EXEC-2022-001844

Department of Energy
Washington, DC 20585

March 18, 2022

MEMORANDUM FOR GERALDINE L. RICHMOND
UNDER SECRETARY FOR SCIENCE AND INNOVATION

FROM: MATTHEW B. MOURY
DIRECTOR
OFFICE OF ENVIRONMENT, HEALTH, SAFETY AND SECURITY

SUBJECT: Approval of a Permanent Variance from Title 10 CFR Part 851, *Worker Safety and Health Program*, During Construction of the Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment Project at the Sanford Underground Research Facility

ISSUE: Whether to approve a permanent variance application submitted by Fermi Research Alliance, LLC (FRA), the management and operating contractor at the U.S. Department of Energy (DOE) Fermi National Accelerator Laboratory (Fermilab), from 10 CFR Part 851 for the construction of the Long Baseline Neutrino Facility (LBNF)/Deep Underground Neutrino Experiment (DUNE) project at the Sanford Underground Research Facility (SURF) in Lead, South Dakota.

BACKGROUND: Title 10 CFR § 851.3 defines a contractor as "any entity, including affiliated entities, such as a parent corporation, under contract with DOE, or a subcontractor at any tier, that has responsibilities for performing work at a DOE site in furtherance of a DOE mission." A DOE site is defined in § 851.3 as "a DOE-owned or -leased area or location or other area or location controlled by DOE where activities and operations are performed at one or more facilities or places by a contractor in furtherance of a DOE mission." In performing its DOE mission to operate the Fermilab, FRA is required to comply with the provisions in 10 CFR Part 851 that establish the framework for a worker protection program that will reduce or prevent occupational injuries, illnesses, and accidental losses by requiring DOE contractors to provide their employees with safe and healthful workplaces. FRA must ensure that its subcontractors comply with these requirements.

FRA is seeking a permanent variance from § 851.23(a)(7) during the construction of the LBNF/DUNE project. This provision would require FRA and its subcontractors to comply with the requirements in 29 CFR Part 1926, "Safety and Health Regulations for Construction." Specifically, FRA is requesting a variance from the requirements of 29 CFR § 1926.800(k)(3).

The LBNF/DUNE project is a deep level (4,850 ft) underground research lab that is ventilated mechanically through exhaust fans. The construction project will excavate three caverns one mile underground and is estimated to be completed in approximately two years. Due to the restricted airflow in the existing underground drifts and the large-scale caverns to be constructed, FRA will not be able to consistently comply with the 30 feet per minute (fpm) rate required in 29 CFR § 1926.800(k)(3), across the underground working face area where drilling and blasting will be taking place. As a result of the existing tunnel and drift size differentials (face opening sizes) within the underground facility, maintaining consistent 30-fpm airflows in the large caverns would create increased airflow velocities throughout the existing underground space. The increase in airflow velocities would create additional hazards including airborne dusts and silica contaminants in the DOE-leased space managed by FRA and the space operated by the South Dakota Science and Technology Authority (SDSTA), a quasi-state of South Dakota organization.[1] The hazards related to the increased airflow velocities were identified through analysis of a simulation model of the underground space.

Title 10 CFR § 851.30 authorizes Under Secretaries[2] to approve variances after considering the recommendation of the Associate Under Secretary for Environment, Health, Safety and Security (now, Director of the Office of Environment, Health, Safety and Security (EHSS Director)).[3] Title 10 CFR § 851.31(a) requires the contractor desiring the variance to submit a written application to the appropriate Cognizant Secretarial Officer (CSO),[4] who may forward the application to the EHSS Director. FRA submitted the permanent variance application to DOE's Office of Science (SC), and on February 28, 2022, the SC Deputy Director for Field Operations forwarded the permanent variance application to the EHSS Director with the recommendation that approval be subject to the condition that "If there are changes in assumption[s] that would impact ventilation/fan usage, notice will be provided to DOE in advance of conducting work that includes modeling and validation that the terms of the DOE approved variance are being met."

Upon receipt of the application from a CSO, 10 CFR § 851.31(a)(3) requires the EHSS Director to review the application and make a written recommendation to approve the application, approve the application with conditions, or deny the variance application. Based on the information provided in the variance application and additional information obtained through the review process, the EHSS Director agrees with the SC Deputy

---

[1] The SURF site is owned and operated by the SDSTA; the LBNF/DUNE facility will be constructed in a DOE-leased portion of SURF.

[2] Under Secretary is defined in § 851.3 as "with respect to a particular situation, the DOE official who serves as the Under Secretary for Science and Energy [now the Under Secretary for Science and Innovation], or Under Secretary for Management and Performance, or the Under Secretary for Nuclear Security/Administrator for National Nuclear Security Administration who has primary line management responsibility for a contractor."

[3] The EHSS Director is referred to in 10 CFR Part 851 by the previous title of "Associate Under Secretary for Environment, Health, Safety and Security."

[4] CSO is defined in § 851.3 as "with respect to a particular situation, the Assistant Secretary, Deputy Administrator, Program Office Director, or equivalent DOE official who has primary line management responsibility for a contractor, or any other official to whom the CSO delegates in writing a particular function under this part."

Director for Field Operations that this variance application submitted by FRA should be approved, subject to the conditions outlined below. Copies of the February 28, 2022, Memorandum from the SC Deputy Director for Field Operations regarding the variance application and the FRA variance application are attached.

JUSTIFICATION: FRA is requesting a permanent variance from 10 CFR § 851.23(a)(7) for the period of construction only, due to the inability of FRA and its subcontractors to consistently comply with the airflow requirements in 29 CFR § 1926.800(k)(3). Instead, FRA and its subcontractors will adopt a localized ventilation approach versus the general dilution ventilation requirement of 30-fpm prescribed in 29 CFR § 1926.800(k)(3). The localized ventilation approach is expected to:

- Minimize wind velocities in the auxiliary tunnels that supply ventilation to the project to reduce the dust/silica exposures in the entire underground; and

- Eliminate the sitewide hazard that would be created while also ensuring LBNF-related personnel exposures are maintained below the applicable American Conference of Governmental Industrial Hygienists (ACGIH®) Threshold Limit Values.

This information, along with other information included in the variance request, supports the conclusion that implementation of FRA's permanent variance would provide workers a place of employment that is as safe and healthful as would result from compliance with 10 CFR § 851.23(a)(7), as required by Subsection (d)(2)(ii) of 10 CFR 851.31, *Variance Process*.

Based upon a review by the EHSS Director and EHSS staff, the EHSS Director recommends approval of FRA's permanent variance application, subject to the following:

(1) The recommended approval is contingent upon implementation of the specific conditions, practices, means, methods, operations, or processes being used as described in the 8 October 2021, Revised 18 February 2022, variance request;

(2) If there are changes in assumptions that would impact ventilation/fan usage, notice must be provided by FRA to the Fermi Site Office Manager that includes modeling and validation that the terms of the approved variance are continuing to be met, in advance of conducting work; and

(3) FRA must ensure that each subcontractor:

   a. Is in compliance with the requirement of 10 CFR § 851.10(a)(2)(ii) to conduct work in accordance with a DOE-approved worker safety and health program before work is performed at a DOE site in furtherance of a DOE mission;

b. Complies with the specific conditions, practices, means, methods, operations, or processes being used as described in FRA's permanent variance application; and

c. Notifies FRA and the Fermi Site Office Manager if there are changes in assumptions that would impact ventilation/fan usage, in advance of conducting work, which includes modeling and validation that the terms of the approved variance are continuing to be met.

RECOMMENDATION: That you approve the permanent variance for the construction of the LBNF/DUNE project, subject to compliance with the conditions listed above. This recommendation is contingent upon the requirement that the variance will expire upon completion of construction of the LBNF/DUNE project, as indicated in the request by FRA.

APPROVE: GLR DISAPPROVE: ____ NEEDS DISCUSSION: ____ DATE: 04/07/22

Attachments

EXEC-2022-001844

Department of Energy
Washington, DC 20585

March 18, 2022

MEMORANDUM FOR GERALDINE L. RICHMOND
UNDER SECRETARY FOR SCIENCE AND INNOVATION

FROM: MATTHEW B. MOURY
DIRECTOR
OFFICE OF ENVIRONMENT, HEALTH, SAFETY AND SECURITY

SUBJECT: Approval of a Permanent Variance from Title 10 CFR Part 851, *Worker Safety and Health Program*, During Construction of the Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment Project at the Sanford Underground Research Facility

ISSUE: Whether to approve a permanent variance application submitted by Fermi Research Alliance, LLC (FRA), the management and operating contractor at the U.S. Department of Energy (DOE) Fermi National Accelerator Laboratory (Fermilab), from 10 CFR Part 851 for the construction of the Long Baseline Neutrino Facility (LBNF)/Deep Underground Neutrino Experiment (DUNE) project at the Sanford Underground Research Facility (SURF) in Lead, South Dakota.

BACKGROUND: Title 10 CFR § 851.3 defines a contractor as "any entity, including affiliated entities, such as a parent corporation, under contract with DOE, or a subcontractor at any tier, that has responsibilities for performing work at a DOE site in furtherance of a DOE mission." A DOE site is defined in § 851.3 as "a DOE-owned or -leased area or location or other area or location controlled by DOE where activities and operations are performed at one or more facilities or places by a contractor in furtherance of a DOE mission." In performing its DOE mission to operate the Fermilab, FRA is required to comply with the provisions in 10 CFR Part 851 that establish the framework for a worker protection program that will reduce or prevent occupational injuries, illnesses, and accidental losses by requiring DOE contractors to provide their employees with safe and healthful workplaces. FRA must ensure that its subcontractors comply with these requirements.

FRA is seeking a permanent variance from § 851.23(a)(7) during the construction of the LBNF/DUNE project. This provision would require FRA and its subcontractors to comply with the requirements in 29 CFR Part 1926, "Safety and Health Regulations for Construction." Specifically, FRA is requesting a variance from the requirements of 29 CFR § 1926.800(k)(3).

The LBNF/DUNE project is a deep level (4,850 ft) underground research lab that is ventilated mechanically through exhaust fans. The construction project will excavate three caverns one mile underground and is estimated to be completed in approximately two years. Due to the restricted airflow in the existing underground drifts and the large-scale caverns to be constructed, FRA will not be able to consistently comply with the 30 feet per minute (fpm) rate required in 29 CFR § 1926.800(k)(3), across the underground working face area where drilling and blasting will be taking place. As a result of the existing tunnel and drift size differentials (face opening sizes) within the underground facility, maintaining consistent 30-fpm airflows in the large caverns would create increased airflow velocities throughout the existing underground space. The increase in airflow velocities would create additional hazards including airborne dusts and silica contaminants in the DOE-leased space managed by FRA and the space operated by the South Dakota Science and Technology Authority (SDSTA), a quasi-state of South Dakota organization.[1] The hazards related to the increased airflow velocities were identified through analysis of a simulation model of the underground space.

Title 10 CFR § 851.30 authorizes Under Secretaries[2] to approve variances after considering the recommendation of the Associate Under Secretary for Environment, Health, Safety and Security (now, Director of the Office of Environment, Health, Safety and Security (EHSS Director)).[3] Title 10 CFR § 851.31(a) requires the contractor desiring the variance to submit a written application to the appropriate Cognizant Secretarial Officer (CSO),[4] who may forward the application to the EHSS Director. FRA submitted the permanent variance application to DOE's Office of Science (SC), and on February 28, 2022, the SC Deputy Director for Field Operations forwarded the permanent variance application to the EHSS Director with the recommendation that approval be subject to the condition that "If there are changes in assumption[s] that would impact ventilation/fan usage, notice will be provided to DOE in advance of conducting work that includes modeling and validation that the terms of the DOE approved variance are being met."

Upon receipt of the application from a CSO, 10 CFR § 851.31(a)(3) requires the EHSS Director to review the application and make a written recommendation to approve the application, approve the application with conditions, or deny the variance application. Based on the information provided in the variance application and additional information obtained through the review process, the EHSS Director agrees with the SC Deputy

---

[1] The SURF site is owned and operated by the SDSTA; the LBNF/DUNE facility will be constructed in a DOE-leased portion of SURF.

[2] Under Secretary is defined in § 851.3 as "with respect to a particular situation, the DOE official who serves as the Under Secretary for Science and Energy [now the Under Secretary for Science and Innovation], or Under Secretary for Management and Performance, or the Under Secretary for Nuclear Security/Administrator for National Nuclear Security Administration who has primary line management responsibility for a contractor."

[3] The EHSS Director is referred to in 10 CFR Part 851 by the previous title of "Associate Under Secretary for Environment, Health, Safety and Security."

[4] CSO is defined in § 851.3 as "with respect to a particular situation, the Assistant Secretary, Deputy Administrator, Program Office Director, or equivalent DOE official who has primary line management responsibility for a contractor, or any other official to whom the CSO delegates in writing a particular function under this part."

Director for Field Operations that this variance application submitted by FRA should be approved, subject to the conditions outlined below. Copies of the February 28, 2022, Memorandum from the SC Deputy Director for Field Operations regarding the variance application and the FRA variance application are attached.

JUSTIFICATION: FRA is requesting a permanent variance from 10 CFR § 851.23(a)(7) for the period of construction only, due to the inability of FRA and its subcontractors to consistently comply with the airflow requirements in 29 CFR § 1926.800(k)(3). Instead, FRA and its subcontractors will adopt a localized ventilation approach versus the general dilution ventilation requirement of 30-fpm prescribed in 29 CFR § 1926.800(k)(3). The localized ventilation approach is expected to:

- Minimize wind velocities in the auxiliary tunnels that supply ventilation to the project to reduce the dust/silica exposures in the entire underground; and

- Eliminate the sitewide hazard that would be created while also ensuring LBNF-related personnel exposures are maintained below the applicable American Conference of Governmental Industrial Hygienists (ACGIH®) Threshold Limit Values.

This information, along with other information included in the variance request, supports the conclusion that implementation of FRA's permanent variance would provide workers a place of employment that is as safe and healthful as would result from compliance with 10 CFR § 851.23(a)(7), as required by Subsection (d)(2)(ii) of 10 CFR 851.31, *Variance Process*.

Based upon a review by the EHSS Director and EHSS staff, the EHSS Director recommends approval of FRA's permanent variance application, subject to the following:

(1) The recommended approval is contingent upon implementation of the specific conditions, practices, means, methods, operations, or processes being used as described in the 8 October 2021, Revised 18 February 2022, variance request;

(2) If there are changes in assumptions that would impact ventilation/fan usage, notice must be provided by FRA to the Fermi Site Office Manager that includes modeling and validation that the terms of the approved variance are continuing to be met, in advance of conducting work; and

(3) FRA must ensure that each subcontractor:

   a. Is in compliance with the requirement of 10 CFR § 851.10(a)(2)(ii) to conduct work in accordance with a DOE-approved worker safety and health program before work is performed at a DOE site in furtherance of a DOE mission;

b. Complies with the specific conditions, practices, means, methods, operations, or processes being used as described in FRA's permanent variance application; and

c. Notifies FRA and the Fermi Site Office Manager if there are changes in assumptions that would impact ventilation/fan usage, in advance of conducting work, which includes modeling and validation that the terms of the approved variance are continuing to be met.

RECOMMENDATION: That you approve the permanent variance for the construction of the LBNF/DUNE project, subject to compliance with the conditions listed above. This recommendation is contingent upon the requirement that the variance will expire upon completion of construction of the LBNF/DUNE project, as indicated in the request by FRA.

APPROVE: GLR DISAPPROVE:____ NEEDS DISCUSSION:____ DATE: 04/07/22

Attachments

Department of Energy
Office of Science
Washington, DC 20585

February 28, 2022

MEMORANDUM FOR MATTHEW MOURY
DIRECTOR
ENVIRONMENT, HEALTH, SAFETY AND SECURITY

THROUGH: J. STEPHEN BINKLEY
ACTING DIRECTOR
OFFICE OF SCIENCE

FROM: JUSTON K. FONTAINE
DEPUTY DIRECTOR FOR FIELD OPERATIONS
OFFICE OF SCIENCE

SUBJECT: Submittal of a Permanent Variance to 10 CFR 851, *Worker Safety and Health Program,* During Construction for the Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment Project at the Sanford Underground Research Facility

As part of the Long Baseline Neutrino Facility (LBNF)/ Deep Underground Neutrino Experiment (DUNE) Project at Sanford Underground Research Facility (SURF) in Lead, South Dakota, Fermi Research Alliance (FRA), the Management and Operating Contractor at Fermilab, will oversee the excavation of three caverns a mile underground, which is estimated to be completed in approximately two years. The construction of LBNF/DUNE is required to be performed by FRA in accordance with 10 CFR 851.23(a)(7), 29 CFR 1926, "Safety and Health Regulations for Construction" and requirements must be flowed down through the applicable subcontracts.

The Office of Science (SC) has received a request from FRA for a permanent variance to 10 CFR 851 for the construction of the LBNF/DUNE project. Due to the restricted airflow in the existing underground drifts and the large-scale caverns to be constructed, FRA, and their subcontractors Thyssen Mining and, Inc. (TMI) and Kiewit Alberici Joint Venture (KAJV), will not be able to consistently comply with the 29 CFR 1926.800(k)(3) prescribed 30 feet per minute (fpm) across the underground working face area where drilling and blasting will be taking place.

The increase in airflow velocities would create additional hazards including airborne dusts and silica contaminants throughout the underground space, including beyond the space managed by FRA, and managed by the South Dakota Science and Technology Authority, a quasi-state of South Dakota. The hazards related to the increased airflow velocities were identified through analysis of a simulation model of the underground space.

FRA is requesting a permanent variance to 10 CFR 851 to adopt a localized ventilation approach versus the OSHA general dilution ventilation requirement of 30 fpm prescribed in 29 CFR 1926.800 (k)(3) for the period of construction only. Upon approval of this variance FRA will flow down appropriate requirements into its subcontracts to implement the ventilation plan.

The expected benefits of a localized ventilation approach will:

- Minimize wind velocities in the auxiliary tunnels that supply ventilation to the project to reduce the dust/silica exposures in the entire underground.
- Eliminate the site wide hazard that would be created while also ensuring LBNF-related personnel exposures are maintained below the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values.

The Office of Science has reviewed the ventilation plan, industrial hygiene plans for both FRA, and its subcontractor TMI, and work planning processes and procedures to ensure that the proposed plan is able provide a place of employment that is "as safe and healthful" as would be provided by compliance with 10 CFR 851. The variance will expire upon completion of construction of LBNF.

In accordance with the requirements of 10 CFR 851 I am forwarding this request to you to provide a recommendation to the Under Secretary for Science and Innovation to approve, approve with conditions, or deny the variance.

SC is requesting the following condition of approval to the Under Secretary's approval memorandum:

- If there are changes in assumption that would impact ventilation/fan usage, notice will be provided to DOE in advance of conducting work that includes modeling and validation that the terms of the DOE approved variance are being met.

February 18, 2022

Nigel S. Lockyer
Director

P.O. Box 500, MS 105
Kirk Road and Pine Street
Batavia, Illinois 60510-5011
USA

Office: 630.840.6723
lockyer@fnal.gov

Mr. Roger Snyder
Site Office Manager
Fermi Site Office
U.S. Department of Energy
P. O. Box 2000
M/S 118
Batavia, Illinois 60510-5011

Dear Mr. Snyder,

Attached is the request for a variance to 10 CFR 851 Worker Safety and Health to adopt a localized ventilation approach verses the dilution ventilation requirement as prescribed in 29 CFR 1926.800(k)(3). Fermi Research Alliance (FRA) and its subcontractors Thyssen Mining, Inc. (TMI) and Kiewit Alberici Joint Venture (KAJV) agree that the mitigations detailed in the variance request are protective of worker safety and confirm that the requirements can be effectively implemented. Upon approval, FRA will implement the variance as a modification to the respective subcontracts. TMI and KAJV have committed to performing work in accordance with the requirements of the variance. FRA will provide oversight and ensure compliance with the approved variance.

Sincerely,

Nigel S. Lockyer

Executive Summary

Fermi Research Alliance (FRA) is committed to supporting research and operations by protecting the environment, health, and safety of our staff, subcontractors, and the community.

FRA is constructing the Long Baseline Neutrino Facility at the Sanford Underground Research Facility (SURF) in Lead, South Dakota. The construction project will excavate three caverns a mile underground and is estimated to be completed in approximately two years. The construction is required to be performed in accordance with 10 CFR 851. In 10 CFR 851.23(a)(7), 29 CFR 1926, "Safety and Health Regulations for Construction" is identified as an applicable standard that the contractor must comply with at the covered workplace and flowed down through the applicable subcontracts. Due to the restricted airflow in the existing underground drifts and the large-scale caverns to be constructed, FRA will not be able to consistently comply with the 29 CFR 1926.800(k)(3) prescribed 30 feet per minute (fpm) across the underground working face area where drilling and blasting will be taking place. As a result of the existing tunnel and drift size differentials (face opening sizes) within the underground facility, maintaining consistent 30-fpm airflows in the large caverns would create increased airflow velocities throughout the existing underground space. The increase in airflow velocities would create additional hazards including airborne dusts and silica contaminants throughout the underground space, beyond the space managed by FRA. The hazards related to the increased airflow velocities were identified through analysis of the ventilation simulation model of the underground space. Modeling will continue throughout excavation and computational fluid dynamics (CFD) modeling will be conducted in advance to simulate airflow for major phases (benches C, E, and G).

