air Quality and Quantity

3. Ventilation

3.2 The airflows to the individual parts of the mines shall be measured before initial use by vehicles and subsequently at least every six months and after any change in the ventilation system. The results shall be entered in the operating log.

Noise Standards

2. Cab and Seats

2.9 Noise Protection—The noise emission from a vehicle shall not exceed the values attainable by the state of the art.

NORTH RHINE-WESTPHALIA

The regulations for North-Westphalia are divided into specific regulations for hard coal, nonhard coal, monorails, and locomotives.

Types of Engines Permitted

Hard Coal

258 Paragraph 1—Non-tracked vehicles with their own means of propulsion may be used underground only if their design has been accepted by the State Regional Mines Inspectorate.

244 Paragraph 1—Only those locomotives may be used underground whose design has been accepted by the State Regional Mines Inspectorate.

Locomotives

11.22 Two-cycle engines with crankcase ventilation may not be used.

Monorails

Powered vehicles with built-in engines, such as diesel crabs used on monorail suspended railways, may be used underground only if their design is accepted by the Regional Mines Inspectorate. The following requirements must be met for design acceptance of diesel crabs.

3.2.1 Four-cycle diesel engines cooled by water must be used as engines, possibly with indirect fuel injection. The engines including the corresponding accessories must be made with a precipitation-protected design.

Testing and Certification Procedures of Engines and Auxiliary Equipment

Nonhard Coal

101, paragraph 1 of this regulation, the diesel engine shall be subject to appropriate testing and acceptance.

Vehicles in nonhard coal mines in the State Regional Mines Inspectorate District shall be exempt from the special requirements for environmental protection for the diesel engine and the electrical operating means.

Hard Coal

Engines to be used underground shall be subjected to an engine design test at the Rheinisch-Westfaelische Technische Ueberwachungs-Verein e.V., Essen, according to the "Current Technical Requirements for Design Testing of Diesel Engines for Vehicles used Underground in Mines Endangered by Mine Gas and Mines not Endangered by Mine Gas."

Monorails

An application shall be filed for design acceptance in accordance with the Mines Decree of the Regional Mines Inspectorate of North Rhine-Westphalia for Hard Coal Mines of February 20, 1970 for each type of vehicle, said application containing the information and documents included in the attachment.

Locomotives

11.20 The engine must be built and have its power limited so that when it is new the CO content of the undiluted exhaust fumes at idle and at full load does not exceed 0.5 volume %. The CO content may not exceed 0.12 volume % even after long operation. Proof of this fact must be provided for each engine design on the basis of a test stand test, attested by a test certificate from a responsible individual designated by the Regional Mines Inspectorate.

Fuel Quality Specifications

Characteristics	Limiting values
Flashpoint	Over 55° C.
Density at 15° C	0.82 to 0.86 g/cm ³ .
Kinematic viscosity at 20° C ...	2 to 8 mm ² /s (centistokes).
Filtrability	In summer, to 0° C; in winter, to -12° C.
Coking tendency	Not over 0.05 weight % coke (Conradson test).
Ignitability	Cetane number minimum 45.
Sulphur content	Less than 0.30 v.H. of weight.
Water content according to Karl Fischer.	Maximum 500 mg/kg.
Total amount evaporated up to 350° C.	Minimum 85 vol. %

Engine Emission Control Requirements

Monorails

3.2.2 Pollutants in Exhaust Fumes and Temperatures

In the tests for design acceptance, the pollutants in the undiluted exhaust fumes must not exceed the following limits:

- With 0% CH₄ in the ambient air:

Carbon monoxide (CO)	550 ppm
Oxides of nitrogen (NO _x)	750 ppm
Of these, nitrogen dioxide (NO ₂) must not exceed	75 ppm
- With 1% CH₄ in the ambient air:

Carbon monoxide (CO)	1,200 ppm
Oxides of nitrogen (NO _x)	1,000 ppm
Of these, nitrogen dioxide (NO ₂) -must not exceed	200 ppm

Engine exhaust fumes from vehicles that are intended for use in mine environments containing more than 1% CH₄ must not exceed the following limiting values in the design acceptance, measured with 1.5% CH₄ in the intake air:

Carbon monoxide (CO)	1,800 ppm
Oxides of nitrogen (NO _x)	1,000 ppm
of which nitrogen dioxide (NO ₂) -must not exceed	200 ppm

The engine exhaust fumes from these vehicles must be mixed with the ambient air, forcibly, in a ratio of at least 1:20 (for example by mixing with engine cooling air).

Locomotives

11.10 The exhaust line must be cooled by suitable means to the point where the outside walls at no point are hotter than 200° C.

11.11 At the end of the exhaust line, downstream of the water tank (Number 11.17), a stub with a self-closing valve must be provided for sampling exhaust.

11.12 In the case of single-cylinder engines, the exhaust fumes must be cooled directly behind the cylinder head (in multicylinder engines, at the beginning of the common exhaust line) by injected water.

11.17 The exhaust fumes must be forced through a water tank. The water tank must be fillable from the injection water tank.

11.19 Devices for cooling the exhaust gases must ensure that their temperature does not exceed 70° C at the outlet.

Procedures and Frequency of Testing Engine Exhaust Gases

Hard Coal

3.2 Continuous Exhaust Gas Fumes testing

Measurement Intervals -

every 3 months by operator
prior to vehicle entering service, after 2,000 hours operation (but at least every 12 months), after 6 months out of service, after major overhaul by a responsible person.

Sampling -

at the exhaust manifold, i.e., upstream of the water tank and any catalyzers.

3.1 In addition to the pollutants listed in the design guidelines for diesel crabs, hydrocarbons (total hydrocarbons ≤ 200 ppm) and soot blackness number (S < 3 according to the Bosch filter method) are currently being determined.

Mine Air Quality and Quantity Requirements

Hard Coal

4.1.1 For each kW of diesel engines operated, at least:
8.2 m³/min with no more than 1,200 ppm CO in the exhaust; 5.4 m³/min with no more than 800 ppm CO in the exhaust; 4.1 m³/min with no more than 600 ppm CO in the exhaust;

4.1.2 For Diesel Crabs and Trackless vehicles for each kW of rated power of diesel engines operated:

6 m³/min with no more than 0.5% CH₄ in the intake air; 8 m³/min with no more than 1.0% CH₄ in the intake air; 10 m³/min with no more than 1.5% CH₄ in the intake air;

4.2 Measured gases and maximum permissible concentrations:

CO ₂	10,000 ppm
CO	50 ppm
H ₂ S	20 ppm

Nonhard Coal

All pollutants contained in the exhaust fumes must be diluted by the ventilation until they are below the maximum permissible concentrations for the workplace (MAC). The minimum ventilation level per kW of engine power is 2.7 m³/min.

The following maximum workplace concentrations are used as limiting values (MAC levels):

carbon dioxide (CO ₂)	5,000 ppm
carbon monoxide (CO)	30 ppm
nitrogen dioxide (NO ₂)	5 ppm
sulfur dioxide (SO ₂)	2 ppm
hydrocarbons	1 ppm formaldehyde or 1.0 acrolein.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Measuring pollutant concentrations

Hard Coal

Depending on the measurement point, continuously, weekly, monthly, or every three months.

Type of Measurement -

In the hoisting shaft, in all the entrance and exit galleries of a ventilated section, in all areas where diesel engines are operated.

Test Method

Depending on the measurement point, strip chart recorders, testtubes or chemical analyses in tanks filled with samples.

Nonhard Coal

The other requirements listed under A (Hard-Coal Mining) basically also apply to the use of diesel engines in nonhard coal mining.

Noise Standards

2.2 Noise Protection

The noise emitted by diesel crabs shall be limited to the minimum level possible according to the state of the art. This requirement shall be satisfied when the noise does not exceed the following emission levels:

75 dB (A) when running empty
83 dB (A) when running full

SAARLAND

Types of Engines Permitted

185. – Transportation Using Locomotives

(1) Only those locomotives whose design has been accepted by the Regional Mines Inspectorate may be used underground. Changes to locomotives may be made only with permission from the Regional Mines Inspectorate. Only parts supplied by the manufacturer or equivalents thereof may be used in overhauls.

(2) The use of portable diesel engines underground with the exception of the engines on locomotives whose design is accepted in accordance with 185, paragraph 1 by the Regional Mines Inspectorate requires permission from the Regional Mines Inspectorate.

The design acceptance is based upon the Design Guidelines for Mine Locomotives of February 22, 1958.

Other portable units with diesel propulsion such as mobile loaders, transporters, or gallery-digging machines require no design acceptance. The Regional Mines Inspectorate will issue permission in each individual case for their use.

11. Special Guidelines for Diesel Locomotives

11.9 The air intake line must have an oil-bath filter.

11.22 Two-cycle engines with crankcase ventilation may not be used.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Regulations for Mobile Diesel Units

Diesel locomotives must be accepted by the Regional Mines Inspectorate. The design acceptance is based upon the Design Guidelines for Mine Locomotives of February 22, 1958. The Mines Inspectorate will then issue a permit in each individual case for operation of locomotives which conform to the design.

The above mentioned design guidelines for mine locomotives shall apply to the diesel engines, and the vehicle design guidelines (for vehicles in mines not endangered by mine gas) from the Regional Mines Inspectorate in Clausthal will be used.

Testing and design acceptance of locomotives is carried out in accordance with the above design guidelines. The application for design acceptance is examined by authorized experts. The design investigation of the diesel engine for emission of pollutants and precipitation protection is performed by the Rheinisch-Westfaelische TUV in Essen, which specializes in this area. Before it is first put into service for the first time, the diesel unit is subjected to an acceptance test by authorized experts.

In the Saarland soft-coal mines, the same applies, with the difference that design acceptances are not conducted and measures for precipitation protection are not required.

Fuel Quality Specification

87. Storage and Use

(2) Flammable fluids with a flash point below 55° C may not be used underground. The Mines Inspectorate may grant exceptions.

Generally commercially available diesel fuels are used to operate the engines. The flash point must be above 55° C. A cetane number above 45 is required for ignitability. The sulfur content must be below 0.3%.

Engine Emission Control Requirements

11. Special Guidelines for Diesel Locomotives

11.10 The exhaust line must be cooled by suitable devices to the point where the outside walls are at no point higher than 200° C.

11.12 The exhaust fumes must be cooled by a spray of water in single-cylinder engines immediately behind the cylinder head and in multicylinder engines at the beginning of the common exhaust line.

11.15 Suitable devices must be provided for removing contaminants from the water.

11.17 Exhaust fumes must be conducted positively through a water tank. The water tank must be kept full from the injection water tank.

11.20 The engine must be so designed and have its power so limited that when it is new, the CO content of the undiluted exhaust fumes at idle and at full load is no more than 0.05 vol %. The CO content must not exceed 0.12 vol % even after a long operating time.

In the Saarland soft-coal mines, the use of non-rail vehicles with self-propulsion requires the permission of the Mines Inspectorate. The maximum permissible CO content of undiluted exhaust fumes is often reduced to 600 ppm here.

Procedures and Frequency of Testing Engine Exhaust Gases

Samples of the undiluted exhaust fumes, both at full load and at idle, are regularly collected for studies of the exhaust, always at maximum rpm, and then taken to the laboratory for CO₂ content determination. The sampling is conducted three times a year by the operators and every 6 months by an expert.

Mine Air Quality and Quantity Requirements

30. Internal Combustion Engines

(4) The exhaust fumes from fixed internal combustion engines must be carried away above ground in such fashion that persons cannot be endangered by them.

In hard-coal mines, at least 6 m³/min of air per hp of installed power must be supplied to those galleries in which diesel-operated units are used. The ventilation supply must not be contaminated by diesel fumes.

In soft-coal mines, a ventilation volume of only 3 m³/min per installed hp is required.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Ventilation monitoring activities are carried out to the same extent as in other mines.

Noise Standards

Specific requirements for noise protection on diesel-operated units underground, which go beyond the workplace noise protection guidelines, are nonexistent.

FINLAND

The following information on Finland was excerpted from its Regulations for Safety of Mining (50).

Types of Engines Permitted

61. In underground mines efforts shall be made to use an engine type with exhaust gases of contents as low as possible in nitrogen oxide, carbon monoxide and soot. The sulphuric content of the combustible shall be low as possible. The power of diesel engines shall be restricted to maximum 90 pct of the normal maximal power. Idle running of the engine shall be avoided.

Compression motors shall be equipped with injection pump pressure regulator. The motor shall, if possible, have a positively ventilated crank chamber.

60. The use of petrol engines in underground mines is subject to the approval of the Technical Inspectorate. This provision does not apply to rescue or fire fighting operations.

The use in underground mines of engines driven by liquid gas is prohibited.

Testing and Certification Procedures of Engine and Auxiliary Equipment

48. An engine-driven vehicle or equipment type may be taken into regular use in the mine provided that it fulfils the requirements set forth in the present resolution and has been approved by the mine inspector. Such approval shall include a definition of the nature of use that the vehicle or equipment has been approved for.

49. In the inspection and maintenance of vehicles and equipment the instructions and recommendations of the manufacturer shall be complied with. Directions for the use and maintenance of the vehicles and equipment shall be available in both Finnish and Swedish.

The mine operator shall in writing assign to each vehicle a tender to maintain and inspect the vehicle at fixed intervals and to be responsible for the fact that the vehicle is in the required condition.

Fuel Quality Specifications

60. The sulphuric content of the combustible shall be as low as possible.

Engine Emission Control Requirements

62. Efforts shall be made to keep the CO content of the exhaust gases of overhauled engines below 600 ppm and their soot content below one Bosch unit. For a fully loaded engine the corresponding values should be less than 800 ppm and two Bosch units. The engine may be kept in use for as long as the exhaust content of soot does not exceed by more than 50 pct and that of CO by more than 25 pct the values mentioned before. After this, the engine must be overhauled.

If the engine exhausts do not fulfill the requirements set forth in section 1, the engine shall have to be equipped with an exhaust cleaner.

The provisions of sections 1 and 2 do not apply, however to low-powered engines and to vehicle motors used temporarily or briefly in the mine.

The repair shop or space where test running is to be performed shall be provided with sufficient ventilation and, if necessary, with exhaust gas removal equipment.

Procedures and Frequency of Testing Engine Exhaust Gases

62. The condition of engines used regularly in underground mines shall be checked by measuring the exhaust soot and CO contents after every 150 hours of use, however, at least every second month.

Mine Air Quality and Quantity Requirements

50. Ventilation shall in underground mining be arranged in such manner that the air is as fresh as possible and sufficiently oxygenous so that there will be no transgression of the maximum content limits for toxic substances in working place air as sanctioned by the Ministry of Health and Social Affairs.

Taken into consideration in the planning of the general outlines of ventilation in mines shall be, in addition to exhaust and explosion gases, the dust problems caused by the nature of rock, if any, the possibility of radon occurrence, and fire protection.

Exhaust air shall be led out in a way to prevent its content of dust, radon and other impurities to cause a health risk to workers or surroundings.

Procedures and Frequency of Testing Mine Air Quality and Quantity

51. In working places, where there is a considerable occurrence of exhaust gases, explosion gases, dust or other noxious agents, the contents of substances detrimental to health shall be measured at regular intervals.

The measurements shall be performed so as to produce a representative sample of inhaled air. If there is a significant change in ventilation conditions, the contents of impurities in the air shall be immediately checked.

52. If in any part of the mine the maximum contents referred to in 50 are exceeded, the works in progress in the place in question shall be immediately interrupted until the content of noxious air substances has sufficiently declined.

If the values exceeding maximum contents are not to be reduced in reasonable time, stay and work in the affected area is nevertheless temporarily allowed provided that efficient respirators and breathing apparatuses are used.

Of the measurements a record shall be kept, in which entries shall be made of the measurement performed, its results and subsequent action taken.

Noise Standards

Not specified in available literature.

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FRANCE

Types of Engines Permitted

Title III – Liquid Fuel Engines (51)

Article 60. The engine of liquid fuel vehicles must be able to withstand exposure to air containing firedamp nor suffer deterioration capable of igniting the ambient atmosphere.

Article 61. The engine must not contain any ignition device.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Title III – Liquid Fuel Engine (51)

Article 60. To permit verification that the above condition is well satisfied, the manufacturer must produce, in support of his application, the calculations justifying the dimensions of the various engine components and indicate especially the values of the expected pressures and the safety factors employed.

Article 74. Except for equipment not subject to the order of approval, each device supplied must carry, in a visible and durable fashion, either directly on it, or on a plate permanently attached to it, the following information:

- (1) The manufacturer's name
- (2) The designation of the type of equipment
- (3) Reference to the order of approval
- (4) The serial number

Affixing a serial number is not required for portable electric lamps, cable lead-ins, shut-off parts to cap, cable lead-ins, intervening parts located between a principle casing and the adjacent parts, and connection devices.

Article 75. The equipment covered by preceding Titles I, II and III constructed in total or in part with light alloys containing more than 6 pct magnesium is not capable of approval, unless it is contained within an explosion-proof (fire proof) envelope or protected by insulation under the conditions provided for by the present rule.

However, a list of certain measuring devices, and eventually, the conditions of their use as established by official decisions, will be able to be granted exceptions to the preceding paragraph.

Article 271. In mines containing firedamp the engine must be of a type approved for operation in an atmosphere containing fire damp and the firedamp content must not in any case exceed 1 per 100 at any point along their course.

The approval of the engine types is determined by the ministry as provided for in paragraphs 2 and 3 of article 308*. The conformance of engines to an approved standard must be certified and their maintenance insured by the conditions defined by article 309* and paragraphs 1 and 2 of article 310*.

Article 265. The use of liquid fuel engines in underground works must be preceded by a declaration to the chief mining engineer of their conditions of use. All notable modifications to these must also be the subject of a complementary notification without delay.

Fuel Quality Specifications

Section III – Liquid Fuel Engines (51)

Article 266. The combustible must have a flashpoint greater than 50°C. It must not be transported below except in metallic cylindrical barrels or in tank cars and may not be stored below.

Engine Emission Control Requirements

The available regulations do not specify limits on contents of the exhaust gas. However, quite a bit of detail is given on the physical makeup of the exhaust device.

Title III – Liquid Fuel Engines (51)

Article 62. The air admission and exhaust devices must consist of a stack of small plates conforming to the following conditions:

(1) The plates measure a minimum of 50 mm in depth (in the direction of flow) and a minimum of 2 mm in thickness;

(2) The maximum space between two adjacent plates is 0.8 mm; the spacing is insured by bosses or by lands integral with the plates; these lands or bosses are the same depth as the plates and are close enough together so that the space between the plates cannot be distorted, by an elastic deformation, to a value greater than those indicated above. When the spacing bosses or lands are penetrated by assembly screws, bolts or pins, the joint at the right angles with these between the boss and land of one plate and the adjacent plate, must not be less than 10 mm in radial length from the edge of the penetration.

(3) The means of assembling the plates in a particular stack must render impossible any assembly error which would result in the enlargement of the space between two adjacent plates;

(4) All the constituent parts of the stack of plates, as well as the surfaces of the exhaust apparatus in contact with the stacks of plates, must resist the action of corrosive agents to which they will be exposed in the course of normal operation of the machine.

(5) The plates must, under all circumstances, be protected from shock.

Article 63. The exhaust gases must be cooled, before being discharged into the air, by water spray, by sparging, or by any other effective method.

If the zone where the previous cooling process occurs is upstream of the stacks of plates, it must be designed to resist the corrosive actions to which it will be subjected.

Article 64. If the admission apparatus includes a throttle (butterfly valve damper) enabling one to close the air entrance, this throttle must not be capable of being operated unless the fuel admission is shut off.

Article 65. The passages and chambers between the admission and exhaust apparatus in which the gases and exhaust circulate must comply with the specifications of articles 66 to 72 which follow and must be tested under the conditions specified by articles 15 to 18*.

Article 66. The parts of the chamber must be assembled without the interposition of plastic gaskets, the presence of which is only tolerated to assure water-tightness of the cavities containing a liquid.

Article 67. The length "P" of the assembly joints of the constituent parts of the chamber must not be less than 25 mm.

In the case of screw threads, the length "P" of the joint is conventionally valued at one and a half times the length of the engaged threads measured along the axis of the screw. In any case, a minimum of four threads must be engaged along the length being considered.

Article 68. The holes pierced in the assembly joints of the chamber to receive the screws, bolts or pins must be distributed so that the effective length "d" of the joint at right angles to these holes is not less than 10 mm.

Article 69. The spacing "i" between the two faces of the joint in the case of assembly in a plane, or the difference in diameter of male and female pieces in the case of a cylindrical joint, must not be greater than 0.5 mm.

Article 70. All moving parts which penetrate the walls of the chamber must be guided along a length of at least 25 mm; the maximum play between the moving part and its guide must not be greater than 0.5 mm.

When the moving part and its guide are restrained by two parallel circular cylinders, the difference in the diameter of the two cylinders must not be greater than 0.5 mm.

