Appendix 13.13-A Occupational Health Risk Assessment – Industrial Hygiene

TELKWA COAL
LIMITED

January 27, 2021 Total Safety Reference: 20-217 R02

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Attention: Dan Farmer, COO

Reference: **Initial Occupational Health Risk Assessment for the Tenas Coal Mine**

Introduction

In response to your request, TSS Total Safety Services Inc. (Total Safety) conducted an initial occupational health risk assessment for the Tenas Project, a proposed surface metallurgical coal mine located in British Columbia's, Bulkley Nechako region, 25 km south of the town of Smithers and 7 km southwest of village of Telkwa.

At the time of this report, no construction has commenced for the project. It is our understanding all site buildings will be new construction and equipment sourced will be new. The mine will use open pit methods and the coal will be processed on site in a to-be-purposed built coal processing plant. The processed coal will be transported via truck down a haul route to the rail line (CNR), southeast of Telkwa.

Telkwa Coal Limited retained Total Safety to conduct this initial occupational health risk assessment for the Tenas Project as part of the application for a *Mines Act* (*MA*) permit. *MA* permits are issued by the BC Ministry of Energy, Mines and Low Carbon Innovation (MEMLCI). The MEMLCI outlines the health and safety documents required to be submitted as part of the MA permitting phase in a document titled "Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits", specifically Part 8. Section 8.1.1 requires an initial occupational health risk assessment be developed, that includes but is not limited to:

- All anticipated physical, chemical, biological and ergonomic hazards;
- Strategies to minimize and control those hazards in the design of project components;
- Drawings and detailed plans for HVAC and local exhaust ventilation; and
- Exposure control plans and safe work procedures.

As it is not within our area of expertise, drawings and detailed plans for HVAC have not been included in this risk assessment, but we have referred below to where mechanical ventilation is planned or should be included as part of the controls. Exposure control plans and safe work procedures are also referenced but not included within this document. An initial ergonomics assessment was prepared by Total Safety and should be referenced for ergonomic hazards and controls, including whole-body and hand-arm vibration (Total Safety Ref: 20-217 R01 Rev. 01 dated December 1, 2020).

Note that this initial assessment has considered occupational heath hazards mainly for the operation of the Tenas Project. The construction phase will include logging and other land clearing activities followed by the building of roads and construction of water management structures and buildings, which will be primarily

conducted by contractors who will be required to complete their own detailed risk assessments; however, we have included an overview of anticipated occupational hazards during the construction phase in the Overview of Anticipated Hazards for the Construction Phase section below.

Applicable Legislation

Applicable legislative requirements relating to health and safety are provided in the *Mines Act* and the accompanying *Health, Safety and Reclamation Code for Mines in British Columbia* (June 2017), referred to hereafter as the *Code.* Part 2 of the *Code* outlines Occupational Health requirements.

Methodology

As the mine has not yet been constructed, this initial occupational health assessment was based on several factors but excludes a site review. We relied on our experience related to occupational health in operating mines, particularly coal mines in British Columbia, our education and training as industrial hygienists, applicable legislation (particularly the *Code)*, applicable literature, and information provided by the client.

Overview

The mine will consist of an administration (admin) building, maintenance shop, coal processing plant, coal quality laboratory, pit and several other small structures, including a mine rescue, tire shop and light vehicle buildings constructed of sea containers and fabric structure. Access to and within the mine will be via unpaved roads.

Safety at the mine will be managed by Human Resources and a Health and Safety (OHS) Superintendent who will report to the Mine Manager. There will also be an OHS Committee that meets monthly, a mine rescue team and Occupational First Aid Level 3 (OFA 3) trained personnel.

Site Plan

Appendix A attached provides a site plan for the proposed buildings, light vehicle and heavy vehicle work areas plus pedestrian walkways.

Admin Building

The admin building will be constructed of ATCO trailers fitted together to form a complete building. It will include an office space, first aid room, storage, lunchroom, and Mine Dry. As per the drawing attached in Appendix B, the Mine Dry will include separate facilities for men and women. Each of the men's and women's areas have been preliminarily designed as a flow-through, to include the following:

- Mud room,
- Locker room (150 men's lockers and 40 women's lockers),
- Toilet area (five each of toilets, urinals and sinks on the men's side and four each of toilets and sinks on the women's side), and
- Showers (10 for men and four for women).

The office workers in the admin building are anticipated to have 40-hour work weeks, either five, eight-hour days or four, ten-hour days or three, twelve-hour days.

Maintenance Shop and Warehouse

The maintenance shop will be a standalone building to service heavy duty (HD) vehicles with a separated outdoor welding pad and warm and cold storage warehouses. HD vehicles are typically diesel-powered and will include, but not be limited to; haul trucks, excavators/shovels, loaders, graders, dozers and drills. Work on HD vehicles will be conducted by mechanics either in the maintenance shop or in the field. Hot work (includes welding, cutting and grinding) will be conducted by welders and may be conducted on the

welding pad, outside of the HD maintenance shop, in other areas just outside the shop, or in the field. Most welding will be on mild steel, but will also include hardened steel, aluminum and stainless steel.

Work in the field will typically be un-scheduled (break-downs or similar) where the fix is quick, or scheduled where the equipment cannot be immediately brought back to the shop). In the shop, both scheduled and non-scheduled work will be conducted. Based on the expected number of different pieces of equipment/vehicles serviced and the variety of tasks to be conducted, the work required will be highly variable. Maintenance workers are expected to work 12-hour shifts, with both a night shift and a day shift.

Workers stationed in the warehouse may include a Shipper/Receiver and Warehouse Person. Both positions will involve paperwork and work on computers as well as handling materials. Warehouse workers will likely work a 12-hour shift, dayshift only with an open warehouse on nightshift. There will be a propane or electrically powered forklift which will work in the yard and warehouse and several types of material handling aids.

Note the light vehicle shop and tire shop are part of maintenance but are housed in separate, standalone buildings described below.

Coal Processing Plant

The processing plant will be a stand alone building and will be operated primarily by workers stationed in the control room, heavy media cyclone area, froth flotation work area and dewatering area. Plant workers are anticipated to work 12-hour shifts with both a night shift and a day shift. Operations work is expected to include work in the control room (Operators will spend most of their time sitting in front of computer monitors), adjusting valves, cleaning activities, sampling, and unblocking occasional clogged hoses. There will be water hoses for cleaning the floor of the plant.

Dry, crushed, run-of mine (ROM) coal will be conveyed from the crusher directly into the plant. Dry materials are fed through conveyors and a screen, where water is added and processed coal is separated from the processed rock. There will not be a dryer in the plant. The processed coal will have approximately 10% moisture. Processed coal will be transferred from the plant via conveyors and dumped into a stockpile. There will be a loader at the processed coal stockpile for managing the pile and loading trucks that will haul material to the Rail Infrastructure.

The processing plant will require both unscheduled and scheduled maintenance. Most maintenance will be conducted by electricians and millwrights working 12-hour shifts.

Coal Quality Laboratory

The coal quality laboratory (CQL) will be a stand alone building constructed of connected sea containers, located near the plant. The laboratory staff will perform a variety of tasks pertaining to the collection of samples and their preparation (processing) for coal quality evaluations and measurements. These will be carried out mostly in a coal sample preparation room of the CQL where the coal samples will be processed and the coal quality room where analyses will be performed. Lab workers are anticipated to work 12-hour shifts which will be primarily day shift.

Periodic and regular collection of coal batch samples at designated locations within the plant. The samples, collected in buckets, will be carried from the plant by hand then unloaded at the preparation room. In the preparation room, the following tasks will be performed:

- Bin contents will be dumped into a laboratory size jaw crusher for size reduction.
- Product from jaw crusher will be dumped into a splitter (hopper that separates the coal sample into two fractions).
- One fraction will be spread in a drying tray then placed inside the drying oven.
- The second fraction will be split three times in a smaller drying plan which is also paced inside the drying oven.

- The splitter will be cleaned with compressed air and the last fraction is placed in a small bucket.

In the coal quality room, the following will be conducted:

- Samples received from the prep lab drying oven will be pushed through a sieve, then fed into a splitter.
- The fractions will then be processed in a pulveriser.
- Finally, coal products produced from the pulveriser will be spilt into samples then weighed in a pre-weighed crucible prior to being inserted in an oven for ash or other instruments for sulphur, moisture, and free swelling index.
- Final weights and values will be measured and entered into a computer.

Potable Water Treatment and Wastewater Treatment Plants

There will be a sea container housing a potable water treatment plant located adjacent to the admin building as well as a wastewater (sewage) treatment plant which will be located some distance away from the admin building. One person on each shift will be trained as a class 1 operator to provide support to these facilities.

The potable water treatment system will reportedly be a pre-packaged plant designed and commissioned by FilterCo. Although the specific system has not yet been specified, it is our understanding it will be a chlorination injection system likely to use a peristaltic injection pump to inject liquid chlorine into the distribution system.

The wastewater system will be a BioNest septic tank treatment system that includes a pre-treatment septic tank followed by an aerated inground BioNest growth treatment system, then finally an effluent pump station. The system reportedly requires minimal maintenance and operating attention, with any required activities all done from the outside, eliminating the need for workers to enter the system. The BioNest uses a biological process consisting of an extended aeration fixed film reactor.

Other Buildings - Mine Rescue, Light Vehicle and Tire Shops

The light vehicle service area is planned to be within the light vehicle shop which will be sea containers on either side with a fabric-covered dome structure in-between the sea containers. The floor of this shop will be concrete and will include four overhead roll doors (two on either side). The sea containers will include an office area and storage. Mechanics service the LD vehicles, which typically include pick-up trucks, crew vans, busses and the ambulance.

The tire shop will also be constructed with sea containers on three sides with a fabric-covered dome structure in the centre. The floor of this shop will be gravel and will include one overhead roll door. The sea containers will include an office area and storage. Workers in the tire shop are trained tire technicians who may also be trained for maintenance activities.

The mine rescue building will also be constructed of sea containers with a fabric-covered dome roof, a concrete floor and will include two overhead roll doors. Within the sea containers there will be an office and storage spaces.

Mine Operations (Pit)

Pit vehicles are typically all diesel powered and will include, but may not be limited to haul trucks, excavators/shovels, loaders, graders, dozers and drills. The scale of equipment will be smaller than other operating mines in British Columbia and will likely include for example, 100-ton haul trucks and 777 Cat loaders.

Note that loaders are also used in other areas such as outside the Plant. Workers in the pit are anticipated to work 12-hour shifts with both a night shift and day shift and typically switch between vehicles from one shift to the next.

Pit operations will involve drilling holes using drills (top hammer, down the hole hammer, and/or rotary), blasting using explosives, loading/unloading using loaders, shovels and excavators, moving materials using dozers, grading the roads using graders, transporting coal and rock using haul trucks and suppressing dust using water trucks.

Workers who operate mobile equipment will mainly work in pressurized cabs. There will be other workers working in the Pit, such as supervisors, maintenance personnel and blasters. Equipment operators typically spend most of their shift in their vehicle.

Coal from the pit is dumped through a grizzly, into a crusher, then conveyed from the crusher into the coal processing plant.

Hazard Anticipation/Recognition

This section outlines the anticipated exposure hazards for the Tenas Project and includes major health concerns associated with each hazard. Exposure limits have also been included if they are available. Note that if an exposure limit(s) is not specifically provided in the *Code* – Tables 2-1 and 2-2, the ACGIH *1994-1995 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* are to be used. The three types of Threshold Limit Values (TLVs) are defined as:

1. TLV-TWA – the time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

   Note that when shifts are longer than 8 hours, a correction to the TLV-TWA is required, referred to as concentration equivalence (Ceq), and is calculated as follows:

   $$Ceq = \frac{\text{(8-hour TLV) x 8}}{\text{Shift length in hours}}$$

2. TLV-STEL – the TLV Short Term Exposure Limit (STEL) is the concentration to which workers can be exposed continuously for a period of time, provided the daily TLV-TWA is not exceeded. Exposure must be no longer than 15 minutes, be separated by 60 minutes if repeated, and occur no more than 4 times per day.