FRA is requesting a variance, applicable to the work of its subcontractors, Thyssen Mining (TMI), the excavation contractor and Kiewit-Alberici Joint Venture (KAJV) as the Construction Manager as Advisor (CMa), to adopt a localized ventilation approach verses the Occupational Safety and Health Administration's (OSHA's) general dilution ventilation requirement of the 30-fpm minimum across the entire face of the opening as prescribed by 29 CFR 1926.800(k)(3). The localized ventilation approach provided will minimize wind velocities in the auxiliary tunnels that supply ventilation to the project to reduce the dust/silica exposures in the entire underground. Utilizing the local ventilation approach at the worker eliminates the site wide hazard that would be created while also ensuring LBNF-related personnel exposures are maintained below the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values. The local ventilation approach includes:

- Tailoring the ventilation to both dilute and remove contaminants from the work zone,
- Monitoring both airflow and airborne contaminants per the 2016 ACGIH at the workers' work zone per the FRA's subcontractor's industrial hygiene plan and sampling and monitoring plan.

The requirements for localized ventilation will be addressed in the task specific FRA subcontractor work planning documentation, i.e., Build Plans, Job Hazard Analyzes, and Field Level Risk Assessments.

The ventilation variance will be implemented in three stages on a continual basis:

(1) CFD modeling at Benches C, E and G identifies possible ventilation issues, including areas of stagnation or potential contaminant build up as input to the ventilation plans.

(2) Work planning and control process identifies, documents, and implements the localized ventilation plan for the work activities.

(3) Verification of effectiveness including air flow and air quality and necessary adjustments to the work planning documents and ventilation plans.

TMI will be performing all excavation activities. TMI will have primary responsibility for the engineering and installation of all localized ventilation systems. TMI will also have primary responsibility for verifying and monitoring air flow and air quality at the working spaces within the caverns for their workers. Typical atmospheric hazards mitigated by ventilation include removal of airborne contaminants resulting from blasting, the use of diesel equipment, and dust/silica. Experience shows the existing underground facility has not observed the presence of flammable gases, such as methane or hydrogen sulfide.

FRA and KAJV will be responsible for providing oversight of TMI work activities including verifying the operation of localized ventilation systems including the air flow and air quality monitoring. FRA and KAJV will be responsible for completing air flow and personal sampling requirements for their own employees.

FRA, KAJV, and TMI are dedicated to protecting the workforce. It is critical for all affected workers to be fully aware of this variance and steps have been taken to communicate it and ensure any and all questions have been addressed.

Name and address of Contractor & Subcontractors

Fermi Research Alliance, LLC (M&O Contractor)
Wilson and Kirk Roads, P.O. Box 500, MS#105
Batavia, IL, 60510

Kiewit-Alberici Join Venture (KAJV) (Subcontractor)
201 W Main St, Suite 201
Lead, SD 57754

Thyssen Mining Inc. (TMI) (Subcontractor)
377 Sunshine Lane Spring Creek NV 89815

Name and address of DOE Site or Sited Involved

Sanford Underground Research Facility (SURF) – DOE Underground Leased Space
City of Lead, South Dakota

Type of variance:

Permanent (Only for the duration of the excavation phase of work for the Long-Baseline Neutrino Facility)

A specification of the Standard or Portion thereof, from which the contractor seeks a variance.

§ 851.23 Safety and Health Standards

§ 851.23(a)(7) 29 CFR 1926, *Safety and Health Regulations for Construction*, 1926 Subpart S, *Underground Construction, Caissons, Cofferdams, and Compressed Air*, Section 800(k) titled *Ventilation* (3*)* States: The linear velocity of airflow in the tunnel bore, in shafts, and in all other underground work areas shall be at least 30 feet (9.15 m) per minute where blasting or rock drilling is conducted, or where other conditions likely to produce dust, fumes, mists, vapors, or gases in harmful or explosive quantities are present.

A description of the steps that the contractor has taken to inform the affected workers of the application, which must include giving a copy thereof to their authorized representative, posting a statement, giving a summary of the application, and specifying where a copy may be examined at the place or places where notices to workers are normally posted:

All affected workers have been provided a memorandum informing the stakeholders and workers of the variance request and proposed changes. Supervisors are included in the distribution and requested to meet with their respective workers to ensure all workers understand the changes. FRA, KAJV, and TMI management will also verbally present the details of the memorandum to all workers as part of the daily planning meetings, weekly progress meetings, and monthly all-hands ESH meetings. Affected employees will be offered the opportunity to ask questions of their management related to the variance, or request a private meeting with their management, or ES&H personnel. The memorandum will also be posted in centralized areas where workers' information boards are located. In addition, the variance request has been posted on bulletin boards of workplaces where the approved variance would be applicable. A link to the variance application document has been posted on the Fermilab's Environment Safety & Health Section's webpage at Worker Safety and Health for Subcontractors | Environment, Safety and Health (fnal.gov)

A description of how affected workers have been informed of their right to petition the Associate Under Secretary for Environment, Health, Safety, and Security or designee for a conference:

All FRA, KAJV, TMI, and other sub-tier subcontractor workers participating in the underground excavation activities are informed of their right to petition DOE's Office of the Associate Under Secretary for Environment, Health, Safety and Security through a means of a memorandum. The memorandum will detail the requirements of 10 CFR 851.34 as follows.

> (a) Within the time allotted by a notice of the filing of an application, any affected contractor or worker may file with the Associate Under Secretary for Environment, Health, Safety and Security a request for a conference on the application for a variance.
> (b) A request for a conference filed pursuant to paragraph (a) of this section must include:
> > (1) A concise statement explaining how the contractor or worker would be affected by the variance applied for, including relevant facts.
> > (2) A specification of any statement or representation in the application, which is denied, and a concise summary of the evidence that would be adduced in support of each denial; and
> > (3) Any other views or arguments on any issue of fact or law presented.
> (c) The Associate Under Secretary for Environment, Health, Safety and Security, or designee, must respond to a request within fifteen days and, if the request is granted, indicate the time and place of the conference and the DOE participants in the conference.

This process is explained in the memorandum distributed to all affected workers and their supervisors. FRA, KAJV, and TMI management will also verbally present the details of the memorandum to all workers as part of the daily planning meetings, weekly progress meetings, and monthly all-hands ESH meetings. Affected employees will be offered the opportunity to ask questions of their management related to the variance, or request a private meeting with their management, or ES&H personnel. The memorandum will also be posted in centralized areas where workers' information boards are located. The memorandum is also posted on Fermilab's ES&H Website at: memorandum (fnal.gov). The Variance will also be made available at the work site, centralized workers dry (change houses).

The notification memorandum details how workers can request a copy of the variance from FRA's Chief Safety Officer or LBNF ES&H Manager. FRA will provide the copy of the variance and offer an opportunity to discuss and answer questions.

Any requests for a conference:

Notice has been posted and workers advised of their right to request a conference. FRA will advise DOE Fermi Site Office if it receives a request for a conference.

A description of the conditions, practices, means, methods, operations, or processes used or proposed to be used by the contractor:

LBNF/DUNE Experiment

A global neutrino physics community is developing a leading-edge, dual-site experiment for neutrino science and proton decay studies, known as the Deep Underground Neutrino Experiment (DUNE), which is hosted at Fermilab in Batavia, IL. Fermilab is managed and operated by Fermi Research Alliance (FRA). The facility required for this experiment, the Long-Baseline Neutrino Facility (LBNF), is part of the LBNF/DUNE-US Project and is an internationally designed, coordinated, and funded program. The needed infrastructure consists of underground and surface facilities at both Fermilab in Batavia, IL, and the Sanford Underground Research Facility (SURF) site located in Lead, South Dakota. The underground LBNF/DUNE-US scope at SURF is located in a former gold mine. The FRA underground construction activities at SURF will provide the necessary infrastructure to support large, cryogenic far detectors installed deep underground.

Sanford Underground Research Facility

SURF is located at the site of the former Homestake Gold Mine in Lead, South Dakota[1]. This facility has since been repurposed and extensively modified to accommodate numerous underground science experiments. The site is owned and operated by the South Dakota Science and Technology Authority (SDSTA) and regulatory oversight is provided through Office of Risk Management of the State of South Dakota. Because SURF was originally constructed as a mine, i.e., a facility built for the extraction of minerals (gold) for their own intrinsic value, the existing deep metal mine ventilation conforms to the requirements of the Mine Safety & Health Agency (MSHA) (30 CFR 57.8518 – 8535). The LBNF/DUNE-US facility will be constructed in a DOE leased portion of SURF. SDSTA and FRA have worked together with third party ventilation expert consultants since 2009 to develop, maintain, and refine a detailed model of the underground ventilation pathways throughout the facility. This modelling utilizes a 3D CAD (computer-aided design) model to define the pathways and include all ventilation controls in place. Physical measurements in various locations underground have been used to validate the accuracy of the model and refine the assumptions for areas not directly accessible for measurement. The model is used every time an adjustment for ventilation is needed to support a new project, excavation, or to improve conditions in a location. The model provides a basis for adjustment, the adjustment is made, then measurements are taken to verify the results. These results have proven to be very consistent with the model. Each time this is done, slight model adjustments are also made based on the field measurements to further improve the accuracy. This model includes the design for the planned LBNF/DUNE-US excavation, allowing for planning of appropriate controls as the excavation progresses. This model was used to evaluate the potential impacts of maintaining the 30-fpm face velocity mandated by 29 CFR 1926.800(k). The results are described in this document – the existing Oro Hondo exhaust fan would be at full capacity to meet the demand of concurrent excavation in the three large caverns even if all available capacity was directed to LBNF/DUNE-US (to the detriment of other SURF users). Under such conditions, airflow velocities in those underground areas outside the detector caverns would exceed standard practice for safe use.

LBNF Far Site Conventional Facilities (FSCF) at SURF

As part of the project activities, FRA has contracted with an excavation subcontractor to excavate three large caverns. Two of the caverns will house the detector modules (approximately 92-ft H x 65-ft W x 475-ft L) and a central cavern (approximately 37-ft H x 64-ft W x 624-ft L) will house the utilities needed to support the detectors. LBNF/DUNE-US

[1] Barrick Gold Corporation (Barrick) operated the former Homestake Gold Mine in Lead, SD and when they closed the mine operations, a portion of the land was donated to the state of South Dakota and the use of the property is governed by the Property Donation Agreement (PDA) between Barrick and the state of South Dakota. The state of South Dakota manages the development of the SURF site through the SDSTA.

project will also outfit the new underground spaces with power, ventilation and cooling systems for the cryogens, cyberinfrastructure, water, and other systems necessary to ensure the safety of personnel and experimental equipment. Over the course of approximately two years, an estimated 800,000 tons of rock will be excavated and hoisted to the surface where a conveyor will transport it for deposition in an open cut area approximately one mile from the facility.

The existing underground facilities consist of approximately 370 miles (595 km) of drifts and shafts dispersed between 60 levels. The levels are generally vertically spaced at an interval of 150 ft. (46 m). The underground reaches a maximum depth of 8,150 ft. (2,484m), but the facility is currently flooded with water below the 6,050 level. Typically, existing drifts are approximately 8-ft H x 8-ft W in dimension. The primary underground research facility and where the LBNF/DUNE-US caverns will be located is on the 4850 Level (4850L), where the large volume caverns will be constructed; as noted above, the faces of the detector caverns during excavation will be each approximately 92-ft x 65-ft.

LBNF/DUNE-US project will be the only tenant at the Ross Campus during excavation. The intake (supply) air for the entire underground facility initiates from the Ross and Yates shafts. The exhaust air from the Ross campuses is independent from the Yates Science Campus. The newly constructed raise bore ventilation shaft from the 4850L to the 3650L level to the Oro Hondo exhaust shaft will further enhance the exhaust ventilation (Figure No. 1). This will accommodate the larger pieces of equipment needed to excavate the larger caverns. The raise bore accommodates a more direct air path to the Oro Hondo exhaust pathway; and therefore, the exhaust ventilation from the LBNF/DUNE-US excavation activities will not impact any other tenants in the underground facility.

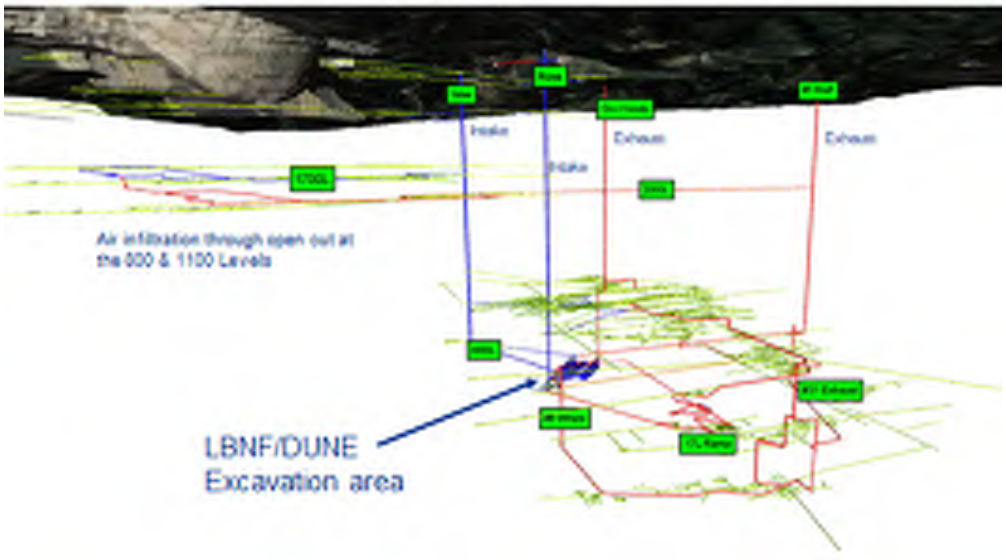


Figure No.1 (Isotropic view of the underground mine displaying the main ventilation pathways servicing the 4850 Level)

The underground excavation will include standard industry drill and blast methods employing diesel equipment such as jumbo drills, bolters, light duty utility vehicles, shotcrete equipment, skid steers, telehandlers, transporters, scissor lifts, and mucker vehicles. The drilling equipment (jumbos and bolters) will only use diesel power when transported to the worksite. The drilling application will be under electric power. The planned construction equipment utilized by the FRA subcontractor will be EPA Tier 3 and 4 diesel engines. The mobile diesel equipment being utilized will meet or exceed the emissions requirements set forth by 29 1926.800(k)(10)(ii)(A).

The caverns will be excavated, and ground support installed starting at the top of the cavern and then excavation will progress downward. The caverns excavation makes the OSHA Ventilation dilution approach impractical, reference Figure No. 2.

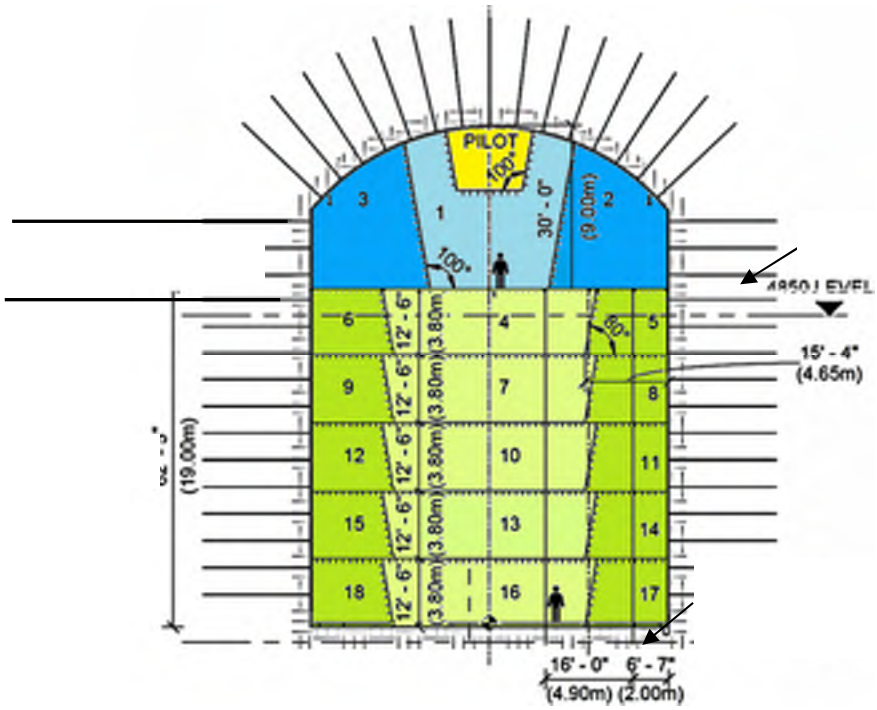


Figure No. 2 (Cross section of North Cavern displaying the dimensions of the space and the sequencing of the excavation)

OSHA Ventilation Standard (29 CFR 1926.800(k)(3)

10 CFR 851 requires compliance with 29 CFR 1926.800(k)(3), in that air velocities in underground work areas shall be at least 30 feet (9.15 m) per minute where blasting or rock drilling is conducted, or where other conditions likely to produce dust, fumes, mists, vapors,

or gases in harmful or explosive quantities are present. When the two detector cavern faces (92-ft H x 65-ft W) and one central utility cavern face (37-ft H x 64-ft W) are multiplied by 30 fpm, the required airflow becomes an approximate total of 430,000 cfm when all three caverns are being excavated concurrently. Potentially creating wind speeds of 20 to 30 mph in the existing drifts (See Appendix A, slides 4 and 5). If this requirement were to be applied, the resulting wind speeds in the much smaller surrounding drifts will greatly increase and uplift additional dust, creating unsafe air quality, introduce visibility issues, and increase worker fatigue while walking in the headings. In addition, directing airflow effectively to the cavern faces would be difficult and therefore, could not meet the airflow velocity requirements as prescribed in 29 CFR 1926.800(k)(3) across the entire cavern faces.

OSHA air monitoring standards require a competent person to test for appropriately safe levels of oxygen and for toxic gases. The OSHA 1926.800(k)(3) approach does not require validation that 30 fpm has adequately controlled the air quality, and therefore, there are no assurances that fresh air sweeping the work area will be adequate to mitigate harmful levels of airborne contaminants within the LBNF/DUNE-US excavation. This is exacerbated in large faces such as the detector caverns with relatively smaller entrance and exit tunnels supplying and exhausting the ventilation air. In these cases, airflow will stratify such that a 30-fpm average velocity will not evenly distribute across the large face, making performance measurements at the work area a better verification of worker protection.

At a minimum, the following practices are common at metal-nonmetal mines and will be utilized to assure a safe work environment for LBNF/DUNE-US project workers:

- Implement appropriate engineering controls to reduce the overall emissions of airborne contaminants (Tier 3 and 4 diesel engines, ultra-low sulfur fuel, emission controls, etc.),
- Require monitoring of worker airborne contaminant exposure levels ((dust, Diesel Particulate Matter (DPM), silica, and certain toxic gases at a minimum)),
- Require most appropriate means and methods (dust collection, particulate filters, auxiliary fans/tubing and other ventilation controls to direct the air where it is needed, etc.) to assure worker health is not compromised, and
- Implement administrative or other additional controls (removal from hazardous exposure and/or work under appropriate respirator protection) where workers are found to be potentially exposed to airborne contaminants.

Utilizing the above practices, FRA will ensure that workers' exposures to airborne contaminants comply with ACGIH 2016 TLVs and the approved NO_2 abatement plan without

increasing airflow velocities to levels that would introduce additional hazards to workers. The NO_2 abatement plan is found in Appendix B. The air monitoring and sampling in the NO_2 abatement plan only applies to workers exposure to NO_2.

Proposed Adoption of Localized Ventilation Approach in Place of 29 CFR 1926.800(k)(3)

In contrast with the OSHA dilution ventilation requirement, the localized ventilation approach for controlling airborne contaminants in underground excavation environments centers around preventing airborne contaminant exposure to protect personnel safety and health.

Ventilation		
OSHA (Dilution Requirement)		**Localized Approach**
1926.800(k)(3)	Prescribe 30-fpm linear velocity of airflow in the tunnel bore, in shafts, and in all other underground work areas where blasting or rock drilling is conducted, or where other conditions likely to produce dust, fumes, mists, vapors, or gases in harmful or explosive quantities are present	30-fpm Average localized ventilation in the drill and blast work area through auxiliary fans and exposure monitoring of contaminants

OSHA's prescribed ventilation standard 1926.800(k)(3) is based on using prescribed airflow (30 fpm) to dilute airborne contaminants in order to control personnel exposures. In addition to providing dilution, the objective of the ventilation regulation is also targeted at removing contaminants from the working face and worker occupied areas to an exhaust location(s) to prevent contaminant accumulation, explosive conditions, and to reduce exposure risks. Dilution ventilation may reduce contaminant gas concentrations in certain areas, but doesn't necessarily prevent air column stratification or eliminate contaminant accumulation in areas where the localized airflow produces eddy currents, reversal airflows, etc. Dilution ventilation does not reduce exposure risks posed by aerosols/particulate contaminants, which must be removed from the working face and worker occupied spaces to reduce exposure risks.