Article 71. No bolt or screw hole must penetrate the walls of the chamber.

This order does not apply however to holes tapped for the purpose of the introduction and discharge of liquids necessary for the functioning of the engine and which, under normal operation, are shut off by a threaded plug.

All pins which penetrate the casing must be made integral.

Article 72. Article 14 is applicable to the chamber parts.

Article 73. The parts whose setup affects safety, other than those pertaining to the chamber, for example the cap of the fuel reservoir and the threaded plugs sealing the admission parts for the light fuses, must not be removable except by the use of a special key.

Procedures and Frequency of Testing Engine Exhaust Gases

Not specified in available literature.

Mine Air Quality and Quantity Requirements

Section III—Liquid Fuel Engines (51)

Article 269. The management of the ventilation must be such that in every gallery, traversed by the engines the carbon monoxide, calculated as a function of the quantity of this gas discharged by the

engines in service in this section and upstream, is less than two parts per 100,000.

In recognition of the difficulties presented by the analysis of exhaust gases in the case of operation under full load for mines not equipped for such analysis, the ministry letter 1G/HSM #110 of October 18, 1955* allows that periodic measurements at maximum no load speed, assuming as the basis of calculation the carbon monoxide output at maximum no load speed increased by 0.8 cm³ per second per effective horsepower of the "locotracteur."

For the sections of gallery where the firedamp content is not zero, it is well to bear in mind the fact that the presence of firedamp in the air supply of a "locotracteur" considerably increases the output of carbon monoxide.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Not specified in available literature.

Noise Standards

My decree of 4 September 1978 which was published in the Official Bulletin of 20 September 1980 established the list of jobs requiring special medical supervision in mining and similar operations. In the mines, such workers necessarily fall under the social security system. For the first time, this decree, in regulation applicable to mining and similar operations, set forth provisions related to noise, since individuals employed in jobs where they are exposed to a sound level above 85 db (A), called high noise level jobs, are henceforth subject to this medical supervision (52).

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HUNGARY

The following information on Hungary was supplied by the National Mine Engineering Inspectorate (53).

Types of Engines Permitted

The Mine Authority does not grant any license for types of diesel engines.

The drilling-, breaking- and loading-machines and also the mine locomotives and transporting and towing trucks of free-wheel are bound of licensing only if the output of the driving motor of internal combustion and underground operation is over 5 kW.

In gassy mine plants only damp-proof diesel engines (hereinafter: motors) should be employed. The motor to be stopped and its electric equipments to be disconnected when the pit gas (methane = CH₄) of the mine air reaches 1 pct.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Only those motors having fuel tanks protected against mechanical and heat effects and also well closed can be used. Their openings' (studs) structure will prevent the outflow and leakage of the fuel stored in the fuel tank in any working position of the machine. The inlet of the fuel tank should either prevent the

overflow or ensure that the fuel shouldn't reach the hot or easily not accessible machine parts in case of overflow.

The fuel pipes must be protected against mechanical and heat effects. It must be secured that the fuel should not be discharged out of the fuel tank in case of damages in the fuel pipes. One should take care of and provide for a device which will prevent unauthorized persons to start the motors.

The machine driven by the motor to be provided either with min. 1 pct. of foam fire extinguisher of 12 kg or with a fire extinguisher filled with CO₂ of 5 kg's. On self-propelled machines a CO₂ fire extinguisher with min. filling of 2 kg to be also attached which can be operated from the driver's cabin.

Fuel Quality Specifications

There is no regulation by the Mining Authority for the fuel quality of the diesel engine.

Engine Emission Control Requirements

The exhaust gas to be cooled, the temperature of its external pipe plate should not exceed 200° C. The outlet of the exhaust gas to be formed in such a way that the exhaust gas should not hazard the operational personnels. A gas scrubber to be built in the exhaust system.

The CO contents of the exhaust gas must not exceed 0.2 percent by volume and also its NO_x contents the 0.05 percent by volume and its temperature the 70° C at the outlet.

Procedures and Frequency of Testing Engine Exhaust Gases

The temperature and the CO and NO_x contents of the exhaust gas to be checked up before the first starting-up and further on quarterly.

Mine Air Quality and Quantity Requirements

The contents of the mine air is adequate if:
 its O₂ (oxygen) contents is min. 19 pct;
 its CO₂ (carbon dioxide) contents is max. 1 pct;
 and its toxic gas contents – as a technical trend concentration – will not exceed the following values:
 0.005 pct (57.0 mg/m³) in case of CO (carbon monoxide);
 0.001 pct (13.9 mg/m³) in case of H₂S (hydrogen sulfide);
 0.0005 pct (13.1 mg/m³) in case of SO₂ (sulfur dioxide);
 0.0005 pct (9.4 mg/m³) in case of NO_x (nitroso-gases).

The virtual temperature of the air at the job site should not exceed 26° C.

The control does not include directly the quantitative requirements but indirectly yes; in the regulations of the permissible minimum and maximum airflow speed for each mine fields and working places.

Procedures and Frequency of Testing Mine Air Quality and Quantity

The CO and NO_x contents of the air to be measured weekly at the mining fields of separate ventilation if equipments of diesel motor are used there.

The CO contents of the extraction air of the broken fields to be measured with a CO-measuring automatic instrument of continuous operation at those locations, where this content is expectedly the highest if there are many motors under operation on that field.

Noise Standards

The Hungarian Standard comprised the following regulations for the acceptable noise level of the job site:

to prevent any hearing loss the noise level hit the workers on noisy job site must not exceed the following values:

85 dB (AI) for the "A" equivalent level and
 max. 125 dB (AI) for pulse type noises.

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INDIA

The following information on India was extracted from "By-laws for Diesel Vehicles" (54). These conditions have not been passed as a law in the country, but are normally imposed on a colliery that seeks permission for the use of shuttle cars in underground mines.

Types of Engines Permitted

20. Engine

Fuel injectors, fuel pumps, or other parts of the fuel injection system, when found to be faulty, shall be replaced with exact duplicates of original equipment and set so that the maximum fuel injection rate is not changed. The fuel pump shall be adjusted properly for the altitude at which the engine is operated as recommended by the manufacturer and the governor setting shall be sealed.

Testing and Certification Procedures of Engine and Auxiliary Equipment

2. Approval of Chief Inspector of Mines

Every diesel vehicle shall be of a type approved by the Chief Inspector of Mines.

7. Examination of Diesel Vehicles

(1) Once at least in every working shift, every diesel vehicle shall be examined by a competent person.

(2) Once at least in every seven days every diesel vehicle shall be examined by an engineer who shall ensure that –

(a) every part requiring to be cleaned is properly cleaned;
 (b) all engine intake and exhaust parts, electrical headlights and all other equipment are in safe operating condition;

(c) there are no unprotected openings in any part of the engine intake or exhaust system between the intake flame arrester and exhaust flame arrester;

(d) all bolts, nuts, screws and other means of fastening enclosures are in place, properly tightened and secured; all screw

covers are kept locked or sealed and the fastenings for the engine cylinder head, intake and exhaust systems are in place properly tightened and secured;

Note: The key or sealing tool shall be only in the care of the engineer or any other specially authorized person.

(3) Every person making an inspection as aforesaid shall forthwith record the result thereof in a bound paged book kept for the purpose and shall sign and date the same.

Fuel Quality Specifications

24. Fuel Oil, Its Transport and Storage

(1) The fuel oil used in the diesel vehicle shall conform to the specifications for diesel fuels as laid down under IS: 1060-1959, or to such other specifications as may be recommended by the manufacturer. The flash point of the fuel shall not be less than 140° F and the sulphur content shall not be greater than 0.5 percent by weight. The fuel shall be kept clean and free from dirt and water.

Engine Emission Control Requirements

12. Ventilation

(5) The engine of a diesel vehicle shall not be kept running when the vehicle is stationary except –

(a) during brief halts while in use, and
 (b) while being tested.

(6) The diesel vehicle driver shall cut off the supply of fuel to the engine –

(a) during every break of operation; and
 (b) if fire is suspected.

13. Exhaust Gases

(1) No diesel vehicle shall be run if the gas emitted from its exhaust contains more than 0.2 percent by volume of Carbon monoxide or 0.1 percent by volume of Oxides of Nitrogen.

14. Flame Traps etc.

(1)(a) The flame trap or traps fitted to the engine inlet shall be carefully attended to and cleaned at intervals fixed by the manager in consultation with the Regional Inspector and the baffle plates shall be renewed as often as may be necessary.

(b) The conditions of the intake flame arrester shall be determined by reading the intake vacuum in millimeters of water on a manometer while the engine is running at full speed and no load, with the diesel vehicle parked. After taking manometer readings, the intake vacuum test plug shall be replaced and sealed to avoid the equipment becoming unsafe.

(2) The flame arrester fitted to the exhaust opening of the diesel vehicle shall once at least in every 24 hours during which the engine has been run, and more often if necessary, be thoroughly cleaned or replaced by a like device in clean condition.

A record of every such cleaning or replacement shall be kept in a bound paged book kept for the purpose.

(3) When the flame trap or arrester is dismantled for cleaning, the plates shall be reassembled carefully to maintain the original proper spacing.

(4) A spaced flame arrester shall be so mounted in the equipment assembly that it is protected from accidental external damage.

(5)(a) When in lieu of a spaced plate flame arrester an exhaust gas cooling-box or conditioner has been fitted as exhaust flame arrester, the cooling box shall be equipped with a device to shut off automatically the fuel supply to the engine at a safe minimum water level and when the final exhaust temperature exceeds 185° F.

(b) A provision shall be made to prevent restarting of the engine after the fuel supply has been shut off automatically until the water supply in the cooling box has been replenished.

15. Exhaust Cooling System

(1) Every diesel vehicle shall be provided with a cooling system for the engine exhaust gas. The heat dissipation capacity of the cooling system shall be capable of reducing the temperature of discharge from the cooling system under any condition of engine operation.

(2) The exhaust gas cooling box shall be drained, flushed and inspected at regular frequent intervals fixed by the manager in consultation with the Regional Inspector of Mines, and cleaned when necessary.

(3) The conditioner and the make up tank shall be filled up with clean water at the beginning of each shift.

16. Intake System

(1) Free flow of air to the intake shall not be restricted in any way. The maximum pressure drop through the intake system at full throttle, no load, shall not exceed the figure specified by the manufacturer for the maximum engine R.P.M.

Note:- Never use more oil in the cleaner than is specified by the manufacturer.

17. Exhaust System

The exhaust piping shall be kept tight at all times, and shall not be restricted by foreign material. The maximum pressure drop through the exhaust at full throttle, no load, shall not exceed the figure specified by the manufacturer for the maximum engine R.P.M.

Procedures and Frequency of Testing Engine Exhaust Gases

18. Air Samples

(1) Samples of the exhaust gases from every diesel vehicle when running on—

(a) full load at maximum speed; and

(b) no load at normal idling speed, shall be taken and analysed once at least in every 30 days.

Mine Air Quality and Quantity Requirements

12. Ventilation

(1) The diesel vehicle shall not be used in any place unless more than 170 cubic metres of fresh air per minute is passing through the place.

(2) When the diesel vehicle is run at any place inbye of the last ventilating connection, the volume of fresh intake ventilation specified above shall be circulated by an auxiliary fan specially installed for the purpose or by any other suitable means approved by the Chief Inspector of Mines.

13. Exhaust Gases

(2) If at any place in a mine in which diesel vehicle works or runs, there is found in the general body of air an amount Carbon monoxide 0.005 percent by volume or an amount of Oxides of Nitrogen exceeding 0.002 percent by volume, immediate steps shall be taken as would be necessary to improve the ventilation so that the percentages of Carbon monoxide and Oxides of Nitrogen are not exceeded.

(3) If at any place in a mine in which a diesel vehicle works or runs, there is found in the general body of the air an amount of Carbon monoxide exceeding 0.01 pct by volume, or an amount of Oxides of Nitrogen exceeding 0.004 pct by volume no engine of diesel vehicle shall be run at that place or at any other place at which such running could affect the ventilation of the first mentioned place. The running of the diesel vehicle may be resumed only after it has been determined that the amount of Carbon monoxide and that of Oxides of Nitrogen in the general body of the air at the first mentioned place does not exceed 0.005 pct and 0.002 pct respectively by volume.

27. Precautions Against Coal Dust

No diesel vehicle shall be used on any roadway or part thereof, unless the percentage of incombustible matter (including moisture) in dust samples which shall be taken from that roadway or part once at least in every seven days is more than 80 pct, or the workings are naturally wet. A record of every such sample shall be recorded in a bound paged book kept for the purpose.

Procedures and Frequency of Testing Mine Air Quality and Quantity

12. Ventilation

(3)(a) Once at least in every week the amount of air passing in every roadway in which vehicles are used shall be measured by a competent person at the following points—

(i) at each end of the roadway or part thereof on which diesel vehicle is used; and

(ii) at such other points as may be fixed by the manager with the approval in writing of the Regional Inspector.

13. Air Samples

(2) Once at least in every week separate samples of the general body of the air shall be taken—

(a) at a point at end of every length of road in which any diesel vehicle runs;

(b) at such other suitable points as may be fixed by the manager;

(c) at any place and time as may be specified by the Regional Inspector of Mines by a notice in writing served on the manager requiring him to appoint the place and time specified in the notice either instead of or in addition to any place and time already appointed by the manager.

The above samples shall be taken at such times as may be appointed by the manager so as to secure the detection of any harmful concentrations of Carbon monoxide and Oxides of Nitrogen produced by any diesel vehicle.

(3) Every sample taken in pursuance of clauses (1) & (2) of this condition shall within four days (without taking into account any

rest day or day of general holiday) of taking thereof be analysed to determine the percentages of Carbon monoxide and Oxides of Nitrogen therein, and particulars of each such analysis shall be recorded forthwith in a book specially kept for the purpose.

26. Determinations of Firedamp Content

(1) Determination of the firedamp shall be made,

(a) by means of an apparatus of a type approved for the purpose by the Chief Inspector of Mines by a competent person appointed for that purpose by the manager of the mine, or

(b) by means of samples of air taken by a competent person so appointed and analysed within four days (without taking into account any rest day or day of general holiday) of the taking thereof.

(2) Determination of the fire-damp content shall be made,

(a) at a point at each end of every length of road in which any diesel vehicle runs; and

(b) at such other suitable points as may be fixed by the manager.

(3) An inspector may, if he is of opinion that any point fixed in pursuance of sub-clause (b) of clause (2) of this condition is unsuitable, serve on the manager a notice requiring him to fix some other point in substitution thereof, and may serve on the manager a notice requiring determinations to be made at any other point specified in the notice in addition to those required by the preceding clause.

(4) Determinations of the firedamp content shall be made at every point required by or under the last preceding conditions, once in every week at the time when the firedamp content is likely to be greatest:

Provided that—

(a) if any determination at any such point shows a firedamp content exceeding 0.8 percent by volume, determinations shall be made at that point at intervals not exceeding 24 hours so long as the content is shown to exceed or to have exceeded that percentage and for the seven next following working days;

(b) if every determination made during a period of thirty days at any such point showed a firedamp content not exceeding—

(i) in the case of point in any other length of road not ventilated by air which has ventilated a working face 0.2 percent by volume;

(iii) in the case of point in any other length of road. 0.6 percent by volume.

it shall be sufficient to make determination at that point at intervals not exceeding 30 days for so long as the firedamp content shown thereby does not exceed that percentage.

(5) Notwithstanding anything contained in clause (4), whenever any alteration is made in the arrangements for ventilating a mine which affects or may affect substantially any length of road in which determination of firedamp content are required to be made a determination of the firedamp content at each point in that length shall be made as soon as any substantial effect of the alteration is apparent.

(6) Where a determination of the firedamp content is made by means of a sample of air, it shall be deemed to be made at the time and place at which the sample is taken.

27. Precautions Against Coal Dust

No diesel vehicle shall be used on any roadway or part thereof, unless the percentage of incombustible matter (including moisture) in dust samples which shall be taken from that roadway or part once at least in every seven days is more than 80 pct, or the workings are naturally wet. A record of every such sample shall be recorded in a bound paged book kept for the purpose.

Noise Standards

Not specified in available literature.

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IRELAND

At present there are no gassy mines in Ireland. Only 5 of the mines have diesel engines underground, totalling 194 engines with a gross horsepower of 22,470 (55).

Types of Engines Permitted

Every mechanically propelled vehicle⁹ in which the motive power is generated by an internal combustion engine shall be constructed so that air entering the engine is cleaned, the exhaust gases are cooled (where necessary) and diluted and the emission of flame or sparks from the vehicle is prevented (56).

Testing and Certification Procedures of Engine and Auxiliary Equipment

Not specified in available literature.

⁹Also pertains to locomotives (57).

Fuel Quality Specifications

Oil shall not be used for supplying motive power to any diesel engine of a mechanically propelled vehicle which does not comply with the standard specified for Class A1 fuels in the "British Standard (Fuels for Oil Engines)" as published by the British Standards Institution (56).

Engine Emission Control Requirements

A diesel engine of a mechanically propelled vehicle shall not be allowed to run below ground in a mine if gas from its exhaust is found to contain more than two parts of carbon monoxide or one part of oxides of nitrogen per thousand (56).

Once in every 24 hours each mechanically propelled vehicle shall be examined externally by a competent person who the manager of the mine shall appoint in writing.

At least once in every 7 days each mechanically propelled vehicle shall be examined by a competent person so appointed who when examining the vehicle shall ensure that every part requiring to be

cleaned is properly cleaned, and the vehicle is in all respects in proper working order (56).

A mechanically propelled vehicle shall not be used in a mine if it is not properly maintained (56).

Any protective device fitted to an exhaust opening of a diesel engine of a mechanically propelled vehicle shall be thoroughly cleaned, or replaced by a like device in clean conditions, whenever necessary, and in any event not less often than once in every period of twenty-four hours for which the engine has been run or if, in relation to any specified device, the manufacturer has specified a period in that regard, not less often than once in every period so specified (56).

Control of exhaust fumes is required and this is accomplished with Olin-Mathieson Diluters mainly, and a few catalytic-type scrubbers (55).

Procedures and Frequency of Testing Engine Exhaust Gases

At least once in every three months a sample of the gas from the exhaust of each diesel engine of a mechanically propelled vehicle in use below ground in the mine shall be taken and tested and such sample shall be taken while the engine is being run both at maximum speed on full load and at normal idling speed on no load (56).

Mine Air Quality and Quantity Requirements

Where in any place below ground in a mine in which diesel vehicles are in use, there is found in the air a concentration of carbon monoxide greater than fifty parts per million the following provisions shall apply—

(a) in case the concentration is greater than one hundred parts per million, the operation of every diesel vehicle in or near the place

shall be discontinued until it is determined that the concentration of carbon monoxide in the air in the place does not exceed fifty parts per million, and

(b) in any other case, immediate steps shall be taken to disperse the concentration (56).

Ventilation in the working area is calculated on the basis of 100 cu. ft. per minute per H. P. of each diesel engine (56).

Procedures and Frequency of Testing Mine Air Quality and Quantity

(2) A sample of the air at each appointed place shall be taken and tested at least once in every month.

(3) Particulars of the test of each sample of air or gas taken in pursuance of this regulation shall be recorded in a book in the form, and shall contain the particulars specified in Part V of the Schedule to these Regulations. The said book shall be provided by the owner of the mine and kept readily available at the mine (56).

Noise Standards

Not specified in available literature.

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JAPAN

The following regulations for Japan (58) are specifically related to testing of the diesel engine.

Types of Engines Permitted

Not specified other than the following:

2. Testing method:

2.1.6 Engine proper:

(1) The joining of both intake-air line and the exhaust system to the engine and manifold should correspond to JISC-0901*.

(2) The fixing points where flame might escape such as cylinder head cover, manifold, etc. should be of shrouding construction.

(3) Packings which can be extruded such as gasket should not be used.

Testing and Certification Procedures of Engine and Auxiliary Equipment

1. General

1.1 This testing method will be applied for the Diesel Engine installed on Locomotives, Loading Machines, Drilling Equipment, Heading Machine and other transportation machines to be used in

coal mine where mainly CH₄ and flammable gas or explosive coal dust might be existing.

1.2 Kinds of tests:

The following tests will mainly be done—

- (1) Construction test including functioning test
- (2) Strength test
- (3) Safety test (flashing test and exhaust gas analysis)
- (4) Temperature test

2. Testing method

2.1 Regarding the test for the construction and the Engine as a whole, the materials, construction and functioning will be checked on the actual goods, drawings and instructions. The following items are checked in detail:

2.1.1 Intake-air line:

(1) The system should be air-tight construction (excluding air filter) against an internal pressure of 8 kg/cm², and to be free from leakage.

(2) The joints in the line should be metallic flange. The gas or depth of gap should apply correspondingly to JISC-0901. Where packings are used, they should not be like gaskets which can be extruded out. The bolt of the joints should be of shrouding construction.