3. TLV-C – the TLV-Ceiling is the concentration that must never be exceeded.

Dust

Note that for the purposes of this assessment, the terms dust and particulates are used interchangeably. Dust on mine sites can be broken down into respirable and inhalable fractions. Inhalable particulates are those particles that can be inhaled by the nose or mouth. Respirable dust is of the greatest concern as the particles are small enough to enter deep into the lungs where gas exchange occurs. Respirable particles have a diameter generally less than 4 microns (µm), which are too small to be viewed by the naked eye. The concern is particle sedimentation into the lungs and/or diffusion into the bloodstream. Dust can either be considered nuisance dust or have more specific properties with more severe health effects e.g. silica, metals or coal dust.

Typical mining activities such as drilling, shovelling, loading, crushing and transporting coal/rock all generate nuisance dust in addition to silica (quartz) and coal dust. Road dust is also anticipated to be a significant concern. The adverse health effects for nuisance dust are predominantly respiratory tract irritation.

Nuisance dust which has no specific health effects associated with it is also referred to as Particulates Not Otherwise Classified (PNOC).The *Code* adopts the exposure limits for nuisance dust from the ACGIH TLV®

1994-1995, which is 10 mg/m^3 for 8-hr exposure for inhalable particulates (TLV-TWA) or 6.66 mg/m^3 for 12-hr exposure, and 3 mg/m^3 for 8-hr exposure to respirable particulates or 2 mg/m^3 for 12-hr exposure.

Silica (quartz)

Silica exists in both crystalline and amorphous (non-crystalline) forms. Quartz is the most common form of crystalline silica. One of the most significant hazards on coal mine sites is crystalline silica, which is a basic component of soil, sand, granite and many other minerals.

Crystalline silica has been classified by the International Agency for Research on Cancer (IARC) as a group 1 carcinogen, based on a relationship between exposures among workers to increased risk of lung cancer. Crystalline silica can also cause silicosis (a non-reversible fibrotic lung disease) and has been linked to pulmonary tuberculosis, chronic obstructive pulmonary disease (COPD), and autoimmune disease (rheumatoid arthritis).

Crystalline silica exposure primarily occurs through inhalation. Table 2-1 of the *Code* lists an 8-hour TLV-TWA exposure limit of 0.05 mg/m^3 for quartz. The 12-hour adjusted exposure limit is 0.033 mg/m^3.

Coal

Processes on site can create airborne coal dust. The respirable fraction is the most hazardous. Exposure to high levels of airborne coal is known to cause Coal Workers' Pneumoconiosis (CWP), commonly and historically referred to as Black Lung Disease. It is the carbon in the coal that is the concern. Respirable coal particulates that reach the gas exchange region of the lungs are deposited, and since the lungs cannot absorb or break down the particles, the lungs encapsulate them, forming nodules. As exposure continues, the nodules progress in the lungs, causing the lungs to become rigid and loose elasticity. CWP is chronic and may be fatal.

Table 2-1 of the *Code* lists the 8-hr TWA for respirable coal dust as 2 mg/m^3 or 1.33 mg/m^3 for 12-hr exposure.

Welding Fume/Gas

Hot work, including welding, grinding and cutting will mostly be conducted in the welding shop; however, small scale hot work may also be conducted on machinery in other area of the shop or plant, outside the shop, or out in the field. Most work conducted will be on mild or hardened steel; however, hot work may also be conducted on aluminum or stainless steel.

Welding fumes are generally a mixture of metallic oxides, silicates and fluorides. Fumes are formed when a metal is heated above its boiling point and its vapours condense into very fine particles (solid particulates). Fumes come from the metal alloys and coatings/residues on metal being welded. Some ingredients in coatings or residues can have toxic effects, such as metal working fluids, oils and rust inhibitors, lead oxide primer paints, etc. In addition, depending on the materials, additional hazards may be present, for example, if welding is conducted on stainless steel, hexavalent chromium is a concern and if welding on hardened surfaces (e.g. for heavy equipment), manganese is a concern. Some specific metals are considered designated substances (carcinogens, reproductive hazards and/or sensitizers) and therefore welding fumes should be considered ALARA substances (exposures should be kept As Low As Reasonably Achievable).

Other than the fumes, welding gases which are used for welding (e.g. argon) and which result from the welding process (e.g. CO) as well as gases/vapours produced from thermal breakdown of coatings (organic vapours), are also of potential concern. The health effects[1] and applicable exposure limits (*the Code,* adopted from the ACGIH TLV® 1994-1995*)* of the welding fumes/gases are summarized in Table 1 below:

[1] WorkSafe Alberta. 2009. Welders' Guide to Hazards of Welding Gases and Fumes.

Table 1: Welding Fume/Gas Exposure Health Effects and Exposure Limits (1 of 2)

Agent	Health Effects	8-hr EL	12-hr EL
Fume			
Aluminum	Respiratory irritant.	5 mg/m^3	3.3 mg/m^3
Beryllium	"Metal Fume Fever." A carcinogen. Other chronic effects include damage to the respiratory tract.	0.002 mg/m^3	0.0013 mg/m^3
Cadmium Oxides	Irritation of respiratory system, sore and dry throat, chest pain and breathing difficulty. Chronic effects include kidney damage and emphysema. Suspected carcinogen.	0.01 mg/m^3	0.0066 mg/m^3
Chromium	Increased risk of lung cancer. Some individuals may develop skin irritation. Some forms are carcinogens (Cr VI TLV-TWA of 0.01 mg/m^3).	0.5 mg/m^3	0.33 mg/m^3
Copper (fume)	Acute effects include irritation of the eyes, nose and throat, nausea and "Metal Fume Fever."	0.2 mg/m^3	0.13 mg/m^3
Fluorides	Acute effect is irritation of the eyes, nose and throat. Long-term exposures may result in bone and joint problems. Chronic effects also include excess fluid in the lungs.	2.5 mg/m^3	1.66 mg/m^3
Iron Oxides	Siderosis – a benign form of lung disease caused by particles deposited in the lungs. Acute symptoms include irritation of the nose and lungs. Tends to clear up when exposure stops.	5 mg/m^3	3.33 mg/m^3
Lead	Chronic effects to nervous system, kidneys, digestive system and mental capacity. Can cause lead poisoning.	0.05 mg/m^3	0.033 mg/m^3
Manganese	“Metal Fume Fever.” Chronic effects may include central nervous system problems.	1 mg/m^3	0.66 mg/m^3
Molybdenum	Acute effects are eye, nose and throat irritation, and shortness of breath.	5 mg/m^3	3.33 mg/m^3
Nickel	Acute effect is irritation of the eyes, nose and throat. Increased cancer risk has been noted in occupations other than welding. Also associated with dermatitis and lung problems.	1 mg/m^3	0.66 mg/m^3
Vanadium	Acute effect is irritation of the eyes, skin and respiratory tract. Chronic effects include bronchitis, retinitis, fluid in the lungs and pneumonia.	0.05 mg/m^3 (as vanadium pentoxide)	0.033 mg/m^3 (as vanadium pentoxide)
Zinc	Metal Fume Fever.	5	3.3
Gas			
Carbon Monoxide	Absorbed readily into the bloodstream, causing headaches, dizziness or muscular weakness. High concentrations may result in unconsciousness and death	25 ppm	17 ppm
Hydrogen Fluoride	Irritating to the eyes and respiratory tract. Overexposure can cause lung, kidney, bone and liver damage. Chronic exposure can result in chronic irritation of the nose, throat and bronchi.	3 ppm (Ceiling)	-
Nitrogen Oxides	Eye, nose and throat irritation in low concentrations. Abnormal fluid in the lung and other serious effects at higher concentrations. Chronic effects include lung problems such as emphysema.	25 ppm as NO, 1 ppm as NO_2	17 ppm as NO, 0.7 ppm as NO_2
Ozone	Acute effects include fluid in the lungs and hemorrhaging. Very low concentrations (e.g., one part per million) cause headaches and dryness of the eyes. Chronic effects include significant changes in lung function.	0.1 ppm (Ceiling)	-

Table 1 (Continued 2 of 2)

Agent	Health Effects	8-hr EL	12-hr EL
Organic Vapours			
Aldehydes	Irritant to eyes and respiratory tract.	Varies based on compound	Varies based on compound
Isocyanates	Eye, nose and throat irritation. High possibility of sensitization, producing asthmatic or other allergic symptoms, even at very low exposures.	0.005 ppm (as MDI)	0.0033 (as MDI)
Phosgene	Severe irritant to eyes, nose and respiratory system. Symptoms may be delayed.	0.1 ppm	0.066 ppm
Phosphine	Irritant to eyes and respiratory system, can damage kidneys and other organs.	0.3 ppm	0.2 ppm

Exhaust (Gas/Particulate)

Many types of diesel fueled mobile equipment will be used on site. Operators are expected to remain in the pressurized cabs which provide varying levels of protection from exposure; however, operators may need to exit vehicles depending on the specific work area/location. In addition, mobile equipment will be repaired and maintained on site, and workers may be exposed, particularly indoors if the exhaust is not fully or effectively ventilated to the outside. Gas powered LD vehicles are serviced in the light vehicle shop and therefore workers may be exposed to exhaust from these vehicles as well.

The composition of vehicle exhaust depends on various factors which include the type of engine (heavy or light duty), the size of the equipment, the type of fuel and oil, speed and load of operation, and emission control systems. Exhaust includes particulate and gas components. The particulates include elemental carbon, organic compounds, metals and other trace compounds. Most diesel particulate matter is respirable. The predominant components of the gas are nitrogen, water vapour, and carbon dioxide. A relatively small amount is undesirable noxious or toxic substances, such as carbon monoxide (CO), nitrogen dioxide (NO_2) and nitric oxide (NO).

The International Agency for Research on Cancer (IARC) classifies diesel exhaust as a Group 1, confirmed human carcinogen. This classification was based on sufficient evidence for lung cancer and limited evidence for bladder cancer in humans. Studies of the gaseous phase (particulates removed); however, were inadequate to determine carcinogenicity (gasoline engine exhaust was classified as Group 2B, possibly carcinogenic to humans). Short term exposure to diesel engine exhaust can cause irritation of the eyes, throat, and bronchi, neuro-physiological symptoms such as light-headedness and nausea, and respiratory symptoms such as cough and phlegm. Diesel exhaust may initiate allergic reactions or increase immunological response to other allergens.

Based on recent research, diesel particulate matter (DPM) may be the most hazardous component of diesel exhaust. Table 2-1 of the *Code* sets the 8-hr exposure limit for diesel exhaust particulates (as respirable combustible dust, RCD) as 1.5 mg/m^3 (1 mg/m^3 for 12-hr exposure); however, this value is considered by many to be outdated. Measuring the amount of airborne respirable elemental carbon has instead been found to be a good indicator of exposure to DPM. There are no accepted Canadian exposure limits or guideline values for DPM; however, Australia has a standard of 100 $\mu g/m^3$ (0.1 mg/m^3) of respirable elemental carbon that is becoming widely accepted as an exposure guideline for DPM.

Table 2-1 of the *Code* sets the 8-hr exposure limits for both CO and NO at 25 ppm (16.7 for 12-hr exposure), and 1 ppm for 8-hr exposure to NO_2 (0.66 ppm for 12-hr exposure).

Noise

Noise is unwanted sound, which is produced by vibrating objects and reaches the listener's ears as waves in the air or other media. Noise is one of the most common occupational health hazards. The biggest risk for over-exposure to noise is permanent hearing loss. Annoyance, stress and interference with speech communication are also adverse effects of noise exposure.

Noise is a universal hazard at mines, particularly at the crushers. Table 2-2 of the *Code* has an 8-hr exposure limit for noise of 85 dBA Lex (83 dBA for 12-hr shifts). This includes peak impulse noise but assumes no exposure to steady state noise over 109 dBA and no exposure to peak impulse noise over 140 dBC.

Table 2-3 of the *Code* prescribes the required rating of hearing protection based on maximum equivalent noise level (dBA).