This localized ventilation approach will focus on limiting personal exposure to contaminants through supplemental ventilation at the point of exposure, sampling, and monitoring. This localized ventilation approach will provide flexibility in the methodology for reaching the ultimate goal of protecting workers from exposure to airborne contaminants. The work area is that area in which workers are exposed to contaminants created by the drill and blast operation – primarily the diesel equipment that will be utilized across the width of the

working face, up to 40 feet back from the face, and up to 20 feet above the working surface (floor) at the active excavation. In all areas outside the defined work area, air quality and air flow will continue to be monitored to maintain a safe work environment for personnel in accordance with 29 CFR 1926.800(k)(2) (i.e., 200 cubic feet of fresh air per minute for each worker). In addition, when mobile diesel equipment is utilized or in transport to another work area, the air flow will be maintained in accordance with 29 CFR 1926.800(k)(10)(iii) (i.e., 100 cubic feet of air per minute for each brake horsepower). 29 CFR 1926.800(k)(3) will not apply to those areas outside the defined work area.

The OSHA ventilation standards at 29 CFR 1926.800(k)(3) use minimum airflow requirements to control airborne contaminants in underground construction environments, particularly within excavation of tunnels, shafts, chambers, and passageways. The majority of typical underground excavations are most often unidirectional tunnel developments with unidimensional headings that are relatively straightforward to ventilate and do not possess the complex characteristics of a previously operated mine facility. Typical unidirectional tunnel excavations utilize minimum airflow requirements that are effective in protecting worker health from airborne contaminants while supporting human activity and minimizing dust, toxic gas and DPM emissions. However, due to the complexity of existing ventilation drifts and the excavation at the LBNF/DUNE-US Far Site, achieving the prescribed air velocity of 30 fpm is extremely difficult without introducing new hazards in the underground. This necessitates the need for localized ventilation approach that will be utilized by FRA and FRA's subcontractor(s).

The ventilation variance process is implemented in three stages (1) completion of CFD modeling to identify possible ventilation issues, (2) implementation of the work planning and control process to identify, document, and implement the localized ventilation plan for the work activities, and (3) verification of effectiveness including air flow and air quality.

Stage 1 CFD Modelling

CFD modeling will be done routinely. However, itis impractical to be performed on a round-by-round basis. The ventilation profile will change with every blast in the large caverns as more volume is opened with each blast. CFD modeling will be conducted in advance which will simulate airflow for major phases (benches C, E, and G).

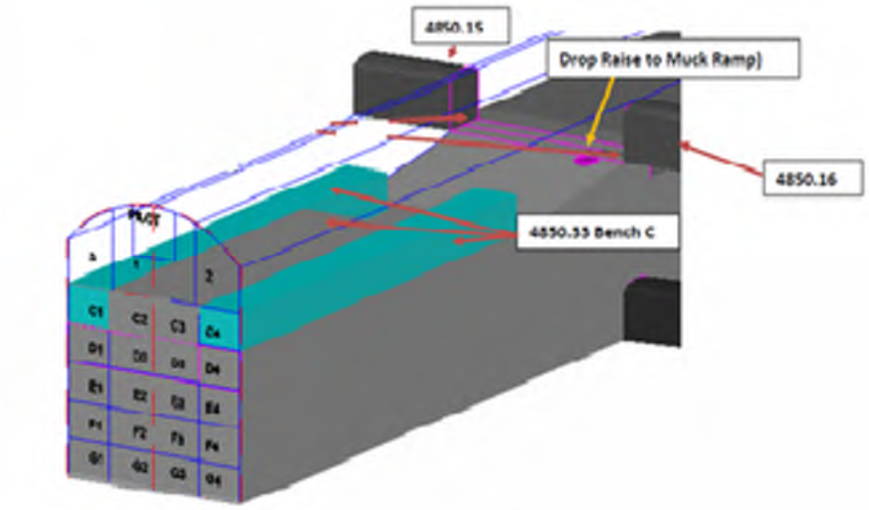


Figure No. 3 (Isometric of North Cavern displaying the benches)

It is not possible to avoid stratification completely; however, Auxiliary fans will be utilized to ensure clean air is directed to the work areas and these areas will have continual air sampling during all work shifts. If CFD modeling predicts an area of possible stratification, mitigations (i.e., localized ventilation and air sampling) will be addressed within the work planning documentation prior to the start of work.

CFD modeling will identify areas of stratification which are expected to be in horizontal layers between the work area (at the bottom of the cavern) and the top of the cavern. These areas are not immediately accessible without aerial lifts and access will be authorized only through the work planning process after ventilation needs are identified and implemented. The use of localized ventilation at the work area where contaminants are generated will minimize the potential for contamination of stratified air, as this focus air flow will carry exhaust away from the work area.

Stage 2 Implementation of Work, Planning & Controls

The localized ventilation approach will provide equivalency with 29 CFR 1926.800(k)(3) by providing, at a minimum, 30 fpm average localized ventilation at the workers' work area, which is also where contaminants are generated, without introducing the additional worker hazards posed by increased airflow velocities throughout the mine. This approach will include monitoring airflow and airborne contaminants per the ACGIH 2016 at the workers' work zone per the FRA's subcontractor's industrial hygiene plan and sampling monitoring plan, see Appendices H, J, and K. The requirements for localized ventilation will be addressed in the task specific FRA subcontractor work planning documentation (i.e., Build Plans, Job Hazard Analyzes, and the Field Level Risk Assessments) see Appendices C, E,

F, G, and I. Work Planning Controls include post-blasting clearing process, real-time gas monitor alarm, air flow monitoring etc. In addition, the subcontractor will utilize the following engineering and administrative controls to ensure personal worker safety and health (See Appendix A – Slides 6, 7, and 8).

Engineering Controls
Utilization of emissions scrubbing technology on mobile equipment
Localized ventilation at the workers' work zone
Emissions testing of subcontractor's mining equipment
Utilization of enclosed cab equipment where possible
Optimizing ventilation to working area
Administrative Controls
Real time personal exposure monitoring
Real time investigation and mitigation of level (alarm set points) exceeding set limits
Real time reporting of levels (alarm set points) exceeding set limits
Area exposure monitoring
Shift duration exposure monitoring badges
Job rotation strategies

The localized ventilation approach which includes supplemental ventilation at the point of exposure based on area cross section to define the required air volume (30 fpm). Effectiveness will be confirmed using air sampling and monitoring of airborne contaminants.

Localized ventilation will be directed to ensure that contaminant levels in those spaces where personnel are working are kept at or below safe levels. It is assumed that some stratification/stagnation of air will occur within other spaces within the caverns, and access to these areas will be prohibited. Stratification/stagnation of concern will be identified based on areas where the air flow is less than 30 fpm velocity. In areas that cannot meet the ACGIH TLVs, restricted access to those areas will be evaluated through the work planning and control process and communicated to the workers during the daily planning meetings. The methods for restricting access will be detailed in the work planning documentation and will be performed by the use of barriers and signage prohibiting access. Procedures for re-entry into these spaces will also be detailed in the work planning documentation and shall include such measures as the use of auxiliary fans and continuous air monitoring, reference Appendix K, Section 7.5.

Stage 3 Verification of Effectiveness

The work area includes the source of contaminants and localized ventilation also assures that this contamination is effectively removed from the work area. The localized ventilation

will be validated through routinely updated ventilation modeling, airflow monitoring and verification, personnel exposure sampling, and continuous air monitoring. FRA's subcontractor Thyssen Mining Inc. (TMI) will utilize the following documents as part of the work planning and controls to meet the requirements of this variance.

- Appendix J - TMI's TM-SOP-17001 Industrial Hygiene Plan.
- Appendix K - TMI's TM-SOP-17010-FSCF Industrial Hygiene Monitoring Procedure.
- Appendix L – TMI's Underground Blasting Safety Procedure
- Appendix M - TMI's LBNF-FSCF-Ventilation Plan - Excavation Series One (Phase 1)
- Appendix N - SURF's Ventilation Plan

In addition, FRA and KAJV will be responsible for completing air flow monitoring and personal sampling requirements for their own employees.

- Appendix H – KAJV's Exposure Sampling
- Appendix D – FRA's LBNF-FSCF Industrial Hygiene Plan

The air quality contaminants being monitored to ensure worker safety include:

Contaminants	ACGIH 2016 Time-Weighted Average (TWA) over an 8-hour workday
CO	25 ppm TWA
CO_2	0.5% TWA
DPM	160 G/m^3 (MSHA)
NO_2	Reference Approved Abatement Plan
Silica	0.025 mg/m^3

Verification that airborne contaminants are effectively managed to safe levels is achieved through multiple monitoring efforts including the following:

- Personal sampling and monitoring (continuous with alarms) found in Appendix D, Section 12.0, Appendix H, Section 4.1 and Appendix K, Section 7.5.
- Temporary area sampling (multiple times daily, documented on a daily basis) found in Appendix D, Section 5.0, Appendix H, Section 4.2, and Appendix J, Section 5.3.1.
- Fixed SURF monitoring (continuous with alarms), found in Appendix N, Section titled "Current Airflow and Monitoring" Section.

Ventilation will be adjusted as needed to ensure safe conditions and to ensure localized ventilation meets the proposed variance requirement of 30 fpm. During the verification

process, if any changes are necessary the work planning documentation is updated, re-reviewed and reauthorized.

A statement showing how the conditions, practices, means, methods, operations, or processes used or proposed to be used would provide workers a place of employment which is as safe and healthful as would result from compliance with the standard from which a variance is sought:

Many of the deep metal mines, much like SURF, have tens to hundreds of miles of headings that move air from the surface deep underground to expansive mining faces that are very complex to ventilate. Because of this, establishing minimum airflow requirements is not practical without the potential for creating additional hazards. There are no assurances that fresh air sweeping the excavations faces at measured airflow velocities greater than 30 fpm as required by 1926.800(k)(3) will be adequate to mitigate harmful levels of airborne contaminants within the LBNF/DUNE-US excavation. Additionally, the wind speed required to achieve the ventilation standard in the cavern excavations (because of the configuration of the SURF tunnels) is likely to result in additional hazards such as the creation of a high air velocity environment and the re-mobilization of airborne contaminants throughout the underground.

Ventilation plans and CFD modeling will assist in the development of the work planning and controls process.

TMI will be performing all excavation activities. TMI will have primary responsibility for the engineering and installation of all localized ventilation systems. TMI will also have primary responsibility for verifying and monitoring air flow and air quality at the working spaces within the caverns for their workers. Worker planning and controls effectiveness is continually evaluated and adjusted based on field experience, i.e., lessons learned. Changes are reviewed with workers as they are made, utilizing in the daily pre-brief meetings which occur prior to work starting on every shift.

All work planning and control documents are submitted and reviewed through the project document management system (Team Binder). All documents within Team Binder have a workflow algorithm that requires review and authorization of work plans. The review process includes the following project stakeholders, excavation subcontractor, CMa, and FRA construction management, including ES&H personnel from each organization. Work plans are not authorized until all stakeholders' review and approve. If resubmittal is required based on stakeholder feedback, then the work plans are modified and resubmitted into Team Binder for review and approval.

FRA and KAJV will be responsible for providing oversight of TMI work activities including verification and effectiveness of the operation of localized ventilation systems including the air flow and air quality monitoring. FRA and KAJV will be responsible for completing air flow monitoring and personal sampling requirements for their own employees.

Appendices

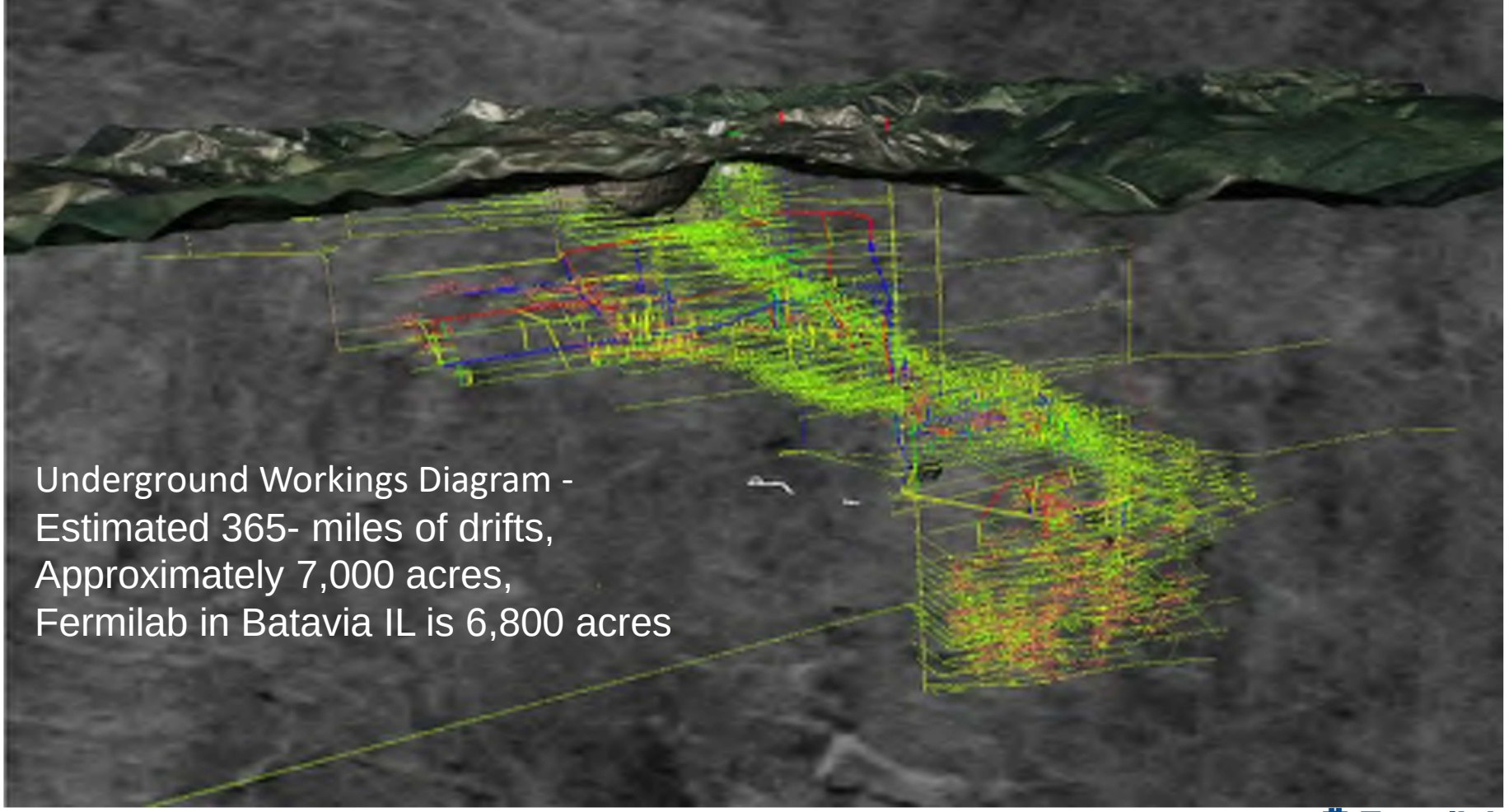
A. LBNF Variance Slides 12-06-2021
B. FRA $N0_2$ Abatement Plan
C. FRA Site Specific Construction ES&H WPC
D. FRA FSCF Industrial Hygiene Plan
E. Hazard Analysis Template
F. Build Plan Template
G. KAJV Specific sections related to WPC
H. KAJV Exposure Sampling
   - Appendix I - Sampling Method Instructions
   - Appendix II - Air Monitoring Form & Chain of Custody
   - Appendix III - Employee Notification
   - Sample at 4850L
I. TMI Specific sections related to WPC
J. TMI SOP 17001 FSCF Industrial Hygiene Plan
K. TMI SOP 17010 FSCF Industrial Hygiene Sampling & Monitoring Procedure
L. TMI Underground Blasting Safety Procedure
M. TMI LBNF FSCF Ventilation Plan – Excavation Series
N. SURF Ventilation Plan

Appendix A - LBNF Variance Slides 12-06-2021

Bottom Line Up Front

The Problem: OSHA 1926.800(k)(3) requires 30-fpm air velocity over the excavation face. As excavation (drilling & blasting) progresses towards opening the Caverns, it becomes more difficult to meet this requirement. In addition, if the 30-fpm was enforced then additional hazards would be created such as airborne containments throughout the existing primary ventilation paths, effecting LBNF excavation subcontractors and impacting the SDSTA operations. We do not believe OSHA envisioned using this requirement in a former underground mine where the governance was MSHA and not OSHA.

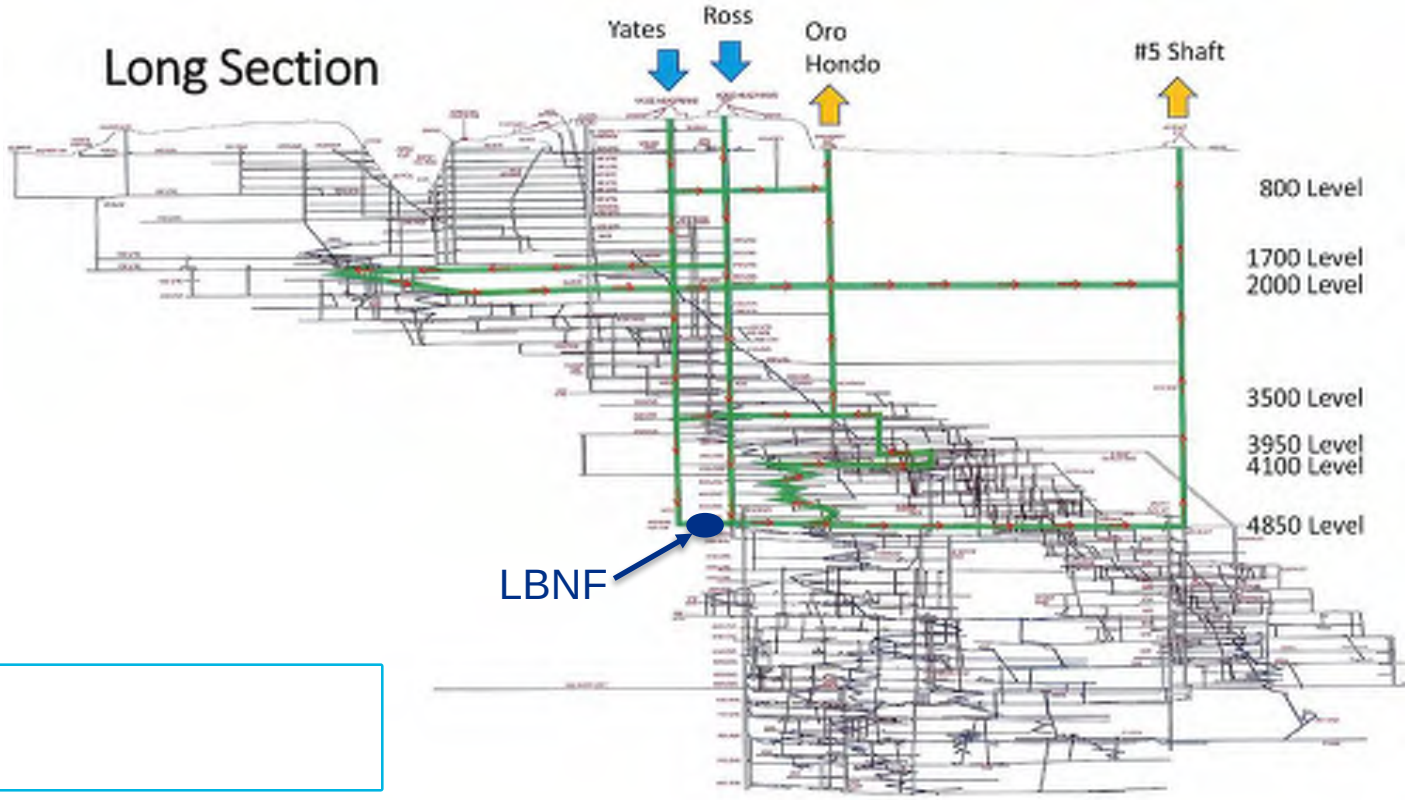
Proposed Equivalency: Provide localized ventilation to meet the 30-fpm air velocity at the workers area via engineering controls (e.g., booster fans & air monitoring). This will enable a safer workplace for LBNF excavation subcontractors and would have no impact on SDSTA operations.