(3) The intake-air line should have a flame arrestor to prevent the flame from the engine interior or the high temperature fine grain igniting the combustible gas. The flame arrestor should be easy to check, repair, clean and exchange, and it should be of sturdy construction and installed in a place where it cannot be easily damaged.

In case the flame arrestor is of lamina-protected construction, it shall be according to one of the following:

(a) Corresponding to the lamina-protected construction as specified in JISC-0901.

(b) If it is of another construction, its safety will be confirmed according to test.

(4) In the Intake-air line, an air filter should be installed in front of the flame arrestor.

(5) An air stop valve should be installed in the Intake-air line.

2.1.2 Exhaust line:

(1) Same as air supply system (1).

(2) Same as air supply system (2).

(3) Same as air supply system (3).

(4) Scrubber for exhaust gas should be provided.

(5) Insulation material should be treated to prevent oil absorption.

(6) Exhaust gas pipe should be installed properly, so that the exhaust gas does not harm person.

(7) In case the collection of exhaust gas is provided, it must be firmly fixed by shrouding construction.

2.1.3 Fuel line:

(1) The fuel tank should be leak-proof steel construction having over 2 mm thickness or equivalent.

(2) The supply of fuel to the fuel tank should be possible only via an automatic closing valve.

(3) The fuel tank should be anti-corrosive.

(4) When special glass is used for the gauge, it should be specially protected against damage.

(5) The fuel tank should be at least 30 cm away from the exhaust system.

(6) The fuel pipe should be of leak-proof construction and of copper.

(7) The fuel pipe should be at least 25 cm away from the exhaust system.

(8) Soldering should be of steel quality.

(9) The fuel volume injection regulator should be set at maximum (injection volume) and sealed.

2.1.4 Cooling system:

(1) Water tank, injection nozzle, pump and other pipings should be of anti-corrosion material.

(2) A suitable filter should be installed at the tank inlet and injection pump inlet.

(3) The final temperature of the exhaust gas should not exceed 70° C.

(4) The water used in the injection should be sufficiently filtered and a pressure gauge for the water injection should be installed in the operator's cabin.

(5) A water level gauge should be installed in the operator's cabin.

2.1.5 Automated fuel cut-off device:

A device should be provided so that, when the exhaust gas exceeds 70° C, the fuel supply is automatically stopped and the engine stopped.

The automatic fuel cut-off device should be a combination of (a) and (b).

(a) activated by the temperature change in the exhaust gas

(b) dropping of water level in the level tank or abnormality in the injection pressure or other effective methods.

2.1.6 Engine proper:

(1) The joining of both Intake-air line and the exhaust system to the engine and manifold should correspond to JISC-0901.

(2) The fixing points where flame might escape such as cylinder head cover, manifold, etc. should be of shrouding construction.

(3) Packings which can be extruded such as gasket should not be used.

2.1.7 Attached electric apparatus:

Each electric apparatuses are examined based on Test Standard.

2.1.8 Gauges:

The following gauges should be provided and these can be seen easily during operations.

Exhaust gas thermometer

Fuel tank oil level gauge

Water tank level gauge

Cooling water thermometer

Water injection pressure gauge

Lubricating pressure gauge

2.1.9 Extinguisher:

(a) Extinguisher should be provided.

(b) In case the Extinguisher is to be provided with the Engine and either Intake-air line or Exhaust line, it should be operated easily and it should be protected from damage.

2.2 Strength test

2.2.1 Intake-air line (excluding air filter)

Explosion test will be made in an intake-air line by mixture of air and 9.5%-10.5% volumetric methane gas, then inspect whether deform or damage of both connection part and flame arrestor occurred or not.

The test will be made 10 times and, if deform or damage is observed, no approval is given.

2.2.2 Exhaust gas line (without water in the scrubber):

Explosion test will be made in an exhaust-gas line by mixture of air 9.5%-10.5% volumetric methane gas, then inspect whether deform or damage of both connection part and flame arrestor occurred or not.

The test will be made 10 times, if deform or damage is observed, no approval is given.

2.2.3 Fuel line:

The fuel tank and pipe line should withstand the pressure test according to the following expression, and to be free from deformation and leakage.

$$P = H \times S \times 6 \times 10^{-4},$$

where P = Test pressure, kg/cm²,

H = Height of fuel tank, or lowest point of fuel pipe to the highest point of the fuel tank,

and S = Fuel used, kg/m³.

2.2.4 Attached electric apparatuses:

Electric apparatuses attached should apply correspondingly to the Flame-proof Test Regulations.

2.3 Explosion and ignition test

2.3.1 Intake-air line: (excluding air filter)

Explosion test is made with mixture of air and 8-10% volumetric methane gas filled inside of an intake-air line and check whether flame escape can be seen or not. This test is allowed even for one time.

2.3.2 Exhaust line (without water in the scrubber)

The exhaust line is filled with a mixture of air and 8% or 10% volumetric methane gas and ignited and made to explode to examine the escape of flame. This test is repeated over 15 times and flame should not escape even once.

2.3.3 Engine proper

The engine will be operated at maximum nominal capacity and when all parts of the engine have reached a uniform temperature, the following tests will be made. However, the mixed gas surrounding the engine is in a static condition.

In a test chamber filled with a mixture of air and 8% or 10% volumetric methane, the engine is operated for 20-30 minutes and examination will be made to see whether the mixed gas outside the engine is ignited.

In this case, the inlet line and outlet line should be isolated completely from the mixed gas.

2.3.4 Attached electrical equipment

The respective test methods for electrical equipment will apply.

2.4 Temperature test

2.4.1 When engine is operated at full capacity until all parts of engine, exhaust line and cooling system reach uniform temperature, the final temperature of the exhaust gas should not exceed 70° C.

2.4.2 The surface temperature of the engine and its accessories when the engine is operated at maximum nominal capacity until the

temperature is kept static, the temperature is measured. The cooling system can be operated but the surrounding air should be kept static.

An inlet and outlet of the exhaust gas manifold, surface of the engine, flame arrestor and all other parts which are apt to come in contact with the air underground should not exceed 160° C.

Fuel Quality Specifications

Not specified in available literature.

Engine Emission Control Requirements

2.1.2 Exhaust line:

(4) Scrubber for exhaust gas should be provided.

(5) Insulation material should be treated to prevent oil absorption.

(6) Exhaust gas pipe should be installed properly, so that the exhaust gas does not harm person.

2.5.2 Dilution of exhaust gas

Exhaust gas to be discharged after the water scrubber must be in the following condition.

CO under 1,200 ppm (volume)

NO₂ under 1,000 ppm

Procedures and Frequency of Testing Engine Exhaust Gases

2.5.3 Taking of exhaust gas samples

The exhaust gas samples will be taken the following operation condition of the engine.

(a) at lowest speed and without load

(b) at highest nominal speed and maximum nominal capacity

(c) at highest nominal speed and 50% of maximum nominal capacity

(d) at highest nominal speed and minimum capacity

In this case, specified concentration of methane gas should be mixed in an intake-air line. These figures will be determined by the Mine Safety Dept. of the government authorities in Hokkaido after the application for the use of Loco Underground is submitted by Taiheiyo. In each of these tests, the sampling of exhaust gas will be taken from in the exhaust gas pipe when the engine has reached an uniform temperature.

Mine Air Quality and Quantity Requirements

Not specified in available literature.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Not specified in available literature.

Noise Standards

Not specified in available literature.

Contact: Hisashi Oki, Director
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MEXICO

The following regulations for Mexico were extracted from its "Safety Regulations for Working Mines" (59).

Types of Engines Permitted

Art. 132—Diesel machines are equipped with motors of the compression-ignition type.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Not specified in available literature.

Fuel Quality Specifications

Art. 132—Diesel machines are designed to operate solely on diesel fuels whose ignition point is no lower than 60° C.

Art. 133.—The diesel fuel shall not contain more than 1.5 pct by weight.

Engine Emission Control Requirements

Art. 132—Exhaust gases from these machines shall pass through a purifying device before being discharged into the atmosphere of the mine. Temperature of the exhaust gases shall not exceed 82° C at the point of exit from the purifier.

Art. 134—The exhaust pipe shall point towards the floor and shall be located at the point farthest removed from the operator.

Art. 140—Concentrations of toxic gases in the exhaust shall not exceed the following limits in volume:

Carbon monoxide	0.25%
Nitrogen dioxide	0.10%
Sulfur dioxide	0.10%
Aldehydes	0.001%

Procedures and Frequency of Testing Engine Exhaust Gases

Art. 139—Samples of the exhaust gases shall be taken no more than 30 centimeters from the exhaust outlet.

Mine Air Quality and Quantity Requirements

Art. 141—In the ambient atmosphere, the oxygen content shall be no less than 20% by volume and poisonous gases shall not exceed the following limits by volume:

Carbon dioxide	0.50%
Carbon monoxide	0.01%
Nitrogen dioxide	0.0005%
Sulfur dioxide	0.0005%
Methane	1.00%

Art. 135—In all work areas where diesel machines are used there must be adequate ventilation. Minimum air flow in those areas

must be 2.121 cubic meters per minute per brake horsepower; this quantity must be added to the quantity of air required for normal ventilation of the mine.

Art. 136 – When the diesel machines are in operation, minimum air flow must be 15.24 meters per minute.

Coal Mines

Art. 177 – The quantity of circulating air shall be sufficient for necessary respiration, for the dilution of gas methane and shall follow the following regulations:

(a) The minimum quantity of air shall be calculated by the largest number of workers per workshift, at the rate of 50 liters per worker per second. Each mule or horse should be counted as two men, and in the case of circular diesel locomotives, add 200 liters per second per horsepower; and,

(b) Methane content shall not exceed 1.0 pct in the exit and 1.5 pct in the partial current, and at work headings one meter from the face of the heading, and 30 centimeters from the ceiling or roof.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Art. 138 – In places where diesel units are operating, ambient air and exhaust gases shall be sampled periodically for nitrogen diox-

ide, sulfur dioxide and carbon monoxide and a record shall be kept of the results.

Coal Mines

Art. 178 – Measurements shall be made biweekly or more frequently, if necessary, of the volume of entering and exiting air from each sector of the ventilation system, as well as the temperature, relative humidity, and the percentage of methane in the air in all areas. The data obtained shall be recorded in a special notebook which shall be available to any interested person.

Art. 186 – Carbon mines shall have all necessary measuring equipment which will permit determination of ventilation and air conditions at any given moment.

Noise Standards

Not specified in available literature.

Contact: Ing. Guillermo P. Salas
Director General
Consejo de Recursos Minerales
Ninos Heroes No. 139
Mexico 7, D.F.

NEW ZEALAND

Types of Engines Permitted

Diesel engines – The Coal Mines Act generally prohibits the use underground of internal combustion engines, except for diesels (60).

Type of Engine (61)

Must be one that has received approval for use by:

- (a) Mines Dept. Queensland, Australia, or
 - (b) Dept. of Mineral Technology New South Wales, Australia,
- or
- (c) National Coal Board, UK.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Proof of approval by above organizations to be provided including original application material (61).

With the written approval of the Inspector, diesel internal combustion engines of a flame-proof type may be installed underground. The regulations specify the following guidelines to be observed when diesel engines are used underground (60):

i. No engine which has any defect which may affect its safe operation may be used.

ii. Diesel engines must be inspected by a person appointed in writing by the mine manager. The results of these inspections and the actions taken to remedy and defects must be recorded in a book, available at the manager's office.

Diesel engines must be daily examined by a competent person other than the driver, and at least once a week by a competent diesel engineer or mechanic. The results of these examinations must be similarly recorded in the book available at the manager's office.

Fuel Quality Specifications

Oil used for fueling diesels used underground must have a flash point of not less than 65.5° open cup as determined in the manner

indicated in the current British Standard Specification, shall not have a sulfur content of more than 0.5 pct by weight, and shall be free from water, sediment and dirt (60).

Engine Emission Control Requirements

If the carbon monoxide content or the nitrogen dioxide content is found to exceed 0.1 percent, the engine must not be used until the quality of the exhaust gases is brought within this limit (60).

4. Specified control measures (60)

ix. Diesels used underground must be fitted with exhaust scrubbers of a design approved by the Inspector. The tanks of exhaust gas scrubbers must be cleaned and filled with fresh water as often as is necessary to maintain efficient operation, but not less than once each working shift.

x. Diesel engine vehicles must not be left running while the vehicles are stationary, except for short periods of time not exceeding one minute.

xi. No diesel engine vehicle may be operated in a mine if the exhaust fumes contain black smoke.

Procedures and Frequency of Testing Engine Exhaust Gases

At least once in every 4 weeks, the undiluted gases of every diesel shall be sampled and analyzed. If the carbon monoxide content or the nitrogen dioxide content is found to exceed 0.1 percent, the engine must not be used until the quality of the exhaust gases is brought within this limit. The samples must be taken when the engine is being run at maximum speed on full load, and at idling speed on no load. A copy of each analysis must be forwarded immediately to the Inspector. At least every 6 months, a laboratory chemical analysis of undiluted exhaust gas samples must be carried out (60).

Mine Air Quality and Quantity Requirements

4. Specified Control Measures (60)

vi. Diesel engined vehicles must not be operated at any working place where coal is being produced, nor are they allowed beyond a point in the mines stipulated by the Inspector.

vii. Diesels shall be used underground only in intake airways where air for ventilation of the airways is drawn from the purest possible source and shall include, in addition to a supply of air sufficient for the maximum number of men employed in the mine at one time, a supply of air for any diesel-engined equipment operating in the mine of sufficient quantity to provide not less than 10,000 cubic feet per minute in the airway.

Diesels shall not be used in the airways if the general atmosphere contains more than:

- (a) 0.002% of carbon monoxide; or
- (b) 0.25% of carbon dioxide; or
- (c) 0.0005% of nitrogen dioxide; or
- (d) 0.0005% of formaldehyde; or
- (e) 0.5% methane

viii. Should the concentrations of gases referred to above be exceeded, immediate steps must be taken to disperse the concentrations and the engines shall not be operated until concentrations fall below the prescribed maximum limits.

Procedures and Frequency of Testing Mine Air Quality and Quantity

2. Frequency of contaminant sampling (60)

The regulations require the following tests be performed in regard to internal combustion engines used underground:

(a) Tests for carbon monoxide and oxides of nitrogen shall be made as often as may be required by the Inspector, but not less than once in each 24 hours.

(b) Tests for methane must be performed at least once in each working shift by a mine official, who must use a methanometer approved by the Inspector for the purpose of each test.

(c) Tests for carbon dioxide and formaldehyde must be performed as often as required by the Inspector, but not less than once in each week.

The results of these tests must be recorded by the person who made the tests and maintained in a record kept at the mine.

Noise Standards

Not specified in available literature.

Contact: Not provided.

NORWAY

Types of Engines Permitted

2.4 Requirements for Engines (62)

Gasoline driven engines will not be used in underground work. Other engine types should be used which pollute as little as possible (for example pre-chamber and rotary engines).

Engines will be kept in good condition with periodic maintenance. Special attention will be paid to the fuel system, nozzles and air filter.

Testing and Certification Procedures of Engines and Auxiliary Equipment

Not specified in available literature.

Fuel Quality Specifications

Not specified in available literature.

Engine Emission Control Requirements

2.4 Requirements for Engines (62)

Idling is to be avoided as much as possible. The same applies to cold start and warming up in mine spaces.

Exhaust gas will be led away so that it does not interfere with the driver and others in the vicinity. Vehicles with internal combustion engines will be equipped with fire extinguishing equipment when underground.

Procedures and Frequency of Testing Engine Exhaust Gases

Section 28

Diesel engines will be regularly inspected and maintained so that exhaust conditions are good (63).

Mine Air Quality and Quantity Requirements

Section 31 Gas and Dust Concentrations (63)

Gas and dust at the work place must be removed. If that is not possible, gas and dust contents in the air will be thinned so that the concentrations in inhaled air can be held below the administrative norms.

Regular control measurements will be taken where it is believed that damaging concentrations could be present.

Note: The norms of the Labor Inspection for air pollution are found in their own publication, "Administrative norms for air pollution in the working atmosphere" (Labor Inspection Order Nr. 361)(64). The norms are subject to continuous reevaluation.

Administrative Norms: TLV's (64)

Nitrogen oxide	25 ppm	30 mg/m ³
Sulfur dioxide	2 ppm	5 mg/m ³
Carbon monoxide	35 ppm	40 mg/m ³
Carbon dioxide	5,000 ppm	9,000 mg/m ³
Nitrogen dioxide	2 ppm	3.6 mg/m ³

Respirable quartz dust (<5 μm) (25%SiO₂+5)

Troublesome (nuisance) dust (total) 10

2.3 Measurements (62)

With the simultaneous presence of two or more damaging substances, there will be greater emphasis on their combined effect than on the individual effects that each could cause alone. Questions of this nature should be brought to the Industrial Hygiene Institute.

Oxygen content in the working air will normally be over 19%.

The temperature in working air will normally be below 30° C.

If it is not possible in practice to remove pollution, or thin it sufficiently, the workers will utilize approved personal protective equipment (for example passing through blasting dust).

Section 29 – General (63)

Satisfactory ventilation must be ensured with tunnel work. Recirculation of polluted air is not permitted.

2.2 Requirement for Ventilation (62)

2.21 General. Natural ventilation will seldom be sufficient to keep the atmosphere clean enough during work in mines. It will therefore be necessary to use artificial ventilation, primarily to take away the damaging/polluting substances as much as possible, and to thin out the remaining substances such as the concentrations of these are as low as possible.

Sucking ventilation with help of a fan can be a useable solution for removing blasting gases from spaces in long tunnels, especially with small cross sections. The method is not suited to diesel operations because of danger of mist formation in the tunnel.

Following are some formulas for the calculation of the requirement for ventilation with tunnel operations which a committee from NVE National Power Works has worked out. The calculations are based on the fresh air supply being 1,200 m³/kg fuel. The committee has among other things decided that with long tunnels there should be a relatively great leakage from the ventilation pipe if a sufficient thinning of the exhaust gases from diesel operation is to be attained (62).

It has been established by measurements of exhaust gas that a diesel-driven loading machine, with diesel oil consumption b (liter/hr) requires an air supply Q_2 (M³/min) = 17.2b.

The necessary amount of air which must be brought to the work face, Q_0 , is $Q_0 = Q_1 Q_2 = 0.65B F + 17.2b$,

where B = loading capacity, (F m³/min),

and F = concentration/administrative norm or C/T.

Procedures and Frequency of Testing Mine Air Quality and Quantity

2.3 Measurements (62)

Regular measurements of the air in the mine where there is work going on will be made, and where there is danger of exceeding the

administrative norms of the Labor Inspection for pollution of the working atmosphere. Measurements will be carried out at least twice each year and at other times when exceeding the administrative norms is suspected.

Only measuring equipment of an approved type will be used.

The Labor Inspection and the Industrial Hygiene Institute can give further guidance on the choice and use of measuring equipment.

Each mine will set up instructions for measuring (testing). The results will be available to all employees. Special attention will be paid to measurements of NO₂, CO and oil mist.

Dust concentrations will be measured and samples analyzed if there is reason to believe that the concentration is too high.

6.3 Danger of gas (65)

Measurements of such places will be taken as often as necessary to hold the gas concentrations under control.

2.2 Ventilation equipment (62)

There will be regular checking of ventilation installations to be sure that the air supply is correct.

Noise Standards

Section 44. – Noise (63)

Effective measures to reduce the noise level must be taken where it is considered necessary. Measurements will be taken.

Note: The danger of hearing damage increases significantly with noise levels over 85 dBA, which must not be exceeded if technically or practically possible.

2.1 Personal Protective Equipment (65)

In working places with high noises the workers will use adequate ear protectors.

Contact: Mining Division
Ministry of Norway
Oslo, Norway

PHILIPPINES

The following rules and regulations for the Philippines have been excerpted from the "Revised Mine Safety Rules and Regulations" handbook (66).

Types of Engines Permitted

Rule 134-7. The use of diesel equipment shall be restricted to places where adequate ventilation is maintained.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Not specified in available literature.

Fuel Quality Specifications

Rule 134-2. The fuel shall have a flash point of 66° C (150° F) or higher and contain less than 0.12 pct sulfur by weight.

Engine Emission Control Requirements

Rule 134-1. The fuel injection system shall be locked to prevent unauthorized changing of air-fuel ratio (approximately 20:1, i.e.,

the engine shall use twenty kilograms of air burning one kilogram of fuel).

Rule 134-3. A cooling system shall be provided for the exhaust gas of the engine.

Rule 134-4. Under normal conditions, the undiluted exhaust gas of the engine shall not contain more than 0.10 pct by volume of carbon monoxide.

Rule 134-5. Provisions shall be made to dilute the exhaust gas with air to not more than 100 parts per millions by volume of carbon monoxide before it is discharged into the surrounding atmosphere.