Heat and Cold Stress

The temperature at the mine (based on Smithers) typically varies from -11°C to 23°C and is rarely below -24°C or above 29°C

Compared with heat stress, cold stress will be of more concern at the mine site. Cold stress occurs when the core body temperature becomes excessively low. Excessive cold working environments can cause workers to undergo physiological and psychological stress. Cold stress cannot only cause conditions such as frostbite and hypothermia, but can reduce productivity in workers even under moderate conditions.

The *Code* does not provide exposure limits for cold stress; therefore, the ACGIH TLV® 1994-1995 are to be used, which include controls and TLVs for working in cold conditions (-7ºC and below). If work is performed continuously at an equivalent chill temperature (ECT) of -7ºC and below, controls such as heated warming shelters should be made available nearby, with the frequency of use depending on the severity of the environmental exposure. For work at or below -12ºC ETC, additional controls should be applied, as per the ACGIH TLV® 1994-1995, particularly points 1-6 of the *Work-Rest Regimen* section. The cold stress section of the ACGIH TLV® 1994-1995 is included in Appendix C. For temperatures at or below -26ºC , see Table 2 below for the TLVs, including the maximum work period and number of breaks required. Corresponding notes for Table 2 can be found in Appendix C.

Table 2: TLVs Work/Warm-up Schedule for Four-Hour Shift

THRESHOLD LIMIT VALUES WORK/WARM-UP SCHEDULE FOR FOUR-HOUR SHIFT*											
Air Temperature Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C (approx)	°F (approx)	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
-26° to -28°	-15° to -19°	(Norm breaks) 1		(Norm breaks) 1		75 min.	2	55 min.	3	40 min.	4
-29° to -31°	-20° to -24°	(Norm breaks) 1		75 min.	2	55 min.	3	40 min.	4	30 min.	5
-32° to -34°	-25° to -29°	75 min.	2	55 min.	3	40 min.	4	30 min.	5	Non-emergency work should cease ↓	
-35° to -37°	-30° to -34°	55 min.	3	40 min.	4	30 min.	5	Non-emergency work should cease ↓			
-38° to -39°	-35° to -39°	40 min.	4	30 min.	5	Non-emergency work should cease ↓					
-40° to -42°	-40° to -44°	30 min.	5	Non-emergency work should cease ↓							
-43° to below	-45° & below	Non-emergency work should cease									

*See Appendix C for notes to accompany Table 2 above.

Light

Poorly lit working environments can potentially lead to occupational health concerns such as eye strain, eye fatigue, trips, falls and similar types of injuries. It is expected that there may be some work areas with low light conditions, particularly during the night shift if precautions are not taken to ensure sufficient lighting is present.

The Part 2.8.1 of the *Code* adopts the ANSI/IES Standard RP-7-1991: “American National Standard Practice for Industrial Lighting”. The standard outlines the recommended lighting ranges for different work tasks and lighting categories. Please see Table 3 below for current lighting requirements as per the above standard.

Table 3: Current Recommended Illuminance Categories and Illuminance Ranges for Interior Industrial Lighting Design (from Ministry of Energy and Mines Workplace Monitoring Procedures Manual, February, 2002)

Type of Activity	Illuminance category	Ranges of Illuminance		Reference workplane
		lx	fc	
Public spaces with dark surroundings	A	20-30-50	2-3-5	General Lighting Throughout
Simple orientation for short temporary visits	B	50-75-100	5-7.5-10	
Working spaces where visual tasks are only occasionally performed	C	100-150-200	10-15-20	
Performance of visual tasks of high contrast or large size	D	200-300-500	20-30-50	Illuminance on Task
Performance of visual tasks of medium contrast or small size	E	500-750-1000	50-75-100	
Performance of visual tasks of low contrast or very small size	F	1000-1500-2000	100-150-200	
Performance of visual tasks of low contrast and very small size over a prolonged period	G	2000-3000-5000	200-300-500	Illuminance on task, obtained by a combination of general and local (supplementary)
Performance of very prolonged and exacting visual tasks	H	5000-75000-10000	500-750-1000	
Performance of very special visual tasks of extremely low contrast and small size	I	10000-15000-20000	1000-1500-2000	

UV Light Radiation

Ultraviolet (UV) light radiation from the sun poses a health risk for workers working outdoors. In addition, welding arcs also pose UV light radiation hazards for welders and workers in the adjacent areas.

UV radiation has shorter wavelengths (higher frequencies) compared to visible light but has longer wavelengths (lower frequencies) compared to X-rays. UV radiation is divided into three wavelength ranges: UV-C (100 – 280 nm), UV-B (280-315 nm) and UV-A (315 – 400 nm).

The shortwave UV radiation (UV-C) poses the greatest risk. The sun emits UV-C, but it is absorbed in the ozone layer before reaching the earth. Therefore, UV-C from the sun does not affect people. The medium wave UV (UV-B) causes skin burns, erythema (reddening of the skin) and darkening of the skin. Although UV-A is less intense than UV-B, it is more prevalent and can penetrate deeper into the skin layers, affecting the connective tissue and blood vessels.

Prolonged human exposure to solar UV radiation may result in acute and chronic health effects on the skin, eye and immune system. Sunburn (erythema) is the best-known acute effect of excessive UV radiation exposure. Over the longer term, UV radiation induces degenerative changes in cells of the skin, fibrous tissue and blood vessels leading to premature skin aging, photodermatoses and actinic keratoses. Another long-term effect is an inflammatory reaction of the eye. In the most serious cases, skin cancer and cataracts can occur.

The intensity of UV radiation is measured in the units of milliwatts per square centimeter (mW/cm^2) which is energy per square centimeter received per second. Also, it is measured in the units of millijoules per square centimeter (mJ/cm^2), which is energy received per unit area in a given time.

There are no *Code* exposure limits for UV radiation. Many jurisdictions follow the limits recommended by the ACGIH. These limits are:

- For the UV-A, exposure to the eye should not exceed 1.0 mW/cm^2 for periods greater than 1000 seconds (17 minutes). For exposure times less than 1000 seconds, the dose (total energy) should not exceed 1000 mJ/cm^2;
- Additional exposure limits apply to the amount of UV light exposure to the skin and the eyes. The amount of UV exposure a person can receive on their skin or eyes during an 8-hour period varies with the wavelength of the UV radiation.

Radiation

Within the Coal Processing Plant, equipment with radiation sources will be used for accurate density measurement of slurries in the coarse circuit (to measure correct medium density) as well as on the thickener underflow. It is our understanding that these radiation sources will be managed by the Plant Manager and Safety Manager in compliance with regulatory requirements and CSA standards. They will all have the appropriate areas marked off to prevent worker access. The active source will reportedly be Cesium-137 or Cobalt-60.

Cesium-137 and Cobalt-60 give off two ionizing hazards: beta particles and gamma rays. Beta particles are easily blocked but gamma rays are very penetrative. The amount and duration of radiation exposure affects the severity or type of health effects, ranging from changes in blood chemistry, nausea and fatigue to internal bleeding, cancer and death.

Part 2.3.11(1) of the *Code* regulates that a worker shall not be exposed to ionizing radiation to a level greater than any of the following:

- 4.0 Working Level Months (20 millisieverts) of radon decay products per year averaged over 5 years and 10.0 Working Level Months (50 millisieverts) in a single year;
- 20 millisieverts (2 Rem) of gamma radiation per year averaged over 5 years and 50 millisieverts (5 Rem) in a single year;
- A combination of radon decay products and gamma radiation totaling 20 millisieverts (2 Rem) averaged over 5 years or 50 millisieverts (5 rem) in a single year.

Note that where measurements indicate a worker is exposed to gamma radiation greater than 2.5 microsieverts per hour (0.25 millirems per hour) at 0.5 meters from the source, a gamma radiation dosimeter shall be provided to and worn by each worker who is exposed.

In addition, employees cannot be exposed to non-ionizing radiation which exceeds the recommendations contained in the publication "*Safety Code 6, Recommended Safety Procedures for the Installation and Use of Radio Frequency and Microwave Devices in the Frequency Range of 10 MHz to 300 GHz"*, published by Health and Welfare, Canada.

Organic Solvents

Products containing organic solvents or volatile organic compounds (VOCs) are expected to be used on site by mechanics such as brake cleaner, solvents in parts washers, oils/grease (hydraulic oil, various engine oils), fuels (gasoline, diesel and propane), and coolant (ethylene glycol). For anyone conducting painting, paints typically contain a variety of VOCs.

The most common health effects associated with organic solvent exposure include nervous system damage (central and peripheral), kidney and liver damage, adverse reproductive effects (sperm changes and infertility), skin lesions and cancer.

Exposure to organic solvents on site would primarily be through inhalation; however, if workers get organic solvents on their skin, dermal exposure may also be a concern. Examples would be mechanics getting solvents on their hands such as brake cleaner, parts wash solvent or oil/grease.

Due to the wide variety of organic solvents potentially used on site, specific exposure limits have not been included. The Workplace Hazardous Materials Information System (WHIMS) - Safety Data Sheets will be referenced for specific hazards including hazardous ingredients, and recommended controls. The *Code* or 1994/1995 ACGIH TLVs will be referenced for specific exposure limits, as required.

Indoor Air Quality

The quality of indoor air is often a major component of worker comfort and satisfaction. Air quality in the workplace may affect productivity, sick time and even the length of time workers stay at a job. Air quality problems can be caused by a variety of sources such as:

- Human metabolic activity;
- Smoking;
- Structural components of the building and contents;
- Off-gassing of VOCs/aldehydes;
- Microbial contamination;
- Mechanical equipment;
- Outside air pollutants that enter the building; and
- Insufficient ventilation (Outdoor Air).

Health complaints and symptoms experienced by workers are usually not specific enough to simplify the identification of the causes. Most identified workplace air quality problems are usually traced to inadequate building ventilation, although psychosocial issues (work related stress due to high job demands, work overload, conflicts at work, perceived lack of managerial support) can be a significant contributory factor. Other common problems are migration of odours or chemical hazards between different areas of the building, recirculation of air within the building and poor odour and environmental control due to insufficient fresh air.

Construction of offices and other indoor spaces using ATCO trailers can often result in the development of indoor air quality concerns, if ventilation requirements for the indoor spaces are not properly reviewed and/or if the building envelope is not properly constructed or maintained.

Industrial standards for air quality have existed for many years. These standards typically set limits for concentrations of contaminants that could result in serious illnesses among workers; however, it has been determined that much lower concentrations of some compounds may cause less severe health effects among workers. The *Code* does not specifically mention indoor air quality; therefore, the Department of Health (Health Canada) publication 93-EHD-166 *Indoor Air Quality in Office Buildings: A Technical Guide* may be referred to (available at http://publications.gc.ca/collections/Collection/H46-2-93-166Erev.pdf). The guide refers to the American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) ventilation standards for quantitative guidelines. The parameters which are required for investigation include carbon dioxide, carbon monoxide, temperature, relative humidity and air motion (if required).

Note that Part 2.1.4 of *Code* defines that "Persons shall not work or remain in any part of a mine, where they may be exposed to air with oxygen content less than 19.5% by volume unless provided with an alternate air supply". Oxygen deficiency is not typically considered as part of indoor air quality. Other than possibly in confined spaces, oxygen deficiency on site is not anticipated to be a significant concern.

Indoor air quality is only one of several factors that can affect comfort in the workplace. Others include noise, lighting, number of individuals per unit area and psychosocial issues. Excessive noise or unsuitable lighting can result in headaches and other symptoms. Increased stress caused by work activity or overcrowding can also contribute to many complaints normally associated with poor air quality.

Chlorine

Chlorine is widely used in disinfection as it oxidizes cellular material, killing biological pathogens. Chlorine is a greenish-yellow gas with a pungent, irritating odour. At lower concentrations, exposure typically results in nose, throat and eye irritation. Exposure to higher concentrations can result in changes in breathing rate and coughing, and lung damage, among others.