Underground Workings Diagram -
Estimated 365- miles of drifts,
Approximately 7,000 acres,
Fermilab in Batavia IL is 6,800 acres

SURF Underground Sectional View

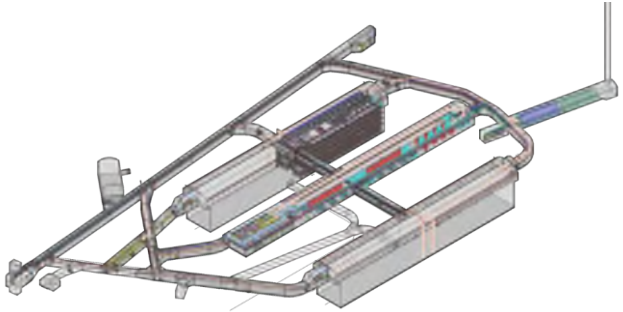
Fresh air to underground

Exhaust air from underground

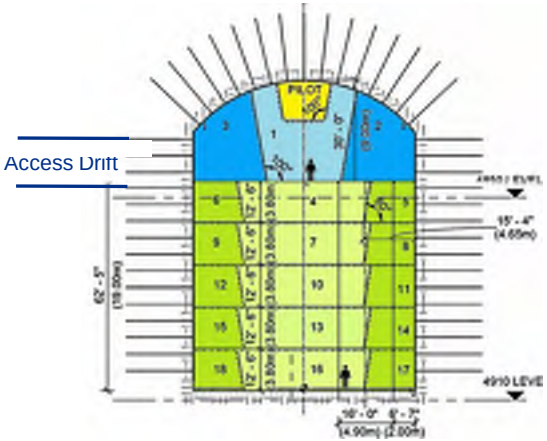


Fermilab

Technical Need for the Variance



LBNF/DUNE-US Isometric



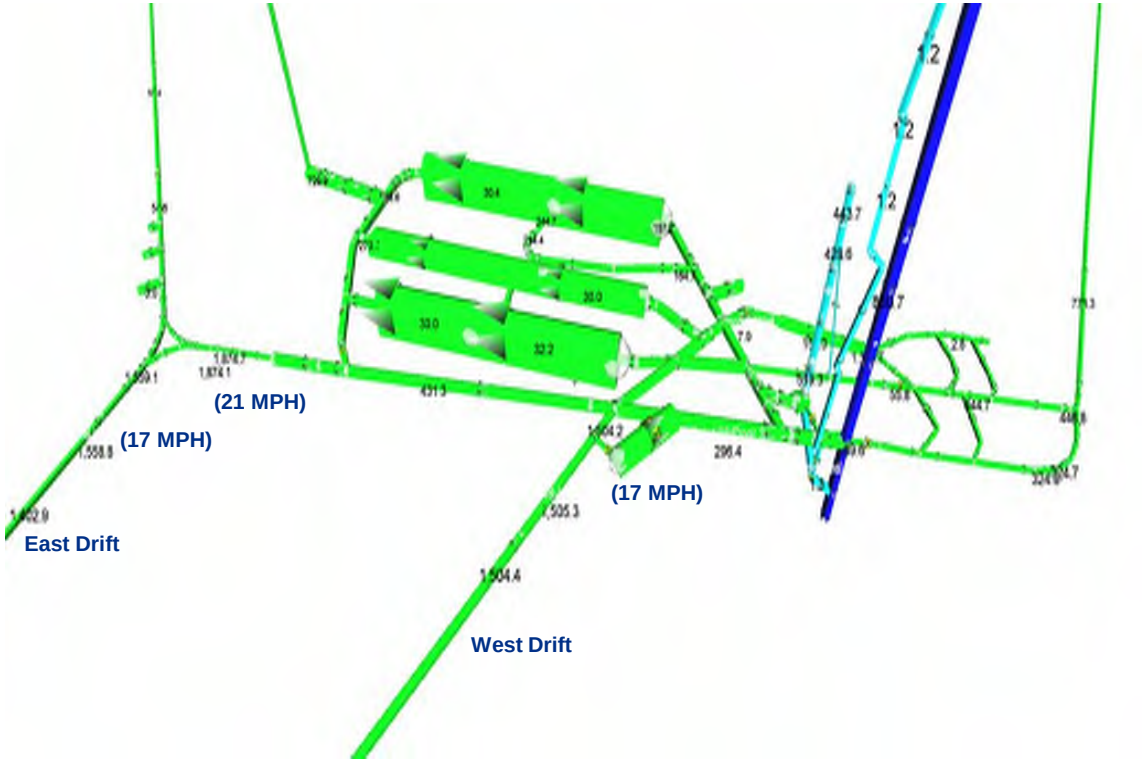
Section View of North Cavern

- OSHA 1926.800(k)(3) requires 30-fpm air velocity over the excavation face
- To accomplish this, the bottom heading of the large caverns would need
  - 30-fpm x 65.6-ft wide x 92.1-ft tall
  - Yields **181,252**-cfm through each cavern; thereby,
- An estimated **450,000**-cfm for all three caverns excavating concurrently requiring a total of 1.3M-cfm exhaust air throughout the existing and excavated caverns
- The wind speed in the surrounding drifts would create a hazardous situation in the underground and would stratify in the caverns; therefore, unlikely to meet the velocity requirement near the ends of the caverns, most likely only in the center
- Rough estimates for wind speeds 20 to 30 mph

Fermilab

Analysis Ross Campus

Note: Ventilation Simulation Software – Ventsim, numbers portrayed are in feet per minute (fpm)

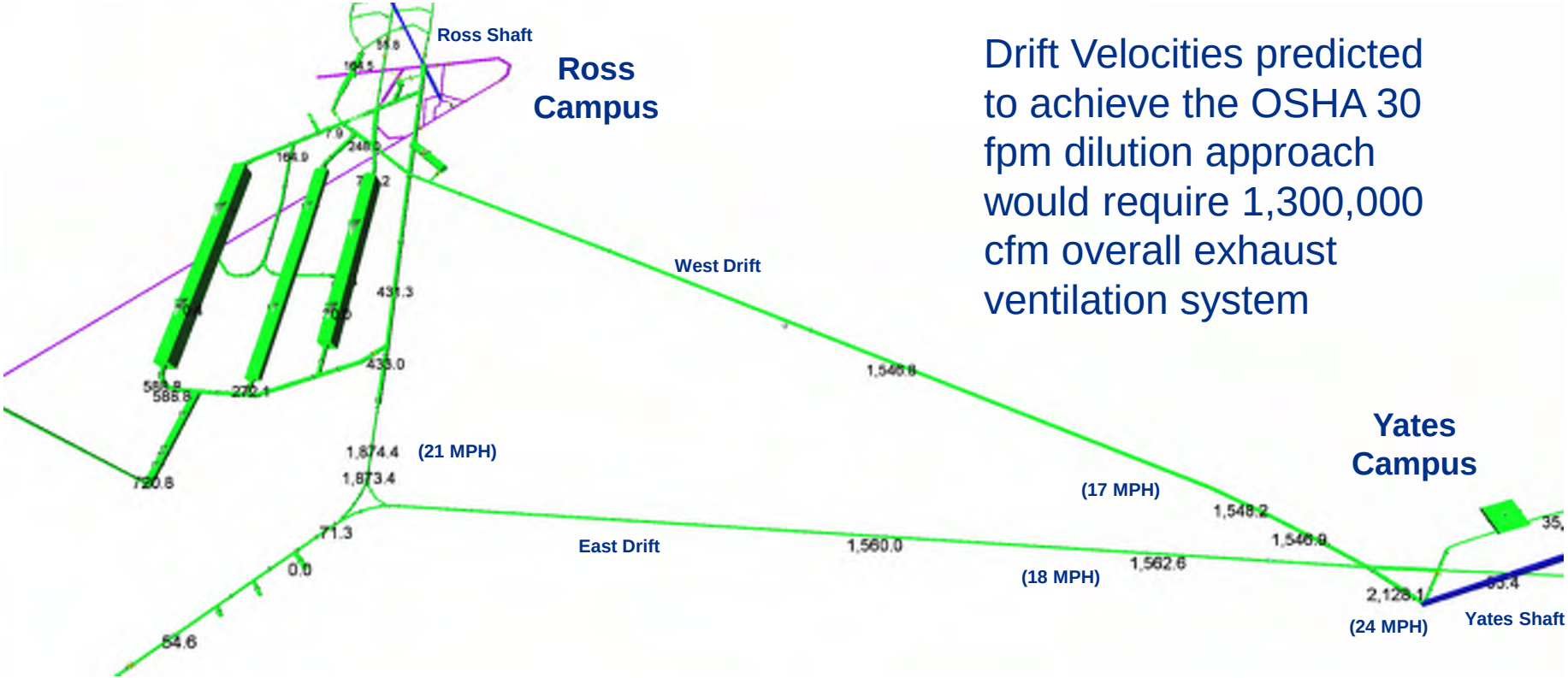


Drift Velocities predicted to achieve the OSHA 30 fpm dilution approach would require 1,300,000 cfm overall exhaust ventilation system

Fermilab

Analysis Yates Campus

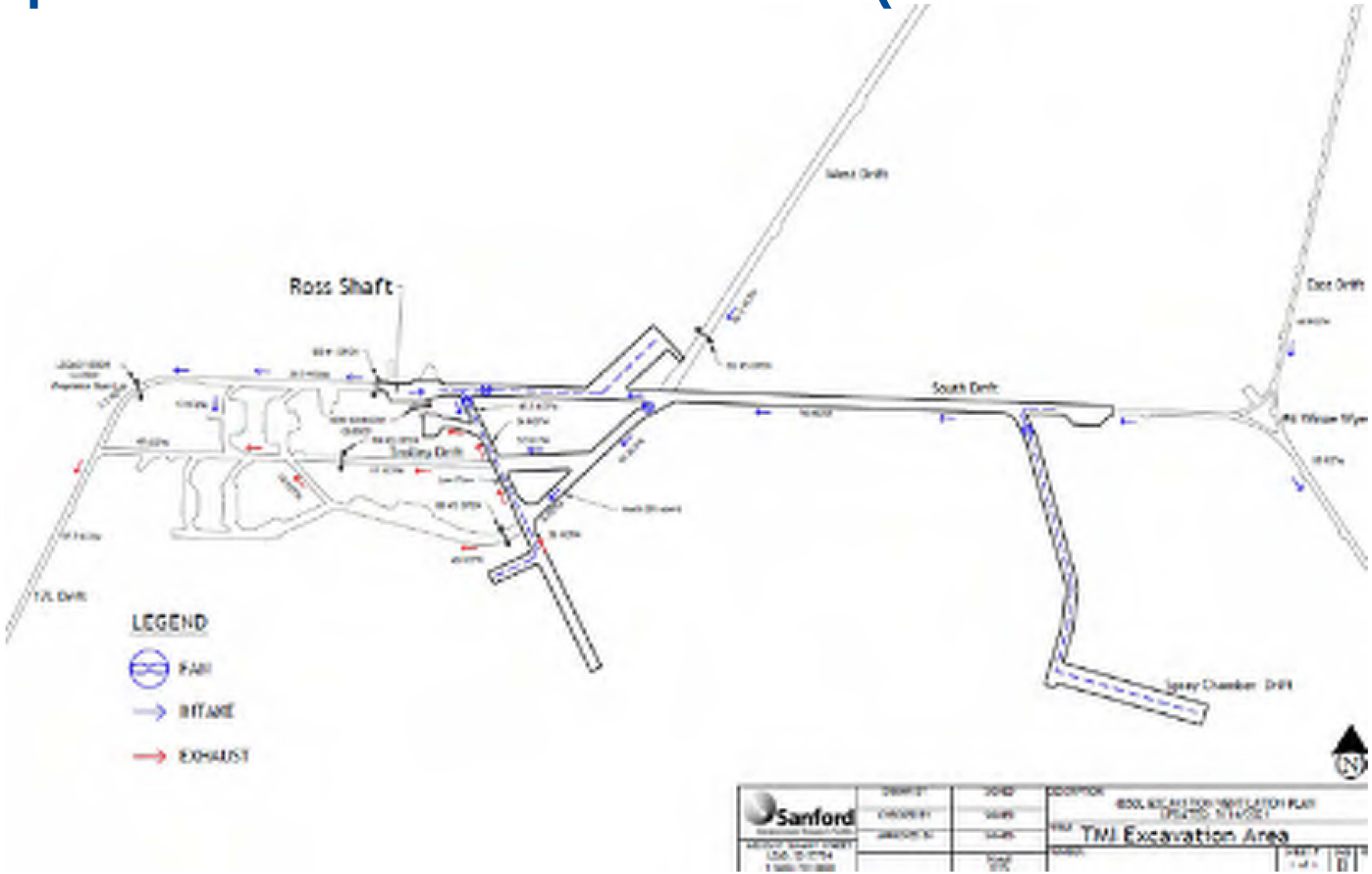
Note: Ventilation Simulation Software – Ventsim, numbers portrayed are in feet per minute (fpm)



Drift Velocities predicted to achieve the OSHA 30 fpm dilution approach would require 1,300,000 cfm overall exhaust ventilation system

Fermilab

Example of Booster Fans Utilization (Localized Ventilation)



Fermilab

Backup Slide

Ventilation Curtains

Flexible Ventilation Duct

Fermilab

Backup Slide

Flexible Ventilation Duct

Booster Fans

Appendix B - FRA $N0_2$ Abatement Plan

Department of Energy
Office of Science
Fermi Site Office
Post Office Box 2000
Batavia, Illinois 60510

June 14, 2021

Dr. Nigel Lockyer
Director
Fermi National Accelerator Laboratory
P.O. Box 500
Batavia, IL 60510

Subject: Abatement Plan for Nitrogen Dioxide

Dear Dr. Lockyer:

The Department of Energy (DOE) – Fermi Site Office is in receipt of Fermi Research Alliance, LLC's (FRA) proposed abatement plan for the control of Nitrogen Dioxide at the Sanford Underground Research Facility (SURF) for the work being performed by FRA subcontractors in support of the Long Baseline Neutrino Facility (LBNF).

This plan provides for mitigations which are necessary to ensure adequate protections are in place for the health and safety of the workers in the underground environment, while facilitating continuous improvement in performance baselines given the changing work landscape. The Fermi Site Office approves the outlined approach in the submitted Abatement Plan for ensuring worker exposure to Nitrogen Dioxide is maintained as low as reasonably achievable.

Until such time as DOE approves an equivalency to ORPS reporting thresholds or frequencies, FRA must comply with all requirements of DOE Order 232.2A for reporting overexposures at the thresholds consistent with 10 C.F.R 851, inclusive of the 2016 American Conference of Governmental Industrial Hygienists (ACGIH) standards.

Sincerely,
Richard K. Verhaagen
Digitally signed by Richard K. Verhaagen
Date: 2021.06.14 12:21:14 -05'00'

Richard Verhaagen
Manager, Fermi Site Office

Cc:
Adam Bihary, FSO
John Scott, FSO
Tiffany Rogers, FSO
Chris Mossey, FRA
Amber Kenney, FRA

LBNF/DUNE-US Project Far Site

Excavation
ACGIH 2016 Abatement Plan Nitrogen Dioxide (NO_2)

Version 1 – June 13, 2021

LBNF Far Site Project Team

Submitted by: Nigel Lockyer, UID:lockyer
Digitally signed by Nigel Lockyer, UID:lockyer
Date: 2021.06.14 10:30:44 -05'00'

Nigel Lockyer, Fermilab Director

Approved by: Richard K. Verhaagen
Digitally signed by Richard K. Verhaagen
Date: 2021.06.14 12:26:36 -05'00'

Rick Verhaagen, Fermi Site Office Manager

Executive Summary

Fermi Research Alliance (FRA) is committed to supporting research and operations by protecting the environment, health, and safety of our staff, subcontractors, and the community.

FRA is constructing the Long Baseline Neutrino Facility at the Sanford Underground Research Facility (SURF) in Lead, South Dakota.

The construction project will excavate caverns a mile underground and is estimated to complete in approximately two years, following which, period operations will ensue, and which will comply with 10 CFR 851 standards in effect at that time. The construction project will utilize heavy diesel equipment for underground excavation and will not be able to consistently comply with 2016 Threshold Limit Value (TLV) for nitrogen dioxide (NO_2) as required by 10 CFR 851 Worker Safety and Health Program.

This abatement plan has been written to reduce worker exposure to NO_2 to as low as reasonably achievable. It is difficult to pinpoint potential NO_2 through ventilation modeling due to the complexity of the ventilation system in relation to the equipment as it moves through the spaces and as the spaces change shape. Ventilation modeling is used to estimate air quality with respect to NO_2, but the monitoring and sampling data will be used to adjust ventilation flows and other controls to minimize exposure. Sampling and monitoring will be performed to continuously analyze potential exposure and adjust mitigations throughout the construction work phases to ensure worker protection. The expectation is the that through these efforts, exposures will be reduced to the lowest practical levels. FRA will submit occurrence reports[1] for any worker exposure that exceeds 3.0 parts per million (ppm) for a time weighted average (TWA) over an eight-hour shift or any worker exposure that exceeds 2.1 ppm for an adjusted TWA over a ten-hour shift.

This plan will prioritize worker safety while making continuous improvement until compliance with 10 CFR 851 is achieved or the project is complete.

[1] Until such time that an equivalency for ORPS threshold reporting is approved, FRA will submit ORPS reports for NO_2 overexposure according to the 2016 ACGIH guidelines.

reasonably achievable will be accomplished through engineering controls, administrative controls, and continuous data collection, baselining, ventilation, and worker exposure estimated calculations. The work will be adjusted throughout by sampling and monitoring of phased work activities to minimize the worker's exposure as reasonably achievable with an approach to continual reduction through practical thoughtful measures applied in real time.

FRA and the subcontractor have deployed monitoring through direct reading personal monitors and are set to an alarm set point[2] that is effective at identifying periods of potential increased exposure to which immediate investigation and response will be applied. The direct read monitoring is not a TLV-TWA but instantaneous information to alert personnel to conditions that could cause a potential NO_2 over-exposure if not addressed in a timely manner. This allows FRA and their subcontractors to address the conditions with supplemental engineering and/or administrative controls to continuously improve conditions in the work environment. It allows the subcontractor to make adjustments to ventilation, worker positioning and equipment operating conditions. The shift duration data extracted from the direct reading personal monitors will be utilized to identify overall effectiveness of the controls to identify any positive and negative trends in performance.

This review process will allow for the quick identification of deteriorating work conditions that would require additional response. Alarm set points are below regulatory limits and based on monitoring data and set at levels low enough to initiate action and review prior to exceeding past performance levels (i.e. continually challenging pursuit of improvement). Identified alarm set points are monitored in real time by direct reading of multi-gas detectors (FRA's subcontractor will be utilizing Industrial Scientific iBrid MX6 or Industrial Scientific Ventis MX4 multi-gas monitors. FRA will utilize MSA Altair 4XR and MSA Altair 5X multi-gas monitors). If the direct-read detector reaches the alarm set point it will alarm and provide textile information to alert workers and are trained to immediately withdraw themselves from the area of the hazard, and to report accordingly to the subcontractor, Thyssen Mining Inc.'s (TMI's), TM-SOP-17001 Industrial Hygiene Plan. Air monitoring is discussed in detail in TMI's TM-SOP-17010-FSCF Industrial Hygiene Monitoring Procedure.

1.1 Roles and Responsibilities

The requirements of this abatement plan will be implemented by the LBNF subcontractor. In order to assure that the excavation activities meet the expectations of this abatement plan, FRA has developed a strategy for oversight. The strategy uses a set of elements to evaluate, observe, correct, and improve how the plan is implemented, monitored, and achieved by the subcontractor.

[2] Alarm set point is a criterion that indicates whether the control measure is functioning as designed. Exceeding the alarm set point implies that action is required.

able to implement Fermilab's ES&H requirements including this abatement plan.
- Implement established Abatement Plan
- Immediately report any deficiencies in the established Abatement Plan

SURF
- Ensure primary ventilation is appropriate and maintained
- Provide access to the existing underground space.

1.2 Air Contaminants

Nitrogen Oxide, NO, and Nitrogen Dioxide, NO_2, are produced by diesel engine exhaust emissions, and are generally referred to as nitrogen oxides (NOx). Together, NOx and Diesel Particulate Matter (DPM), represent the most difficult diesel engine emission products to control. NO is the main contributor to the NOx concentration, and several factors influence the partitioning between NO and NO_2 in the diesel exhaust (E.G Cauda, 2010). It should be noted that neither ACGIH nor OSHA limit DPM exposure but rather limits for the constituents of DPM. NO_2 is a byproduct of diesel fuel combustion and as a gas, it is heavier than air and is a strong oxidizer. FRA reviewed alternative means to mitigate the production of nitrogen oxides and a summary of FRA's conclusions can be found in the appendix material.

The limit for NO_2 as delineated in the ACGIH TLV from the 2005 (3.0 ppm) version to 2016 (0.2 ppm) version was reduced by a factor of 15. The table below shows typical contaminants found in underground excavations and the different regulatory and guidelines exposure limits. OSHA and MSHA are the industry standards for underground excavations across the U.S.

TWA – Time Weighted Average (over 8-hour period)
STEL – Short Term Exposure Limit (over 15-minute period)
(C) – Ceiling Limit (not to exceed at any time)
mg/m^3 – Milligrams/meter cubed
$\mu g/m^3$ - Micrograms per cubic meter
N/A – Not applicable

Table 1 - Comparison of Containments Level

Contaminants	MSHA	OSHA	ACGIH 2005	ACGIH 2016
CO	50 ppm TWA	50 ppm TWA	50 ppm TWA	25 ppm TWA
CO_2	0.5% TWA	0.5% TWA	0.5% TWA	0.5% TWA
DPM	160 $\mu g/m^3$	N/A	N/A	N/A
H_2S	20 ppm (C)	10 ppm TWA	10 ppm TWA	1 ppm TWA
NO_2	5 ppm (C)	5 ppm (C)	3 ppm TWA	0.2 ppm TWA
NO	25 ppm TWA	25 ppm TWA	25 ppm TWA	25 ppm TWA
Silica	0.05 mg/m^3	0.05 mg/m^3 *(0.025 mg/m^3*	0.05 mg/m^3	0.025 mg/m^3

2.0 Abatement Measures

Protective measures will be implemented through the use of the engineering and administrative controls described below. FRA will implement an evolving combination of controls and mitigations to obtain as low as reasonably achievable worker exposure to NO_2 throughout construction.

The goal is to reduce exposure to NO_2 to as low as reasonably achievable for the equipment required for excavation. Access to the construction area is restricted to only the personnel required to perform excavation activities who will be sampled and monitored for NO_2 exposure. Additionally, equipment will be tested, and records kept ensuring diesel equipment exhaust meets the performance requirements set forth by EPA 40 CFR Part 75, this includes NO_2 levels.