Rule 134-6. The percentage of carbon monoxide in the general mine air because of this exhaust gas of the engine shall not exceed 0.01 pct (100 ppm).

Rule 134-8. The quantity of air supplied shall be adequate to dilute all toxic constituents of the exhaust gas (2.0 cu.m/min. or 75 cfm per rated horse-power at maximum in some tunnel work in normal air).

Procedures and Frequency of Testing Engine Exhaust Gases

Not specified in available literature.

Mine Air Quality and Quantity Requirements

Rule 96.—Diesel engines shall not be used in any part of underground workings and in tunnels under construction because of the hazards of carbon monoxide in the exhaust except:

(a) When the velocity of air current is adequate and the following gases are less than the maximum allowable.

Gases	Maximum allowable, %
Carbon Dioxide	0.500
Carbon Monoxide010
Nitrogen Oxide0025
Methane500
Hydrogen Sulfide002
Sulfur Dioxide001

Procedures and Frequency of Testing Mine Air Quality and Quantity

Not specified in available literature.

Noise Standards

Not specified in available literature.

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 Ministry of Natural Resources
 P.O. Box 1595
 Manila, Philippines

POLAND

Types of Engines Permitted

Four-stroke diesel, direct injection, water-cooled (67).

Testing and Certification Procedures of Engine and Auxiliary Equipment

Specific instructions or formats are not provided for testing and certification. However, requirements are given for fuel lines, safety and control systems, induction systems, safety and control systems, exhaust cooling systems, electrical equipment, and antifire accessories. These requirements (68) follow:

Chapter 3.—Fuel Lines

11. Fuel lines should be:

- (1) made of corrosion resistant material having suitable mechanical stability,
- (2) constructed in a manner to protect them from mechanical damage,
- (3) tight and so built that, in case of damage, leaking fuel will not penetrate the exhaust system,
- (4) easily accessible for inspection.

12. The distance of the fuel lines from the exhaust system should not be less than 25mm.

13. Metal fuel lines cannot be joined by a soft solder.

Chapter 4.—Safety and Control Systems

14. A valve easily accessible for manual cut-off of fuel inflow should be installed in the fuel line.

15. The locomotive should be equipped with an automatic system protecting it from excessive temperature of the surface of the external engine and the exhaust system.

16. The locomotive should be equipped with a system of control:
- (1) of pressure of the oil lubricating the engine
 - (2) of pressure of the oil in cases where a hydraulic gear is used
 - (3) of oil temperature in a case where a hydraulic gear is used
 - (4) of temperature of liquid cooling the engine
 - (5) of temperature of exhaust gases.

Chapter 5.—Induction System

17. Intake of the suction line should be equipped with a refining filter.

18. (1) Behind the refining filter there should be installed a flame breaker of the type allowed by the Higher Board of Mining.

(2) The method of building the flame breaker should ensure its protection from mechanical damage and external soiling. The flame breaker should be able to be easily dismantled.

19. All the joints in the induction system must be fireproof and in the case where gaskets are used on the joints, the gasket material should be thermally and mechanically resistant.

20. The induction system of a locomotive engine should undergo testing for static having a value equal to one-and-a half times the value of the maximum pressure of a methane explosion.

23. In diesel engines the maximum lengths and clearances of ports should meet the following requirements:

Type of part	Length, mm	Port, mm
Valve pin	12.5	0.12
Injection nozzle	12.5	.12
Cylinder head	10.0	.05
	25.0	.12
Piston	12.5	.12

24. In flat joints gaskets which are mechanically and thermally resilient must be used.

25. In the circulation of the liquid coolant the engine should have a thermostat built:

- (1) blocking the circulation of the liquid until the temperature has been reached which has been established for moving conditions
- (2) properly controlling the flow of the cooling liquid during engine operation.

Chapter 7.—Exhaust System

26. No part of the external surface of the exhaust system can have a temperature higher than 200° C.

27. On the end of the exhaust system there should exist a closed connector, which serves to collect samples of non-rarified exhaust gases.

28. A flame breaker of the type allowed by the Higher Board of Mining must be used in the exhaust system.

29. The exhaust system should fill the requirements defined in 19 and 20.

Chapter 8.—Exhaust Gases Cooling System

30. The temperature of exhaust gases cannot exceed 70° C.

31. (1) The exhaust gases should be conducted through a water washer.

(2) The content of water in the washer through which the exhaust gases flow should be, within the measure of loss, refilled from an additional container of water, provided with level gauges.

Chapter 9. – Electrical Equipment

32. Electrical equipment for diesel locomotives should:

- (1) meet the requirements of obligatory norms for electrical explosion-proof equipment,
- (2) be permitted by the Higher Board of Mining.

Chapter 10. – Anti-fire Accessories

33. The locomotive should be equipped with a permanent extinguishing system actuated from both of the operator's control cabs.

34. The extinguishing medium should be delivered through a common pipeline to special fog nozzles directed at least toward:

- the fuel injection pump,
- the cut-off valve in the fuel line
- the induction system
- the alternator or generators.

Fuel Quality Specifications

Not specified in available literature.

Engine Emission Control Requirements

Part I – Chapter 6 (67).

21. The content of carbon monoxide in engines before exhaust to the atmosphere should not exceed 0.05 pct, at rated power and during idling of a new engine and after a general overhaul.

Part I – Chapter 7 (67).

26. No part of the external surface of the exhaust system can have a temperature higher than 200° C.

27. On the end of the exhaust system there should exist a closed connector, which serves to collect samples of non-rarified exhaust gases.

28. A flame breaker of the type allowed by the Higher Board of Mining must be used in the exhaust system.

Part I – Chapter 8 (67).

30. The temperature of exhaust gases cannot exceed 70° C.

31. (1) The exhaust gases should be conducted through a water washer.

Part II – Chapter 7 (67).

86. During a pause in the work of a diesel locomotive lasting more than 5 minutes the operator is obliged to immobilize the engine.

Procedures and Frequency of Testing Engine Exhaust Gases

Part II – Chapter 9 (67)

90. (1) Inspection of non-rarified fuel for the content of carbon monoxide should be conducted at least once every two weeks.

(2) A mine laboratory worker authorized by the "Barbara" Experimental Mine can conduct the analysis of non-rarified exhaust gases for carbon monoxide content.

91. Specimens of non-rarified exhaust gases should be collected by pipettes directly from the exhaust system. These specimens should be collected during engine idling and under load at maximum revolutions after 20 minutes of operation.

92. If the analysis of collected specimens of exhaust gases before exhaust to the atmosphere indicates a carbon monoxide content greater than 0.1 pct, the locomotive should be removed from operation immediately. After eliminating the reasons for surpassing the allowable content of carbon monoxide, the locomotive may be placed in operation after a renewed inspection of exhaust gases with a positive result.

Mine Air Quality and Quantity Requirements

IV. COAL MINING HEALTH STANDARDS AS OF 1978 (68).

All accessible workings and premises must be constantly ventilated by a current of air containing not less than 19 volumes per centum of oxygen and not more than:

- 1 volume per centum of carbon dioxide (CO₂)
- 0.002 volume per centum of carbon monoxide (CO)
- 0.00025 volume per centum of nitrogen dioxide (NO₂)
- 0.0007 volume per centum of sulfur dioxide (SO₂)
- 0.0007 volume per centum of hydrogen sulfide (H₂S)

General Regulations (67)

35. In underground mining excavations in non-methane and methane fields only diesel locomotives of explosion-proof construction are allowed to be used.

36. The principal condition for using diesel engines is a concentration of methane in the air of less than 1 pct.

37. Diesel locomotives may be used under the condition that the contents of carbon monoxide in the mine air:

(1) in excavations with separate ventilation and in excavations ventilated by passing currents flowing to the ventilating shaft omitting the ends, will be less than 0.0016 pct,

(2) in excavations ventilated by passing currents flowing to the ends, will be less than 0.001 pct.

38. The discharge of air current in excavations in which diesel engines are used should be at least:

(1) In excavations with separate ventilation and excavations ventilated by passing currents flowing to the ventilating shaft omitting the ends: $Q_p = 62.5 \text{ qCO} + 50 \text{ m}^3/\text{min}$.

(2) in excavations ventilated by passing currents flowing to the ends: $Q_p = 100 \times \text{qCO}$, where: Q_p = required amount of air, m³/min, and qCO = rough amount of carbon monoxide separated from the engines of all the diesel apparatus operating in the excavation in l/min., determined by measurements for every type of apparatus, under the worse working conditions of the engine.

39. In transport excavations, considered in rooms "c" and "b" with regard to the explosion hazard on account of the control of the methane concentration, a methane meter should be constructed on the locomotive which would signal the optical or acoustical concentration of methane 1 pct and greater.

40. When verifying that the methane concentration in the transport excavation has reached 1 pct, the locomotive engine should be immobilized. Renewed mobilization of the locomotive engine may take place with the consent of the supervisor of the ventilation department.

41. (1) Transport with diesel locomotives may be conducted in excavations with flowing or separate ventilation.

(2) Driving diesel locomotives into an excavation with a stopped pipe fan ventilated by separate ventilation is forbidden.

(3) When stopping a pipe fan while a diesel locomotive is operated in a transport excavation vented by this fan the locomotive engine should be immobilized.

(4) Renewed mobilization of a diesel locomotive engine may take place after mobilization of the pipe fan and checking the methane concentration.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Part II – Chapter 8 (67)

87. In excavations in which diesel locomotives are used at least once a month air samples should be collected to determine the content of methane, nitric oxide, and carbon monoxide.

88. Air samples in excavations, in which diesel locomotives are used, should be collected:

(1) in exhausts from the depot chambers and locomotive fuel tankage chambers,

(2) in all transport excavations ventilated by separate ventilation,

(3) in transport excavations ventilated by flowing ventilation, in which adequately for every maximum amount of diesel equipment used in these excavations $n=1, 2, 3 \dots$ and, the outputs of air currents are the least,

(4) in methane poles in all transport excavations ventilated by flowing currents, in which the methane content exceeds 0.5 or in which possibilities exist for growth in the content of methane up to 1 pct or higher.

89. (1) Air samples should be collected during operation of all diesel equipment used in the excavation, in the exhaust current from this excavation and in the excavation vented by air duct sucking in the intake to the air duct.

(2) The ventilation engineer determines the collection areas of the air samples.

93. In the case of proving during the inspection, that the carbon monoxide content in the air exceeds 0.0016 pct, operation of the locomotive must be stopped immediately.

Noise Standards

The permissible noise level of 90 dB(A) has been established in Schedule B of the Order of the Minister of Labor, Wages and Social Affairs of March 17, 1976, on the Maximum Permissible Concentrations and Intensity of Agents Harmful to Health in Work Establishments which entered into force on July 1, 1976. If noise exceeds the above level, protective equipment to reduce the noise to 90 dB(A) must be provided. Rules for measurement of noise shall be established by the Chief Health Inspector. However, such rules, if issued, are not available in the Law Library, Library of Congress, as of this writing (68).

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REPUBLIC OF KOREA

Korea is in the mining situation where mining development is being undertaken on a small scale of underground mineral bodies, and in fact large-scale diesel engines are almost not in use in mining work. There are, of course, cases where comparatively large diesel engines of various kinds are used in the development of lime stones or kaoline, but

they are subject to the vehicular laws or environment control laws (69).

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REPUBLIC OF SOUTH AFRICA

During 1960 the Department of Mines decided to allow mobile diesel powered equipment in South African fiery mines, provided that such equipment complied with the requirements of U.S. Bureau of Mines Schedule 31 "Mobile diesel-powered transportation equipment for gassy noncoal mines and tunnels". Experience with such equipment showed, however, that the American requirements were not always suitable for South African conditions. A survey of national opinion made by the South African Bureau of Standards showed that a national specification that would reduce the hazards of the ignition (by diesel engines) of firedamp-air mixtures or coal-dust deposits, was generally considered desirable.

Such a specification would assist the promotion of safety and the reduction of economic losses in firedamp-endangered mines. On these grounds the Council of the South African Bureau of Standards approved the preparation of the requested specification (70).

Types of Engines Permitted

Chapter 10. - VENTILATION, GASES AND DUST (71)

10.25.1 No internal combustion engine other than a diesel engine shall be used underground in any mine.

10.25.2 No diesel engine shall be used underground—

(a) in any mine unless there is sufficient ventilation to render harmless the exhaust gases produced; and

(b) in any fiery mine or in any other mine in the workings of which there may be a risk of such diesel engine igniting gas or coal dust unless it is of a design and construction approved in writing by the Government Mining Engineer, and then only under such conditions and subject to such restrictions as he may specify.

Section 3. - Requirements (70)

3.1 Engines shall be four-stroke diesel engines that do not use volatile fuels during starting or in operation.

Testing and Certification Procedures of Engine and Auxilliary Equipment

Section 3. - Requirements (70)

3.2 FUEL INJECTION SYSTEM

3.2.1 Setting. The fuel injection system shall be such that the maximum quantity of fuel injected can be permanently set at a desired level and shall be so arranged that access to the means for adjusting this level can be gained only by means of a special key.

1. The presence of flammable gas inside an apparatus may be due to either or both of the following:

(a) *Generation* inside the enclosure of a gas, e.g., gas from the cracking of hydrocarbon oil by the electric arc in oil-immersed switchgear;

(b) *entry* of gas from a surrounding flammable atmosphere via openings in the enclosure.

2. It should be understood that the aim of flameproof enclosure is not necessarily the total avoidance of any gaps in an enclosure. The principle recognizes that some openings are unavoidable in practice and so restricts itself to requiring that the size of such openings shall not exceed the safe limit above which the nature of the escaping flame is such as to ignite a specified flammable atmosphere. On the other hand, it is not the aim to require joints to be deliberately spaced to give an opening.

3. The South African Bureau of Standards has been accepted as a Testing Authority by the Government Mining Engineer.

3.2.2 Fuel Pumps. Fuel pumps shall be of a type that allows the maximum fuel stop to be adjusted to give a calibrated quantity of fuel and the pump then to be mounted on the engine without change of adjustment (e.g., multi-element single block units with integral camshaft and stop).

3.2.3 Governor. The governor that controls engine speed and fuel injection shall not affect airflows to the engine and there shall be provision for locking its adjustment control.

3.2.4 Filters. The system shall include filters that ensure that fuel will be clean when it reaches the fuel pump and the injectors.

3.3 ENGINE INTAKE SYSTEM

3.3.1 Strength. When tested as described in 6.2.2, the intake system shall be capable of withstanding the appropriate test pressure without being damaged. The test pressure shall be an internal pressure equal to four times the maximum pressure observed in the preliminary explosion test given in 6.2.1 or a pressure of 8.6 bar whichever is less.

3.3.2 Joints

(a) Joints in the system shall be metal-to-metal and shall be flanged, spigoted, or screwed, or a combination of these. The thickness of each joint (other than the joint between the manifold and the cylinder head) shall be such that the length of the flameproof path through the joint is at least 25 mm. In the case of the joint between the manifold and the cylinder head, this length shall be at least 12.5 mm.

(b) The joint between the cylinder head and the manifold (that may have a gasket that complies with 3.3.2(c)) shall be tight to such an extent that a 0.05 mm thick feeler gauge cannot enter the joint for a distance of more than 3 mm.

(c) A joint may be fitted with a metal (or metal-clad) gasket of thickness not exceeding 0.5 mm, provided that the gasket is positively positioned by through-bolts or other acceptable means.

(d) Joints shall comply with the requirement of SABS 314* for metal to metal joints in Class A apparatus. Group I enclosures, and each joint shall withstand repeated explosions within the system without permanent deformation and shall prevent the propagation of flame through the joint into a surrounding flammable mixture.

3.3.3 Intake Flame Arrester

(a) Provisions and position. The intake system shall include a flame arrester that will prevent flame from an explosion within the system from igniting a surrounding flammable mixture. The arrester shall be between the air cleaner and the intake manifold. It shall be so attached by means of shrouded bolts that it can be readily removed for inspection and maintenance, and it shall be so mounted that it is protected against accidental external damage.

(b) Construction. The construction of the arrester shall be such that the arrester can be cleaned easily and is capable of withstanding, without showing signs of deterioration, repeated explosions within the intake system. Arresters shall be made of material that is not liable to electrolytic corrosion. The parts of the flame arrester shall be positively positioned to produce a flameproof path that will arrest the propagation of an explosion and shall be so designed that incorrect assembly is impossible.

(c) Spaced plate type arresters. The plates of spaced plate type arresters shall be austenitic stainless steel. The overall length of plates of a given thickness and their width (or the minimum length of the flameproof path) shall conform to the values given (graphically) in Figure 1 (for example, the overall length of plates of thickness 2.5 mm shall not exceed 240 mm and their width shall be at least 32 mm).

The distances between the plates shall not exceed 0.45 mm and the unsupported length of the plates shall not exceed 63 mm.

3.3.4 Air Shut-Off Valve

(a) Except as allowed for in 3.3.4(b), the intake system shall include a valve (operable from the operator's compartment) to shut off the air supply to the engine. The valve shall be such that it can be closed only after the fuel supply to the engine has been shut off and that it is fully open before fuel can be supplied to the engine.

(b) Alternatively the intake system shall include other acceptable means of preventing combustion from taking place in the cylinders (such as flooding the inlet system with inert gas).

3.3.5 Air Cleaner. The intake system shall include an air cleaner such that air entering the flame arrester is clean and that resistance to airflow does not increase rapidly in dusty atmospheres. Filters of the oil bath type shall be acceptable if they include provision to prevent overfilling.

3.3.6 Vacuum-Gauge Connection. The intake system shall include a connection opening to allow the temporary attachment of a vacuum gauge for indicating the pressure drop under flow conditions. This opening shall be closed by a plug or other acceptable device that can be sealed or locked in place when not in use.

3.4 JOINTS IN THE ENGINE

3.4.1 Cylinder Head. The joint between cylinder head and engine block may be fitted with a reliable gasket, held securely in position by through bolts or other acceptable means of preventing a change in alignment.

3.4.2 Valve Guides. Valve guides shall have a clearance of not more than 0.5 mm and a length of at least 25 mm.

3.4.3 Strength of Joints. Joints shall withstand repeated explosions within the engine and its intake and exhaust systems without permanent deformation and shall prevent the propagation of flame through the joint into a surrounding flammable mixture.

3.5 ENGINE EXHAUST SYSTEM

3.5.1 Strength. When tested as described in 6.2.2., the exhaust system shall be capable of withstanding the appropriate test pressure without being damaged. The test pressure shall be an internal pressure equal to four times the maximum pressure observed in the preliminary explosion test given in 6.2.1 or a pressure of 8.6 bar whichever is less.

3.5.2 Joints. The requirements of 3.2.2. shall apply.

3.5.3 Exterior Surfaces. Exterior surfaces of the exhaust system shall be readily accessible (for cleaning) and shall be such that they minimize the accumulation of dust and combustible substances.

3.5.4 Material. All surfaces that are in contact with exhaust gases between the outlet of the exhaust manifold and the exhaust flame arrester mounting flange (including the latter) shall be of austenitic stainless steel or other acceptable corrosion resistant metal.

3.5.5 Exhaust Flame Arrester

(a) Provision and position. The exhaust system shall include a flame arrester that will prevent propagation of flame and discharge of heated particles to a surrounding flammable mixture. The arrester shall be so positioned that only cooled exhaust gas will discharge through it. It shall be so attached by means of shrouded bolts that it can be readily removed for inspection and maintenance, and it shall be so mounted that it is protected against accidental external damage.

(b) Construction. The requirements of 3.3.3(b) and (c) shall apply.

(c) Cooling boxes used as arresters. The exhaust gas cooling box (see 3.5.6(b)) may be used as the flame arrester provided that

(1) it is of a type that brings the exhaust gas into intimate contact with water or an aqueous solution in at least two places,

(2) explosion tests have proved that it will arrest flame,

(3) it is equipped with a device that automatically cuts off the fuel supply to the engine when the liquid in the boxes reaches a certain minimum (safety) level, and

(4) the device that cuts off the fuel supply is so housed that access to it can be gained only by unlocking a compartment or the device is such that it can be adjusted only by the use of special tools (such as those required for shrouded bolts and nuts).

3.5.6 Exhaust Cooling System

(a) Provision. The engine shall have a cooling system for the exhaust gas. The system shall be such that, when tested as described in 6.3, it meets the requirements given in 3.5.6(b) and (d).

(b) Capacity. The heat-dissipation capacity of the system shall be capable of reducing the temperature of the undiluted exhaust gas (at the point of discharge from the cooling system) to a temperature not higher than 76.7° C under all conditions of engine operation. The cooling system shall contain enough liquid (see 3.5.6(c)) to allow operation of the engine under one-third load for 8 hours. The minimum quantity of water or aqueous solution

available for cooling shall be at least 2-2/3 times the consumption during 1 hour when the engine is operating at maximum load and maximum speed.