In the water treatment plant, workers may be exposed to chlorine, as liquid sodium hypochlorite will used as a disinfectant, diluted at point-of-use. It is anticipated the sodium hypochlorite concentration will be about 12% chlorine. Although safer than gaseous chlorine, liquid chlorine still causes some off-gassing of chlorine. By itself, both the gas and the liquid forms are non-flammable and non-explosive; however, both forms will readily support the combustion of many compounds. It will damage moist body surfaces, such as the eyes, nose, throat, lungs, and wet skin.

Concentrations of 3 ppm can cause eye irritation, coughing, and difficulty in breathing and even concentrations as low as 1 ppm may produce slight irritation.

Table 2-1 of the *Code* lists a chlorine gas TLV-TWA of 0.5 ppm (0.33 ppm for 12-hr exposure) and a STEL of 1 ppm.

Hydrogen Sulfide

Hydrogen sulfide is a dense, colourless gas with a strong odour of rotten eggs. It is produced by bacterial processes during the decay of plant and animal protein or through the reduction of sulphate. Hydrogen sulfide is highly toxic, causing pulmonary oedema, unconsciousness or death in a single exposure at high concentrations. Repeated exposure to lower concentrations may cause chronic respiratory symptoms and damage to the central nervous system.

As reported by Radloff Engineering, hydrogen sulfide gas will be produced in the wastewater treatment system, particularly in the septic tanks and BioNest tank. The gas is produced as a by-product of the biological treatment process.

Table 2-1 of the *Code* lists a hydrogen sulfide gas TLV-TWA of 10 ppm (6.6 ppm for 12-hr exposure) and a STEL of 15 ppm.

Biological hazards

- The only anticipated biological hazards are associated with the wastewater treatment plant. The sewage and wastewater may contain a variety of pathogens including bacteria, fungi, parasites and viruses that may cause intestinal, lung, and other infections.
- If infectious illness is a concern, it will be managed through a separate exposure control plan.
- If moisture intrusion into buildings occurs, fungal growth may be a concern.
- There are no exposure limits for biological hazards.

Other Hazards

- **Lead and asbestos** - Since the mine will be newly constructed (all new buildings), we assume no asbestos will be present. In addition, surface coatings are unlikely to contain lead; however, when procuring equipment and finishings on structures, it should be certified as lead and asbestos free.
- **Ergonomics and Vibration** – An initial ergonomics assessment was prepared by Total Safety and should be referenced for ergonomic hazards and controls, including whole-body and hand-arm vibration (Total Safety Ref: 20-217 R01 Rev. 01 dated December 1, 2020). A Musculoskeletal Disorder (MSD) Prevention Training Program will be developed prior to operation of the mine.
- **Confined Spaces –** Confined space hazards will be covered in a separate Confined Space Program so have not been included in this assessment.
- **Cleaning products** – A variety of cleaning products will be used on site, most of which will likely pose little to no inhalation hazard during regular recommended use; however, some are likely to be eye and skin irritants. For all cleaning products, the Safety Data Sheet should be referenced for applicable exposure limits and appropriate controls to be implemented (e.g. use of gloves or eye protection).
- **Other hazards**, such as wood dust, may be present at the mine. If exposure is anticipated, it will be evaluated via a risk assessment (member of Joint Occupation Health and Safety Committee (JOHC), safety department, other experienced worker or private consultant) and a job safety analysis (JSA) and standard operating procedure developed.

Workforce and SEGs

There are anticipated to be a maximum of 170 workers at the mine, with most workers working 12-hour shifts, except in the office. Operations will run 24 hours a day, seven days a week.

Similarly Exposed Groups (SEGs) have been proposed, based on anticipated job positions and tasks. An SEG is defined as a group of workers who generally perform similar tasks for similar periods of time, and therefore their exposures are expected to also be similar. By grouping workers, risk assessments and sampling can be conducted for the group as opposed to individuals, providing more accurate data and more effective allocation of resources both for continued sampling and for implementation of controls.

SEG's have been anticipated based on Total Safety's experience at similar coal mines in BC and elsewhere in Canada, information provided from the client and professional judgement. Please refer to Table 4 below for SEG information. Note the SEGs will be updated prior to mine operations if any information changes, once the mine is operation, upon receipt of initial baseline monitoring, and based on regular sampling thereafter.

Table 4: SEG Information (1 of 2)

Process	Occupation	Anticipated Hazards
Mine Operations (Pit)		
Drilling	Drill Operators	• Noise • Silica and coal dust • Exhaust gas/particulate
Loading	Shovel Operators	• Noise • Silica and coal dust • Exhaust gas/particulate
	Excavator Operators	• Noise • Silica and coal dust • Exhaust gas/particulate
Support Mining Equipment	Dozer Operators	• Noise • Silica and coal dust • Exhaust gas/particulate
	Grader Operators	• Noise • Silica and coal dust • Exhaust gas/particulate
	Front-End Loader (FEL) Operators – Processed Coal	• Noise • Silica and coal dust • Exhaust gas/particulate
	ROM Loaders	• Noise • Silica and coal dust • Exhaust gas/particulate
Hauling	Haul Truck Operators	• Noise • Silica and coal dust • Exhaust gas/particulate
Blasting	Blasters Blaster's Helpers	• Noise • Silica and coal dust • Exhaust gas/particulate
Pit Support	Laborers Pump crew	• Noise • Silica and coal dust • Exhaust gas/particulate
Site Supervision	General Foreman	• Noise • Silica and coal dust • Exhaust gas/particulate
	Supervisor	• Noise • Silica and coal dust • Exhaust gas/particulate
Surveying / Geology / Engineering / Environment	Surveyors/Geologists/Engineers/Environmental Technicians	• Noise • Silica and coal dust • Cold stress • UV Light

Table 4 (Continued 2 of 2)

Process	Occupation	Anticipated Hazards
Maintenance		
HD Maintenance (shop and field)	Mechanics/Electricians	• Noise • Exhaust gas/particulate • Organic solvents • Cold stress (field)
LD Maintenance (shop and field)	Mechanics/Electricians	• Noise • Exhaust gas/particulate • Organic solvents • Cold stress (field)
Welding (shop and field)	Welders/Mechanics	• Noise • Welding fume • UV Light • Cold Stress (outdoors/field)
Fuel/Lube	Fuel/Lube Person[1]	• Noise • Silica and coal dust • Exhaust gas/particulate • Organic solvents
Cleaning activities	Maintenance Labourer	• Noise • Silica and coal dust
Water/Wastewater Treatment Plant Operation	Class 1 Operator	• Noise • Biologicals • Chlorine gas • Hydrogen sulfide gas
Coal Plant		
Plant Maintenance	Plant Operators performing Electrical work	• Noise • Silica and coal dust
	Plant Operators performing maintenance work such as welding	• Noise • Silica and coal dust • Welding fume
Operation and Sampling	Plant Operator	• Noise • Silica and coal dust
	Plant Superintendent/Process Engineer	• Noise • Silica and coal dust
	Electrical Supervisor	• Noise • Silica and coal dust
	Supervisors	• Noise • Silica and coal dust
Coal Quality Lab		
Lab	Lab Technician	• Noise • Silica and coal dust
Lab QC/Supervision	Process Engineer	• Noise • Silica and coal dust
Warehousing		
Warehousing	Warehouse Worker	• None of significant concern

Note:

1. Fuel/lube may be done by equipment operators, not a designated Fuel/Lube person

Hazard Evaluation – Qualitative Preliminary Risk Assessment

A preliminary risk assessment has been developed, based on the probability and health effect/consequences of estimated exposures. This risk assessment is considered qualitative since the mine will be new and no past sampling data is available. The risk estimations were primarily based on our experience and sampling results at other coal mines. The probability rating scale and hazard effect/consequence rating scale are defined below:

- Probability (P) Rating Scale
    - Rating 5 – Almost certain – The exposure occurs frequently – continuous exposure during each shift; a 90% or greater chance of occurrence
    - Rating 4 – Likely – The exposure occurs frequently – at least several times per shift, but not continuously; between 50% - 90% chance of occurrence
    - Rating 3 – Possible – The exposure occasionally occurs – not every shift; between 20% - 50% chance of occurrence
    - Rating 2 – Unlikely – The exposure is not known to have occurred, but may occur in the future; between 5% - 20% chance of occurrence
    - Rating 1 – Rare – The exposure has never been known to occur and is not expected to occur during the shift

- Hazard Effect/Consequence (C) Rating Scale
    - Rating 5 – Catastrophic/High – Exposure to a health hazard is significantly over the exposure limit (e.g. > 10 times the exposure limit); without controls, it can result in an irreversible impact on health
    - Rating 4 – Major – Exposure to a health hazard is equivalent to or over the exposure limit but less < 10 times the limit; without controls, it can result in an irreversible impact on health
    - Rating 3 – Moderate – Exposure to a health hazard is over the action level (50% of the limit), but below the exposure limit; without controls, it may result in irritation, detection of odours, and/or health effects in sensitized individuals, but normal healthy workers should not experience health effects
    - Rating 2 – Minor – Exposure to health hazard is below the action level; Health effects are unlikely
    - Rating 1 – Insignificant – Exposure to a health hazard is negligible (<10% of exposure limit). No anticipated health effects

The following Table 5 illustrates the Risk Matrix – Probability versus Hazard Effect/Consequence.

Table 5: Risk Assessment Ratings Scale (provided by Telkwa)

		Hazard Effect/Consequence					
		Insignificant	Minor	Moderate	Major	Catastrophic	Risk Score
		1	2	3	4	5	
Probability	Almost Certain	11	16	20	23	25	High
	Likely	7	12	17	21	24	Significant
	Possible	4	8	13	18	22	Moderate
	Unlikely	2	5	9	14	19	Low
	Rare	1	3	6	10	15	

The ratings for probability and hazard effect/consequence are estimated based on the characteristics of the operations and work environments, exposure monitoring results at similar coal mines, toxicities and professional judgement.

Please refer to Table 6 below for the qualitative risk assessment. The risk assessments should be reviewed once the mine is in operation and updated periodically, if conditions or operations change or if controls are implemented, and/or as sampling data becomes available. Sampling should be conducted regularly by the safety manager, JOSHC and/or a private consultant, as per the Workplace Monitoring Program, to be developed post-permitting.

The risk assessment only considers the inhalation exposure route, not skin contact or ingestion. The use of respirators and hearing protection were not taken into consideration. Note that the following assumptions are made for the risk assessment:

- All workers will follow all the site safety rules;
- No additional tasks are conducted other than those described in this assessment; and,
- All controls in place will be effectively used and maintained.

R≥21 are defined as high risk and marked with red; R≥5 but <13 are defined as moderate risk and marked with yellow; R≥13 but <21 are defined as significant risk and marked with orange; R<5 are defined as low risk and marked with green.

A risk estimation of “Low” typically means exposure is expected to be below 50% of the exposure limit; “Moderate/Significant” means exposure may be above 50% of the exposure limit and possibly approaching the exposure limit; and “High” means exposure is likely above the exposure limit.

Note that Table 6 only includes a risk assessment for dust, crystalline silica, coal dust, welding fumes/gases, exhaust and noise during operation of the mine and some SEGs have not been included. Please see the

Risk Assessment Exceptions section below for further details on excluded hazards and SEGs, and for additional information on the anticipated hazards during the construction phase.