Where NO_2 levels are found to exceed alarm set points on the direct read monitors, workers will stop their work activity and notify their supervisor and ESH staff per the TMI's TM-SOP-17010-FSCF Industrial Hygiene Monitoring.

All of the efforts described in the engineering and administrative controls sections below work to keep NO_2 exposure to as low as reasonably achievable. FRA will institute the engineering and administrative controls (listed below) and will be continuously applied and adjusted to consistently improve and reduce exposure throughout all the excavation work activities.

Table 2 – Personnel Exposure Abatement Controls

Engineering Controls
Utilization of emissions scrubbing technology on mobile equipment
Emissions testing of subcontractor's mining equipment
Utilization of enclosed cab equipment where possible
Maximizing ventilation to working areas
Administrative Controls
Real time personal exposure monitoring
Real time investigation and mitigation of levels (alarm set points) exceeding set limits
Real time reporting of levels (alarm set points) exceeding set limits
Area exposure monitoring
Shift duration exposure monitoring badges
Sampling data reporting
Job rotation strategies

2.1 Engineering Abatement Controls

Air quality is monitored to ensure the health and safety of workers; to verify compliance; to identify areas of air quality concern; and to assess the efficacy of controls. Air quality is primarily maintained through the use of engineering controls including underground equipment selection, the underground ventilation system and supplemental ventilation.

Scissor Deck	EPA Tier 3 or 4, Diesel	X	X
Telehandler	EPA Tier 3 or 4, Diesel	X	X
Auxiliary Equipment	EPA Tier 3 or 4, Diesel	X	X

Use of modern equipment

FRA's Subcontractor is required to utilize modern mining equipment that meets EPA emission standards for non-road diesel engines, Tier 3 and 4:

Tier 3 equipment:

- Improved airflow through the engine (more responsive turbochargers, improved combustion chamber design, and variable valve timing).
- Precise control of injection (electronically controlled, common-rail injection systems) – A series of small fuel injections during the combustion cycle, instead of on single injection "blast" reduces NOx.
- EGR (Exhaust Gas Recirculation: a portion of the exhaust is routed back into the intake air)

Tier 4 equipment:

- DPF (Diesel Particulate Filter).
- CCV (Closed Crankcase Ventilation: Blow-by gases that get into the crankcase are recirculated back into the engine instead of vented to the atmosphere).
- SCR (Selective Catalytic Reduction: A reduction reaction converts NOx to nitrogen, water, and CO_2.)

Use of Underground Air Doors / Blast Doors

In order to divert additional clean air flow to areas where NO_2 is high, air doors / blasts doors can be used to enhance the airflow in the desired direction.

Supplemental Ventilation Controls for Diesel Equipment

When applicable, booster fans with temporary ducting, portable and auxiliary fans will be utilized to relocate the discharge of the exhaust to a point away from the workers where this cannot be accomplished through orientation of the equipment. This equipment does not reduce emissions but removes it from the immediate work area and reduces personnel exposure.

Installation and configuration of these "temporary ducting" is highly dependent on the layout of the work area and the supply of the local ventilation to the area. The blowers are electric and require a power feed to the equipment. This fixed position system of temporary ducting is suitable for work that is in a single area for prolonged periods of time (e.g. scissor lifts). It would not be practical for frequently mobile equipment. Additional work control aspects for using blowers and exhaust temporary ducting will be incorporated including the availability of the local exhaust ventilation systems and conditions for use.

as these connections complete and allow for increased ventilation flow. Muck will to be transported directly through the enlarged and/or new drifts to a new grizzly separated from the Ross Shaft air intake. All ancillary spaces will be completed during this phase.

- Phase 3 - Excavate main caverns (Feb 2022 – Apr 2023)
  - Continuous mucking
  - During Phase 3, the three large caverns will be developed using the full fleet and full ventilation availability. Muck will pass through a small passage to a mucking ramp at the lowest level of excavation, providing a direct mucking route to the new grizzly separated from the other excavated spaces.

- Phase 4 - Rock removal complete; place concrete floors (Apr 2023 – Apr 2024)
  - Intermittent use of smaller, diesel equipment
  - During phase 4, concrete placement is completed throughout the areas excavated in phases 1-3. Concreting will prioritize the north cavern, then develop from the furthest point away from the Ross shaft back to the shaft. This minimizes construction traffic on the newly placed concrete. Diesel equipment use during this period is substantially less than previous phases and is limited to the vehicles transporting the concrete from a batching area in the entrance to the South cavern.

At the start of each phase, the subcontractor's ventilation model will be evaluated, and baseline air sampling data will be collected. During each phase, sampling and monitoring[2] will continue throughout the excavation activity. The appropriate alarm set points and controls will be continuously evaluated by FRA as conditions change and the controls will be developed by FRA Subcontractor, and only implemented after review and approval by FRA during each phase.

The following process provides an overview of how the NO_2 abatement approach is to be implemented for all four phases of construction. Full-shift NO_2 samples are required to measure personnel exposure and in order to re-characterize the baseline as abatement activities are implemented. Baselines are established at the beginning of each new phase and at commencement of any new activity. This will be based on the subcontractor's prescribed plan TM-SOP-17010-FSCF Industrial Hygiene Monitoring. For example, within each phase there are unique activities and changes in ventilation configuration that will trigger new baseline sampling and subsequently revised alert levels (as well as any new mitigations justified so as to continue potential exposure reduction). These activities would include such things as the introduction of new equipment to the underground, heading break throughs resulting in ventilation changes or the introduction of new administrative controls such as job rotation and positioning.

as defined in the Subcontractor's sampling plan to re-establish exposure baseline and will continuously wear NO2 direct-read monitors. If direct-read monitor alarms at the 2.1 ppm alarm set point, workers will leave the area and notify supervisor and ESH personnel to investigate and implement supplemental controls before work can commence.

4.0 Reporting

The following describes FRA's reporting strategy:

Table 4 – NO_2 Reporting

NO_2 Results	Reporting
NO_2 sampling results	Provided to FSO monthly or upon request
>3 ppm NO_2 TWA (Over exposure for 8hr shift) or any personnel exposure that exceeds 2.1 ppm for an adjusted TWA over a ten-hour shift[4]	Submit via ORPS/NTS processes FRA will submit occurrence reports for any worker exposure that exceeds 3.0 parts per million (ppm) for a time weighted average (TWA) over an eight-hour shift or any worker exposure that exceeds 2.1 ppm for an adjusted TWA over a ten-hour shift[4]

Quarterly reviews will be performed to document lessons learned and best practices of the engineering and administrative controls. In addition, the quarterly reviews will assess the sampling and monitoring data to identify and implement opportunities for continuous improvement.

[4] Until such time that an equivalency for ORPS threshold reporting is approved, FRA will submit ORPS reports for NO2 overexposure according to the 2016 ACGIH guidelines.

Appendix – Mitigation Strategies Considered Infeasible

The following table includes strategies that FRA considered as potential abatement approaches that were determined to increase safety risk to personnel working in the underground excavation environment.

Abatement Strategy	Mitigation Option	Evaluation
Personal Protective Equipment (PPE)	Respiratory protection	The only respirator cartridge that filters NO_2 is specific to a CBRN (Chemical Biological, Radiological, Nuclear). Respirator cartridges to protect personnel from NO_2 exposure are only available for purchase by Department of Defense. Therefore, controlling worker exposure to NO_2 utilizing air purifying respirators is not feasible. Additionally, using supplied air is also not feasible. Air supply systems are single bottle and usually last only 20-minutes and weigh 20-lbs. This would put an unmanageable burden on personnel and increase the risk for other worker injury (J Occup Environ Hyg., 2020).
Eliminate diesel equipment	Battery Electric Vehicles (BEV)	Utilizing BEVs would require a significant enhancement to the electrical infrastructure underground to accommodate charging stations. Due to the potential worker exposure for electrical injuries during installation and use of the charging systems, and the increase challenges of fire hazard and risks for rescue of personnel in a facility utilizing lithium-ion battery powered equipment, FRA determined that using BEVs increased risk in comparison to use of diesel equipment (Center for Disease Control and Prevention, 2018) (Centers of Disease Control & Prevention, 2014).

Appendix C - FRA Site Specific Construction ES&H WPC

LBNF Far Site Construction Environment, Safety and Health Plan (CESHP)

* SECTIONS PROVIDED

Document number: ***dune-doc-559***

Document Approval

Signatures Required	Date Approved
Originator: Michael Andrews, ES&H Manager, LBNF	Michael P. Andrews Digitally signed by Michael P. Andrews Date: 2021.10.29 08:39:51 -05'00'
Approver: Michael Gemelli, Far Site CF Project Manager, LBNF	Michael Gemelli Digitally signed by Michael Gemelli Date: 2021.10.29 08:00:01 -06'00'
Approver: Mary Convery, Deputy Project Director for Facilities, LBNF	Mary Convery, UID:convery Digitally signed by Mary Convery, UID:convery Date: 2021.11.01 14:49:47 -05'00'
Approver: Elaine McCluskey, Project Manager, LBNF	Elaine McCluskey, UID:mccluskey Digitally signed by Elaine McCluskey, UID:mccluskey Date: 2021.11.09 08:51:55 -06'00'
Approver: Christopher Mossey, Project Director, LBNF	Christopher Mossey, UID:cmossey Digitally signed by Christopher Mossey, UID:cmossey Date: 2021.11.09 09:31:34 -06'00'

Revision History and Version Control

This version of the document may not be the current or approved revision. The current revision is maintained in the LBNF/DUNE Document Management System (DocDB) where all internal Project document approvals are managed. DocDB can be accessed through the web by authorized users (https://docs.dunescience.org/) and this document can be identified by the document and version number as indicated in the Version Control Table below.

Note: The version number in the table below and DocDB may not match. The currently approved version is always available in DocDB.

DocDB	Version	Responsible Person	Version Date	Description of Changes
559	Rev 1	Mike Andrews	7/26/17	Updated SURF Training Requirements and minor edits
559	Rev 2	Mike Andrews	12/1/18	Updated to integrate SURF and KAJV processes
559	Rev 3	Mike Andrews	12/17/19	Update to address new SURF Explosive Materials Management Chapter and add Appendix A
559	Rev 4	Mike Andrews	2/28/20	Update Roles & Responsibilities, emergency reporting requirements, other minor updated to excavation & PPE Sections
559	Rev 5	dlnewhart	4/7/20	Format update and minor grammatical changes
559	Rev 6	dlnewhart	9/29/20	Include IH-Infectious Disease Pandemic
559	Rev 7	Mike Andrews	6/15/21	Update ACGIH references to 2016 and add Nitrogen Dioxide section in 13.3.10 referencing LBNF Excavation ACGIH 2016 Abatement Plan Nitrogen Dioxide (NO_2)

Table of Contents

The types of emergencies that must be reported include, but are not limited to, fire, explosion, personnel injury/illness, security incident, vehicle accident, utility failure, inclement weather including lightning strikes, severe hail, high winds, tornados, possible contamination incident, or a toxic or flammable material spill or release.

A site map showing assembly points and directions to the Subcontractor's authorized medical facility shall be posted conspicuously at the project location (e.g., site project office) and included as part of their SSCSP (This should be the last page of the SSCSP to facilitate easy retrieval). A copy shall also be posted at the Subcontractor's project field office. Upon award of the work, contact the LBNF Far Site ESH Coordinator for electronic copies of evacuation routes and assembly areas to include in the SSCSP's map(s), as needed.

2.3.5 LBNF Site Rules and Safety Requirements

The LBNF Project enforces site rules and requirements. The LBNF Project specifies unacceptable Subcontractor employee acts or conduct and has an established list of site safety requirements addressing areas of frequent violation and/or serious hazard potential.

The subcontractor shall investigate all Notice of Safety Violation and submit a report to the LBNF Far Site Construction Coordinator within 24 hours of receipt of written notification.

All permits described in this CESHP and required for work at SURF will be obtained by the Subcontractor through the LBNF Far Site Construction Coordinator.

2.4 Fermilab Special Emphasis

2.4.1 Work Planning and Control

Subcontractors shall establish a clearly defined work planning and control process that demonstrably integrates safety requirements into the work planning and execution process to protect the workers, public, and the environment. Fermilab advocates the following five core Integrated Safety Management (ISM) functions for work activities and applies them as a continuous cycle with the degree of rigor appropriate to address the type of work activity and the hazards involved:

- **Define the Scope of Work.** Translate missions into work, set expectations, identify and prioritize tasks, and allocate resources.
- **Analyze the Hazards.** Identify, analyze, and categorize hazards and potential environmental impacts associated with the work.
- **Develop and Implement Hazard Controls.** Identify and agree upon standards and requirements, identify controls to prevent/mitigate hazards, establish the ES&H parameters, and implement controls.
- **Perform Work Within Controls.** Confirm readiness and perform work safely and in the prescribed manner to protect workers, the public, and the environment.
- **Provide Feedback and Continuous Improvement.** Gather feedback on the adequacy of controls from workers and appropriate stakeholders, identify and implement opportunities for improvement, and conduct line management and independent oversight.

Key to this CESHP is a HA(s) developed for each work activity. The HA is a core safety management mechanism.

The level of detail within each SSCSP and corresponding HA should be commensurate with the size, complexity, and risk level of the construction project. The necessary coordination between the work to be performed by the Subcontractor and that of the Sub-subcontractors shall be the responsibility of the Subcontractor.

The HAs for each work task shall be available at each worksite.

2.4.2 Stop Work Authority

If unanticipated/unsafe conditions are identified or non-compliant practices are observed during construction activities, workers should recognize that the work activity in which they are engaged should be stopped and notify their supervisor and health & safety officer of this action. All workers on the LBNF project have the authority to stop work in any situation that presents an imminent threat to safety, health, and the environment. Work may not resume until the circumstances are investigated and deficiencies corrected, including the concurrence of the LBNF Far Site Project Manager and LBNF ESH Manager.

2.4.3 LBNF/SURF Site Rules

The following acts or conduct are prohibited at the SURF site and are violations. The Subcontractor will be held responsible for subcontractor workers engaging in such behavior, and the Subcontractor's SSCSP shall reflect that violations may result in disciplinary action, such as offending parties being removed from the site:

4 Construction Hazard Identification and Control Process

4.1 Applicability

The requirements of this section apply to all Subcontractors and lower-tier sub-subcontractors (hereafter referred to as "Subcontractor") construction work activities for LBNF unless otherwise specifically exempted by the LBNF ESH Manager. This section provides the requirements for establishing a method for identifying, controlling, and documenting hazards associated with Subcontractor work activities and communicating this information to all affected workers.

4.2 Regulatory Requirements

Subcontractor methods for identifying, controlling, and documenting hazards associated with Subcontractor work activities shall be conducted in accordance with the following statutory requirements:

- Fermilab Environment, Safety, and Health Manual
- SURF Environment, Health, and Safety Manual
- 10 CFR 851, Worker Safety and Health Program
- 29 CFR 1926, Construction
- 29 CFR 1910, General Industry

4.3 SURF and Fermilab-Specific Requirements/Permits

In addition to Section 4.2, all Subcontractor work activities shall meet the following specific Fermilab requirements for hazard identification and control.

The subcontractor is responsible for understanding the scope of work in sufficient detail to ensure that the work is effectively planned for each definable work activity, the hazards associated with the work are identified, and the planned protective measures are implemented.

This shall be accomplished utilizing the Hazard Analysis (HA) process described in Section 4.3.3 below. The SSCSP Template provides guidance on developing HA's. The HA analyses shall be available in the immediate vicinity where the work is being performed and copies of completed HIAs kept in the Subcontractor's files until the project is completed.

4.3.1 Hazard Identification and Assessment

The subcontractor must establish procedures to identify existing and potential workplace hazards and assess the risk of associated workers' injury and illness. Procedures must include methods to:

- Assess worker exposure to workplace hazards through appropriate workplace monitoring;
- Document assessment of safety workplace hazards using recognized exposure assessment and testing methodologies and, where necessary, use of accredited and certified laboratories;
- Record observations, testing, and monitoring results;
- Perform routine job activity-level hazard analyses.

4.3.2 Hazard Prevention and Abatement

The subcontractor must establish and implement a hazard prevention and abatement process to ensure that identified and potential hazards are prevented or abated in a timely manner.

- For hazards identified either in the facility design or during the development of procedures, controls must be incorporated in the appropriate facility design or procedure.
- For existing hazards identified in the workplace, Subcontractors must:
    - Prioritize and implement abatement actions according to the risk to workers;
    - Implement interim protective measures pending final abatement;
    - Protect workers from dangerous safety and health conditions.

Subcontractors must select hazard controls based on the following hierarchy:

1. Elimination or substitution of the hazards where feasible and appropriate;
2. Engineering controls where feasible and appropriate;
3. Work practices and administrative controls that limit worker exposures;
4. Personal protective equipment.

Subcontractors must address hazards when selecting or purchasing equipment, products, and services.

The Subcontractor is responsible for understanding the scope of work in sufficient detail to ensure that the work is effectively planned for each definable work activity, the hazards associated with the work are identified, and the planned protective measures are implemented. This shall be accomplished utilizing the Hazard Analysis (HA) process described in Section 4.3.3 below.

4.3.3 Hazard Analyses

For each separately definable construction activity (e.g., excavations, foundations, structural steel, roofing, electrical, mechanical) the Subcontractor shall develop a HA before commencement of the associated work/definable feature. Definable work activity is a task that is

separate and distinct from other tasks and has separate control requirements. Definable work activity may be identified by different trades or disciplines or it may be work by the same trade in a different environment. Also, hazard analysis documentation should include the requirement to develop critical lift plans for specific phases of installation activities.

Within each definable work activity, there may be other sub-phases of work that warrant separate HAs. It will be the responsibility of the Subcontractor to determine the best break-down of separately definable activities and the subsequent work steps in order to produce clear, concise, and effective HAs. The Subcontractor's HAs shall be kept at the worksite and available for review by the LBNF Far Site Construction Coordinator and the LBNF ESH Coordinator.

Fermilab recommends using a graded approach in the development of HAs; however, the Subcontractor HAs shall be developed in sufficient detail to preclude confusion and misunderstanding and shall be commensurate with the size, complexity, and risk level of the construction activity. When used appropriately, the graded approach will incorporate the level of rigor for implementing the work planning and control attributes based on the importance/significance of the activity in relation to the associated hazards and consequences.

The analyses shall contain and/or meet the following elements as applicable to the activity:

- Identification of the definable work activity;
- Identification of the job steps for each work activity (cross-reference to detailed Construction Work Plans or Procedures where possible;
- Identification of the foreseeable hazards for each step/activity and the planned protective measures to include appropriate protective devices and/or equipment, as needed;
- Identification of competent persons required for workplace inspections of the construction activity, where required by OSHA standards;
- Identification of Emergency Response Action relative information. (e.g., gas shutoff valve location).;
- Identification of project-required hold-points or other logistical requirements;
- Address additional hazards revealed by supplemental site information (e.g., site characterization data, as-built drawings);
- Provide drawings and/or other documentation of protective measures for which applicable Occupational Safety and Health Administration (OSHA) standards require preparation by a Professional Engineer or another qualified professional;
- Review and approval of the HA by Subcontractor Management;

- Made available for review to the LBNF Far Site Construction Coordinator and ESH Coordinator before the start of work activities;
- Signatures of the involved workers to signify that they have been briefed on and understand the requirements of the HA, and acknowledge their intended compliance with the HA. Attach additional signature pages as needed.

The completed HA shall be made available for review on the job site where the relevant work is being performed.

The Subcontractor shall conduct a pre-task/phase meeting that discusses the corresponding HA, the work tasks, and associated procedures and hazards with all affected parties to identify and coordinate logistics, controls, and communications required for the activity. Each worker involved in that work must sign the HA before performing work. All HAs must be kept at the worksite to be available for review by workers and oversight personnel.

If, while working, it is discovered that the controls addressed in the HA will not/do not provide adequate protection then the task at hand shall be stopped and not be continued until the hazards have been re-assessed, the HA updated, and adequate controls implemented. In these instances, the Subcontractor may make field changes (i.e., red line, pen/ink changes) as needed to reflect changing conditions associated with the activity. All affected Subcontractor personnel involved in the work being performed shall review each HA and subsequent updates/changes. The updated HA shall be made available for review by LBNF FSCF Construction Coordinator and ESH Coordinator.

The subcontractor may use mini-HAs for very specific tasks under the auspices of an overall Hazard Analysis for a large activity. The subcontractor should specify where and how mini-HAs will be used and keep all records associated with these the same as for non-mini-HAs.

4.3.4 Worker Training

The Subcontractor shall ensure that affected workers are made aware of foreseeable hazards and the protective measures described within the Hazard Analysis before beginning work on the activity. To that end, the Subcontractor shall provide a Safety Orientation to all Subcontractor and sub-subcontractor employees before their starting work. The orientation, as a minimum, shall include a review of the Subcontractor's safety program, Work Planning and Control, a review of the emergency numbers, egress routes and assembly points. Each employee shall sign a register

acknowledging having attended the orientation. The Subcontractor shall also produce evidence of the employees' assimilation of the information.

SURF has requirements that Subcontractor must provide a "Guide" on all levels work activities will be taking place. All Guides, split into Surface and Underground categories, receive extra training. Subcontractors are required to have sufficient Guides trained to support their workers during normal activities. Guides are to be particularly trained in emergency response procedures, including underground evacuation and use of the underground Refuge Chamber.