(c) Method of cooling. Cooling shall be effected by passing the exhaust gas through water (or a dilute aqueous solution of a suitable compound) contained in a cooling box (conditioner), or by a spray of water (or of a dilute aqueous solution of a suitable compound) that enters the exhaust system near the outlet of the exhaust manifold, or by a combination of these two methods.

Openings shall be provided for drainage and cleaning all parts of the cooling system; such openings shall be closed by a plug or other acceptable device that can be sealed or locked in place when not in use.

(d) Automatic shut-off. The cooling system shall include a device that will automatically shut off the fuel supply to the engine when the temperature of the exhaust gas (at the point of discharge from the cooling system) rises above 85.0° C. This device shall be so housed that access to it can be gained only by unlocking a compartment, or the device shall be such that it can be adjusted only by the use of special tools (such as those required for shrouded bolts and nuts).

(e) Combination of low water level cut-off and temperature cut-off. It shall be permissible to provide one device which can fulfill both the functions of the low water level cut-off and of the temperature cut-off; or alternatively the two devices may act on the same fuel cut-off valve.

3.5.7 Surface Temperatures of Engine and Exhaust System. The engine shall incorporate means for ensuring that when tested as described in 6.3, the temperature of any external surface of the engine or the exhaust system will not exceed 204° C under any condition of engine operation. Water-jacketed components shall have integral jackets and positive circulation of water in the jackets shall be ensured. The engine shall be fitted with a device that cuts off the fuel supply to the engine when the water in the cooling jacket(s) reaches boiling point. This device shall be so housed that access to it can be gained only by unlocking a compartment, or the device shall be such that it can be adjusted only by the use of special tools (such as those required for shrouded bolts and nuts).

NOTE: Insulating covers shall be deemed not to be acceptable means of controlling surface temperatures.

3.5.8 Gas-Tightness of Exhaust System. The joints in the exhaust system shall be gas-tight, i.e., such that it is not possible for exhaust gas to leak through them under any condition of engine operation. Gas tightness shall be achieved by the use of ground joints or by using thin metal (or thin metal-clad gaskets) in the joints. All the joints shall be fitted with adequate through-bolts, and gaskets shall be aligned and held securely in position by the bolts or by other acceptable means.

3.5.9 Discharge of Exhaust Gas. Discharge of the exhaust gas shall be such that the gas is directed away from both the operator's compartment and the vicinity of the heads of persons working near the equipment.

3.5.10 Pressure-Gauge Connection. The exhaust system shall include a connection opening at a suitable point to allow the temporary attachment of a pressure gauge for measuring the total back-pressure in the system. The opening shall also be suitable for the temporary attachment of gas-sampling equipment. The opening shall be closed by a plug or other acceptable device that can be sealed or locked in place when not in use.

3.6 FUEL-SUPPLY SYSTEM

3.6.1 Fuel Tank

(a) Position. The tank shall be in a fixed position relative to the engine and there shall be no provision for the attachment of separate auxiliary fuel tanks.

(b) Construction. The tank shall be made of metal at least 1.60 mm thick. Seams shall be welded and the tank shall be free from leaks.

(c) Drain plug. The tank shall have a drain plug (not a valve or a petcock) which shall be locked in position.

(d) Filling facilities. Filling facilities shall be such that fuel can be added only through a self-closing valve positioned at least 300 mm away from the exhaust manifold of the engine and preferably

below it. The valve shall constitute a fuel-tight (but not an air-tight) closure when fuel is not being added. Any part of the valve that may become detached during the addition of fuel shall be secured to the tank by a chain or other acceptable means of attachment. The design of the filler opening or of the filler cap (see 3.6.1(e)) shall be such as to prevent extraction of fuel by methods such as dipping waste material into the tank.

(e) Filler cap. The filler opening shall have a filler cap containing a vent that ensures that atmospheric pressure is maintained inside the tank. The vent shall be small enough to prevent the splashing of fuel through it. The filler cap shall be attached to the tank by a hinge or other acceptable means.

3.6.2 Fuel Lines. All fuel lines shall be so installed that they are protected against damage during normal use of the engine or equipment and they shall be such (and shall be so secured) that vibration will not cause failure.

3.6.3 Cut-off Valve. The fuel supply system shall include a cut-off valve (additional) to the normal shut-off valve in the fuel injection system that enables the engine to be stopped by the fuel operator in an emergency.

3.7 ELECTRICAL EQUIPMENT

All electrical equipment fitted to the diesel engine and to the ancillary apparatus shall comply with the appropriate requirements of SABS 314 or of SABS 549.*

3.8 FRICTION CLUTCH BELL HOUSING

All joints and apertures in a friction clutch bell housing shall comply with the requirements of SABS 314 for metal-to-metal joints in Class A apparatus for use in Group I gas, and the minimum length of flameproof path shall be at least 25 mm.

3.9 MAINTENANCE INSTRUCTIONS

Each engine or piece of diesel powered equipment shall be accompanied by full instructions for its maintenance. These instructions shall include maintenance of flameproofness.

SECTION 4. – MARKING (70)

4.1 The following information shall be given in clear, conspicuous, and permanent marking on each engine:

- (a) The trade name or registered trade mark or the name of the manufacturer;
- (b) the type designation; and
- (c) the serial number.

SECTION 6. – INSPECTION AND METHODS OF TEST (70)

6.1 INSPECTION.

Inspect and measure the sample drawn for compliance with all the appropriate requirements given in Sections 3 and 4 other than those tested in terms of 6.2 and 6.3.

6.2 STRENGTH TESTS OF INTAKE AND EXHAUST SYSTEMS

6.2.1 Explosion Tests. Remove the engine intake and exhaust systems from the engine block. Blank off their manifold with suitable metal plates and remove the air cleaner from the engine intake system. Then, using a mixture of the Group I gas (firedamp) and air, subject each system to the tests given in Subsection 8.6 of SABS 314.

6.2.2 Pressure Test. At the conclusion of the explosion tests, subject each system to a pressure equal to four times that recorded in the appropriate preliminary test (see Subsection 8.6.3 of SABS 314) or 8.6 bar whichever is less. Apply this pressure by one of the methods given in Subsection 8.7(a) of SABS 314.

At the conclusion of the test, closely examine the systems for signs of damage.

6.3 EXHAUST COOLING SYSTEM TEST

(a) Fill all compartments designed to hold cooling water with the minimum quantity of water recommended by the manufacturer. Operate the cooling spray (if provided). Make no special provision for the circulating cooling air over the engine or the components of the cooling system.

(b) Allow the engine to reach temperature equilibrium.

(c) Measure by any convenient method the temperature of the undiluted exhaust gas at different loads and speeds up to maximum load and speed.

(d) At maximum load and speed determine the quantity of water consumed in unit time and check for compliance with the requirements of 3.5.6(b).

(e) Operate the engine under any convenient conditions, and withdraw water from the cooling system until the exhaust-gas temperature just exceeds (85.0° C) and check for compliance with 3.5.6(d).

(f) By any convenient means, cause the temperature of the water in the cooling jackets to reach boiling point, and check that the automatic fuel cut-off operates at this point.

(g) Measure, by any convenient means, the surface temperatures of the engine and exhaust system throughout the tests given in this subsection (6.3) for compliance with the requirements of 3.5.7.

Fuel Quality Specifications

Not specified in available literature.

Engine Emission Control Requirements

CHAPTER 10. – VENTILATION, GASES, AND DUST (71)

10.25.3 Every diesel engine used underground shall be provided with means whereby the air entering the engine is cleaned, the exhaust gases before being expelled are cooled and where expelled are diluted, and the emission of flames or sparks is prevented. These means shall be maintained in an effective condition.

10.25.5 The operations of a diesel engine underground shall be discontinued until conditions have been remedied –

(a) if the air at any place where it is being used is found to contain more than 100 parts of carbon monoxide or five parts of oxides of nitrogen per 1,000,000 by volume, or

(b) if the exhaust gases of the engines are found to contain more than 100 parts of carbon monoxide or 1,000 parts of oxides of nitrogen per 1,000,000 by volume, or

(c) if the engine is found to have any defect which may cause danger to persons.

10.25.6 The engine of a diesel powered unit underground shall not be kept running idle except while being tested or during brief halts while in use.

SECTION 3. – REQUIREMENTS (70)

3.5.5 The exhaust system shall include a flame arrester that will prevent propagation of flame and discharge of heated particles to a surrounding flammable mixture.

3.5.6 The engine shall have a cooling system for the exhaust gas. The heat dissipation capacity of the system shall be capable of reducing the temperature of the undiluted exhaust gas (at the point of discharge from the cooling system) to a temperature not higher than 76.7° C under all conditions of engine operation. The cooling system shall contain enough liquid to allow operation of the engine under one-third load for 8 hours. Cooling shall be effected by passing the exhaust gas through water (or a dilute aqueous solution of a suitable compound). A device shall be included to automatically shut off the fuel supply system to the engine when the temperature of the exhaust gas rises above 85.0° C.

3.5.7 The temperature of any external surface of the engine or the exhaust system shall not exceed 204° C under any condition of engine operation.

3.5.8 The joints in the exhaust system shall be gas-tight, i.e., such that it is not possible for exhaust gas to leak through them under any condition of engine operation.

3.5.9 Discharge of the exhaust gas shall be such that the gas is directed away from both the operator's compartment and the vicinity of the heads of persons working near the equipment.

Procedure and Frequency of Testing Engine Exhaust Gases

CHAPTER 10. – VENTILATION, GASES AND DUST (71)

10.25.4 Where a diesel engine is used underground samples shall be taken –

(b) at intervals not exceeding three months, of gas emitted from the exhaust of the diesel engine when the engine is developing maximum power and when the engine is idling.

The percentage by volume of carbon monoxide or oxides of nitrogen present in each sample shall be determined and a record kept of the results.

Mine Air Quality and Quantity Requirements

CHAPTER 10. – VENTILATION, GASES AND DUST (71)

Permissible Quantities of Gas and Dust

10.6.6 In the general body of the air at any place where persons are required to work or travel, under normal working conditions –

(a) the amount of carbon dioxide shall not exceed 5,000 parts per 1,000,000 of air by volume.

(b) the amount of carbon monoxide shall not exceed 100 parts per 1,000,000 of air by volume.

(c) the amount of oxides of nitrogen shall not exceed five parts per 1,000,000 of air by volume.

(d) the amount of hydrogen sulphide shall not exceed 20 parts per 1,000,000 of air by volume.

(e) the amount of inflammable gas shall be insufficient to show a distinct cap on the reduced flame of a safety lamp, and

(f) the concentration of dust shall not exceed such standard as may from time to time be specified by the Government Mining Engineer.

Quantity and Velocity of Air – Metalliferous and Diamond Mines

10.7 In every controlled-metalliferous or controlled diamond mine unless exempted in writing by the Inspector of Mines –

10.7.1 the velocity of the air current along the working face of any stope shall average not less than 0.25 metre per second over the working height; and

10.7.2 the quantity of air supplied at the working face of every development end such as a tunnel, drive, crosscut, raise or winze which is being advanced and at the bottom of any shaft in the course of being sunk shall not be less than 150 cubic decimeters per second for each square metre of the average cross-sectional area of the excavation.

Quantity and Velocity of Air – Coal Mines

10.8 In every coal mine not exempted in writing by the Inspector of Mines –

10.8.1 the quantity of fresh air in cubic decimeters per second supplied throughout the 24 hours to each ventilating district shall be not less than 25 multiplied by the maximum mass in metric tons of coal and rock mined per shift in such district;

10.8.2 no ventilating district shall at any time contain more than 200 persons;

10.8.3 in longwall working the velocity of the air current along any face shall average not less than 0.25 metre per second over the working height;

10.8.4 in bord and pillar working, roadways that carry a unidirectional flow of air over the whole of their cross-sectional area from the main intake to the main return aircourse of any section of the workings for the purpose of ventilating such workings shall be provided and maintained to carry such flow as close as practicable to every working place in such section. The average velocity of the air

current through any such roadway at its nearest point from any working place which it serves with air shall not be less than 0.25 metre per second;

10.8.5 the quantity of air supplied at the face of any heading which is being advanced in coal and which has advanced more than 20 metres from its point of communication with the nearest roadway that is carrying a unidirectional flow of air over the whole of its cross-sectional area from the main intake to the main return air-course of the section of the workings in which such heading is being advanced shall not be less than 150 cubic decimetres per second for each square metre of the average cross-sectional area of the heading;

10.8.6 the quantity of air supplied at the face of any tunnel being advanced in stone or in dyke and at the face of any shaft in the course of being sunk shall not be less than 150 cubic decimeters per second for each square metre of the average cross-sectional area of the excavation and waterblast shall be installed in accordance with regulation 10.10.5.

Procedures and Frequency of Testing Mine Air Quality and Quantity

CHAPTER 10 – VENTILATION, GASES, AND DUST (71)

Air Measurement and Dust Sampling – Controlled Metalliferous and Diamond Mines

10.9.1 At every controlled metalliferous or controlled diamond mine, where the manager is required to make an appointment, determinations shall be made during the main working shift not less than once in 3 months of the ventilation and environmental conditions and the amount of dust in the air in the main airways and at the faces of working stopes, development ends and shafts in the course of being sunk and such other places as directed by the manager. Where in the opinion of the Inspector of Mines regular determinations of the concentrations of carbon dioxide, carbon monoxide, oxides of nitrogen and hydrogen sulphide in the air of the working places are necessary, he may, with the approval of Government Mining Engineer, require determinations to be made at such intervals as he may specify.

Air Measurements and Dust Sampling – Non Controlled Metalliferous and Diamond Mines and Works

10.9.2 At any metalliferous or diamond mine not referred to in regulation 10.9.1, and at works where in the opinion of the Inspector of Mines regular determinations of the concentration of dust

and gases in the air of the working place are necessary, he may, with the approval of the Government Mining Engineer, require the determinations to be made at such intervals as he may specify.

Air Measurements and Dust Sampling – Coal Mines

10.9.3 At every coal mine not exempted in writing by the Inspector of Mines measurements shall be made during the main working shift not less than once a month of –

(a) the quantity of air circulating through the mine and each ventilating district, and

(b) the quantity of air circulating through every working section and the average velocity of the air current along the faces and in the roadways referred to in regulations 10.8.3 and 10.8.4.

10.9.4 In every coal mine measurements shall be made during the main working shift not less than once in 6 months or at such intervals as the Government Mining Engineer may permit of the amount of dust in the air in representative working places in each section while drilling, cutting, breaking, loading or transfer of coal or rock is taking place.

Record

10.9.5 A record of the measurements made in terms of regulations 10.9.1, 10.9.2, 10.9.3 and 10.9.4 shall be kept.

Returns

10.9.6 A return of the average volume of air per minute downcast during the main working shift, the maximum number of persons underground at one time and such other information relating to ventilation, temperature and dust as may be required by the Government Mining Engineer shall be forwarded to the Inspector of Mines by the manager of –

(a) every controlled metalliferous or controlled diamond mine once every 12 months, and

(b) every coal mine, not exempted by the Inspector of Mines, once every 3 months.

Noise Standards

Not specified in available literature.

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ROMANIA

The following information on Romania has been extracted from "The Departmental Norms for the Protection of Labor in Mining Activity" (72).

Types of Engines Permitted

Art. 1 For traction in the underground mining works are accepted the Diesel locomotives manufactured according to the specifications* established by CCSM Petrosani regarding the construction of the locomotives underground mining.

Testing and Certification Procedures of Engine and Auxiliary Equipment

The following articles cover requirements, specifications, conditions for operation, conditions for verification

during operation, requirements by the technical manual, and required documents and evidence.

Art. 2. The operation specifications are the ones indicated in the technical manual by the vendor and, for the underground operation, the following are especially important:

– The maximum readjustment power of the Diesel engine accepted for underground (respectively the maximum flow of the injection pump);

– The cooling of the engine and of the burning gases;

– The concentration of the toxic components of the burning gases;

– The flame-gas-proof protection (in the case when the locomotives are intended for mines with explosive potential atmosphere).

Art. 3. The classification and the definitions regarding the Diesel locomotives for underground are the ones from the specifications indicated by Art. 1.

Art. 4. The conditions for admission in underground are established by the department norms for the protection of labor in mining, edition 1977 art. 47, 184 and 193, as well as art. 90 and 91.*

Art. 5. The measures for the safety of operation of the Diesel locomotives in underground are shown according to the nature of the hazard as follows:

a. The elimination of the hazard of intoxication due to the burning gases which contain toxic and cancerous substances (carbon oxide, nitrogen oxides, sulfur oxides, aldehydes). The representative gas which is monitored is the carbon monoxide (also the fume density is monitored). By constructive measures applied to the Diesel engine, the toxic components are limited to a concentration easy to dilute in the natural draft.

b. The elimination of the fire hazard due to the temperature of the exhaust system and the flammability of the fuels and lubricants. There are in use means of cooling, means to avoid the access of the combustible substances to the hot parts and means for protection. The locomotive is equipped with a fixed fire extinguisher (with carbonic acid).

c. The flame-gas-proof protection. Beside the requirements listed under b, the entrance and evacuation gallery are built according to the norms of the STAS 6877/2-74 "Explosion-proof Casing"*. Also, special rules are imposed upon the engine starting and the lighting equipment, whereas the other mechanisms of the locomotive shall not present the risk of ignition by sparks or heating by friction.

Art. 6. The operation of the Diesel locomotives in underground mining works is allowed only after the verification of the fulfillment of the rules prescribed by the norms mentioned in Art. 4 and by the technical manual of the locomotive.

Art. 7. When putting into service, one carefully verifies the engine and the Diesel fuel feeding installation for unsealed places where the Diesel fuel or oil could leak. The start (or the continuation of the operation) is forbidden if such defects are detected or if the engine and the associated subassemblies are dirty with diesel fuel, oil, dust or other combustible substances. The adjustment and revision operation, during which leakages of diesel fuel or oil are possible, must be performed in places specially set up for this purpose.

Art. 8. Also, when putting into service, one carefully verifies the other mechanisms of the locomotive which contain oil and especially the ones with oil under pressure (hydraulic transmissions, hydrostatic transmissions, gears).

Art. 9. At least once a day the start of the locomotive shall be done in shed, where one shall verify the conditions imposed for the operation and the water cooling systems of the engine and of the exhaust system.

Art. 41. The verification of the Diesel locomotives during operation is implemented according to the vendor indications, from the technical manual. The following verification steps shall be especially taken into consideration:

- A. During 8 hours of operation:
- a. one adds water in the tank for spraying (and it is verified often during the shift, adding it as many times as necessary);
 - b. one monitors carefully the operation of the locomotive.
- B. After 16 hours of operation:
- a. one verifies the water level from the muffler and adds it if necessary;
 - b. one verifies the water level in the engine radiator;
 - c. one lubricates the pump for spraying water;
 - d. one verifies the fuel feeding system;
 - e. one verifies the general conditions of the locomotive and cleans it;
 - f. one verifies the transmission and braking systems.
- C. After 50 hours of operation:
- a. one cleans the exterior of the exhaust parts and the other engine parts by wiping with a cloth soaked in detergent, then one washes with water; it is prohibited to use any petroleum products for this purpose;
 - b. one removes the water from the muffler and one adds up to the level with clean water; to ameliorate the corrosiveness in the

muffler, one puts several pieces (boulders) of calcium carbonate (lime stone) which will be replaced every 50 hours;

- c. one verifies the water filter;
- d. one dismounts and cleans the nozzle for water spraying;
- e. one verifies the operation of the engine and one performs the necessary adjustments;

f. other works required in the technical manual.

D. After 100 hours of operation:

- a. one cleans the packages of plates from the exhaust and the interior of the muffler with 2%-5% NaOH Solution (caustic);
- b. one cleans the package of plates from admission;
- c. one verifies the transmission belts;
- d. other works required in the technical manual.

E. After 200 hours operation:

- a. one verifies the tightness of the connections at intake and exhaust;
- b. one verifies the pump for water spraying (the flow and the system tightness);
- c. one visually verifies the condition of the engine operation regarding the burned gases;
- d. one verifies and cleans the engine injectors;
- e. one verifies the electrical lighting system;
- f. one verifies the transmission and braking systems;
- g. other works required by the technical manual.

F. After 400 hours of operation:

- a. one dismounts, cleans and polishes with an instrument the nozzle for water spraying;
- b. one verifies the tightening of the screws of the cylinder cover;
- c. one cleans the engine cooling system (according to the indications from the technical manual);
- d. other works required by the technical manual.

G. After 1,200 hours of operation:

- a. one dismounts, verifies and cleans the cylinder cover;
- b. one verifies the CO concentration and the fume density in the exhaust gases with the special set for measurement; the verification is done for idling, for maximum rotative speed and for maximum load (which is implemented for example by lifting the locomotive on stand-offs such that the wheels will be free and one applies the brakes), see also Art. 14 and 15.