Table 6: Qualitative Preliminary Risk Assessment (1 of 2)

Hazard / SEG	PNOC (Dust)			Crystalline Silica			Coal Dust			Welding Fumes/Gases			Diesel Exhaust			Noise		
	P	C	R	P	C	R	P	C	R	P	C	R	P	C	R	P	C	R
Mine Operations (Pit)																		
Drill Operators	3	3	13	3	3	13	3	2	8	1	1	1	3	2	8	4	4	21
Shovel Operators	3	2	8	3	2	8	3	2	8	1	1	1	3	2	8	5	3	20
Excavator Operators	3	2	8	3	2	8	3	2	8	1	1	1	3	2	8	5	3	20
Dozer Operators	3	2	8	3	2	8	3	2	8	1	1	1	3	2	8	5	3	20
Grader Operators	3	2	8	3	2	8	3	2	8	1	1	1	3	2	8	5	3	20
FEL Operators – Processed Coal	3	2	8	3	2	8	3	3	13	1	1	1	3	2	8	5	3	20
ROM Loaders	3	2	8	3	2	8	3	2	8	1	1	1	3	2	8	5	3	20
Haul Truck Operators	3	2	8	3	3	13	3	3	13	1	1	1	3	2	8	5	3	20
Blasters/Helpers	4	4	21	4	4	21	3	3	13	1	1	1	4	3	17	5	4	23
Labourers and Pump Crew	3	3	13	3	4	18	3	3	13	1	1	1	4	3	17	4	4	21
General Foreman	2	2	5	2	2	5	2	2	5	1	1	1	2	2	5	4	2	12
Supervisor	2	2	5	2	2	5	2	2	5	1	1	1	2	2	5	4	2	12
Surveyors/Geologists/Engineers/Environmental Tech's	3	3	13	3	4	18	3	2	8	1	1	1	2	3	9	3	4	18
Maintenance																		
Mechanics/Electricians (LD Shop/field)	2	2	5	2	3	9	2	2	5	2	2	5	4	3	17[1]	4	4	21
Welders/Mechanics (welding pad/field)	2	3	9	2	3	9	2	2	5	4	4	21	3	2	8	4	4	21
Mechanics/Electricians (HD Shop/field)	2	2	5	2	3	9	2	2	5	2	2	5	4	3	17	4	4	21
Fuel/Lube Person	2	2	5	2	3	9	2	2	5	2	2	5	3	3	13	4	4	21
Labourer	3	2	8	3	2	8	2	2	5	1	1	1	2	2	5	3	3	13
Class 1 Operator (WTP/STP)	2	2	5	2	2	5	2	2	5	1	1	1	1	1	1	3	3	13

Notes:

1) Includes gasoline exhaust
2) The risk assessment only considers the inhalation exposure route, not skin contact or ingestion.
3) Respirators and hearing protection were not taken into consideration for the risk rating. Other controls were taken into consideration.

Table 6: (Continued 2 of 2)

Hazard / SEG	PNOC (Dust)			Crystalline Silica			Coal Dust			Welding Fumes/Gases			Diesel Exhaust			Noise		
	P	C	R	P	C	R	P	C	R	P	C	R	P	C	R	P	C	R
Coal Plant																		
Plant Operators performing electrical work	2	2	5	3	2	8	2	2	5	1	1	1	1	1	1	4	4	21
Plant Operators performing maintenance work such as welding	3	2	8	3	2	8	3	2	8	4	4	21	1	1	1	4	4	21
Plant Operators performing plant tasks only	3	2	8	3	3	13	3	2	8	1	1	1	1	1	1	4	4	21
Plant Superintendent/Process Engineer	2	2	5	2	2	5	2	2	5	1	1	1	1	1	1	3	3	13
Electrical Supervisor	2	2	5	2	2	5	2	2	5	1	1	1	1	1	1	4	3	17
Supervisors	2	2	5	2	2	5	2	2	5	1	1	1	1	1	1	3	3	13
CQL																		
Lab Technician	4	3	17	4	4	21	3	3	13	1	1	1	1	1	1	4	4	21
Process Engineer	2	2	5	2	2	5	2	2	5	1	1	1	1	1	1	2	2	5
Warehousing																		
Warehouse Worker	2	2	5	2	2	5	2	2	5	1	1	1	2	2	5	1	1	1

Notes:

1) The risk assessment only considers the inhalation exposure route, not skin contact or ingestion.
2) Respirators and hearing protection were not taken into consideration for the risk rating. Other controls were taken into consideration.

Risk Assessment Exceptions

For those hazards and SEGs not included in Table 6, we have provided some additional discussion. As the septic tanks and BioNest water treatment tanks will be below ground, exposure to hydrogen sulfide gas and biological pathogens is expected to be low during routine operation; however, depending on the location of the vent pipe(s) for the systems, some controls may be required. If entry into the tanks is required, this will be covered under the Confined Space Program and associated hazard assessments and entry procedures.

For the potable water treatment plant, as the chlorination system has not yet been specified and designed, a risk assessment cannot be conducted but should be done prior to construction.

Ergonomics and confined space hazards will be managed in separate programs. Concerns with lighting, heat/cold stress, UV light, paint vapours and biological hazards should be assessed, as required. Other potential exposures should be evaluated as they are recognized, such as dermal hazards associated with cleaning product use and oil/grease ingestion. For projects outside the scope of regular operations, a risk assessment should be conducted either internally by the OHS Superintendent, JOSHC or by an external consultant prior to the start of the project.

First aid attendants and those who work in office settings have not been included in Table 6. First Aid Attendants will have highly variable exposure potential, mainly depending on where on site they are

required to attend to a patient, and the conditions at the time. For workers in office settings, indoor air quality is the primary anticipated concern and should be assessed/evaluated as concerns arise.

Overview of Anticipated Hazards for the Construction Phase

For the construction phase, a formal risk assessment has not been completed as this work will be done by contractors who will be required to conduct their own risk assessments. Much of the same occupational health hazards are anticipated to be a concern during the mine's construction as during operations, as follows:

- Logging and other land clearing activities:
  - Noise from machinery,
  - Silica and dust from earth disturbance or rock breaking,
  - Wood dust,
  - Vehicle exhaust,
  - Ultraviolet radiation exposure from the sun for those working outside, depending on weather and time of year,
  - Heat and cold stress for those working outside, depending on weather and time of year.
- Building of roads and water management structures:
  - Noise from machinery,
  - Silica and dust from earth disturbance, particularly crushing and screening activities or rock breaking,
  - Vehicle exhaust,
  - Ultraviolet radiation exposure from the sun for those working outside, depending on weather and time of year,
  - Heat and cold stress for those working outside, depending on weather and time of year.
- Building construction:
  - Noise from a variety of sources,
  - Silica and dust from any earth disturbance and concrete work, particularly any concrete mixing, cutting or finishing,
  - Vehicle exhaust, if applicable,
  - Ultraviolet radiation exposure from the sun for those working outside, depending on weather and time of year,
  - Heat and cold stress for those working outside, depending on weather and time of year,
  - Welding fume from any hot work (e.g. welding bolted connections, platework).

Exposure Controls

For the construction phase, the contractors should be submitting health and safety plans, exposure control plans, safe work procedures and any other relevant documentation to Telkwa prior to starting work. Telkwa should review these documents to ensure they address occupational health hazards and include sufficient controls to protect the contractor's workers from over-exposure.

During the operation of the mine, a statistically valid sampling strategy should be established so that exposures for each job category (SEG) and hazard can be accurately assessed. This should be outlined in the Workplace Monitoring Program, to be developed post-permitting.

When deciding on, developing, implementing and reviewing control measures, the hierarchy of controls should be followed: elimination/substitution, engineering controls, administrative controls and personal protective equipment (PPE). Integrating controls in the design of a mine, particularly engineering controls, is crucial in protecting workers and typically much easier than having to implement controls once the mine is operational.

General recommended controls are provided below. Recommended and/or planned controls specific to areas of the mine are provided in Tables 7 to 10.

General Dust/Silica Controls

Engineering Controls

1) Dust suppressing equipment should be implemented where possible and practicable;
2) Where possible, ventilation should be used to draw air away from the areas where workers are conducting activities that are producing dust, and out of the worker's breathing zone;
3) Where possible workers should be located away from the dust that is being generated, such as inside sealed equipment cabs and/or within control rooms with filtered ventilation systems;
4) The machines and tools used should be inspected and maintained regularly. Any air filters should be changed frequently and the sealed enclosures (keeping windows and doors closed) maintained during operation; any pressurized cabs should be inspected and regularly maintained; and
5) Water or other dust suppressants should be applied, where possible, to reduce dust production.

Administrative Controls

1) Wet cleaning methods should be used instead of dry methods such as the use of compressed air or dry sweeping;
2) If practicable, the work time that involves dust exposure should be limited;
3) Where possible, workers should be rotated through any high exposure tasks to limit the amount of time any one worker spends at these tasks;
4) Workers should clean off and/or remove shoes and dirty clothing prior to entering common buildings, including the lunchrooms and offices;
5) Use of water trucks and the annual road application of calcium chloride will be used to reduce airborne dust;
6) Workers should follow appropriate work practices to reduce dust creation/disturbance;
7) Workers should be directed to follow good personal hygiene practices which should include thoroughly washing their hands/faces and exposed skin prior to breaks and at the end of their shifts;
8) Workers should be trained in the hazards in their working environment, the mandatory requirements and best practices to protect their health. This will include specific training on the hazards of respirable crystalline silica and coal/PNOC dust; and
9) A Silica Exposure Control Plan (ECP) should be developed and implemented, as well as task-specific safe work procedures (SWPs).

Personal Protective Equipment (PPE) Controls

1) Use of respirators (N95/equivalent or other air purifying respirator with a minimum of P100 filters), as required;
2) Any workers wearing respirators must be fit tested and trained to properly use the respirators. Respirators should be selected according to individual need (e.g. size and comfort) and to meet the work area hazards;
3) A Respiratory Protection Plan should be developed and implemented; and
4) Other PPE including hard hats, coveralls, work gloves, hearing and eye protection should be worn and must be compatible with the respirators (e.g. welders' helmets).

General Noise Controls

Engineering Controls

1) Engineering noise control options should be investigated and when practical, be implemented. Controls may include the following:
    - Enclosures, barriers, screens and/or partitions around machines generating significant noise;
    - Proper maintenance to reduce noise levels generated by machines/engines or similar;
    - The installation of sound absorptive materials, such as materials with porous facing and membranes, when practicable, in areas with high noise levels to absorb noise; and
    - The noise produced should be considered when purchasing equipment.

Administrative Controls

1) Noise testing should be conducted throughout site to identify noise hazard areas (areas with sound levels ≥ 83 dBA) and these areas clearly marked with warning signs;
2) Workers should be educated and trained about noise hazards, ways to reduce noise levels and how to protect themselves during work;
3) Hearing tests should be provided to affected workers upon initial hire and annually, or as otherwise required;
4) Administrative measures should be taken to ensure:
    - Workers wear hearing protection, when required;
    - Workers wear hearing protection properly;
    - Workers avoid noise sources, where applicable.
5) A Hearing Conservation Program and should be developed and implemented.

Personal Protective Equipment (PPE) Controls

1) Affected workers should wear hearing protection during work. Foam ear plugs, ear muffs, and/or other types of acceptable hearing protection may be used; Table 2-3 of the *Code* specifies the required rating of hearing protection depending on maximum equivalent noise level (dBA).

General Welding Controls

Whenever practicable, welding should be conducted either outdoors with the worker conducting the welding standing upwind and any other workers in the area upwind of the welding location, or in an area with local exhaust ventilation (LEV), such as in the welding shop when practical/available (see Table 7). When using LEV, the duct should be positioned horizontally to the weld location to draw contaminants such as fumes away at the source and avoiding fumes in the welder's breathing zone. Fans may also be used to direct the fume away from the welder. Welding tasks should be planned in a manner to allow as much ventilation in the area of the weld as possible and thus reduce worker exposure.

In addition, workers conducting welding should be trained in the hazards of welding, including the hazards of fumes/gases and the mandatory requirements and best practices to protect their health. A welding ECP and SWPs should be developed and implemented.

Any workers conducting welding should wear a minimum of a half-face respirator with P100 filters under their welding helmet. See the general dust/silica controls section above for additional recommendations relating to respirators.

General Exhaust Gas/Particulate Controls

Most controls related to vehicle exhaust apply to the maintenance shop. Refer to Table 7 for details. If any other diesel, gasoline or propane powered equipment is run onsite, it should be run outside only (e.g. diesel generators). An electric-powered forklift is preferable over a propane forklift for the warehouse; however, if a propane forklift is used, controls should be in place such as limiting the time it is used indoors, ensuring

adequate ventilation (i.e. keeping bay doors open) and monitoring for CO. Consideration may be given to the installation of a fixed CO monitor, installed in an areas(s) where the forklift operates most frequently if it is propane powered.