4.3.5 Record of Training

The Subcontractor shall ensure that workers acknowledge being informed of the hazards and protective measures associated with assigned work activities and understand those requirements. Each worker involved in that work must sign the HA before performing work.

4.4 Subcontractor Responsibilities

The provisions of this procedure apply to the development and implementation of the Subcontractor's Hazard Identification and Control program. The Subcontractor shall be responsible for implementing an effective Hazard Identification and Control program that:

- Identifies, evaluates, and controls potential and existing hazards/agents in the workplace through the pre-Hazard planning process;
- Incorporates the controls into the Hazard Analyses;
- Determines that engineering devices, administrative controls, and personal protective equipment are available, appropriate, tested, and utilized by employees;
- Determines employees are trained as required;
- Have provisions to manage and notify Subcontractor and LBNF Construction Management when there are changes related to the work scope, materials, and/or processes that may introduce new or different hazards to the project.

4.5 References

- 10 CFR 851, Worker Safety and Health Program

- SURF Environment, Health, and Safety Manual
- 29 CFR 1926, Construction Standards
- 29 CFR 1910, General Industry Standards
- 30 CFR Part 57 ad 75 Ventilation and Refuge Chambers

Appendix D - FRA FSCF Industrial Hygiene Plan

LBNF FSCF: Industrial Hygiene Plan

1.0 Purpose

The purpose of this document is to ensure Industrial Hygiene sampling and monitoring is performed at the LBNF FSCF project in accordance with 10 CFR 851 DOE Worker Safety and Health Program and national regulatory standards and when possible, recognized guidance values. This document also provides information to establish a program that evaluates and manages employee risks associated with potential health exposures in the workplace. The goal for this program is establish and implement controls that protect employees using sound work practices. These work practices shall share authority by implementing both engineering and administrative practices. When these two principles are not effective enough to protect personnel, personal protective equipment can and will be used to safeguard workers.

2.0 Scope

This plan applies to industrial hygiene activities performed for protecting the health of all Fermi Research Alliance (FRA) employees for the LBNF project at the Sanford Underground Research Facility (SURF) in Lead, SD.

3.0 Definitions

- **Action Level (AL):** This is a level at which action is required. Many industrial hygiene professionals use the action level to evaluate workplace exposure: It is usually identified as half the PEL or TLV.

- **Categories of Exposure Limits:** There are three important categories of exposure limits that apply to TLVs, PELs, and RELs: time-weighted average, short-term exposure limit, and ceiling:
  - *Time-Weighted Average:* This is the average concentration for an 8-hour workday or 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.
  - *Short-Term Exposure Limit (STEL):* This is a short-term TWA exposure to which workers can be continuously exposed for up to 15 minutes without suffering from

irritation, chronic or irreversible tissue damage, or narcosis of sufficient degree to increase the likelihood of accident or injury.

- *Ceiling (C):* This is the concentration that should not be exceeded during any part of the workday, even for a very short duration.

- **Chemical Stressors:** Chemical risks such as respirable dust and its silica content, diesel particulate matter (DPM), welding fumes, solvent vapors, nitrogen dioxide, carbon monoxide, etc. which personnel may be exposed to.

- **Industrial Hygiene:** According to the American Industrial Hygiene Association (AIHA), industrial hygiene is "that science and art devoted to the anticipation, recognition, evaluation, and control of those environmental factors or stresses arising in or from the workplace which may cause sickness, impaired health and well-being or significant discomfort among workers or among the citizens of the community."

- **NIOSH Manual of Analytical Methods (NMAM):** NMAM is a collection of methods for sampling and analysis of contaminants in workplace air. These methods have been developed or adapted by NIOSH or its partners and have been evaluated according to established experimental protocols. The NMAM can be found at NIOSH's website at <http://www.cdc.gov/niosh/nmam>. NMAM also includes chapters on quality assurance, sampling, portable instrumentation, etc.

- **Physical Stressors:** Physical risks such as noise, radiation, heat, and cold to which personnel may be exposed.

- **Skin Designation:** In looking up exposure limits, you may see a skin designation. This alerts you that there is a potential significant contribution to the overall exposure through the skin, eyes, and mucous membranes. This designation is an alert that air sampling alone may be insufficient to quantify exposure.

- **Threshold Limit Value (TLV – ACGIH *2016)*:** The level to which it is believed that a worker can safely be exposed day after day for a working lifetime without adverse health effects.

4.0 Responsibilities

Laboratory Director

The Laboratory Director is responsible for assuring that the Industrial Hygiene program is in place and effectively monitoring Industrial Hygiene systems.

Chief Safety Officer

The Chief Safety Officer is responsible for fully participating in all the elements that make up the Industrial Hygiene program. Assuring the personnel assigned to the Industrial Hygiene activities possess the experience, knowledge, skills, and abilities to perform effectively.

LBNF/DUNE-US ESH Manager

The LBNF/DUNE ES&H Manager is responsible for providing overall policy and guidance on ES&H issues, and for working with the line organizations to make available necessary input from ES&H professionals and other support. Fermilab ES&H personnel will be enlisted to assist the Project in ensuring that the standards, requirements, and ES&H policies are effectively translated into suitable controls for work activities.

Industrial Hygiene Group

The Industrial Hygiene Group is responsible for using the anticipation, recognition, evaluation, and control (AREC) process described in FESHM 4100: Industrial Hygiene Program to identify potential Industrial Hygiene issues for either new or existing activities/processes. Support LBNF far site in developing the IH plan, sampling strategies, interpretation of results and periodic reviews.

FSCF ESH Coordinator

The FSCF ESH Coordinator is responsible for:

- Communicating potential health exposure risks to both management and employees
- Developing and implement a sampling/monitoring program
- Develop Similar Exposure Groups (SEGs) for the FSCF project team
- Selecting applicable sampling methods
- Coordinating the resources necessary to execute this plan
- Executing the prescribed sampling and monitoring
- Evaluate sampling/monitoring results
- Communicating he results of sampling/monitoring to management and employees
- Recommending preventative/corrective actions as appropriate
- Facilitating reviews by multi-disciplinary teams to evaluate the effectiveness of the plan and any resulting control measures and mitigation strategies

5.0 List of Agents to be Monitored

SUBSTANCE	COMPLIANCE STANDARD	LOCATION	SAMPLE TYPE	FREQUENCY	COLLECTION METHOD
CARBON MONOXIDE	2016 ACGIH TLV = 25 ppm	Maintenance Equipment Bay Underground	Grab	At Baseline and at the start of any new activity	Altair 4XR or 5X Multi-gas Meter
DIESEL PARTICULATE MATTER Graphite (Use GS-1 plastic cyclone)	160 µg / m^3 Total Carbon (MSHA) TLV 2.0	Underground	Area / Personal	At Baseline and at the start of any new activity	NIOSH 5040 DPM 25mm Filter 1 um Porosity
RESPIRABLE DUST (Collect simultaneously with respirable silica using GS-3 plastic cyclone)	OSHA 1910.1000 Table Z-1 PEL = 5 mg/m^3 8-hour TWA	Underground	Personal	At Baseline and at the start of any new activity	NIOSH 0600 Matched Weight or Tared PVC Filter 5.0 um Porosity)
RESPIRABLE SILICA DUST (Collect simultaneously with respirable dust using GS-3 plastic cyclone)	OSHA 1910.1153(c) PEL = 50 µg/m^3 8-hour TWA ACGIH 2016 TLV = 25 µg/m^3	Underground	Personal	At Baseline and at the start of any new activity	NIOSH 7500 Matched Weight or Tared 5 um PVC 37mm Filter
NITROGEN DIOXIDE	ACGIH 2016 TLV = 0.2 ppm	Underground	Personal	At Baseline and at the start of any new activity	ChemDisk NO_2 monitoring badges
OCCUPATIONAL NOISE	OSHA 1910.95 PEL = 90 dBA as 8-hour TWA 85 dB OSHA HCS 85dB ACGIH 2016 TLV	Underground	Personal	At Baseline and at the start of any new activity	Noise Dosimeters 3M Edge 5 Dosimeter

6.0 Shift Duration Adjustment

As ACGIH TLV limits are set according to a standardized 8-hour workday, those exposure limits must be adjusted for shifts in excess of 8 hours. FRA utilizes the Brief and Scala method to adjust TLV limits for shift durations other than 8 hours. The equation for the method is noted below.

TLV_{adj}= TLV x Daily Reduction Factor

TLV_{adj} = TLV x {8/h_d} x {(24-h_d)/16}

Where h_d = hours worked per day

For a 12 hour shift the adjustment would be as follows:

TLV_{adj} = TLV x {8/12} x {(24-12)/16}

TLV_{adj} = TLV x {2/3} x {3/4}

TLV_{adj} = TLV x (0.5)

7.0 Baseline Exposure Assessment

No employee may be exposed to concentrations exceeding the PEL, STEL or TLV without a corrective action being implemented.

The ESH Coordinator will develop and implement a program of sampling and monitoring designed to identify and evaluate employee health exposures in the workplace. This program will be designed such that workplace exposures are anticipated, recognized, evaluated, and controlled to within recognized safe limits.

7.1 Anticipation

Based on experience and shared knowledge of the work environment, the ESH Coordinator will anticipate which potential health exposures can reasonably be expected to be present in the workplace. (Examples: Noise from mining activities, dust and silica from the blasting and extraction of rock, NO2 generated by diesel engines).

7.2 Recognition

The ESH Coordinator will work with management to recognize unexpected health exposures that may become present in the workplace. Recognition of these exposures may arise in several manners.

- Evidence of exposure as indicated in a Injury/Illness Investigation
- Recognition of potential exposures during Job Planning & Hazard Assessment activities

- Review of product SDS information
- Indicative results from medical surveillance activities
- Concerns or complaints shared by employees
- Information about an unexpected exposure that has been shared by a contractor or subcontractor partner

8.3 Evaluation

One anticipated or recognized, potential health exposures shall be evaluated by the appropriate means available. Generally, this involves some systematic form of data collection such as air sampling, gas monitoring, dosimetry testing, or augmented medical surveillance. The evaluation may be qualitative or quantitative in nature depending on which solutions may be available.

8.3.1 Qualitative Evaluation

Qualitative evaluation may be based upon the collection of objective data to make a determination if a process or activity is safe. This may include information gathered from safety data sheets, toxicological information, quantities, occupational exposure limits, existing data, sources of exposure and controls.

8.3.2 Quantitative Evaluation

Quantitative evaluation is based upon the collection of measurable data such as can be gathered through sampling or monitoring activities such as dust or silica sampling, dosimetry, or gas monitoring.

8.4 Control

Controls will be selected and implemented to ensure workplace exposures to workers are limited at or below recommended safe limits. Where possible and reasonable to do so, worker exposures shall be limited to as low as reasonably possible.

When selecting controls, the hierarchy of controls approach shall be followed to ensure the most effective available controls are employed wherever possible. The hierarchy of controls is as follows:

1. Elimination
2. Substitution
3. Engineering Controls
4. Administrative Controls5. Personal Protective Equipment (PPE)

8.5 Similar Exposure Groups (SEGs)

As part of the baselining process, the ESH Coordinator will divide the project team into similar exposure groups that will allow inferences to be drawn about exposures from one member of the SEG to another. Thus, sampling performed on a subset of the SEG would provide reliable information about the exposures of all members of the SEG. SEGs will be established based on personnel within the SEG having similar factors affecting their potential exposures: similarity in the frequency of the tasks they perform, the materials and processes with which they work, and the similarity of the way in which they perform those tasks. If a particular SEG shows no potential to be overexposed to some workplace health exposure, then no baseline is necessary for that exposure within that SEG.

8.6 Minimum Baseline Sampling

For each SEG, all workplace exposures that have the potential to be above OEL should be evaluated as part of the baseline. The possible overexposures shall be identified through anticipation and/or recognitions, and baseline exposure levels shall be established for each. The preferred number of samples to be collected for each exposure within each SEG is between six to ten. Collecting less than six samples leaves some uncertainty about the exposure profile, while more than ten samples will result in only marginal improvement in refining the exposure.

8.7 Initial Baseline Sampling

Baseline exposures shall be established for each SEG at the start of excavation, giving the project an understanding of the exposure levels to which the project team members are generally exposed and allowing for suitable controls to be employed as necessary.

8.8 Revised Baseline Sampling

Work shall be performed to revisit the baseline measurements when significant changes occur within the project that have the potential to make a marked difference to exposure levels. These significant change points include, but are not limited to, the following:

- The activation of the 4850-3650 raise bore for upcast ventilation of the project workspaces
- The initiation of the second level cuts in the main caverns
- An increase of 20% or more in the total horsepower of the diesel fleet being utilized
- At any time that a significant change in ventilation is encountered

8.9 Evaluation of Baseline Sampling

The results of baseline sampling shall be reviewed to identify any potential overexposures to project team members. If potential overexposures are identified, the ESH coordinator will consult with the Fermilab ESH Industrial Hygiene group on potential control measures and any further sampling needs. Control measures will be employed as necessary to reduce exposures to safe levels.

8.10 Annual Sampling Plan

At the start of each year, the ESH Coordinator will generate a new sampling plan for the project that accounts both for the baseline information already available and for any changes to the exposure levels that can be anticipated for the year. The sampling plan will outline what sampling is required for each SEG and the timeline for that sampling to be performed. The scheduling of sampling should take into consideration the timeliness of sampling, especially around anticipated change points, but should also balance the sampling out over time so as not to place impractical demands on the ESH department.

Once the plan has been developed, it shall be shared with the Fermilab ESH Industrial Hygiene group for review and comment.

Once the plan has been finalized, it shall be posted in a location available to all members of the project team, and it shall be communicated to the project team through email to ensure all personnel understand the plan moving forward for the year.

9.0 Sampling/Monitoring Equipment

9.1 Noise Monitoring Equipment

3M Edge 5 dosimeters (2)

3M SoundPro sound level meter

3M QC-10 calibrator

9.2 Silica/Dust/DPM Sampling Equipment

Gilian GilAir Plus air sampling pumps (4)

TSI 5200 Series mass flow calibrator

SKC Calibration chamber

SKC GS-1 DPM cyclones (2) (1.7 lpm flowrate)

SKC GS-3 silica/dust cyclones (4) (2.75 lpm flowrate)

SGS 25mm 3-pc UW PVC sampling cassettes (for DPM)

SGS 37mm 3-pc WW PVC sampling cassettes (for silica/dust)

9.3 NO_2 Monitoring Equipment

AT Labs Chem Disk NO_2 monitor badges

9.4 Multi-gas Monitoring Equipment

MSA 4XR four gas multi-gas meters (O_2, LEL, CO, NO_2) (4)

MSA 5X four gas multi-gas meters (O_2, LEL, CO, NO_2) (2 for confined space applications)

MSA GX2 docking station (for charging, bumping, and calibration of monitors)

10. Air Sampling Process (silica/dust/DPM)

10.1 Personal silica/dust/DPM monitoring shall be performed for a minimum of 600 minutes for employees working 12-hour shifts. Employees working 10-hour shifts should be sampled for a minimum of 480 minutes.

10.2 ESH Coordinator Sampling Process

10.2.1 Determine the reason for sampling and select a method for the airborne contaminant to be sampled.

10.2.2 A unique identifier shall be generated for each individual sample. The nomenclature for each sample shall be as follows:

YYYY-MM-DD-SI-NNN
Where, YYYY is the four digit year
MM is the two digit month
DD is the two-digit day of the month
SI is the samplers initials
NNN is the number of the sample for the day.

For example, if Simon Pollard initiates two samples on July 2, 2020, then the two samples would be named 2020-07-02-SP-001 and 2020-07-02-SP-002 respectively.

10.2.3 Calibrate the sampling pumps, with the proper media, to the desired flowrate. The flowrate will be performed using the appropriate calibrator (TSI 5200 Mass Flow Calibrator). Documentation shall be retained that verifies that the calibrator has been certified by the manufacturer within the past 12 months. The calibrator will be sent to the manufacturer each year for certified calibration.

10.2.4 Initiate the Sampling Record properly identifying the employee ID, monitor number/media identifier for each sampled/monitored employee.

10.2.5 Initiate the Exposure Sampling Activity Record (field notes), give to the employee to be sampled, and instruct the employee in how to fill out the record through their shift.

10.2.6 Place the sampling equipment on the selected individuals or in the selected area. Conduct the sampling according to the selected method. Deviations from the method should be carefully documented and utilized at the ESH Coordinator's determination.

10.2.7 For air sampling, stress to the employee the importance of keeping the cyclones upright and unblocked during sampling.

10.2.8 The collection device must be attached to the shirt collar in a vertical position within seven inches of the worker's breathing zone. Sampling tubes should be in a vertical position to prevent channeling of the air contaminant through air spaces in the sorbent. Membrane filters for dusts should be pointed downward and in a vertical position to prevent ambient dust from falling into the filter. NO_2 badges need to be attached in a vertical position.

10.2.9 Follow up with the sampled individuals during the shift to ensure the sampling trains are being worn properly and are operating correctly. Document in the field notes what the employee is doing (ie. If operating equipment document the equipment used). Check sampling trains frequently for correct operation. Note any control measures being employed in the field.

10.2.10 Exercise care when changing media in the field to ensure the sample media is not contaminated.

10.2.11 Terminate sampling at the end of the sampling period.

10.2.11.1 Air pumps shall be shut off and collected from sampled employee. Cyclones must be kept in a vertical position to prevent sample contamination from material within the grit pot.

10.2.11.2 ChemDisk NO_2 monitoring badge needs to be closed to terminate sampling.

10.2.12 Confirm the identity of media at the end of sampling and process as required.

10.2.13 Cassettes from air pump shall be maintained in a vertical position. Cassette will be used during post calibration of the air pump. Post-calibrate the sampling pumps utilizing accepted method. A difference of more than 5% from the pre-calibration must be interpreted by the ESH Coordinator.

10.2.14 Collect the sampled employees Exposure Sampling Activity Record and review with employee to ensure completeness.

10.2.15 Complete the Sampling Record sheet.

10.2.16 Store the sample media as required by the sampling method.

10.3 Preparation for Transport to Laboratories

10.3.1 For silica/dust/DPM sampling, LBNF FSCF has pre-selected SGS Galson – East Syracuse, New York. This lab is:

a) AIHA accredited for the constituent of concern

b) Has the capability to follow the NIOSH method selected

c) Will provide a quality assurance/quality control data package for the constituent concern, on request

Note: The sampler must be alert to special needs or procedures. For example, is the analysis required to be completed within 24 hours of sampling?

10.3.2 For NO_2 sampling, LBNF FSCF has preselected AT Labs – Boardman, Ohio. AT Labs is the source for the badge monitors, and the cost of analysis is included when the ChemDisk badge monitors are purchased.

10.3.3.1 Utilize chain-of-custody procedures:

a) Be sure that the sampler completes the SGS Galson Chain of Custody form for cassette. Specify the NIOSH method and sample numbers for each cassette shipped on the sampling form. Sign and date the SGS Galson Laboratory Chain of Custody and place it inside the shipping container prior to tape sealing.

b) Be sure that the sampler completes the AT Labs Chain of Custody form for the NO2 badges. Sampling numbers for each badge will be shipped on the sampling form. Sign and date the AT Labs Chain of Custody and place it inside the shipping container prior to tape sealing.

10.3.4 Utilize field blanks for 10% of the sample population for each day's sampling. A minimum of one (1) field or blank will be included in each sample set.

10.4 Sample Shipping

10.4.3 The Safety Coordinator shall carefully pack the samples and associated blanks with plenty of padding along with the Laboratory Analysis Request/Chain of Custody form.

10.4.4 Packing material that develops or holds an electrostatic charge (such as Styrofoam or "peanuts") should not be used with particulate sampling media.

10.4.5 Ensure samples are shipped in a timely manner. Air samples shall not be stored on site for more than 48 hours before they are shipped to the lab.

10.4.6 Utilize FedEx Package US Airbill to create shipping label for the package. Retain the top copy of the Airbill label as a record until a message from the lab indicates that the samples have been received.

10.4.7 Transport the labeled package to a FedEx Drop off box in Spearfish for timely shipping.

10.5 Record Keeping

10.5.1 A file folder shall be created for each sample in the DUNE ES&H Coordination shared website. That file folder shall be named after the samples unique identifier (ie 2020-07-02-SP-001)

10.5.2 The ESH Coordinator shall scan both the Sampling Record and the Exposure Monitoring Activity record, along with the laboratory chain of custody document, and place these files in the file folder.

10.5.3 The ESH Coordinator will then enter the applicable sampling data into the Exposure Monitoring Sample Tracker workbook in the DUNE ES&H Coordination shared website

10.6 Laboratory Results

10.6.1 Once sample results are received from the laboratory, the results shall be reviewed by the ESH Coordinator. Samples with results that appear counterintuitive will be investigated to determine whether a sampling or analytical error has occurred.

10.6.2 The ESH Coordinator will enter the results into the Exposure Monitoring Sample Tracker workbook in the DUNE ES&H Coordination shared website.

10.6.3 The ESH Coordinator will communicate in writing the results of the sampling to the employee who was sampled within 14 days of receiving the analytical results. The employee will be given the opportunity to review the results and to ask any questions they may have. The employee will return a signed copy of the notification letter for inclusion in the sample file on the DUNE ES&H Coordination shared website.