- c. one verifies, cleans and adjusts the injection equipment according to the instructions from the technical manual of the locomotive;

- d. one examines carefully the condition of the parts from intake and exhaust (gallery, intake, cylinder cover, exhaust pipe, muffler) and if there are degradations or corrosion, one assesses if it is necessary to repair;

e. other works required by the technical manual.

H. After 3,600 hours of operation:

- a. one verifies the engine condition, the toxicity of the exhaust gases, one verifies and adjusts the injection equipment;
- b. one verifies the condition of the transmission and brake parts;
- c. one examines carefully the condition of the exhaust pipe and of the muffler and, if necessary, one verifies by the hydrostatic pressure test.

I. Other Works Required by the Technical Manual

Art. 42. After 6,000 hours of operation one makes a detailed verification of all the subassemblies of the locomotive, one checks all the parts subjected to wear and corrosion and one replaces them if necessary, one verifies at 8 atm hydrostatic pressure the intake gallery, the channels of the cylinder cover, the exhaust pipe and the muffler.

Art. 43. For the repair of the parts which belong to the intake and exhaust system, as well as the equipment of the electrical lighting systems of the flame-gas-proof locomotives, one requires to abide by the rules imposed for electrical with flame-gas-proof protection explosion-proof casings.

Art. 44. The technical manual of the locomotive shall be available for the persons in charge of the maintenance and the handling of the locomotives (at least in the possession of the team leader).

Art. 45. In the specialized department of the mine, there shall exist the main drawings of the components and the catalogue of the spare parts.

Art. 46. The garages shall have operation logbooks with the evidence of the operations, revisions and repairs, as well as the fuel and lubricants consumption.

Also, they shall have instructions for the operation of Diesel locomotives in underground and specific instructions for local conditions regarding the operation of Diesel locomotives and of the existing equipment.

The operators shall have the annual medical check-up for this position.

Art. 47. The handling, maintenance and operation of the diesel locomotives shall be effected only by qualified personnel, who have received instruction, and have been examined and authorized.

Fuel Quality Specifications

Not specified in available literature.

Engine Emission Control Requirements

Art. 15. Ordinarily the density of the fume seen by eye in the exhaust gases shall be negligible. If the fume shows up in the exhaust gases, it means that the engine is not tuned-up or that the injectors are defective and the revision is necessary. Periodically, the density of the fume shall be measured with instruments (see the program under chapter 4).

Art. 16. After the break-in is over, the CO concentration in the burned gases does not go over 0.05% by volume, and the density of the fume 15 degree Bosch respectively 0.055 g/m³ solide slurries (during the break-in these limits are 30%-40% larger), if the engine is well tuned-up (according to the indications in the technical manual of the locomotive) and it is not affected by quality in fabrication.

If the CO concentration reaches 0.12% by volume or if the fume density reaches 25 degree Bosch (0.111 g/m³ solide slurries) the locomotive shall be revised for the elimination of the causes which generate the increase of the burned gases toxicity.

Conditions to Avoid the Fire Hazard

Art. 18. The operation of the engine cooling and exhaust system (the exhaust pipe and the muffler) in the parameters specified by the technical manual, as well as the perfect tightness of the fueling system and the oiling system represent the main conditions for fire prevention.

Art. 19. The operation of the system to spray water in the exhaust pipe is controlled after every start (touching by hand the body of the spraying nozzle it shall be felt cooler than the exhaust) and continuously during operation (monitoring the water consumption from the tank).

Art. 20. It is prohibited to start or to continue the operation if:

- the cooling system by water spraying in the exhaust pipe does not work or it does not have water;
- the exhaust pipe is punched, has leaky joints or the cooling is not provided according to the indications in the technical manual.
- the muffler has holes or cracks (through which the water from the cooling bath leaks or one observes gases blowing);
- one observes lack of tightness of the fuel and oil systems;
- the fire extinguisher system with carbonic acid is missing or is incomplete (or the gas bottle is empty).

Art. 21. Periodically, all the subassemblies of the locomotive are cleaned and washed, so that it shall be not possible to deposit combustible substances. A special attention shall be directed toward the engine and the exhaust system. The cleaning of the locomotive is done using water and detergents. It is prohibited to use for this purpose underground any kind of petroleum products.

Conditions for Flame-gas-proof Protection

Art. 23. For the locomotives with flame-gas-proof protection, the access gallery and the associated channels from the cylinder cover, by one side and the muffler plus the exhaust pipe plus the associated channels from the cylinder cover by the other side, represent explosion-proof casings and are treated as such during operation, in similar manner with the equipments built according to STAS 6877/2-74* (explosion-proof casing Exd I) and it is also required that the joints between the exhaust pipe and the muffler to be hermetic.

Art. 24. The entrance in the intake gallery and the exits from the muffler are closed with special "breathing" devices (packages of plates) according to the instructions mentioned in Art. 1 and STAS 6877/2-74. To dismount and to clean these devices (which are made of stainless steel for durability and for reduction of the soot adhesion) it is demanded to observe the rules required for explosion-proof joints STAS 6877/2-74.

Art. 25. Because some components of the burned gases (sulfur oxides) form with water corrosive substances, during operation the condition of the parts from the exhaust of the engine shall be periodically verified. The verification is done:

- visually every day (not to be water leaks in the cooling shell of the exhaust connected to the cooling circuit of the engine, not to be water in the muffler, not to be gases blowing from other places except the exits, with packages of plates);

- by the hydrostatic pressure test (at 8 atm) according to the schedule from chapter 4 of these instructions (the muffler, the exhaust pipe and the channels in the cover of the cylinder are tested independently).

Note: To neutralize the corrosive acide substances, in the water bath in the muffler shall permanently exist 2-3 Kg pieces (boulders) of calcium carbonate (lime stone).

Art. 26. The deteriorated joint gaskets (there where they are made so by construction) shall be replaced with gaskets identical to the original ones. The joints between cylinder cover and the exhaust pipe and between the exhaust pipe and the muffler shall be always hermetic.

Art. 27. For the locomotives equipped with clutch with friction between engine and the gear box, one warns us that the clutch represents a dangerous source of setting fire if it is not well adjusted, if it has the plates with the ferrodo destroyed (worn-out, broken) and if it is not strictly maneuvered according to the instruction from the technical manual. The clutch shall be subject to an exigent verification as often as possible. The dry clutches with the plates without ferrodo are prohibited.

Art. 28. Also, one warns us that the friction sparks between the wheels of the locomotive and the rails (railroad) and between the wheels and metallic brake shoes are dangerous for the lighting of methane. For that:

- it is forbidden the operation of the locomotive with the skidding of the wheels on the rails;
- the reduction of speed shall be done as much as possible by the reduction of the fueling of the engine, and the brake shall be used for stopping only as the last resort.

Art. 29. The lighting equipment of the locomotive is operated according to the rules established for the electrical equipments with flame-gas proof protection.

Procedures and Frequency of Testing Engine Exhaust Gases

Conditions for the Limitation of the Toxicity

Art. 12. The quantity of the equipment for injection and the strict observation of the verifications and adjustments (flow, pressure) imposed by the vendor in the technical manual of the locomotive, are essential elements in limiting the exhaust gases' toxicity.

Art. 13. The exhaust gases' toxicity shall be periodically verified according to the indications from Art. 4, of these instructions and after every medium or capital repair or every time the adjustment of the injection equipment is modified versus the one required by the technical manual.

Art. 14. The concentration of the carbon monoxide is only measured with instruments intended to be used for the verification of the exhaust gases from the engines with internal combustion (for example the set Dräger Werk Lubeck, type 21/31 CH 304 with the probe CH 214 and with the measuring tubes (CH20601) with the measuring range 100-300 ppm (0.01-0.3% by volume) CO.

Mine Air Quality and Quantity Requirements

Art. 17. The ventilation of the mining works where the Diesel locomotives work is ruled by the norms mentioned in Art. 4 with the following definitions:

- a. up to 0.06% by volume CO, 3 m³/min and CP;
- b. between 0.06% and 0.08% by volume CO, 4 m³/min and CP;
- c. between 0.08% and 0.12% by volume CO, 6 m³/min and CP;
- d. at 0.12% by volume CO and over, the locomotive shall be placed out of operation.

To avoid the useless pollution of the underground atmosphere, it is recommended to shut off the engine during the longer stops.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Not specified in available literature.

Noise Standards

Not specified in available literature.

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C.C.S.M.
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2675 Petrosani, Romania

SPAIN

Types of Engines Permitted

Not specified in available literature.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Draft requirements for a Spanish standard are being compiled by a working group. Currently French (Cerchar) procedures are followed (73).

Fuel Quality Specifications

Not specified in available literature.

Engine Emission Control Requirements

Emission Control (74)

Present regulations: only specification is maximum temperature of + 30C above ambient for gassy mines.

New regulations (soon to be mandatory): maximum 1,500 ppm CO in undiluted exhaust.

Procedures and Frequency of Testing Engine Exhaust Gases

Not specified in available literature.

Mine Air Quality and Quantity Requirements

Minimum Quantity of Air (74)

Present and new regulations: minimum of 180 L/sec of clean air per brake H.P.

New regulations: maximum 50 ppm CO in general body.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Not specified in available literature.

Noise Standards

Not specified in available literature.

Contact: Direccion General de Minas e Industrias de la
Construction
Ministerio de Industria y Energia
Serrano 37
Madrid, Spain

SWEDEN

Types of Engines Permitted

Combustion Engine Exhaust (75)

b. The engine should be of a suitable type for both the particular mining-machine and operation. Turbocharging should be avoided for loaders.

The engine should be regularly maintained in good condition, the more important consideration being the fuel system and intake air filter. The air filter should be of a type, such as oil bath type, which does not clog in the underground environment.

c. The engine fuel setting should be adjusted to give no more than 90% of the power rating for above ground use. If soot is visible

in the exhaust (black soot) the engine should be removed for adjustment.

d. The engine should be equipped with a system which ducts the crankcase gases to the air intake manifold, so called positive crankcase ventilation.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Ventilation (75)

18. If combustion engines are planned, or where expansion of their use is contemplated, a plan must, within a reasonable time, be

made available to the Health and Safety Administration for comments.

67. Manufacturers of diesel- or compressed air-powered loaders and haulers for underground use should perform tests to determine levels of exhaust gas constituents, visibility-reducing soot and noise, and make the results available to the buyer.

Fuel Quality Specifications

Combustion Engine Exhaust (75)

When driving tunnels, use a diesel fuel with a distillation temperature of 150-290°C, and no more than 0.1% sulphur. Such fuel does not reduce the power level, but lowers the level of CO, SO₂ and soot, and prolongs engine life.

The fuel should be kept clean and cleanliness observed during refueling. A dirty fuel tends to damage the fuel system which in turn leads to increases in pollutant levels in the exhaust.

Engine Emission Control Requirements

Appendix 1b (75)

Engine Exhaust

In workplaces where diesel-powered equipment is used for loading and transport, the ambient level of CO and NO_x must regularly be determined at intervals suitable to each particular situation, but, as a rule, at least biweekly. At a new workplace, or where new or altered equipment is brought into operation, or where the ventilation system is changed, the levels of CO, CO₂ and NO_x must promptly be determined anew, regardless of previous determinations.

In such cases, even oxygen levels, sulphur and formaldehyde levels should be reestablished.

If the level of carbon monoxide sampled downstream catalytic afterburner, exceeds the normal reading by 25%, the engine must be adjusted and/or the catalytic reactor rehabilitated. A properly adjusted and maintained diesel should, as a rule, not emit levels of CO higher than 600 ppm at idle, or 800 ppm at full load.

Ventilation (75)

18 c. Combustion engines must not be idled unnecessarily. Even braking a vehicle with the engine, or idling to warm up a cold engine, must be limited. Where several diesel-driven engines are parked, evacuation of the exhaust must be provided for by means of a system directly connected to the tailpipe (during idling).

66. Diesel-driven loaders and haulers must be of such construction that the requirements of appendix 1b can be maintained. Such equipment should also be equipped with means providing dilution of the exhaust. The exhaust must be directed away from and located at a sufficient distance from the operator, and also be arranged in such a manner that the exposure of workers near the machine is minimized.

Loading machines should have watersprays capable of wetting the muckpile at the point of loading (digging). These sprays must be able to function also at freezing temperatures.

Procedures and Frequency of Testing Engine Exhaust Gases

Ventilation (75)

18 d. Diesel-driven equipment in regular use must be regularly checked with respect to its exhaust, in accordance with appendix 1b. If such equipment does not meet the requirements of appendix 1b, its use must be immediately discontinued.

Appendix 1b (75)

Continuous Monitoring of the Exhaust From Diesel-Driven Machinery

On every diesel-powered machinery in regular use, checks must be made at least every 150 engine hr, or at minimum every other

month. These should include smoke, and where catalytic afterburners are used, also the level of CO in the undiluted exhaust.

1. Tests to be made with the machine in neutral, with engine up to temperature and at 75 to 100% of full load/rpm. Samples to be taken in the exhaust pipe, upstream of the scrubber, but downstream of a catalytic reactor, if such exists.

If possible, the sample is preferably taken under full load. This can be done on machines with torque-converters with locked wheels, or with a loaded machine on grade.

2. Smoke measurements to be performed by the Bosch method, or equivalent, for example Hartridge.

3. If the smoke reading exceeds the normal by 50%, the equipment must be taken out of the work cycle and adjusted before return thereto. A properly operating engine, especially one 150 kW or over, exhibits a Bosch-reading not over 1 at idle, and not over 2 at full load.

Mine Air Quality and Quantity Requirements

Appendix 1 (75)

Required Fresh Air Volume

The volume of air required for dilution and displacement of diesel exhaust can be calculated as follows:

$$q_a = 0.27 P q_s K / 3,600,$$

where q_a = air required, m³/sec,

0.27 = fuel consumption, kg/kWh,

P = engine power rating, kW,

K = load factor—0.15 for horizontal transport; 0.30 for load-haul operations (over 25-m one-way haul distance); 0.45 for loading (less than 25-m one-way haul distance),

and q_s = specific air requirement, m³/kg fuel consumed—5,000 m³/kg when diluting in low rooms; 3,000 to 4,000 m³/kg when diluting in high rooms.

Appendix 1c (75)

Monitoring for Toxic Gases and Oxygen Deficiency

Measurements must be performed so that they are representative of the air breathed by those working in the mine. Therefore, they must be made where the mine personnel normally work, and at regular intervals during the entire workshift.

Engine Exhaust

In workplaces where diesel-powered equipment is used for loading and transport, the ambient level of CO and NO_x must regularly be determined at intervals suitable to each particular situation, but, as a rule, at least biweekly. At a new workplace, or where new or altered equipment is brought into operation, or where the ventilation system is changed, the levels of CO, CO₂, NO₂ and NO_x must promptly be determined anew, regardless of previous determinations.

In such cases, even oxygen levels, sulphur and formaldehyde levels should be reestablished.

Where the same equipment is used for both loading and haulage, the above measurements should be made at the place of loading.

Ventilation (75)

17. The lowest possible air-contamination shall be sought in the workplace. The levels of air-contaminants shall be guided by Part 100, appendix 3:30b which lists TLV's with respect to gases from blasting and from diesel-engines, in underground mines and excavations, the values shown in the table below must not be exceeded. If these values rise above those shown, immediate remedial action must be taken, or the men must be removed from the workplace.

Constituent	Level, ppm, during an average exposure of—	
	30 min, counted from first measurement	8 hr, counted from first measurement
CO	50	25
CO ₂	15,000	5,000
NO ₂	3	2
¹ NO _x	30	20

¹NO + NO₂.

Note: Especially diesel exhaust, but also blasting fumes, contain a great many constituents. Exposure to some of these can cause discomfort and, in some case, constitute a health risk. For most of these constituents, an acceptable means of routine measurement is lacking. The values shown in the table are, however, considered safe, even considering the difficulty of reliable measurements.

Since even CO₂ is important in this connection, the 5,000 ppm-limit is complimented by setting an upper limit (15,000 ppm) which requires remedial action within 30 min.

The oxygen level must not fall below the following levels:

Diesel driven machinery	Average volume percent O ₂ —	
	30 min, counted from first measurement	8 hr, counted from first measurement
Not used ¹	17	19
Used ²	19	20

¹ Intended to prevent oxygen deficiency.

² Intended to assure normal combustion to preclude excess pollutants in the exhaust.

18. Development and distribution of toxic gases from blasting and from combustion engines, as well as dust and oil mist, must be limited as far as possible. Electric power should be used where possible.

19. Satisfactory ventilation must be arranged so that gas, dust, etc., cannot accumulate in amounts which can cause discomfort;

constitute a health hazard; or reduce the oxygen level below that specified. In this respect the following must be observed:

The general requirements for ventilation for radon in accordance with paragraphs 18-25, 25-27 and 31 must be met.

The applicable requirements of appendix 1 must be observed in all underground construction and mining activities.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Ventilation (75)

20. The air quality in the workplace must be checked with respect to toxic gases from blasting and combustion engines, and with respect to oxygen level and dust. This must be done by measurements to the extent and in a manner specified in (a).

(a) Gases from blasting and combustion engines and oxygen deficiency: Measurements shall be made in accordance with appendix 1c. A record of these shall be kept showing time, location and levels. If excessive values are indicated, the type of corrective measure shall be given. This record must be available for review at the workplace.

Noise Standards

Proper devices and procedures shall be included in loading machines and transport vehicles, in order to minimize noise (75).

If measurements exceed 85 dBA, further investigations must be performed to determine risk for hearing damage (76).

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SWITZERLAND

Types of Engines Permitted

Since very little construction equipment is manufactured in Switzerland most of the equipment used is of foreign origin. As the important producing countries have standard tests and industrial safety construction standards, we do not conduct additional testing (77).

Testing and Certification Procedures of Engine and Auxillary Equipment

We have no test procedures, as such, random checks for industrial safety of equipment are made according to the accompanying guidelines (Forcu 1574)*(77).

Fuel Quality Specifications

We have specifications as to Diesel qualities. For the whole of Switzerland, the sulfur content is fixed at 0.5%. However, various checks have shown that it is 0.2 to 0.3% (77).

Engine Emission Control Requirements

5.3.3 Diesel Engines (78)

Diesel engines shall be tuned so that the fuel is burned with as little smoke as possible.

Procedures and Frequency of Testing Engine Exhaust Gases

We do not test exhaust gas (77).

Mine Air Quality and Quantity Requirements

For diesel-powered equipment, 4 m³ fresh air/min are required. This amount of air is based on 5 ppm NO, which may only increase briefly to 10 ppm (77).

4. Ventilation of Workplaces (78)

4.1 Ventilation of Workplaces.—Continuous and sufficient ventilation of all workplaces underground shall be provided by a forced or natural flow of air.

4.2 Required Air Volume.—The required air volumes will be found in the "Guidelines for Dimensioning and Operation of Forced Ventilation During the Performance of Underground Work" (SUVA Form 1484)*.

Note: The following tables give "Maximum Allowable Concentrations" (MAC) for diesel contaminants (79). Reference 79 does not state that these are enforced standards.

Table 2.—Overview of the major air pollutants present during the construction of tunnels and their allowable concentrations

Substance and characteristics	Effects	Value
Dust—Particles of floating matter: >5 μ m, rapid sedimentation, <5 μ m, slow sedimentation, <5 μ m, penetrating into lungs.	Silicosis. Quartz and certain silicates are dangerous.	See table 3.
Carbon dioxide (CO ₂)—Most often in large quantities in the blasting area and in diesel exhaust.	Odorless; in high concentrations (>4 vol %) headaches, fainting.	5,000 ppm.
Carbon monoxide (CO)—In large quantity in most explosives (blasting areas.)	Odorless; in concentrations greater than 1 vol % (1,000 ppm), dangerous. Nausea fainting, death.	50 ppm.
Nitrogen gas—Mixture of NO and NO ₂ and other higher oxides of nitrogen, most often represented by the formula NO ₂ . In the blasting areas and exhaust gas.	At concentration of 10 to 50 ppm.: coughs->edema of the lungs->death.	NO, 25 ppm; NO ₂ , 5 ppm.
Aldehyde—Most often represented by formaldehyde (H ₂ CO); also higher aldehydes and acrolein (CH ₂ : CH.CHO). In diesel exhaust.	Coughing fits, inflammation of the eyes and throat.	Formaldehyde, 5 ppm; acrolein, 0.1 ppm.
Sulfur dioxide (SO ₂)—Produced by the sulfur in diesel fuels.	Biting odor, coughing fits; in higher concentrations edema of the lungs.	5 ppm.

NOTE.—ppm = cm³/m³.

Table 3.—MAC values for dust

Quartz content, pct	Values for particles less than 5 μ m, mg/m ³	Quartz content, pct	Values for particles less than 5 μ m, mg/m ³
10 to 20	10	50 to 70	2
20 to 30	5	>70	1
30 to 50	3		

Procedures and Frequency of Testing Mine Air Quality and Quantity

In addition to subjective evaluation of the atmospheric conditions, the quantity of air required by the ventilation plan is checked at the start of work and then at frequent intervals. At the same time, the composition of the air underground is checked (77).