Workers throughout site should avoid vehicle exhaust plumes. In addition, training and education on vehicle exhaust should be conducted for shop workers, mobile equipment operators, and anyone else who may be required to work near operating mobile equipment. This training should provide workers with information such as the importance of the implemented controls and how to protect themselves and others.

Wastewater System Controls (Hydrogen Sulfide and Biological Pathogens)

For the wastewater treatment plant, as the septic tanks and BioNest treatment tanks will be below ground, exposure to hydrogen sulfide gas and biological pathogens will reportedly be low during routine operation. We recommend sampling for hydrogen sulfide once the system is fully operation to confirm the exposure risk is low. An exposure control plan and safe work procedures may be required.

If entry into the tanks is required, it must be covered under the Confined Space Program and associated hazard assessments and entry procedures.

If workers will or may come in contact with sewage or wastewater, engineering controls and administrative controls, particularly work practices, are the best ways to protect workers from exposure to biological contaminants. This may include:

1. Training and education about the hazards of wastewater and sewage, including good hygiene practices and illness reporting,
2. A place nearby with clean water and soap for workers to wash their hands and cleanup after their work
3. The correct PPE for the task, which may include gloves, goggles, a face-shield, water resistant suit or a respirator,
4. Cleaning facilities or services for clothing and equipment, and
5. Ensure workers do not store soiled clothes with other clothes.

Chlorine Controls

As the potable water treatment plant has not yet been designed and specified, most controls cannot be determined for chlorine. An emergency shower, eye wash station and first aid kit will reportedly be installed in the water treatment system building (Seacan). Once the system has been designed/specified, a further risk assessment should be conducted to ensure sufficient controls will be implemented, particularly engineering controls, as applicable. A chlorine exposure control plan and safe work procedures will also likely be required as well as air monitoring once the system is fully operational.

Other Controls

If contractors are conducting work on site, they should be required to submit safe work plans to the mine prior to the start of work, including controls in place to prevent occupational exposures. The mine should review the plans to ensure they meet or exceed regulatory requirements for protection of all workers (contractors and Telkwa Coal workers). Once work commences, the mine should monitor the contractors to ensure all controls are in place and effective. Occupational sampling may be conducted, as required.

Procurement should ensure materials used for structures and all equipment are certified as lead and asbestos free, including certificates, as applicable.

Note that confined space hazards and ergonomics and vibration controls are covered in separate programs. For others hazards such as light, heat/cold stress, organic solvents and indoor air quality, controls will be implemented, as required.

Table 7: Maintenance (Heavy-Duty/Light-Duty/Welding/Warehouse/Water Treatment) - Hazards and Controls

Common/Anticipated Hazards	Controls
Welding fume exposure from hot work (welding, cutting, grinding)	• Ensure good ventilation (conduct outside or use LEV) • Use of respirator (minimum half-face, protection factor of 10) with P100 filters
UV exposure from welding processes	• Use of eye protection by workers conducting welding and those assisting them in their work (properly shielded safety eyewear) • Use of protective screens/shields designed for UV radiation where bystanders may be exposed
Noise exposure	• Use of hearing protection during loud activities, until noise monitoring is conducted

Exhaust gas/particulate exposure from the operation of mobile equipment indoors	• Equipment should be run outdoors whenever possible
	• Use of LEV:
	  ○ As reported by Telkwa, fixed snorkel style LEV will be installed, to be attached to vehicle exhaust
	  ○ LEV should be attached to vehicle exhaust whenever mobile equipment is run indoors
	• General (dilution) ventilation:
	  ○ As reported by Telkwa, manual switch-activated exhaust ventilation will be present at ceiling height, for use as required
	• Vehicles should be run for as little time as possible in the shop when exhaust not attached to LEV, e.g. just for backing in/out;
	• Workers should avoid visible vehicle exhaust plumes (in the shop and elsewhere on site);
	• Consideration should be given to the installation of fixed carbon monoxide (CO) monitors in the HD shop to alert workers of exhaust gas build-up

Organic solvent exposure	• Review SDS for products used, e.g. brake cleaners, parts wash solvent, paints, cleaning agents, oil/grease/fuels, etc., and implement controls, as required, which may require respirators or increased ventilation. • Where possible, use products with a lower hazard rating/level • Ensure workers thoroughly wash their hands to remove solvents before eating, drinking, smoking or using the washroom
Poor lighting, especially under vehicles and in warehouse (racking areas/yard, if applicable, during non-daylight hours)	• Ensure sufficient lighting in all areas for the tasks performed, which may include headlamps or task lighting
Silica/dust exposure	• Remove as much caked-on mud from vehicles/equipment as practical before entering shop/work area • Regularly clean the floors • Close bay doors when wind is blowing dust indoors • Wash equipment prior to major maintenance functions
Cold/Heat stress for workers working outdoors	• Dress for the weather/temperature • If the work area is located where wind can be an issue, consider a wind break • Conduct work indoors during cold weather, whenever possible • Conduct heat stress monitoring, as required
UV sun exposure for workers working outdoors	• Ensure workers either have their skin covered and/or are wearing appropriate sunscreen when exposed to UV outdoors • Ensure workers have appropriate tinted eye protection

Table 8: Plant, Operations and Maintenance - Hazards and Controls

Common/Anticipated Hazards	Controls
Airborne silica/coal/dust exposure (Crusher, Plant and Rail Infrastructure)	• Application of water where possible: the ROM coal will reportedly be fed through a screen where water could be added • Workers should wear a particulate respirator in the crusher when in operation • Ensure housekeeping is maintained to keep the levels of dust and particulate as low as possible (refer to cleaning activities below for additional information) • Dust reducing shrouds or "hoods" should be considered at the ends of conveyors at plant loadout areas. • When conducting loadout at the plant, if significant visible dust is present and is blowing towards the plant or other areas where workers are located, loadout should stop until the dust clears, the wind changes direction, and/or a surfactant can be added to the processed coal as it comes out the plant into the stockpile to reduce dust emissions. • The trucks transporting coal between the coal processing plant and Rail Infrastructure will reportedly be tarped to reduce dust emissions. • A water spray system is reportedly planned by Telkwa at Rail Infrastructure. • A surfactant will reportedly be sprayed on the coal at Rail Infrastructure to reduce dust during storage • A surfactant will reportedly be sprayed on the rail cars at Rail Infrastructure to reduce dust during transport to the port. • If building cleaning activities produce significant airborne dust, respirators (N95 or half-face with P100 filters) may be required • Consider the installation of a vacuum system to reduce/eliminate the use of dry-sweeping and/or compressed air for cleaning
Noise exposure	• Hearing protection should be worn at all times within the plant and crusher when in operation, excluding the control room, until noise monitoring is conducted
Organic solvent exposure	• Review SDS for products used, e.g. brake cleaners, parts wash solvent, paints, cleaning agents, oil/grease/fuels, etc., and implement controls, as required, which may require respirators and/or increased ventilation • Where possible, use products with a lower hazard rating/level • Ensure workers thoroughly wash their hands to remove solvents before eating, drinking, smoking or using the washroom
Poor lighting	• Ensure sufficient lighting in all areas based on tasks performed
UV exposure from welding processes	• The use of eye protection devices by workers conducting welding and those assisting them (properly shielded safety eyewear) • The use of protective screens/shields designed for UV radiation for places where bystanders may be present

Table 9: CQ Lab - Hazards and Controls

Common/Anticipated Hazards	Controls

Dust/silica/coal dust exposure (Particularly in the prep room, during cleaning of splitters with compressed air)	• LEV in the prep room
	  ○ Reported by Telkwa that fixed snorkel style with adjustable ducts will be installed
	  ○ LEV should be moved/adjusted by workers to most effectively capture dust at the source
	• LEV should be installed in any other areas anticipated to have significant dust exposure such a fume hood in the CQ lab
	• When conducting work in the prep room, respiratory protection should be used (N95 or half-face with P100)

Noise exposure	• Wear hearing protection when in the plant and during noisy activities in the CQ and Prep rooms of the coal lab (i.e. use of jaw crusher and splitter and during blow-down of lab equipment)

Table 10: Mine Operations (Pit) - Hazards and Controls

Common/Anticipated Hazards	Controls
Dust/silica/exhaust exposure (normal operation)	• Workers in mobile equipment and vehicles should always keep the cab doors and windows shut • Time spent outside cabs should be kept to as low as possible • Mobile equipment without pressurized cabs should work solo (i.e. not in pairs), if possible, ensuring they are not driving in close proximity (i.e. in visible dust cloud) behind other vehicles • Regular cleaning should be conducted inside all mobile equipment cabs and any other vehicles on-site to reduce the levels of visible dust to levels as low as reasonably achievable • Use water trucks to minimize airborne dust, particularly in warmer, drier months • Ensure proper maintence of mobile equipment (regularly change air filters, ensure door seals are maintained) • Maintain a blast clearance zone of 700 meters for all workers (as reported) • Use of respirators (minimum half-face, protection factor of 10) with P100 filters for blasters during dusty conditions, as required
Noise exposure	• Prior to conducting noise monitoring, hearing protection should be worn in noisy equipment, particularly when exiting the cab around running equipment

Conclusions

The mine is anticipated to have a variety of chemical, physical and biological hazards. Priority for control implementation should be given based on the risk levels in the qualitative assessment and control selection should be based on the hierarchy of controls. If hazards cannot be eliminated or substituted, engineering controls should first be considered such as design of work areas and buildings, and equipment selection, use and maintenance. Administrative controls should be in place such as worker training as well as the development and implementation of individual programs, plans and procedures referenced throughout this assessment. Finally, as a last line of protection, PPE should be implemented where other controls are not sufficient in controlling worker exposure to identified hazards.

This report is an initial assessment prior to the actual development of the mine. Once the mine has been developed, the industrial hygiene-related hazards and this risk assessment should be re-assessed.

Limitations

This report has been prepared in accordance with established Industrial Hygiene practices. It is intended for the exclusive use of Telkwa Coal Limited to assist them in complying with the *Health, Safety and Reclamation Code for Mines in British Columbia, 2017*. The use of this document for any other purposes is at the sole risk of the user.

Statement of Qualifications

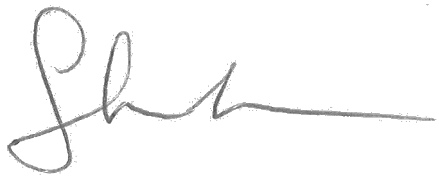
Total Safety has been providing consulting services in the environmental and industrial hygiene fields in British Columbia, since 1990. Our personnel include the following:

- Industrial Hygienists (CIH, ROH)
- Canadian Registered Safety Professionals (CRSP)
- Occupational Health and Safety Consultants

Our company also carries Comprehensive General Liability and Environmental Errors & Omissions Liability Insurance.