11. Noise Sampling Process

11.1 Personal noise monitoring shall be performed for a minimum of 600 minutes for employees working 12-hour shifts. Employees working 10-hour shifts should be sampled for a minimum of 480 minutes.

11.2 ESH Coordinator Sampling Process

11.2.1 A unique identifier shall be generated for each individual sample. The nomenclature for each sample shall be as follows:

YYYY-MM-DD-SI-NNN
Where, YYYY is the four digit year
MM is the two digit month

DD is the two-digit day of the month
SI is the samplers initials
NNN is the number of the sample for the day.

For example, if Simon Pollard initiates two samples on August 17, 2021, then the two samples would be named 2021-08-17-SP-001 and 2021-08-17-SP-002 respectively.

11.2.2 Calibrate the dosimeter to 114.0 dB utilizing the QC-10 calibrator.

11.2.3 Initiate the Sampling Record properly identifying the employee ID and the dosimeter number for each sampled/monitored employee.

11.2.4 Initiate the Exposure Sampling Activity Record (field notes), give to the employee to be sampled, and instruct the employee in how to fill out the record through their shift.

11.2.5 Place the sampling equipment on the selected individuals or in the selected area. Conduct the sampling according to the selected method. Deviations from the method should be carefully documented and utilized at the ESH Coordinator's determination.

11.2.6 For noise sampling, stress to the employee the importance of keeping the monitor unblocked during sampling.

11.2.7 The collection device must be attached to the shirt collar in a vertical position close to the employee's ear.

11.2.8 Follow up with the sampled individuals during the shift to ensure the sampling trains are being worn properly and are operating correctly. Document in the field notes what the employee is doing (ie. If operating equipment document the equipment used). Check sampling equipment frequently for correct operation. Note any control measures being employed in the field.

11.2.9 Terminate sampling at the end of the sampling period by ending the sampling run on the dosimeter

11.2.10 Confirm the identity of dosimeter at the end of sampling and process as required.

11.2.11 Collect the sampled employees Exposure Sampling Activity Record and review with employee to ensure completeness.

11.2.12 Perform post calibration of the dosimeter as required and record the post-calibration figure on the Sampling Record.

11.2.13 Complete the Sampling Record sheet.

11.2.14 Connect the dosimeter to the dosimeter charging dock and extract the sampling data from the dosimeter using the TSI Quest Detection Management Software (DMS).

11.2.15 The ESH Coordinator shall query the data to ensure that the data downloaded from the dosimeter appears to be properly recorded.

11.3 Record Keeping

11.3.1 A file folder shall be created for each sample in the DUNE ES&H Coordination shared website. That file folder shall be named after the samples unique identifier (ie 2021-08-17-SP-001)

11.3.2 The ESH Coordinator shall scan both the Sampling Record and the Exposure Monitoring Activity record, along with the laboratory chain of custody document, and place these files in the file folder.

11.3.3 The ESH Coordinator will then enter the applicable sampling data into the Exposure Monitoring Sample Tracker workbook in the DUNE ES&H Coordination shared website

11.3.4 The ESH Coordinator will communicate in writing the results of the sampling to the employee who was sampled within 14 days of receiving the analytical results. The employee will be given the opportunity to review the results and to ask any questions they may have. The employee will return a signed copy of the notification letter for inclusion in the sample file on the DUNE ES&H Coordination shared website.

12. Continuous Gas Monitoring

FRA utilizes MSA continuous gas monitoring to ensure that personnel who may be exposed to expected gaseous contaminants can determine what the levels of those contaminants may be in the atmosphere to which they are exposed and to ensure immediate notification of the employee should they be exposed to levels of those contaminants above recognized safe levels.

12.1 Any FRA employee utilizing continuous gas monitoring equipment will first be properly trained in the use and care of the equipment, including basic operation of the unit, bump testing prior to use, and appropriate responses to alarm information.

12.2 No FRA employee or escorted visitor shall travel the underground project spaces without at least one person in their party carrying a continuous gas detector.

12.3 FRA's continuous gas monitors are configured to monitor for oxygen (O_2), carbon monoxide (CO), nitrogen dioxide (NO_2), and concentrations of combustible gasses around their lower explosive limits (LEL).

12.3.1 Oxygen is measured in percent by volume (%). Alarm conditions occur at oxygen concentrations <19.5% and >23.0%.

12.3.2 Carbon monoxide is measured in parts per million (ppm). Alarm conditions occur at 25 ppm (low alarm) and 100 ppm (high alarm).

12.3.3 Nitrogen dioxide is measured in parts per million (ppm). Alarm conditions occur at 1.5 ppm (low alarm) and 3.0 ppm (high alarm).

12.3.4 Combustible gases are measured in percent of the lower explosive limit (%LEL). Alarm conditions occur at 10% (low alarm) and 20% (high alarm).

12.4 All continuous gas monitors must be calibrated a minimum of once per month by the ESH Coordinator.

12.5 All continuous gas monitors must be bump tested each shift prior to use.

12.6 Continuous gas monitors shall be carried upon the employee's person such that they are fully exposed to the atmosphere around the employee and do not become blocked behind any clothing or any other barrier that would impede the atmosphere from entering into the monitor.

12.7 Upon the sounding of an oxygen alarm, whether <19.5% or >23.0%, the employee and any other personnel in the area will immediately evacuate and barricade off the area and will immediately notify the supervisor responsible for the work are and the ESH department. It will be the responsibility of the supervisor/ESH department to safely investigate the cause of the oxygen alarm condition.

12.8 Upon the sounding of a CO, NO_2, or LEL low alarm, the employee and any other personnel in the area shall exit the area and investigate the source of the alarm condition.

12.9 Upon the sounding of a high CO, NO_2, or LEL alarm, the employee and any personnel in the area shall evacuate the heading in which the alarm is occurring and head towards fresh air, barricade off the heading upon exiting, and will immediately notify the supervisor responsible for the work are and the ESH department. If secondary accesses are available to the heading in question, then those secondary accesses shall also be barricaded. It will be the responsibility of the supervisor/ESH department to safely investigate the cause of the high alarm condition.

12.10 Personnel utilizing continuous gas monitoring equipment for confined space applications require specific confined space entry training which stipulates how the continuous gas monitoring equipment shall be used in those situations.

Appendix E - Hazard Analysis Template

HAZARD ANALYSIS

DATE PREPARED: **PREPARED BY:**

OPERATION:

STEP BY STEP PLAN:

1)
2)
3)
4)
5)
6)

Access Identification

Location	Type

Ergonomic risks

Lifting	☐
Repetitive Motion	☐
Vibration	☐
Awkward Position	☐

Life Changing Categories	Evident Risk	LSA Plan Included
Confined Space	☐	☐
Lifting and Rigging	☐	☐
Cranes	☐	☐
Maintenance of Traffic	☐	☐
Energy Isolation	☐	☐
Temporary Structures	☐	☐
Excavation	☐	☐
Utilities	☐	☐
Human Equipment Interface	☐	☐
Working at Heights	☐	☐
Marine Work	☐	☐
Steel Erection	☐	☐
Night Work	☐	☐
SDS Attached	☐	☐
Other Safety risks	☐	☐
_____	☐	☐
_____	☐	☐
_____	☐	☐

Unique PPE	Required
Cutting Goggles	☐
Face Shield	☐
Leather/Kevlar Chaps	☐
Respiratory Protection	☐
Toe/Foot Guards	☐
Ear Plugs/Muffs	☐
Life Vest/PFD	☐
Welding Hood	☐
Welding Leathers	☐
Other PPE:	☐
Other PPE:	☐
Other PPE:	☐
Other PPE:	☐
Other PPE:	☐
	☐

Superintendent

Prepared and reviewed by:

Name	Signature

Foreman

Note: Solutions are part of the operation plan.

	Step 1:	Step 2:	Step 3:
WHAT IS THE WORST THAT COULD HAPPEN?			
PREVENTION PLAN (Focus on Behaviors)			
HOW ARE YOU MOST LIKELY TO GET HURT?			
PREVENTION PLAN (Focus on Behaviors)			
OTHER RISKS TO BE AWARE OF?			
PREVENTION PLAN (Focus on Behaviors)			

	Step 4:	Step 5:	Step 6:
WHAT IS THE WORST THAT COULD HAPPEN?			
PREVENTION PLAN (Focus on Behaviors)			
HOW ARE YOU MOST LIKELY TO GET HURT?			
PREVENTION PLAN (Focus on Behaviors)			
OTHER RISKS TO BE AWARE OF?			
PREVENTION PLAN (Focus on Behaviors)			

Appendix F - Build Plan Template

Kiewit/Alberici
JOINT VENTURE
Fermi LBNF FSCF

BUILD PLAN

BUILD RISK: LOW / MOD. / HIGH

PROJECT: _____

OPERATION: _____

COMPLETED BY: _____ **DATE:** _____

REVIEW AND APPROVAL (RISK) *All must be signed per risk level*	
Sponsor:	(H)
Proj Mgr:	(H)
Proj Engr:	(H,M)
Safety	(H,M)
Gen Supt:	(H,M,L)
Craft Supt:	(H,M,L)

LIFE-CHANGING CATEGORIES	
	1. CONFINED SPACE
	2. LIFTING AND RIGGING
	3. CRANES
	4. MAINTENANCE OF TRAFFIC
	5. ENERGY ISOLATION
	6. TEMPORARY STRUCTURES
	7. EXCAVATION
	8. UTILITIES
	9. HUMAN EQUIPMENT INTERFACE
	10. WORKING AT HEIGHTS

PRODUCTION GOALS		GO TO WORK CHECK LIST		
CLEAR SIMPLE GOAL (MAKE IT EASY TO SEE IN FIELD)		ITEMS ARE ATTACHED	Yes	N / A
		STS LIST	☐	☐
		PM LIST	☐	☐
MH / UNIT GOAL	$ / UNIT GOAL	QUALITY CHECKLISTS	☐	☐
		ENGINEERING DESIGNS	☐	☐
		HOLD POINTS DEFINED IN STEPS	☐	☐

Key Elements of Building Work

ERGONOMICS:
MATERIAL HANDLING BEST PRACTICES:
OPERATION SHUTDOWN INPUT:

WBS CODE	WBS DESCRIPTION	
HP (X)	OPERATION STEPS FOR THIS BUILD PLAN	LCC #s
	1)	
	2)	
	3)	
	4)	
	5)	
	6)	
	7)	
	8)	

Kiewit/Alberici

The 6 Elements of Work

Must be completed prior to starting work

PEOPLE (Crew size, Special skills):
•
•
•
•
•
•
•
•
•
•
•
•
•

EQUIPMENT:
•
•
•
•
•
•
•
•
•
•
•
•

ACCESS:
•
•
•
•
•
•
•
•
•
•
•
•
•

TOOLS:
•
•
•
•
•
•
•
•
•
•
•
•
•

MATERIALS (Permanent Materials):
•
•
•
•
•
•
•
•
•
•
•
•
•

INFORMATION NEEDED:
•
•
•
•
•
•
•
•
•
•
•
•
•

KIEWIT PROJECT_____ OPERATION:_____

Description

STEP # _____

WHAT IS THE WORST THAT COULD HAPPEN?

PREVENTION PLAN (Focus on Behaviors)

SKETCH

Critical Info

OTHER RISKS TO BE AWARE OF?

PREVENTION PLAN (Focus on Behaviors)

Description

SKETCH

Critical Info

STEP # _____

WHAT IS THE WORST THAT COULD HAPPEN?

PREVENTION PLAN (Focus on Behaviors)

HOW ARE YOU MOST LIKELY TO GET HURT?

PREVENTION PLAN (Focus on Behaviors)

OTHER RISKS TO BE AWARE OF?

PREVENTION PLAN (Focus on Behaviors)

Description

SKETCH

Critical Info

STEP # _____

WHAT IS THE WORST THAT COULD HAPPEN?

PREVENTION PLAN (Focus on Behaviors)

HOW ARE YOU MOST LIKELY TO GET HURT?

PREVENTION PLAN (Focus on Behaviors)

OTHER RISKS TO BE AWARE OF?

PREVENTION PLAN (Focus on Behaviors)

Appendix G - KAJV Specific sections related to WPC

Kiewit/Alberici
JOINT VENTURE

Environment Safety & Health Plan

Long Baseline Neutrino Facility
Far Site Facilities Project

Subcontract No. 636269

* SECTIONS PROVIDED

Revision History

Revision Number	Revision Description	Effective Date
1	Submittal Review Comments	-
2	Submittal Review Comments	9/7/18
3	Site Coverage - Paramedics Plan	11/05/18
4	Section Updates: Explosives, Sampling, JHA/LSA, PPE (Gloves, Hardhat Lanyards and poster)	3/29/2020

Table of Contents

KAJV and Sub-Subcontractors shall obtain SDSTA underground guide training for all superintendents, foremen and supervision for groups working underground. Completing underground guide training takes 3 business days over a one week period. Where required by contract, a trained guide will be on every working level.

SURF Training
All personnel shall attend SURF ESH Site Orientation prior to performing any work onsite. Per contract, the URF Surface and Underground training modules classes are approximately one hour each in duration. The training class are conducted in the SURF Administration Building at 7:00 Monday through Friday by the SURF ESH Department.

Visitors
All visitors to the site shall attend SURF Training prior to site access and be escorted by KAJV or Sub-Subcontractor Guides. Visitors shall have a JHA or Mini JHA applicable to the areas of the job site visited or review the JHA/Mini JHA for the operations visited.

1.F – HAZARD ANALYSIS

The purpose of the Job Hazard Analysis (JHA) is to identify hazards that will be encountered during the operation and identify protective measures and other actions to eliminate the hazard. A JHA will be completed prior to the start of construction and submitted for FRA approval. The JHA will be developed during the work planning process and should include input from the Superintendent, Foreman and craft workers.

The Three Phase Control system will be used on this project for all Definable Features of Work (DFOW). Refer to the Construction Quality Management Plan and QSP-09 Three Phase Control System for detailed information on the three phases. The JHA will be prepared for all DFOW's and reviewed in the Preparatory and Initial phase meetings. During the Follow-Up Phase of work, the JHA will be reviewed and signed by each member of the work crew prior to the start of work. When updates are required to a JHA, the foremen will document the changes and crew members will sign and date again to acknowledge the changes.

The JHA can be supplemented with a Mini JHA which is a method to evaluate and document hazards and corrective actions in a real time manner. Reference Section 2.C for additional details on the JHA and the Mini JHA. KAJV ES&H Manager and FRA ES&H may review updated Mini JHA's in the field during construction.

1.G – HEALTH & SAFETY RECORDS

KAJV will maintain all occupational safety and environmental records for the project. A log and copy of certifications for all personnel with cardiopulmonary resuscitation (CPR) and first aid training. KAJV will maintain records required by federal and state regulations, and other records as required

2.C – HAZARD ANALYSIS & LSA VERIFICATION BOOK

PROCEDURES:

A Job Hazard Analysis (JHA or LSA), or similar, is a tool utilized to focus on the job tasks and the associated hazards with those tasks, before they occur. They specifically focus on the relationship between the worker, the task, the tools, and the workplace environment. Ideally, after we have identified the uncontrolled hazards, we must work towards eliminating or reducing them to an acceptable risk level.

When developing a thorough JHA or LSA we should include five key steps:

1. Ownership by employees performing the tasks
2. Review past incidents on the project or within the company for accident history, misses and any Red Diamond events that relate to the task at hand.
3. Conduct a preliminary review of the tasks and hazards associated.
4. List, Rank, and Set priorities for the hazardous tasks.
5. Outline the tasks into manageable steps.

When identifying hazards, we need to be asking ourselves these questions:

1. What can go wrong?
2. What are the consequences?
3. How could it arise?
4. What are the likely contributing factors?
5. How likely is it that the hazard will occur?
6. What can we do to eliminate the hazard?

It is our policy to have a 100% coverage with an LSA Verification Book for all operations that reflect the current scope of work. The full JHA form ("The green form") will be produced to provide training to our employees for major operations, however, an LSA Verification is necessary to ensure all tasks have coverage. New LSA's will be needed to be developed as the work progresses and the hazards change. Each working employee (staff or craft) is required to develop their LSA for their operations.

An LSA Verification must be reviewed with any new employees that joins a task already in progress before they can begin work.

An LSA Verification must be prepared for the use of high-risk tools, such as, air operated chipping guns, or air operated equipment. Many other tools or small pieces of equipment should be included in this regard.

An LSA Verification must be prepared for a high risk, short duration operation. These high-risk operations should have input in the LSA by the Project Manager and supervision involved with the operation. A high-risk operation is determined by potential exposures to schedule impacts, costs exposures, exposures to impact the public, and a severe potential to injure our employees. Some

examples of high risk operations include ground support, work on pressurized systems, any work near the public, and all excavation operations.

We will not begin any operation without a thorough LSA that has been reviewed with the crew. Any operation found without a current, reviewed LSA on hand will be shut down.

LSA's must be specific when calling out the PPE when we are relying on PPE as our last line of defense against a hazard. One example of this is within our glove policy. Gloves are required 100% of the time while working or handling materials. The specific type of glove to be worn for that specific operation should be clearly called out within the LSA. The situation, for example, where the use of a glove creates a larger hazard should also be called out clearly in the LSA and signed/approved by the Superintendent.

RESPONSIBILITIES:

- It is the responsibility of all Foremen and Superintendents conducting the specific task that an LSA is completed.
- The Superintendent is responsible to complete the JHA for the DFOW prior to the Preparatory Phase meeting.
- It is all parties' responsibility, from Project Manager to Craft employee, to sign off on the LSA if they are involved with, or working around, a specific operation.
- The Project Manager and/or ES&H Manager shall get both District Safety Manager and Sponsor approvals to use any forms outside of those listed below.

TRAINING:

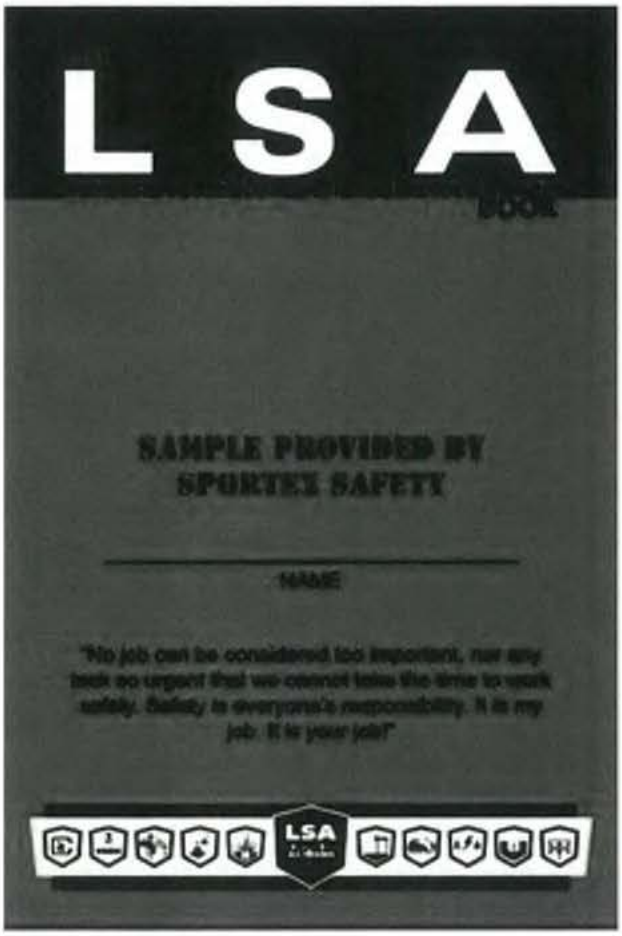
- Training on the LSA Verification form completion is to be handled during the indoctrination process as this is a fundamental to our safety program.

CHECKLIST/FORMS:

- "LSA" – LSA Verification Book

REFERENCES:

- Section 1.F of this manual
- OSHA


L S A
BOOK
SAMPLE PROVIDED BY
SPORTEX SAFETY
NAME
"No job can be considered too important, nor any task so urgent that we cannot take the time to work safely. Safety is everyone's responsibility. It is my job. It is your job!"
LSA


LSA CATEGORY CHECKLIST
CONFINED SPACE
LIFTING & RIGGING
CRANES
MAINTENANCE OF TRAFFIC
ENERGY ISOLATION
TEMPORARY STRUCTURES
EXCAVATION
UTILITIES
HUMAN EQUIPMENT INTERFACE
WORKING AT HEIGHTS
FOREMAN
DATE
OPERATION
MORNING
MIDSHIFT
AFTERNOON
STEP BY STEP PLAN:
1.
2.
3.
4.
5.
HAZARDS FOR EACH STEP
SAMPLE PROVIDED BY
SPORTEX SAFETY
HAZARD MITIGATION PLAN
SIGNATURES:
6.
7.
8.
9.
10

HAZARD ANALYSIS

DATE PREPARED: **PREPARED BY:**

OPERATION:

STEP BY STEP PLAN:

1
2
3
4
5
6

Access identification

Location	Type

Ergonomic risks

Lifting	☐
Repetitive Motion	☐
Vibration	☐
Awkward Position	☐

Strategic Risks	Evident Risk	Needs Special Planning
Equipment	☐	☐
Exposure to Falls	☐	☐
Confined Space	☐	☐
Traffic	☐	☐
Trenching / Excavation	☐	☐
Lock-Out / Tag-out	☐	☐
MSDS Attached	☐	☐
Utilities	☐	☐
Electrical	☐	☐
Critical Lift Plan	☐	☐
On the Spot Lift Plan	☐	☐
Steel Erection	☐	☐
Night Work	☐	☐
Falsework / Shoring	☐	☐
Other Safety risks	☐	☐
	☐	☐
	☐	☐
	☐	☐

Unique PPE	Required
Cutting Goggles	☐
Face Shield	☐
Leather/Kevlar Chaps	☐
Respiratory Protection	☐
Toe/Foot Guards	☐
Ear Plugs/Muffs	☐
Life Vest/PFD	☐
Welding Hood	☐
Welding Leathers	☐
Other PPE:	☐
Other PPE:	☐
Other PPE:	☐
Other PPE:	☐
Other PPE:	☐
	☐

Superintendent

Prepared and reviewed by:

Name	Signature

Foreman

Note: Solutions are part of the operation plan.