Noise Standards

The following is an excerpt from the noise table (79).

Earthmoving machinery	Noise at work-place, dBA	Hearing protection at exposures, %
Excavators	95	>10
Transporters	90	>30

17. Personnel Protection (78)

17.4. Hearing protection.—In work areas with high noise levels, where technical means cannot lower the noise level below the limit injurious to hearing, workers must wear hearing protectors suitable for the noise conditions.

Contact: Volksirtschafts department
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Gerwerbe und Arbeit
Bundegase 8, Bern, Switzerland

U.S.S.R.

The following information on the U.S.S.R. was extracted from its "Production Regulations for Diesel-Driven Transport in Coal and Shale Mines" (80).

Types of Engines Permitted

- 1.3 Four-stroke diesel engines must be used for transport drive.
- 1.14 Equipment which ensures predilution of exhaust gases before their discharge into the atmosphere can be used.

Testing and Certification Procedures of Engine and Auxiliary Equipment

- 1.2. Diesel-driven transport must satisfy the "Safety Regulations in Coal and Shale Mines," the definitions of "PIVRE," the "Health Regulations in Mine Operation of the Coal and Shale Industry," the

"Unifying Requirements for Increasing the Technical Level and the Safety of Electric Locomotives, Traveling Working Stock, Belt and Drag Conveyors and Mines of the Coal Industry," the "Regulations of the Traffic Ordinance," and the present "Regulations."

Diesel engines with ancillary equipment built in accordance with the requirements of these "Regulations" must be labeled to indicate the degree of explosion protection ((in a rectangle)–PB) and the type of explosion protection ((in circle)–C). The clear inscription (Approved for Operation in Mines Subject to the Danger of Gas and Dust Explosion) must be attached to the machine.

Approval for production manufacture of diesel machinery (diesel locomotive, selfpropelled carts, tractors, etc.) is prepared by Institutes MakNII (State Research Institute for Work Protection in Mining of the Eastern Regions) according to the model of the manufacturing enterprise and is confirmed by the "Committee for Maintaining Work Protection in Industry and for Mining Supervision attached to the Council of Ministers of the USSR."

1.57. Designs of diesel-driven transport must be coordinated with Institute MakNII (State Research Institute in Makeyevka for Operating Safety in Mining) for the Institute WostNII (Research Institute for Work Protection in Mining of the Eastern Regions).

II. FACTORY TESTS OF DIESEL-DRIVEN MINE TRANSPORT

2.1 Any newly manufactured machine must undergo factory tests.

2.2. Factory tests include:

- Testing and determination of operating capabilities of machine overall;
- Determination of basic technical data of the machine (effective power, speed, pull, hoisting speed, braking path, etc.);
- Operating check of diesel engine starting systems;
- Determination of duration of machine operation with full tank of fuel and water for cooling and clean-up of exhaust gases;
- Operating test of heat protection device of engines;
- Temperatures monitoring of surface heat-up of exhaust system of the engine and temperature of exhaust gases discharged into the atmosphere;
- Monitoring of exhaust gas composition and operating efficiency of neutralizer;
- Operating test of fire protection system;
- Determination of time of blockage of exhaust flame extinguishers.

2.3. The machinery must be tested on loading stands or in product testing departments.

2.4. The duration of machine operation with water supply should be determined as simple operating time of the machine under full load.

2.5. Operation of the heat protection device should be monitored under maximum load and rpm of the diesel engine by means of:

- artificial interruption of water injection into the exhaust pipe (in case of exhaust pipe cooling by sprinkling of exhaust gases);
- covering the radiator shutters or temporarily shutting off the engine fan or draining water from the air conditioning system (for cooling of the exhaust pipe using a water jacket).

2.6. The heat protection device must shut off the engine at surface heat-up of the exhaust pipe up to $140 \pm 10^\circ \text{C}$ or of exhaust gases at the outlet to the atmosphere up to a temperature of $70 \pm 5^\circ \text{C}$.

Fuel Quality Specifications

1.6. Diesel fuel with an ignition temperature in a closed crucible of not less than 55°C and a sulphur content of not greater than 0.2 pct by weight with an anti-smoke additive can be used as fuel for the machinery.

Use of fuel of unknown types is prohibited.

Engine Emission Control Requirements

1.7. The conditionally allowable evolution of toxic components expressed in grams per hour relative to 1 HP of installed engine power should not exceed the values given in table 1 during operation in all gears.

Table 1.—

Component	Evolution, g/HP per hour—	
	Before gas cleanup	After gas cleanup
Carbon monoxide . .	10.0	4.0
Nitrogen oxide relative to NO ₂ .	5.0	5.0

For the evolution values cited the concentrations of the carbon monoxide and nitrogen oxide after clean-up of the exhaust gases should not exceed 0.08 pct and 0.07 pct relative to volume.

NO₂ concentration standard was ascertained from a determination computation of the ion nitride by means of Griesz-Ilosvay Reagent.

Use of other methods to determine nitrogen oxides is authorized under the condition that the analysis results are given relative to the NO₂ equivalent adopted in these "Regulations."

To compute any evolution component, the following formula is recommended:

$$B = 0.45 Mc (W/N) \text{ g/HP/HR,}$$

where M = molecular weight of the component, g,

c = concentration of component in constituent of exhaust gas, in pct relative to volume,

W = ejection of exhaust gases, m³/hr,

and N = engine power, HP.

1.8 All transport must be equipped with liquid neutralizers intended for cooling and clean-up of exhaust gases before they are released into the atmosphere of the mine.

The use of both pure water in the neutralizers and aqueous solvents which neutralize toxic components of the exhaust gases is allowed. Use of toxic or highly corrosive reagents is prohibited.

1.9 The liquid neutralizers must ensure cooling of the exhaust gases released into the atmosphere to a temperature of 70°C or less.

1.10. The liquid neutralizers must insure the required degree of clean-up of the exhaust gases without additional filling of the machinery with neutralization solution for a duration of at least 7 hours operation of the unit under full load.

1.11 The housing for the liquid neutralizer must ensure convenient flushing and cleaning of the latter as well as the possibility of liquid level monitoring.

1.12. All transport subject to redesign must also be equipped with catalytic neutralizers for carbon monoxide and for other products of incomplete combustion.

1.14. The exhaust openings of the machinery must be arranged such that the possibility of penetration of undiluted exhaust gases into the driver's compartment and within the range of respiration of individuals located near the machine is precluded. The direction and velocity of the exhaust gas flow should not contribute to additional dust formation underground.

Procedures and Frequency of Testing Exhaust Gases

1.13 A nozzle for sampling of the exhaust gases for analysis must be provided in the exhaust space of the liquid neutralizer.

1.46. The inlets for supply of the fire extinguishing mixture of water into the exhaust or intake system as well as the nozzles for sampling exhaust gases must have flame extinguishers in the form of channels with a diameter of maximum 1 mm over a length of at least 13 mm or with a diameter of maximum 0.8 mm over a length of at least 5 mm.

2.7 Measurements of diesel surface heat-up and of exhaust gases must be taken at fixed temperatures of the water which cools the engine and at an air temperature of at least 20°C .

The surfaces of the exhaust manifolds of the exhaust pipe, the cylinder block and engine cylinder heads must be monitored. The exhaust gas temperature is measured directly at the exhaust opening of the machine.

2.10. Undiluted exhaust gases from diesel machinery must be analyzed for carbon monoxide and nitrogen oxide content. Absolute deviation in determining carbon monoxide should not exceed 0.01 pct, and that of nitrogen oxide (relative to dioxide) should not exceed 0.001 pct by volume.

2.11. Gas samples for analysis must be taken at maximum idle rpm, and at 75 and 100 pct engine load at nominal rpm, directly after filling the air conditioning unit and after three and seven hours of engine operation.

2.13. Results of factory tests must be collected in a report which must be included in the technical documentation supplied with the machine.

In addition to standard data, the report must also indicate toxicity, temperature, and flow rate of exhaust gases for each operating mode of the machine.

2.14. Until a standardized type program has been developed all factory test procedures on test models of diesel driven mining machines must be coordinated with Institute MakNII or Institute WostNII.

Mine Air Quality and Quantity Requirements

Not specified in available literature.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Not specified in available literature.

Noise Standards

Not specified in available literature.

Contact: Not provided.

UNITED KINGDOM

Types of Engines Permitted

4. Diesel-Power Units (81)

93. Only water-cooled diesel engines will be considered for approval for use in coal mines. On such engines the air intake, combustion and exhaust systems must be able to withstand, without permanent deformation, any explosion that may occur within such enclosures and prevent the transmission to the outside atmosphere of such flame or products of combustion as would ignite flammable gas present in the atmosphere. Flexible pipes may be used in the inlet and exhaust systems provided they are of a design which satisfies the Executive. The design and construction of engines for which approval is sought must comply with the appropriate requirements of this Part. It should be noted that every individual inlet and exhaust system of an approved type must be pressure tested by the manufacturer before being put into use.

94. Air-cooled diesel engines may be permissible for use in non-coal mines subject to their meeting the appropriate requirements of this Part.

95. Diesel engines of the indirect injection type are preferred.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Certification Procedures (82)

1. Written applications by manufacturer or accredited agent for non-UK firms

2. Application to be accompanied by:

(a) technical description and specification including maximum speed, load and gradient

(b) technical drawings of general arrangement and details of inlet, combustion, exhaust, cooling, hydraulic, pneumatic and electrical systems

(c) appropriate fee

TESTING PROCEDURES (81)

Diesel powered locomotives, vehicles and equipment

Stage 1 testing

155. Stage 1 testing comprises the static testing of appropriate parts of the diesel engine inlet and exhaust systems in order to determine their ability to withstand an internal explosion without the transmission of flames or incandescence material into the surrounding atmosphere.

156. The tests will be carried out at the Health and Safety Executive Laboratories, Buxton, and will be generally in accordance with BS 4683*: Part 2: 1971 Clauses 15.3.1 and 15.4. The gas used for the tests will be pentane. The applicant will be provided for connecting the apparatus to the test rig.

Stage 2 testing

157. Stage 2 testing, which is normally carried out after the inlet and exhaust systems have successfully completed Stage 1 testing, comprises the operational testing of a complete engine on a dynamometer test bed. Where the design of a locomotive or vehicle makes it necessary the tests may, alternatively, be carried out on a complete locomotive or vehicle. The tests will normally be carried out at the HSE Laboratories, Buxton, but alternative arrangements to carry out these tests elsewhere may be permitted at the discretion of the Executive.

158. Tests will be carried out on the unit at outputs up to full power to determine:

(a) the maximum temperature which the engine, exhaust system (including the exhaust flame trap) and associated ancillary equipment can attain;

(b) the maximum temperature of the undiluted exhaust gases emerging from the flame trap;

(c) the maximum concentrations of carbon monoxide and oxides of nitrogen present in the undiluted exhaust gas;

(d) the efficacy of the various safety devices fitted to the engine to stop it in the event of:

(i) failure of linkage between governor and fuel pump;

(ii) shortage of water in the conditioner box;

(iii) excessive temperature of engine coolant;

(iv) loss of engine oil pressure; and

(v) excessive fluid transmission temperature; and

(e) the ratio of dilution of the exhaust gases.

159. Additional tests as (a), (b) and (c) will be carried out using a 1.25% methane in air mixture for the engine intake. These tests will be for record purposes only.

Fuel Quality Specifications

Fuel Oil (83)

27. The manager of every mine in which any diesel locomotive runs shall make and secure the efficient carrying out of arrangements whereby—

(a) no fuel oil is used for the generation of energy in that locomotive other than oil of a specification approved by the Minister:

(b) no oil for use as aforesaid is taken below ground otherwise than in a suitable container which does not leak; and

(c) any such oil at any time stored below ground (otherwise than in the tanks of locomotive)—

(i) is kept in a filling station in a suitable container which does not leak; and

(ii) does not exceed in quantity, such quantity as, together with any oil than in the tanks of locomotives for which it has been brought below ground, is likely to be consumed by those locomotives (having regard to their normal use) within the period of 48 hours next following.

Engine Emission Control Requirements

Exhaust system (81)

100. Where an exhaust gas conditioner box of the water bath type is provided, it must be designed to hold sufficient water to cool the exhaust gases and must be adequately baffled to ensure that the gas fully mixes with the water. The box must be manufactured from stainless steel or other material acceptable to the Executive. The water capacity of the system should be sufficient to permit the engine to operate at one-third load factor for a period of eight hours. A device must be provided to stop the engine automatically when the water level falls below the minimum operating level.

103. (a) The temperature of the undiluted exhaust gas issuing from the flame trap located on the outlet side of any conditioner box or in any other case, issuing from the conditioner box discharge opening, must not exceed 70°C.

(b) Exhaust gases shall be discharged away from the driver's cab or seat position.

119. The exhaust gas, before dilution, must not, when the engine is on test, at idling, half load and full load conditions contain more than: 1,500 ppm carbon monoxide; and 1,000 ppm oxides of nitrogen.

Catalytic devices may be used to meet this requirement, but in such cases particular attention will need to be given to the surface temperature and exhaust gas temperature requirements.

120. Provision must be made to dilute the exhaust gas with air before it is discharged into the surrounding atmosphere. The ratio of dilution must not be less than 15:1 under all conditions of engine loading;

121. Provision must be made in the exhaust system for the convenient sampling of heat exhaust gases without infringing the flameproof enclosure.

Exhaust gases (83)

29. The manager of every mine in which any diesel locomotive runs shall ensure that no such locomotive runs therein if—

(a) in the case of a locomotive in a mine of stratified ironstone or of shale, being a locomotive which was in use before the first day of May, nineteen hundred and forty-nine or was required to be delivered under a contract made before that date, gas emitted from its exhaust contains more than 0.4 pct by volume of carbon monoxide or 0.15 pct by volume of oxides of nitrogen; or

(b) in any other case, gas emitted from its exhaust contains more than 0.2 pct by volume of carbon monoxide or 0.1 pct by volume of oxides of nitrogen.

30. (1) No person for the time being operating any diesel locomotive in a mine shall keep the engine running when that locomotive is stationary except—

- (a) during brief halts while the locomotive is in use; or
- (b) while the locomotive is being tested.

Procedures and Frequency of Testing Engine Exhaust Gases

Exhaust gases (83)

31. (1) The manager of every mine in which any diesel locomotive runs shall make and secure the efficient carrying out of arrangements whereby samples are taken by a competent person appointed for the purpose by him and analysed in accordance with the following provisions of this regulation.

(2) At intervals not exceeding ninety days separate samples of the gas emitted from the exhaust of every diesel locomotive in use in the mine shall be taken when the engine of the locomotive is—

- (a) developing maximum power; and
- (b) idling with the locomotive stationary.

Exhaust protection devices to be cleaned or replaced once every 24 hours running (82).

Mine Air Quality and Quantity Requirements

Exhaust gases (83)

30. (2) If at any place in a mine in which a diesel locomotive runs there is found in the general body of the air an amount of carbon

monoxide exceeding 0.005 pct by volume, the manager shall forthwith take such steps as are necessary so to improve the ventilation at that place so that the percentage of carbon monoxide is not exceeded.

(3) If at any place in a mine in which a diesel locomotive runs there is found in the general body of the air an amount of carbon monoxide exceeding 0.01 pct by volume, the manager shall ensure that no engine of a diesel locomotive is run at that place or at any other place at which such running could affect the ventilation at the first mentioned place until it has been determined that the amount of carbon monoxide in the general body of the air at the first mentioned place does not exceed 0.005 pct by volume.

Ventilation (84)

55. (2) Without prejudice to the general application of the foregoing subsection—

(a) ventilation produced in a part of a mine shall be deemed for the purposes of that subsection not to be adequate for the purpose of diluting carbon dioxide so as to render it harmless unless the amount thereof in the general body of the air in that part of the mine is not more than one and a quarter pct by volume or, if a smaller percentage by volume is prescribed, that smaller percentage;

(b) ventilation produced in a part of a mine shall be deemed for the purposes of that subsection not to be adequate for the purpose of providing air containing a sufficiency of oxygen unless the amount of oxygen in the general body of the air in that part of the mine is not less than 19 pct by volume.

Procedures and Frequency of Testing Mine Air Quality and Quantity

(3) At intervals not exceeding 30 days, separate samples of the general body of the air shall be taken at places and times appointed by the manager so as to secure the detection of any harmful concentration of carbon monoxide produced by any diesel locomotive. An inspector may by notice served on the manager require him to appoint any place specified in the notice either instead of or in addition to any place already appointed by the manager (83).

Noise Standards

Noise (81)

77. The design of locomotives and vehicles must take into account the need to keep noise to the lowest practical levels consistent with current technology. The additional noise created when the locomotive or vehicle is moving should be taken into account when assessing overall noise levels.

78. Noise levels, at the position of the driver's head, during normal operations underground should, so far as is reasonably practicable, be kept below 90 dB(A).

79. Surveys should be made of emitted noise levels, both in the cab and at such position 0.5 m from the nearest part of the locomotive or vehicle as will give a representative picture of the noise emitted by the locomotive or vehicle, details of which, including the conditions of test chosen by the manufacturer, must be submitted to the Executive prior to the issue of the approval.

80. Check tests may be made to establish the noise levels of new designs of locomotives and vehicles under service conditions, and any radical departure from the level specified in 78 may be considered as justification for the revocation of an approval.

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UNITED STATES

The eight criteria for the United States have been summarized and presented in tables 1 through 6 following the "Introduction." The information presented in the tables was excerpted from the Code of Federal Regulations, Chapter 30, Mineral Resources (1-7).

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YUGOSLAVIA

The following regulations for Yugoslavia (85) describe the technical standards for machines with diesel engines that are used in underground non-gassy mines. For the purpose of these regulations diesel machines will be understood to be all types of machines used in underground mine workings (except for diesel locomotives).

Types of Engines Permitted

Article 5. As a rule, 4-stroke diesel engines are used for diesel machines with indirect injection of fuel (2-stage combustion), or engines with direct injection of fuel.

Testing and Certification Procedures of Engine and Auxiliary Equipment

Article 3. Diesel machines may not be used before they have been certified as suitable for use in underground mine workings in non-gassy mines, for which a certificate of suitability is issued.

Article 4. Certification from Article 3 is issued by an organization of associated labor that is authorized to conduct such examinations in accordance with regulations of a republic or autonomous region.

Fuel Quality Specifications

Article 52. Fuels for diesel machines should conform to Yugoslav standards for diesel fuels, the instructions of the machinery manufacturer and the following requirements:

- (1) the ignition point of the fuel in a closed vessel (according to Abel-Pensk) should be below 60° C;
- (2) the content of sulfur in weight percent should be below 0.5;
- (3) the cetane number should be 45;
- (4) the fuel should not contain mechanical impurities.

Engine Emission Control Requirements

Article 5. The exhaust pipes of diesel machines must be directed upward and should be located so that fumes do not directly threaten the driver or assistant driver.

The parts of the exhaust pipes that become heated during operation of the engine must be protected against accidental contact and a hole be built into the pipes with a cap through which a probe can be placed to take samples of the exhaust gases.

Article 41. The established values for concentration of soot in exhaust from diesel machines for mine use can amount to no more than 50% of the maximum allowable values.

Article 49. If the CO = 0.12% by volume in the exhaust gases of the diesel machines, the machine must be removed from operation.

Procedures and Frequency of Testing Engine Exhaust Gases

Article 49. (1) At the beginning of each shift a carbon monoxide (CO) reading must be taken in the exhaust gases of diesel machines

in front of the gas filters. If the reading establishes that the value of CO = 0.12% by volume in the exhaust gases of the diesel machines, the machine must be removed from operation.

After servicing (repair), suitability of the diesel machine must be recertified from Article 3 of these regulations.

(5) Once a year chemical testing of the exhaust gases of diesel machine engines should be carried out. These tests should include oxygen, carbon monoxide, sulfur dioxide, oxides of nitrogen and aldehydes. The content of soot in the exhaust gases should also be determined.

Samples of exhaust gases for analysis should be taken from in front of and behind the filters, if filters are used. The results of chemical analysis should be kept at least 1 year, or until the next annual test.

Article 50. Readings for carbon monoxide and other harmful gases and determination of the content of soot in the exhaust gases of diesel machine engines should be carried out more frequently than provided for by the provisions of Article 49 of these regulations, if it is found that the content of carbon monoxide or soot is close to the maximum values cited in Articles 40 and 41 of these regulations.

Article 51. For each mine in which diesel machines are operating the following data must be recorded in the ventilation log or in a specially established log:

- (1) effective power of the engine of each diesel machine;
- (2) amount of gases that the diesel machine engine emits;
- (3) composition of the exhaust gases;
- (4) amount of fresh air required to dilute exhaust gases to maximum permissible values given in Article 40 of these regulations.