Yours truly,

Total Safety

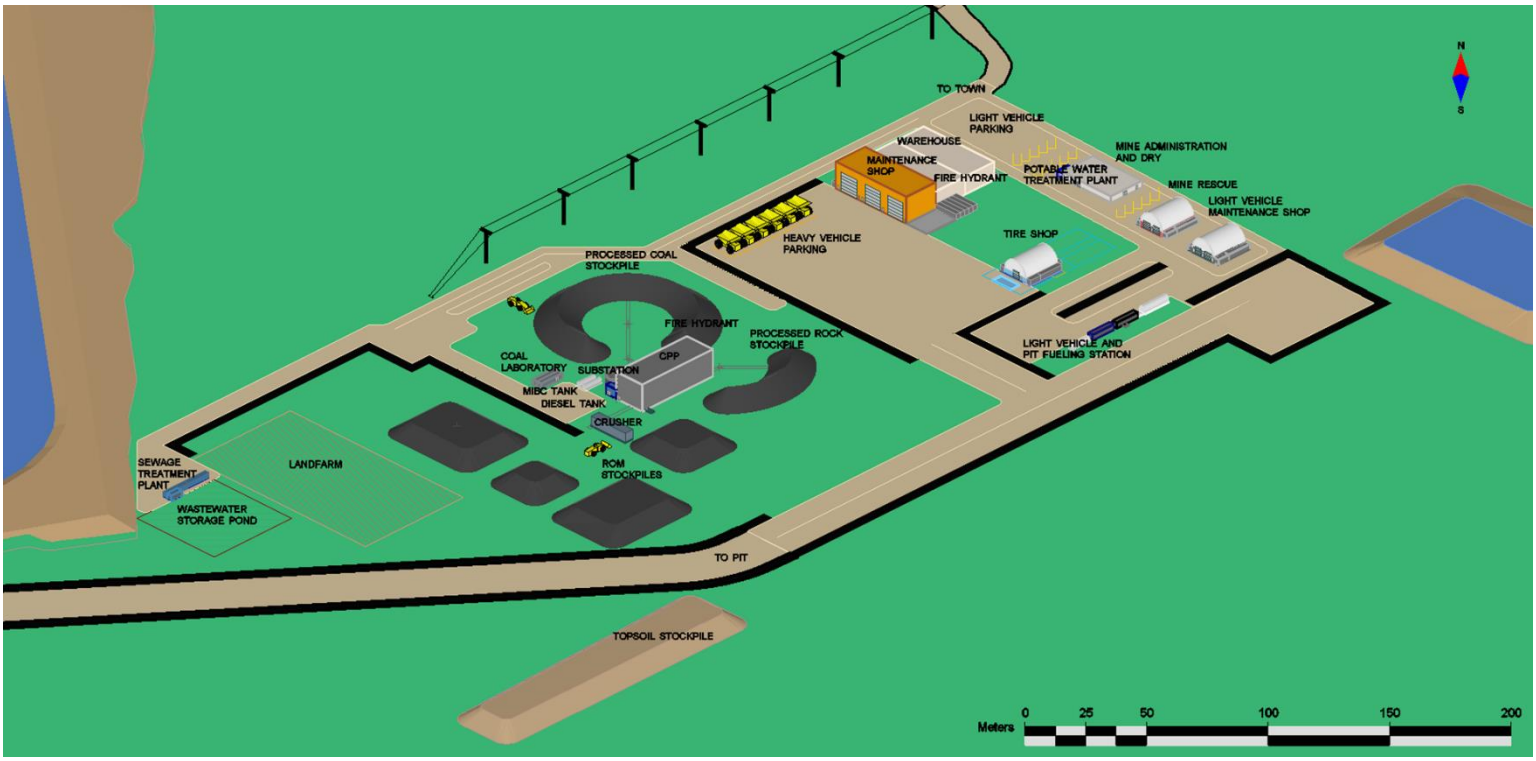


Shannon McIntosh, BSc, CIH, CRSP
Manager, Industrial Hygiene
Report

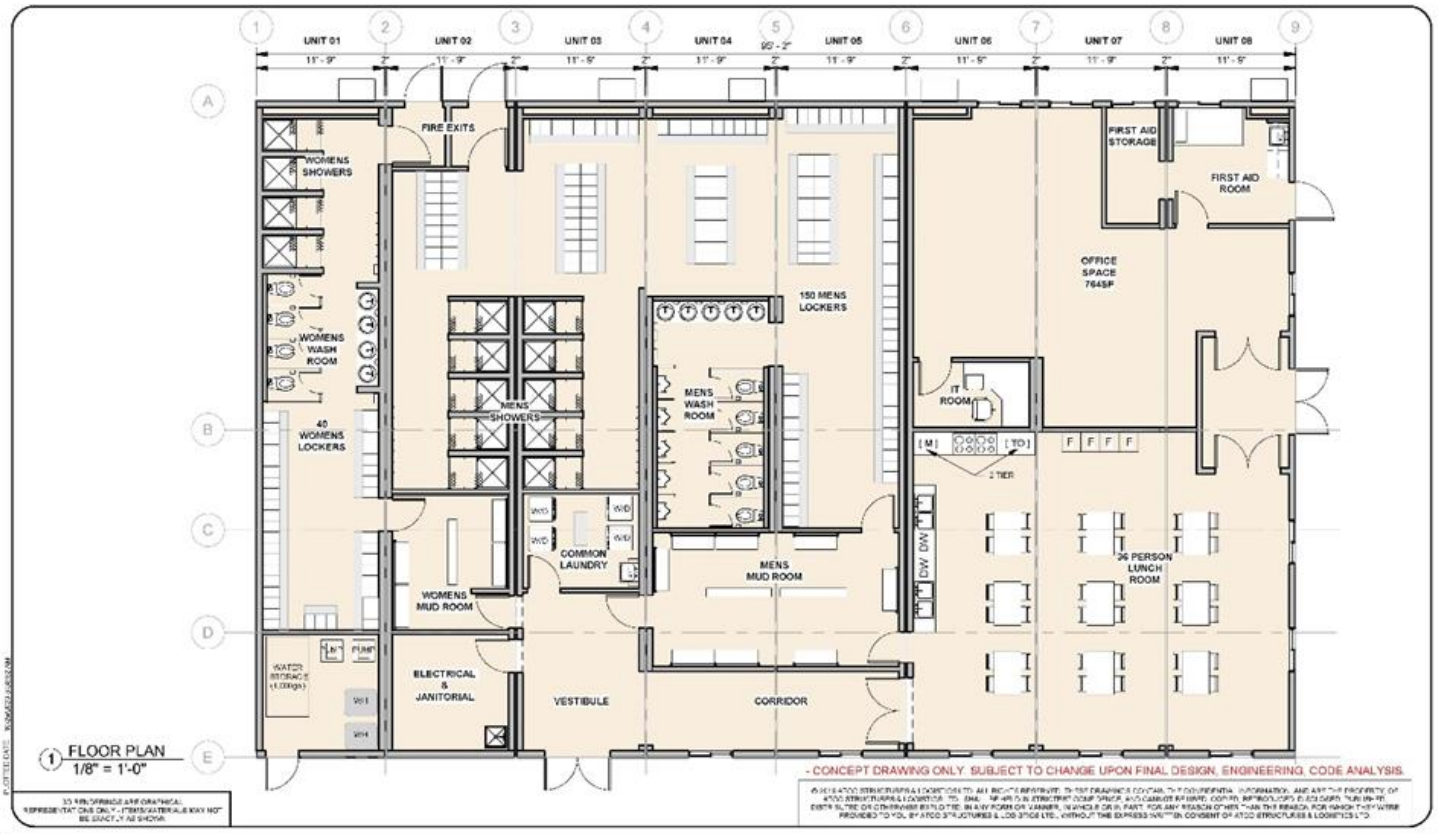
Jennifer Blair, MSc, CIH
Manager, Industrial Hygiene
Report Review

Ref: 20-217 R02

Appendix A: Site Plan



Appendix B: Admin Building Drawing



ATCO

DRAWN BY: NM
DATE: 2020-10-29
DESCRIPTION: ISSUED FOR REVIEW

TELKWA COAL
ADMINISTRATION BUILDING

SALES DRAWING
NOT FOR CONSTRUCTION

2020-085 R2 BD-01 REV. B

Appendix C: ACGIH TLV® 1994-1995 – Section on Cold Stress (p. 71 to 79)

ADOPTED THRESHOLD LIMIT VALUES

AIRBORNE UPPER SONIC AND ULTRASONIC ACOUSTIC RADIATION

These TLVs refer to sound pressure levels that represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse health effects. The values listed in Table 1 should be used as guides in the control of noise exposure and, due to individual susceptibility, should not be regarded as fine lines between safe and dangerous levels. The levels for the third-octave bands centered below 20 kHz are below those which cause subjective effects. Those levels for 1/3 octaves above 20 kHz are for prevention of possible hearing losses from subharmonics of these frequencies.

TABLE 1. Permissible Airborne Upper Sonic and Ultrasound Acoustic Radiation Exposure Levels

Mid-Frequency of Third-Octave Band kHz	One-Third Octave—Band Level in dB re 20 μPa
10	80
12.5	80
16	80
20	105
25	110
31.5	115
40	115
50	115

Subjective annoyance may occur in some sensitive individuals at levels between 75 and 105 dB at 20 kHz 1/3 octave band and hearing protection or engineering controls may be needed to minimize or prevent the annoyance.

COLD STRESS

The cold stress TLVs are intended to protect workers from the severest effects of cold stress (hypothermia) and cold injury and to describe exposures to cold working conditions under which it is believed that nearly all workers can be repeatedly exposed without adverse health effects. The TLV objective is to prevent the deep body temperature from falling below 36°C (96.8°F) and to prevent cold injury to body extremities (deep body temperature is the core temperature of the body determined by conventional methods for rectal temperature measurements). For a single, occasional exposure to a cold environment, a drop in core temperature to no lower that 35°C (95°F) should be permitted. In addition to provisions for total body protection, the TLV objective is to protect all parts of the body with emphasis on hands, feet, and head from cold injury.

Introduction

Fatal exposures to cold among workers have almost always resulted from accidental exposures involving failure to escape from low environmental air temperatures or from immersion in low temperature water. The single most important aspect of life-threatening hypothermia is the fall in the deep core temperature of the body. The clinical presentations of victims of hypothermia are shown in Table 1. Workers should be protected from exposure to cold so that the deep core temperature does not fall below 36°C (96.8°F); lower body temperatures will very likely result in reduced mental alertness, reduction in rational decision making, or loss of consciousness with the threat of fatal consequences.

Pain in the extremities may be the first early warning of danger to cold stress. During exposure to cold, maximum severe shivering develops when the body temperature has fallen to 35°C (95°F). This must be taken as a sign of danger to the workers and exposure to cold should be immediately terminated for any workers when severe shivering becomes evident. Useful physical or mental work is limited when severe shivering occurs.

Since prolonged exposure to cold air, or to immersion in cold water, at temperatures well above freezing can lead to dangerous hypothermia, whole body protection must be provided.

1. Adequate insulating dry clothing to maintain core temperatures above 36°C (96.8°F) must be provided to workers if work is performed in air temperatures below 4°C (40°F). Wind chill cooling rate and the cooling power of air are critical factors. [Wind chill cooling rate is defined as heat loss from a body expressed in watts per meter squared which is a function of the air temperature and wind velocity upon the exposed body.] The higher the wind speed and the lower the temperature in the work area, the greater the insulation value of the protective clothing required. An equivalent chill temperature chart relating the actual dry bulb air temperature and the wind velocity is presented in Table 2. The equivalent chill

TABLE 1. Progressive Clinical Presentations of Hypothermia*

Core Temperature °C	Core Temperature °F	Clinical Signs
37.6	99.6	"Normal" rectal temperature
37	98.6	"Normal" oral temperature
36	96.8	Metabolic rate increases in an attempt to compensate for heat loss
35	95.0	Maximum shivering
34	93.2	Victim conscious and responsive, with normal blood pressure
33	91.4	Severe hypothermia below this temperature
32	89.6	Consciousness clouded; blood pressure becomes difficult to obtain; pupils dilated but react to light; shivering ceases
31	87.8	
30	86.0	Progressive loss of consciousness; muscular rigidity increases; pulse and blood pressure difficult to obtain; respiratory rate decreases
29	84.2	
28	82.4	Ventricular fibrillation possible with myocardial irritability
27	80.6	Voluntary motion ceases; pupils nonreactive to light; deep tendon and superficial reflexes absent
26	78.8	Victim seldom conscious
25	77.0	Ventricular fibrillation may occur spontaneously
24	75.2	Pulmonary edema
22	71.6	Maximum risk of ventricular fibrilation
21	69.8	
20	68.0	Cardiac standstill
18	64.4	Lowest accidental hypothermia victim to recover
17	62.6	Isoelectric electroencephalogram
9	48.2	Lowest artificially cooled hypothermia patient to recover

*Presentations approximately related to core temperature. Reprinted from the January 1982 issue of *American Family Physician*, published by the American Academy of Family Physicians.

temperature should be used when estimating the combined cooling effect of wind and low air temperatures on exposed skin or when determining clothing insulation requirements to maintain the deep body core temperature .

2. Unless there are unusual or extenuating circumstances, cold injury to other than hands, feet, and head is not likely to occur without the development of the initial signs of hypothermia. Older workers or workers with circulatory problems require special precautionary protection against cold injury. The use of extra insulating clothing and/or a reduction in the duration of the exposure period are among the special precautions which should be considered. The precautionary actions to be taken will depend upon the physical condition of the worker and should be determined with the advice of a physician with knowledge of the cold stress factors and the medical condition of the worker.

TABLE 2. Cooling Power of Wind on Exposed Flesh Expressed as Equivalent Temperature (under calm conditions)★

Estimated Wind Speed (in mph)	Actual Temperature Reading (°F) 50	40	30	20	10	0	−10	−20	−30	−40	−50	−60
	Equivalent Chill Temperature (°F)											
calm	50	40	30	20	10	0	−10	−20	−30	−40	−50	−60
5	48	37	27	16	6	−5	−15	−26	−36	−47	−57	−68
10	40	28	16	4	−9	−24	−33	−46	−58	−70	−83	−95
15	36	22	9	−5	−18	−32	−45	−58	−72	−85	−99	−112
20	32	18	4	−10	−25	−39	−53	−67	−82	−96	−110	−121
25	30	16	0	−15	−29	−44	−59	−74	−88	−104	−118	−133
30	28	13	−2	−18	−33	−48	−63	−79	−94	−109	−125	−140
35	27	11	−4	−20	−35	−51	−67	−82	−98	−113	−129	−145
40	26	10	−6	−21	−37	−53	−69	−85	−100	−116	−132	−148
	LITTLE DANGER In < hr with dry skin. Maximum danger of false sense of security					*INCREASING DANGER* Danger from freezing of exposed flesh within one minute.						*GREAT DANGER* Flesh may freeze within 30 seconds.
(Wind speeds greater than 40 mph have little additional effect.)	Trenchfoot and immersion foot may occur at any point on this chart.											

★ Developed by U.S. Army Research Institute of Environmental Medicine, Natick, MA.

Equivalent chill temperature requiring dry clothing to maintain core body temperature above 36°C (96.8°F) per cold stress TLV.

Evaluation and Control

For exposed skin, continuous exposure should not be permitted when the air speed and temperature results in an equivalent chill temperature of –32°C (–25.6°F). Superficial or deep local tissue freezing will occur only at temperatures below –1°C (30.2°F) regardless of wind speed.

At air temperatures of 2°C (35.6°F) or less, it is imperative that workers who become immersed in water or whose clothing becomes wet be immediately provided a change of clothing and be treated for hypothermia.

TLVs recommended for properly clothed workers for periods of work at temperatures below freezing are shown in Table 3.

Special protection of the hands is required to maintain manual dexterity for the prevention of accidents:

1. If fine work is to be performed with bare hands for more than 10–20 minutes in an environment below 16°C (60.8°F), special provisions should be established for keeping the workers' hands warm. For this purpose, warm air jets, radiant heaters (fuel burner or electric radiator), or contact warm plates may be utilized. Metal handles of tools and control bars should be covered by thermal insulating material at temperatures below –1°C (30.2°F).
2. If the air temperature falls below 16°C (60.8°F) for sedentary, 4°C (39.2°F) for light, –7°C (19.4°F) for moderate work, and fine manual dexterity is not required, then gloves should be used by the workers.

To prevent contact frostbite, the workers should wear anticontact gloves.

1. When cold surfaces below –7°C (19.4°F) are within reach, a warning should be given to each worker to prevent inadvertent contact by bare skin.
2. If the air temperature is –17.5°C (0°F) or less, the hands should be protected by mittens. Machine controls and tools for use in cold conditions should be designed so that they can be handled without removing the mittens.

Provisions for additional total body protection are required if work is performed in an environment at or below 4°C (39.2°F). The workers should wear cold protective clothing appropriate for the level of cold and physical activity:

1. If the air velocity at the job site is increased by wind, draft, or artificial ventilating equipment, the cooling effect of the wind should be reduced by shielding the work area or by wearing an easily removable windbreak garment.
2. If only light work is involved and if the clothing on the worker may become wet on the job site, the outer layer of the clothing in use may be of a type impermeable to water. With more severe work under such conditions, the outer layer should be water repellent, and the outerwear should be changed as it becomes wetted. The outer garments should include provisions for easy ventilation in order to prevent wetting of inner layers by sweat. If work is done at normal temperatures or in a hot environment before entering the cold area, the employee should make sure that clothing is not wet as a consequence of sweating. If clothing is wet, the employee should change into dry clothes before entering the cold area. The workers should change socks and any removable felt insoles at regular daily intervals or use vapor barrier boots. The optimal frequency of change should be determined empirically and will vary individually and according to the type of shoe worn and how much the individual's feet sweat.
3. If exposed areas of the body cannot be protected sufficiently to prevent sensation of excessive cold or frostbite, protective items should be supplied in auxiliary heated versions.
4. If the available clothing does not give adequate protection to prevent hypothermia or frostbite, work should be modified or suspended until adequate clothing is made available or until weather conditions improve.
5. Workers handling evaporative liquid (gasoline, alcohol or cleaning fluids) at air temperatures below 4°C (39.2°F) should take special precautions to avoid soaking of clothing or gloves with the liquids because of the added danger of cold injury due to evaporative cooling. Special note should be taken of the particularly acute effects of splashes of "cryogenic fluids" or those liquids with a boiling point that is just above ambient temperature.

Work–Warming Regimen

If work is performed continuously in the cold at an equivalent chill temperature (ECT) or below –7°C (19.4°F), heated warming shelters (tents, cabins, rest rooms, etc.) should be made available nearby. The workers should be encouraged to use these shelters at regular intervals, the frequency depending on the severity of the environmental exposure. The onset of heavy shivering, frostnip, the feeling of excessive fatigue, drowsiness, irritability, or euphoria are indications for immediate return to the shelter. When entering the heated shelter, the outer layer of clothing should be removed and the remainder of the clothing loosened to permit sweat evaporation or a change of dry work clothing provided. A change of dry work clothing should be provided as necessary to prevent workers from returning to work with wet clothing. Dehydration, or the loss of body fluids, occurs insidiously in the cold environment and may increase the susceptibility of the worker to cold injury due to a significant change in blood flow to the extremities. Warm sweet drinks and soups should be provided at the work site to provide caloric intake and fluid volume. The intake of coffee should be limited because of the diuretic and circulatory effects.

For work practices at or below –12°C (10.4°F) ECT, the following should apply:

TABLE 3. Threshold Limit Values Work/Warm-up Schedule for Four-Hour Shift☆

Air Temperature—Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C (approx.)	°F (approx.)	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
–26° to –28°	–15° to –19°	(Norm. Breaks)	1	(Norm. Breaks)	1	75 min	2	55 min	3	40 min	4
–29° to –31°	–20° to –24°	(Norm. Breaks)	1	75min	2	55 min	3	40 min	4	30 min	5
–32° to –34°	–25° to –29°	75 min	2	55 min	3	40 min	4	30 min	5	Non-emergency work should cease	
–35° to –37°	–30° to –34°	55 min	3	40 min	4	30 min	5	Non-emergency work should cease			
–38° to –39°	–35° to –39°	40 min	4	30 min	5	Non-emergency work should cease					
–40° to –42°	–40° to –44°	30 min	5	Non-emergency work should cease							
–43° & below	–45° & below	Non-emergency work should cease									

Notes for Table 3 :

1. Schedule applies to any 4-hour work period with moderate to heavy work activity, with warm-up periods of ten (10) minutes in a warm location and with an extended break (e.g., lunch) at the end of the 4-hour work period in a warm location. For Light-to-Moderate Work (limited physical movement): apply the schedule one step lower. For example, at –35°C (–30°F) with no noticeable wind (Step 4), a worker at a job with little physical movement should have a maximum work period of 40 minutes with 4 breaks in a 4-hour period (Step 5).
2. The following is suggested as a guide for estimating wind velocity if accurate information is not available:
   5 mph: light flag moves; 10 mph: light flag fully extended; 15 mph: raises newspaper sheet; 20 mph: blowing and drifting snow.
3. If only the wind chill cooling rate is available, a rough rule of thumb for applying it rather than the temperature and wind velocity factors given above would be: 1) special warm-up breaks should be initiated at a wind chill cooling rate of about 1750 W/m^2; 2) all non-emergency work should have ceased at or before a wind chill of 2250 W /m^2. In general, the warmup schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatization and clothing appropriate for winter work. On the other hand, the chart slightly over-compensates for the actual temperatures in the colder ranges because windy conditions rarely prevail at extremely low temperatures.
4. TLVs apply only for workers in dry clothing.

☆Adapted from Occupational Health & Safety Division, Saskatchewan Department of Labour.

1. The worker should be under constant protective observation (buddy system or supervision).
2. The work rate should not be so high as to cause heavy sweating that will result in wet clothing; if heavy work must be done, rest periods should be taken in heated shelters and opportunity for changing into dry clothing should be provided.
3. New employees should not be required to work fulltime in the cold during the first days of employment until they become accustomed to the working conditions and required protective clothing.
4. The weight and bulkiness of clothing should be included in estimating the required work performance and weights to be lifted by the worker.
5. The work should be arranged in such a way that sitting still or standing still for long periods is minimized. Unprotected metal chair seats should not be used. The worker should be protected from drafts to the greatest extent possible.
6. The workers should be instructed in safety and health procedures. The training program should include as a minimum instruction in:
   a. Proper rewarming procedures and appropriate first aid treatment.
   b. Proper clothing practices.
   c. Proper eating and drinking habits.
   d. Recognition of impending frostbite.
   e. Recognition of signs and symptoms of impending hypothermia or excessive cooling of the body even when shivering does not occur.
   f. Safe work practices.

Special Workplace Recommendations

Special design requirements for refrigerator rooms include the following:

1. In refrigerator rooms, the air velocity should be minimized as much as possible and should not exceed 1 meter/sec (200 fpm) at the job site. This can be achieved by properly designed air distribution systems.
2. Special wind protective clothing should be provided based upon existing air velocities to which workers are exposed.

Special caution should be exercised when working with toxic substances and when workers are exposed to vibration. Cold exposure may require reduced exposure limits.

Eye protection for workers employed out-of-doors in a snow and/or ice-covered terrain should be supplied. Special safety goggles

to protect against ultraviolet light and glare (which can produce temporary conjunctivitis and/or temporary loss of vision) and blowing ice crystals should be required when there is an expanse of snow coverage causing a potential eye exposure hazard.

Workplace monitoring is required as follows:

1. Suitable thermometry should be arranged at any workplace where the environmental temperature is below 16°C (60.8°F) so that overall compliance with the requirements of the TLV can be maintained.
2. Whenever the air temperature at a workplace falls below –1°C (30.2°F), the dry bulb temperature should be measured and recorded at least every 4 hours.
3. In indoor workplaces, the wind speed should also be recorded at least every 4 hours whenever the rate of air movement exceeds 2 meters per second (5 mph).
4. In outdoor work situations, the wind speed should be measured and recorded together with the air temperature whenever the air temperature is below –1°C (30.2°F).
5. The equivalent chill temperature should be obtained from Table 2 in all cases where air movement measurements are required; it should be recorded with the other data whenever the equivalent chill temperature is below –7°C (19.4°F).

Employees should be excluded from work in cold at –1°C (30.2°F) or below if they are suffering from diseases or taking medication which interferes with normal body temperature regulation or reduces tolerance to work in cold environments. Workers who are routinely exposed to temperatures below –24°C (–11.2°F) with wind speeds less than five miles per hour, or air temperatures below –18°C (0°F) with wind speeds above five miles per hour, should be medically certified as suitable for such exposures.

Trauma sustained in freezing or subzero conditions requires special attention because an injured worker is predisposed to cold injury. Special provisions should be made to prevent hypothermia and freezing of damaged tissues in addition to providing for first aid treatment.