Mine Air Quality and Quantity Requirements

Article 40. The composition of mine air must completely conform to Yugoslav standards concerning the maximum permissible concentrations of harmful, dangerous and toxic gases, vapors, dusts, smoke, mineral powders etc. in the atmospheres of working spaces and work sites.

In mine spaces where diesel machines are operating ventilation must be supplied so that the content of the oxygen in the air does not drop below 19% by volume.

For hazardous gases that occur in the air of mine spaces where diesel machines are operating the maximum permissible concentration at which work can continue without special protective devices is:

- (1) carbon monoxide (CO)–0.005% by volume;
- (2) carbon dioxide (CO₂)–0.5% by volume;
- (3) nitric oxide (NO)–0.0025% by volume (as oxides of nitrogen NO_x)–0.0025% by volume;
- (4) nitrogen dioxide (NO₂)–0.0005% by volume;
- (5) sulfur dioxide (SO₂)–0.0004% by volume;
- (6) formaldehyde–0.00008% by volume (as aldehydes (C_nH_nO)–0.0010% by volume);
- (7) acrolein–0.00001% by volume.

Procedures and Frequency of Testing Mine Air Quality and Quantity

Article 39. Mines in which diesel machines are used must have mechanical ventilation by means of ventilators.

Mine spaces in which diesel machines are operating must be specially ventilated by the compression or combined method of ventilation.

Article 42. The amount of air required for ventilation of mine spaces in which diesel machines are operating is determined based on an approved mine design in agreement with the provisions of these regulations.

In calculating the amount of air needed to dilute the exhaust gases to the maximum permissible values given in Article 40 of these regulations the participation of catalytic and water filters is not taken into account.

Article 43. Work sites with required ventilation in which diesel machines are operating must be continuously ventilated during their operation in the manner provided for by the approved mine design.

Stopping of ventilation and changing the direction of main air stream are only permitted in the manner provided for by the safety and rescue plans.

Article 44. Portions of the mines where diesel machines are used represent a special ventilated section.

In exceptional instances deviations from the provisions of paragraph 1 of this article can be made, but in so doing conditions must be ensured so that the concentration of harmful gases and soot remains within the prescribed limits and fire protection measures are intensified.

The measures from paragraph 2 of this article are provided for in the safety and rescue plan.

Article 45. The air stream is conveyed directly into the exhaust airstream of the mine from spaces in which exploration is being carried out or where new sections of the mine are being opened and in which diesel machines are operating.

Article 46. Work sites for maintenance and repair of diesel machines should be ventilated with a fresh air stream and the gases created by diesel machines vented from the work site by ventilation ducts into the exhaust air stream.

Article 47. The amount and temperature of air in ventilated sections in which diesel machines are operating should be measured twice a month, as well as during each significant change in ventilation conditions.

Article 48. In sections where diesel machines are operating the amount of air must not be reduced below the values provided for by the approved mine design, and if this occurs, the number of diesel machines in operation must be immediately reduced.

Article 49. In mine spaces where diesel machines are operating the following chemical tests and indications of the mine air and exhaust gases must be carried out:

After servicing (repair), suitability of the diesel machine must be recertified from Article 3 of these regulations.

(2) Every 15 days during operation of the largest number of diesel machines a carbon monoxide (CO) and carbon dioxide (CO₂) reading must be taken in the air in the mine spaces in which the diesel machines are operating.

The readings are entered in the ventilation log;

(3) Once every 3 months chemical testing of the mine air must be carried out by taking samples at work sites where diesel machines are operating and the temperature of the exhaust gases must be measured and the content of soot in them determined. Chemical tests must include oxygen (O₂), carbon monoxide (CO) and carbon dioxide (CO₂).

Samples of mine air for chemical testing should be taken during operation of the largest number of diesel machines. The results of chemical analysis should be kept for at least 1 year,

(4) Once a year chemical tests of mine air must be carried out at work sites where diesel machines are operating. These tests should include oxygen, carbon monoxide, carbon dioxide, sulfur dioxide, oxides of nitrogen (as NO_x), and aldehydes. The results of the chemical tests should be kept at least one year (or until the next annual test).

Noise Standards

Not specified in available literature.

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REFERENCES¹⁰

1. U.S. Code of Federal Regulations. Title 30—Mineral Resources; Chapter I—Mine Safety and Health Administration, Department of Labor; July 1, 1984.

2. _____. Title 30—Mineral Resources; Chapter I—Mine Safety and Health Administration, Department of Labor; Subchapter E—Mechanical Equipment for Mines; Tests for Permissibility and Suitability; Fees; Part 36—Mobile Diesel-Powered Transportation Equipment for Gassy Noncoal Mines and Tunnels; July 1, 1984.

3. _____. Title 30—Mineral Resources; Chapter I—Mine Safety and Health Administration, Department of Labor; Subchapter N—Metal and Nonmetal Mine Safety and Health, Part 57—Safety and Health Standards—Metal and Nonmetal Underground Mines; July 1, 1984.

4. _____. Title 30—Mineral Resources; Chapter I—Mine Safety and Health Administration, Department of Labor; Subchapter D—Electrical Equipment, Lamps, Methane Detectors; Tests for Permissibility, Fees; Part 18—Electric Motor-Driven Mine Equipment and Accessories; July 1, 1984.

5. _____. Title 30—Mineral Resources; Chapter I—Mine Safety and Health Administration, Department of Labor; Subchapter N—Metal and Nonmetal Mine Safety and Health; Part 75—Mandatory Safety Standards—Underground Coal Mines; July 1, 1984.

6. _____. Title 30—Mineral Resources; Chapter I—Mine Safety and Health Administration, Department of Labor; Subchapter E—Mechanical Equipment for Mines; Tests for Permissibility and Suitability; Fees; Part 31—Diesel Mine Locomotives; July 1, 1984.

7. _____. Title 30—Mineral Resources; Chapter I—Mine Safety and Health Administration, Department of Labor; Subchapter E—Mechanical Equipment for Mines; Tests for Permissibility and Suitability; Fees; Part 32—Mobile Diesel-Powered Equipment for Noncoal Mines; July 1, 1984.

8. Ilsley, L. C., and E. J. Gleim. State Regulations Pertaining to the Use of Internal-Combustion Engines in Coal and Metal Mines and in Tunnels. BuMines IC 7019, 1938, 8 pp.

9. Holtz, J. C., and E. J. Gleim. State Regulations Pertaining to the Use of Internal-Combustion Engines Underground. BuMines IC 7789, 1957, 24 pp.

10. Waytulonis, R. W. State Regulations Pertaining to the Use of Internal-Combustion Engines Underground. BuMines IC 8845, 1981, 76 pp.

¹⁰A title enclosed in parentheses is a translation from the language in which the work was published.

11. Lloyd, M. R. (Londonderry Industrial Safety Centre, New South Wales, Australia). Letter to J. N. Murphy, BuMines, Pittsburgh, PA, June 11, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
12. _____. Letter to J. N. Murphy, BuMines, Pittsburgh, PA, June 20, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
13. Cook, H. G. Memorandum to J. N. Murphy, BuMines, Pittsburgh, PA, June 16, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
14. Federal Parliament of Australia. Northern Territory Regulations—Mines Safety Control. pp. 18-46.
15. Lloyd, M. R. (Londonderry Industrial Safety Centre, New South Wales, Australia). Letter to J. N. Murphy, BuMines, Pittsburgh, PA, Aug. 23, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
16. Department of Mines and Energy, Australia. Mines and Works Inspection Regulations, 1920-1978. Pp. 17-49.
17. State of South Australia. Regulations Under the Noise Control Act, 1976-1977. July 6, 1978, pp. 1-3.
18. Federal Parliament of Australia. Mines (Gold and Minerals) Underground Mining General Regulations. 1977, pp. 39-44.
19. State of Western Australia. Mines Regulations for 1946-1974. 1974, pp. 63-66.
20. Director General of Mines, Belgium. Belgian Circular Concerning Mining Locomotives. 10 pp; transl. available from Natl. Transl. Ctr., Chicago, IL.
21. Cook, H. G. Memorandum to J. N. Murphy, BuMines, Pittsburgh, PA, Aug. 18, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
22. Dainty, E. D., and G. Lobay. Flameproof Diesel-Powered Vehicles for Use in Gassy Underground Coal Mines (Iteration No. 6). Can. Explosive Atmospheres Lab., July 4, 1974, 43 pp.
23. Dainty, E. D. (Energy, Mines and Resources, Canada). Letter to J. N. Murphy, BuMines, Pittsburgh, PA, Apr. 23, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
24. Smith, T. (Alberta Workers' Health, Safety, and Compensation). Letter to J. N. Murphy, BuMines, Pittsburgh, PA, May 19, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
25. Ministry of Energy, Mines, and Petroleum Resources, British Columbia, Canada. Mining Regulation Act. Ch. 265, 1979, 85 pp.
26. _____. Coal Mine Regulation Act. Ch. 52, 1979, 69 pp.
27. Dainty, E. D. (Energy, Mines and Resources, Canada). Letter to J. N. Murphy, BuMines, Pittsburgh, PA, Apr. 23, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
28. Province of Manitoba. The Mines Act, Manitoba Regulation 254/73. Queens Printer, Manitoba, Jan. 1981, 103 pp.
29. Glassford, R. H. (Manitoba Department of Energy and Mines). Letter to J. N. Murphy, BuMines, Pittsburgh, PA, May 19, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
30. Swartz, J. V. Coal Mining Health Standards in Canada. Libr. of Congr., Law Libr., Washington, DC, 1977, 92 pp.
31. Province of Newfoundland. The Mines (Safety of Workmen) Regulations, 1957, 1979, 178 pp.
32. Archibald, J. G. (Department of Labour and Manpower, Newfoundland). Letter to J. N. Murphy, BuMines, Pittsburgh, PA, May 12, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
33. Department of Labour and Manpower, Newfoundland. The Occupational Health and Safety Regulations, 1979. Queens Printer, Newfoundland, June 27, 1979, 116 pp.
34. Province of Nova Scotia. Coal Mines Regulation Act. Queens Printer, Halifax, Nova Scotia, Ch. 36, 1972, 143 pp.
35. _____. Metalliferous Mines and Quarries Regulation Act. Queens Printer, Halifax, Nova Scotia, Ch. 183, 1976, 83 pp.
36. Ontario Ministry of Labour. Occupational Health and Safety Act and Regulations for Mines and Mining Plants. Ch. 321 and Regulation 694, 1980, 310 pp.
37. Ontario Ministry of Labour, Underground Diesel Equipment Code. Mines Engineering Branch, Feb. 1, 1977, 8 pp.
38. Government of Quebec. Regulations for the Health and Safety in Mines and Open Pits. Commission on Work Safety and Hygiene, Sec. 65, Jan. 1980, 6 pp.
39. Province of Quebec. Rules Relative to the Quality of the Work Environment. Official Gazette of Quebec, v. 111, No. 59, Dec. 19, 1979, pp. 7847-7848.
40. Province of Saskatchewan. Mines Regulations—Part XXII: Use of Diesel Engines Underground. Saskatchewan Gazette v. 74, No. 38, pt. 2, Sept. 22, 1978, pp. 723-787.
41. Office of the Commissioner, Yukon Territory. Mining Safety Ordinance, Commissioners Order No. 1977/241. Queens Printer, Whitehorse, Yukon Terr., Jan. 27, 1978, 58 pp.
42. Cormier, A. G. Letter to C. H. MacDonald, May 14, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
43. Pinochet, M. T. (Servicio Nacional de Geología y Minería). Memorandum to J. N. Murphy, BuMines, Pittsburgh, PA, July 20, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
44. Ministry of Minerals, Chile. Reglamento de Policía y Seguridad Minera (Regulations of the Police and Mining Security). Supreme Decree No. 32, Feb. 28, 1969, 33 pp.; transl. available from Natl. Transl. Ctr., Chicago, IL.
45. Ministry of Public Health, Chile. Relamento Sobre Concentracione Ambientales Maximias Permisibles en los Lugares de Trabajo (Regulation on Maximum Permissible Environment Concentrations in the Workplace). Supreme Decree No. 19, Mar. 18, 1976, 10 pp.; transl. available from Natl. Transl. Ctr., Chicago, IL.
46. Yu, S. (Fushun Coal Research Institute, China). Letter to J. N. Murphy, BuMines, Pittsburgh, PA, Feb. 4, 1983; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
47. Ministry of Labor and Social Security, Colombia. Resolucion Numero 02400 de 1979 (Resolution Number 02400 of 1979). May 22, 1979, 64 pp.; transl. available from Natl. Transl. Ctr., Chicago, IL.
48. Palmer, E. Coal Mining Health Standards in the Federal Republic of Germany. Libr. of Congr., Law Libr., Washington, DC, 1978, 63 pp.
49. Regional Mines Inspectorate, West Germany. Regulations Concerning Diesel Motor Equipment in the Mines of West Germany. 275 pp., transl. available from Natl. Transl. Ctr., Chicago, IL.
50. Ministry of Commerce and Industry of Finland. Resolution passed by the Ministry of Commerce and Industry Regarding the Regulations for the Safety of Mining. No. 921, Nov. 28, 1975.
51. Parliament of France. Règles d'agrément du matériel électrique, des lampes de sûreté à flamme et des locomotives à combustibles liquides (Rules for Artification of Electrical Equipment Safety Flame Lamps, and Liquid Fuel Locomotive Engines). Official J. French Republic—Gassy Mines, No. 1207, 1973, pp. 405-416; transl. available from R. W. Waytulonis, BuMines, Minneapolis, MN.
52. Minister of Industry, France. Memorandum to Interdepartmental Director of Industry. Aug. 18, 1980, 4 pp.; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
53. Laszlo, M. (Országos Banyamuszaki Fofelugyeloseg, Budapest, Hungary). Letter to J. N. Murphy, BuMines, Pittsburgh, PA, Sept. 1, 1982, 4 pp.; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
54. Parliament of India. By-Laws for Diesel Vehicles. Appendix 182B (in pursuance of Regulation 181(1) of the Coal Mines Regulations). 1957, 11 pp., available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
55. Sinclair, J. N. (Industrial Inspectorate of Ireland). Letter to N. Paas (Foster-Miller Associates), Dec. 15, 1981; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.
56. Statutory Instruments, Ireland. Mines (Mechanically Propelled Vehicles) Regulations. Stationery Office, Dublin, Ireland, S.I. No. 153, 1973, 30 pp.
57. _____. Mines (Locomotives) Regulations. Stationery Office, Dublin, Ireland, S.I. No. 23B, 1971, 17 pp.

58. Diet of Japan. (Testing Methods for Explosion-Proof Diesel Engines for Coal Mines.) Japanese Vorschrift, 10 pp. Transl. from Japanese to German; then from German to English; transl. available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.

59. Mexico. Reglamento de Seguridad en los Trabajos de las Minas (Safety Regulations for Working Mines). Siaro Official (Official Daily) of the Federation, Mar. 13, 1967, pp. 260-261; transl. available from Natl. Transl. Ctr., Chicago, IL.

60. McGuirl, M. C., and L. B. Murphy. Coal Mining Health Standards in New Zealand. Libr. of Congr., Law Libr., Washington, DC, 1977, 35 pp.

61. Cook, H. G. Memorandum to J. N. Murphy, BuMines, Pittsburgh, PA, June 4, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.

62. Directorate of Labor, Norway. Ventilasjon av bergrom (Ventilation of Mine Spaces). Regulations for the Working Environment Law. Order No 317, Aug. 19, 1976, 26 pp., transl. available from Natl. Transl. Ctr., Chicago, IL.

63. _____. Arbeid i tunnelanlegg (Work in Tunnels). Order No. 418, Feb. 4, 1977, 12 pp.; transl. available from Natl. Transl. Ctr., Chicago, IL.

64. _____. Administrative normer for forurensning i arbeidsatmos faere (Administrative Norms for Pollution in the Working Atmosphere). Order No. 361, Aug. 1978, 27 pp.; transl. available from Natl. Transl. Ctr., Chicago, IL.

65. _____. Arbeid i gruver (Work in Mines). Order No. 38, Nov. 8, 1973, 4 pp.; transl. available from Natl. Transl. Ctr., Chicago, IL.

66. Fernandez, J. C. (Director of Mines and Geosciences, Philippines). Letter to J. N. Murphy, BuMines, Pittsburgh, PA, Apr. 28, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.

67. Sobala, J. Zastosowanie napedow spalinowych w glebinowych kopalniach wegla (The Use of Diesel Engines in Underground Coal Mines). Wiad. Gorn. No. 2-3, 1981, pp. 52-58; transl. available from Natl. Transl. Ctr., Chicago, IL.

68. Ministry of Mining, Poland. Wytyczne budowy i eksploatacji lokomotyw spalinowych kopalnianych kolei podziemnych (Guidelines on the Construction and Exploitation of Underground Mining Railway Diesel Locomotives). Mech. Energy Dept., Katowice, Dec. 1976, 25 pp.; transl. available from Natl. Transl. Ctr., Chicago, IL.

69. Kim, M. S. (Korea Institute of Energy and Resources). Letter to J. N. Murphy, BuMines, Pittsburgh, PA, Apr. 27, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.

70. South African Bureau of Standards. Standard Specifications for Diesel Engines for Use in Fiery Mines. SABS 888-1967, Apr. 19, 1967, pp. 61-78.

71. Parliament of the Republic of South Africa. Mines and Works Act and Regulations of the Republic of South Africa. Kerlaw Publ. Ltd., June 1, 1977, pp. 63-73.

72. The Ministry of Mining, Oil, and Geology, Romania. Instructiuni Tehnice La "Normle Departamentale de Protectie a Muncii in Activitatea Minera" (Technical Instructions for the "Departmental Norms for the Protection of Labor in Mining Activity"). 1977, 11 pp.; transl. available from Natl. Transl. Ctr., Chicago, IL.

73. Cook, H. G. Memorandum to J. N. Murphy, BuMines, Pittsburgh, PA, Aug. 18, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.

74. _____. Memorandum to J. N. Murphy, BuMines, Pittsburgh, PA, Aug. 7, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.

75. Swedish Labor Health and Safety Administration. Berg-Anvisningar, Anvisningar angaende vissa skyddsatgarder under jord i gruva, stenbrott och bergbygge (Mountain Directions, Directions Regarding Some Safety Measures, Precautions Underground in Mines and Fragmenting, Breaking Rocks and Mountain Construction, Building). No. 67-1969, rev. 1974, printed 1979; transl. available from R. W. Waytulonis, BuMines, Minneapolis, MN.

76. Parliament of Sweden. Buller i Arbetslivet (Noises in Work Life). No. 110, LiberTryck, Stockholm, Sweden, Apr. 1, 1976, 18 pp.

77. Bachofen, G. (National Swiss Organization for Accident Insurance). Letter to J. N. Murphy, BuMines, Pittsburgh, PA, June 18, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.

78. Swiss Accident Insurance Institute. Richtlinien zur Verhtung von Unfallen und Berufskrankheiten bei der Durchfuhrung von Untertagarbeiten (Accident Prevention, Guidelines for Prevention of Accidents and Occupational Diseases in the Performance of Underground Work). Feb. 1978; 15 pp., transl. available from Natl. Transl. Ctr., Chicago, IL.

79. Institute for Highway Construction and Underground Works of the Federal Polytechnical School of Zurich, Switzerland. Ventilataion des Tunnels en Construction (The Ventilation of Tunnels Under Construction). Sep. 20, 1982, 97 pp.; transl. available from Natl. Transl. Ctr., Chicago, IL.

80. Ministry of the Coal Industry of the U.S.S.R. Herstellungsvorschriften fur Transportmittel mit Dieselantrieb in Kohle- und Schieferbergwerken (Production Regulations for Diesel-Driven Transport in Coal and Shale Mines). Makejewka-Donbass, Makejewka, Donezker Gobiet, Lichatschewa 60, 1974; Transl. from Russian to German; then from German to English; transl. available from Natl. Transl. Ctr., Chicago, IL.

81. Health and Safety Executive, United Kingdom. Test and Approval of Diesel and Storage Battery Powered Locomotives and Trackless Vehicles and Diesel Powered Equipment for Use Underground in Mines. Testing Memo 12, Dec. 1977, 40 pp.

82. Cook, H. G. Memorandum to J. N. Murphy, BuMines, Pittsburgh, PA, May 21, 1982; available upon request from R. W. Waytulonis, BuMines, Minneapolis, MN.

83. Parliament of the United Kingdom. The Coal and Other Mines (Locomotives) Regulations. S.I. No. 1771, 1956, pp. 163-175.

84. Health and Safety Executive, United Kingdom. The Law Relating to Safety and Health in Mines and Quarries. Part 1. Her Majesty's Stationery Office, London, England, 1972, 207 pp.

85. Assembly of Yugoslavia. (Regulations Concerning Technical Standard for Machines With Diesel Engines Used in Underground Mine Workings in Non-Gassy Mines.) No. 11-91-13290/1, Aug. 10, 1978, 29 pp.; transl. available from Natl. Transl. Ctr., Chicago, IL.