Kiewit Safe

	Step 1:	Step 2:	Step 3:
WHAT IS THE WORST THAT COULD HAPPEN?			
PREVENTION PLAN (Focus on Behaviors)			
HOW ARE YOU MOST LIKELY TO GET HURT?			
PREVENTION PLAN (Focus on Behaviors)			
OTHER RISKS TO BE AWARE OF?			
PREVENTION PLAN (Focus on Behaviors)			

SAFETY BEGINS WITH ME **Kiewit Safe**

2020

	Step 4:	Step 5:	Step 6:
WHAT IS THE WORST THAT COULD HAPPEN?			
PREVENTION PLAN (Focus on Behaviors)			
HOW ARE YOU MOST LIKELY TO GET HURT?			
PREVENTION PLAN (Focus on Behaviors)			
OTHER RISKS TO BE AWARE OF?			
PREVENTION PLAN (Focus on Behaviors)			

Kiewit Safe

Appendix H - KAJV Exposure Sampling

EXPOSURE SAMPLING PROCEDURE

FERMI LBNF – 1B EXCAVATION

Lead, South Dakota 57754

Project Number 204CT03679

January 12, 2022

PREPARED FOR:

Mr. Gerry Anderson
Kiewit/Alberici Joint Venture
201 W. Main Street, Suite 201
Lead, South Dakota 57754

PREPARED BY:

Atlas Technical
11117 Mockingbird Drive
Omaha, Nebraska 68137

CONTENTS

TABLES

APPENDICES

DOCUMENT INFORMATION

Prepared for	Kiewit/Alberici Joint Venture
Project Name	Fermi LBNF – 1B Excavation

Contact Information

Atlas Technical
11117 Mockingbird Drive
Omaha, Nebraska 68137

Telephone: 402-697-9747

Tim.jacobsen@oneatlas.com
www.oneatlas.com

Document Control

Version	Date	Author	Kiewit Approved	Date of Approval
1	1/12/2022	T. Jacobsen		

1.0 INTRODUCTION

At the request of Kiewit/Alberici Joint Venture, Atlas Technical (Atlas) is providing the following exposure sampling procedures for airborne contaminants including, but not limited to the following: carbon dioxide (CO_2), carbon monoxide (CO), diesel particulate matter (DPM), nitrogen dioxide (NO_2), noise, respirable crystalline silica (RCS), respirable dust and total diesel hydrocarbons (vapor) at the Fermi LBNF – 1B Excavation in Lead, South Dakota. Potential employee exposures may occur while performing various work tasks at the site. This procedural sampling plan provides guidance to establish compliance in accordance to contractual and regulatory requirements for protecting Kiewit staff from occupational exposures to the identified contaminants at the job site. This plan provides industrial hygiene guidance on exposure monitoring, sampling methods, employee notification, and recordkeeping for management by on-site Kiewit staff.

Compliance with this exposure sampling procedure does not relieve the project of obligation to comply with all applicable federal, state and local regulations governing these compounds or substances. If other applicable legal standards are more stringent, they take precedence. This document is supplemental to site safety documents, includes hazards reported by the site personnel to Atlas, and is not intended to be inclusive of all potential hazards or hazardous situations that may arise in the execution of the site work.

1.1 Brief Kiewit Employee Work Descriptions

Currently, the Kiewit Construction Management as Advisor role (CMa) consists of the following: Excavation Superintendent, Field Engineer, Safety Coordinator, Construction Manager, Quality Manager, Project Manager and ESH Manager. These titles coincide with the organizational chart on file. The Excavation Superintendent, Field Engineer, Safety Coordinator work seven 10-12 hour days per week underground. The Construction Manager, Quality Manager, Project Manager and ESH Manager typically spend a few hours per week underground with the balance of the time above ground. Kiewit is in a supervisory role and does not performing tasks such as loading, mucking, shotcreting, drilling, bolting or operating equipment in the mine, but work in the same environment where these activities commence.

2.0 POTENTIAL HEALTH HAZARDS

Various potential health hazards have been identified at the site. Agents or stressors to be monitored are included below and do not intend to cover all potential agents. As work continues through phases, additional concerns may be brought to the attention of the supervisors or managers through job hazard analysis and pre-planning activities. The following list is provided as a baseline for the current work and is not intended to be inclusive of all possible exposures. The following is based on previous work within the mine and known contaminants. The intent of the sampling plan is to add to it as needed throughout the project.

2.1 Carbon Monoxide

Carbon monoxide (CO) is a colorless, odorless, and tasteless gas that is present in the exhaust gases of internal-combustion engines and blasting within the mine. Carbon monoxide interferes with the transport of oxygen from the lungs to the tissues. Early signs of carbon monoxide poisoning include headache, weakness, dizziness, nausea, and fainting.

2.2 Diesel Particulate Matter (DPM)

Diesel particulate matter is the particulate component of diesel engine exhaust and contains soot and aerosols such as ash, sulfates, silicates, and metallic particles. DPM is a respirable concern and short-term exposure may cause headache, dizziness, and irritation to the eyes, nose and throat. Workers with potential exposure to DPM include miners, construction workers, heavy equipment operators, tunnel workers, truck drivers, and material handling operators.

2.3 Nitrogen Dioxide (NO_2)

Nitrogen dioxide is a gas created primarily by diesel engines. Breathing NO_2 can irritate the respiratory tract (nose and throat) and cause shortness of breath. Higher exposures may cause pulmonary edema (buildup of fluids in the lungs) and may interfere with the blood's ability to carry oxygen causing headaches, dizziness, and fatigue and, in extreme situations, death. Repeated exposures have led to lung damage. NO_2 has a strong odor. Equipment powered by diesel engines, various welding (arc) or cutting work may release measurable quantities of NO_2.

2.4 Noise

The American Conference of Governmental Industrial Hygienists (ACGIH) has established threshold limit values (TLVs) which are more protective than the standards currently required by the Occupational Safety and Health Administration (OSHA). The ACGIH TLV is exceeded when the dose is more than 100% as indicated on a dosimeter set with a 3 dB exchange rate and an eight-hour criteria level of 85 dBA.

In addition, employees may not be exposed to impulse or impact noise exceeding a 140 decibel (dB) peak sound pressure level. No employee shall be exposed unprotected to continuous noise greater than 115 dBA.

If peak noise levels are found to be below 80 dBA in an area, no monitoring is required provided there are no substantial process or equipment changes.

2.5 Respirable Crystalline Silica (RCS) & Respirable Dust

Crystalline silica comes in three primary forms including quartz, cristobalite, and tridymite. Quartz is the most common form and is naturally present in many types of rock and sand. Quartz makes up approximately 12% of the earth's crust. When crystalline silica is crushed, ground, scraped or otherwise made into dust, it can create an occupational health hazard for exposed workers. If the dust particles are fine enough to be inhaled deep into the lungs, they are said to be "respirable." Occupational exposure to RCS has been linked to silicosis, lung cancer, pulmonary tuberculosis,

and airway diseases. Potential activities that may lead to RCS exposure include the following: drilling, grinding, blasting, crushing rock; loading and transporting crushed rock; grout work; and cement/concrete-forming activities.

2.6 Total Diesel Hydrocarbons

Diesel fuel is a mixture of hydrocarbons with certain flammability characteristics and chemical properties and is used to power mobile mining equipment at the site. Diesel may be inhaled in the form of fine aerosolized particles or droplets, or as vapor given off by the diesel fuel as it evaporates. Exposure under normal use conditions is not likely harmful; however, there are potential health effects from short-term and long-term exposures to be aware of and environments should be adequately tested to confirm overexposures do not occur. Short-term exposure in small amounts may cause irritation to the eyes and nose, headache and nausea. Long-term respiratory exposure may cause respiratory disease, kidney damage, blood pressure issues and potentially cancer. Prolonged skin contact can lead to dermal irritation and is associated with increased risk of skin cancer in some laboratory animal studies. The ACGIH TLV specifies an eight-hour time weighted average (TWA) for total diesel hydrocarbons (vapor and aerosol) of 100 mg/m^3.

2.7 Metal Working Fluids / Oil Mists

Metalworking fluids (MWFs) are used to reduce heat and friction and to remove metal particles in industrial machining and grinding operations. There are numerous formulations, ranging from straight oils (such as petroleum oils) to water-based fluids, which include soluble oils and semisynthetic/synthetic fluids. MWFs may cause respiratory irritation and build-up in areas with restricted ventilation.

2.8 Occupational Exposure Limits

Table A - Summary of Contaminants and Occupational Exposure Limits

Stressor	Exposure Limits	Source
Carbon Monoxide	25 ppm	2016 ACGIH TLV
Diesel Particulate Matter	0.16 mg/m^3 of total carbon	MSHA TWA
Nitrogen Dioxide	0.2 ppm	2016 ACGIH TLV
	Exception: 3.0 ppm for Excavation Phase - Per Abatement Plan	
Noise (Personal)	85 dBA 85 dBA	OSHA AL (HCS) 2016 ACGIH TLV
Respirable Crystalline Silica	0.050 mg/m^3 0.025 mg/m^3	OSHA 8-Hour TWA 2016 ACGIH TLV
Respirable Dust	5 mg/m^3	OSHA 8-Hour TWA
Total Diesel Hydrocarbons (vapor)	100 mg/m^3	2016 ACGIH TLV

Oil Mist	5 mg/m^3 total	OSHA 8-hour TWA NIOSH 8-hour REL

Key:
OSHA = Occupational Safety and Health Administration, PEL = Permissible Exposure Limit, AL = Action Level, TWA = Time Weighted Average, ACGIH = American Conference of Governmental Industrial Hygienists, TLV = Threshold Limit Value, MSHA = Mine Safety and Health Administration, mg/m^3 = milligrams per cubic meter, ppm = parts per million, dBA = decibels, A-weighted; REL = NIOSH Recommended Exposure Limit; ACGIH TLV for Noise = 85 dBA 8 hr TWA with a 3 dB exchange rate.

2.8.1 Extended Shift TLV Adjustment

Threshold Limit Values (TLVs) apply to 8-hour workdays. ACGIH recommends application of the Brief and Scala Model when working longer shifts. This model reduces the TLV for these longer shift scenarios. The calculation is presented in the graphic below.

Table B – Brief and Scala Model

Adjusted TLV = Reduction Factor x TLV
$\text{Reduction Factor} = \frac{8}{\text{daily hours worked}} \times \frac{24-\text{daily hours worked}}{16}$

3.0 EXPOSURE CHARACTERIZATION / RISK ASSESSMENT

3.1 PURPOSE

The intent of safety, management and engineering team is to protect employees from exposure at or above the occupational exposure limits (OELs) outlined above in Table A.

3.2 PROCESS

Prior to initiating an existing or new work activity, safety, management, and engineering will consider if identified contaminants or hazards are present or reasonably expected to be present or created by the task at a level above the OEL. Kiewit staff will complete this initial exposure assessment before work is initiated. Previous documents, past reports, exposure data, work plans, drawings, safety data sheets, job hazard analyses (JHAs), and other reports from the site will be reviewed to aid in characterizing potential exposures and identifying potential overexposures.

Background or area sampling may be considered to characterize potential exposures. This thorough exposure assessment should be documented. When this review is complete, and it is determined there is a potential exposure, occupational exposure monitoring will be conducted.

If prior acceptable monitoring data is on file from within the last 6 months, representing a similar task with similar controls, work environment, materials, ventilation, tools/equipment, and workmanship level, the data will be reviewed to determine if the work activity has been characterized.

If prior data is reviewed and unacceptable, exposure monitoring will be conducted.

If prior data is not available, exposure monitoring will be conducted.

If prior data is reviewed and found to be similar representing a similar task with similar controls, work environment, materials, ventilation, tools/equipment, workmanship level, and is below the OEL, no further monitoring will be conducted. Appropriate safety precautions should be written into the work activity plan.

If work activities or conditions do not change, each work area and task will be re-evaluated and/or audited annually.

If work practices or exposures result in exceeded occupational exposure limits, the hierarchy of controls will be utilized to mitigate exposures. The principles in the hierarchy of controls includes hazard mitigation through elimination, substitution, engineering controls, administrative controls and/or personal protective equipment. Personal protective equipment is typically understood to be the least effective option on the list.

4.0 AIR SAMPLING METHODS

4.1 Personal Sampling

A competent person will conduct or oversee air sampling whenever these is a potential to exceed the applicable occupational exposure levels using the standards of the ACGIH 2016, OSHA, and MSHA. When employees work 10-hour shifts, monitoring should be for 8 hours. Eight-hour shifts should be monitored a minimum of 7 hours. Monitoring should always include the period of greatest potential exposure during the shift.

Calibrate sampling pumps to a primary standard prior to and immediately after sampling. The calibration form will be used, filled out completely, signed off by the hygienist and made part of the project record. Further sampling instructions are included in Appendix I, Sampling Methods and Instructions.

The suggested number of employees monitored will be included in the sampling plan spreadsheet as a baseline effort and will be modified as work progresses, and results are received. In addition, sampling should be conducted for at least 25 percent of employees with similar exposures on at least 25 percent of the workdays within each project phase or a minimum of 6 samples per activity.

Air sampling will be conducted initially, periodically, and whenever a change in the mechanical equipment, process, control equipment, ventilation, personnel, or work practices may reasonably be expected to result in new or additional exposures at or above the occupational exposure limit (as listed in Table A), or when the employer has any reason to believe that new or additional exposures at or above the occupational exposure limit have occurred.

At least one breathing zone air sample will be collected in the area of highest exposure for each task in each work area. Nearby workers will be considered if generated contaminants drift across other workers' breathing zones.

A representative number of employees will be sampled in areas where many employees are conducting similar tasks. In representative sampling, employee(s) who are expected to have the highest exposures will be included in the sampling.

For RCS, where the most recent monitoring indicates employee exposures at or above the action level but at or below the PEL, the monitoring will be repeated within six months of the most recent monitoring. Where the most recent monitoring indicates employee exposure above the PEL, the monitoring will be repeated within three months of the most recent monitoring. When the most recent (non-initial) monitoring is below the action level, repeat the monitoring within six months until two consecutive samples collected 7 or more days apart indicate that airborne levels are below the AL. Then air sampling may be discontinued, unless there is a change in the process as specified above.

For work shifts exceeding 8 hours, air sampling will be conducted for the 8 continuous hours with the expected highest exposure, e.g. for 10-hour shift, start sampling following morning set-up until clean-up time (assuming clean-up does not involve tasks that increase exposures).

The Permissible Exposure Limit (PEL) is the maximum concentration of a listed contaminant to which an unprotected worker may be exposed during the course of workplace duties. PELs are expressed as an eight-hour, time weighted average (TWA) exposure limit. The regulatory TWA is a calculation using sampling results projected to a full eight hours. Time not measured is projected as zero exposure. This plan is based on collecting 8-hour samples whenever samples are collected.

When 10-hour shifts are worked, follow the Brief and Scala Model, recommended by ACGIH, to adjust TLVs.

Field blanks for each contaminant monitored will be collected daily or per shift monitored. At least one field blank for every 10 samples collected in the field will be collected to ensure handling and media are not contaminated prior to use or during shipment from the facility.

Personal monitoring shall be conducted using a pre- and post-calibrated dosimeter, programmed for A-weighting, slow response, 80 dBA threshold, 85 dBA criterion level, 3 dBA Exchange Rate, and meeting or exceeding the requirements for a Type 2 dosimeter per the ANSI S1.25, "Specification for Personal Dosimeters". The calibrator must be recommended by the dosimeter manufacturer and the difference between the before and after calibration shall be within plus or minus 1 dB. All intermittent, continuous, and impulse sound level from 80-140 dB shall be integrated into the dosimetry measurement.

Employees working in high noise areas (85 dBA or above) shall be monitored at least every two years to determine their noise exposure. Any employee found to be exposed to a single 8-hr TWA of 85 dBA or greater must be enrolled in the Hearing Conservation Program (HCP).

4.2 Area Sampling

Kiewit will utilize Industrial Scientific iBrid MX6 units or Industrial Scientific Ventis MX4 units to monitor for gasses in real-time. The manufacturer instructions will be followed for the programming, maintenance, calibration, charging, usage and recordkeeping of the monitoring equipment.

Units shall be programmed to alarm and warn the user of hazardous gas concentrations. Based on historical activity at the site, the primary gas concern is NO2 levels. Any alarm or alert shall cause the user to exit the area and contact their supervisor for further instructions. Work in the area of the alarm shall be shut down until ventilation or investigation is complete.

In the event there is an NO_2 alarm, implement any necessary mitigation following the ACGIH 2016 Abatement Plan Nitrogen Dioxide (NO_2)

In cases where there are no alarms during the shift, the unit shall be downloaded and the data reviewed in a timely manner. The results shall be compared to ESH team for acceptable limits.

Any personnel being monitored shall don the gas monitor for the duration of their shift.

5.0 EMPLOYEE NOTIFICATION

Affected employees will be notified in writing of air sampling results no later than 15 working days after the receipt of the results of sampling.

If the results indicate the employee exposure has exceeded the OEL. The written notice will include the type of corrective actions being taken as appropriate.

The results will be accessible by posting or made readily available in an accessible location for all employees (e.g., breakroom bulletin board).

Subcontractors, if undertaking any exposure monitoring, will be responsible to notify their employees of air monitoring results in compliance with this section at a minimum.

6.0 RECORDKEEPING

All hard copy/electronic records generated because of this procedure will be forwarded to the project manager, safety and engineering. These records will be maintained in accordance with the company policy.

All air sampling data that is collected will be entered into an Industrial Hygiene Sampling electronic database.

Records will be made available to the affected employee upon request and included in safety meeting topics.

Records are to be maintained for length of employment plus 30 years.

APPENDIX I
SAMPLING METHOD INSTRUCTIONS

Nitrogen Dioxide Sampling

Analytical Method: UMEx 200 Passive Sampler for NO2, OSHA Method ID-182

Equipment:

- Monitor **badge** (inside pack with attachment clip), Passive sampler, SKC UMEx 200 Passive Sampler for NO2
- **Do Not Open Pouch with Badge Until Ready for Use**
- IH Air Sampling Record & Worksheet (IH worksheet)
- COC
- Black Sharpie

Sampling Method:

1. Before sampling, check the expiration date on the label on the outside of the pouch. Do not use after the last day of the month indicated.
2. **Do Not Open Pouch with Passive Sampler (AKA Badge) Until Ready for Use.**
3. Assign a badge to an employee.
4. Open foil pouch, remove badge and save pouch to send badge to lab.
5. Enter the date and location on the back of the badge.
6. Assign a sample ID for person being sampled.
7. There is no calibration for badge usage.
8. Slide the sampler or badge cover to the “on” position when ready to begin sampling.
9. **Record the start time on the IH worksheet.**
10. Clip badge to pocket or lapel of person monitored near the breathing zone up to 8 hours.
11. Explain sampling process to employees, e.g. I will be attaching badge to collar, you will wear the badge for entire work shift including break & lunch. If you need to remove badge for any reason, get assistance to remove and put back on making sure it is in the breathing zone. Who to contact if you lose the monitor or damage it, when equipment will be picked up. Keep track of what you do during the day (typical tasks &/or unusual events) on the IH worksheet.
12. Record sample ID, sample number, worker name, location, and activity for each sample on the IH Worksheet.
13. Record temperature and relative humidity of the work area on the IH Worksheet.
14. At the end of the sampling time, slide the sampler cover to the “off” position to stop sampling.
15. **Record stop time on IH worksheet** and back of the badge.
16. Place the badge in the original pouch immediately after sampling and seal the pouch.
17. Open and close an unused badge and label “Field Blank” while in your sampling area.
18. Place field blank and samples into a plastic bag.
19. Complete IH worksheet. Crosscheck sample numbers with info on IH worksheet. Calculate total sample times and volumes.
20. Complete COC and scan/copy. Email copy of IH Worksheet & COC to: tim.jacobsen@atcgs.com. Seal COC in plastic bag with samples.
21. Ship samples via FedEx or UPS Ground to accredited laboratory.

Diesel Particulate Matter (DPM) Sampling

Analytical Method: NIOSH 5040, elemental carbon, organic carbon, total carbon with jeweled impactor.

Equipment:

- Diesel Particulate Matter (DPM) cassette
- Nylon cyclone
- Cassette holder
- Low-flow sampling pumps calibrated to **1.7 liters per minute (LPM) – Always maintain pumps on chargers the night before sampling for a full charge.**
- IH Air Sampling Record Worksheet (IH worksheet)
- COC
- Black Sharpie
- Belts or duct tape to make belt
- Calibration jar & tubing
- Primary calibration (TSI 4146)

Sampling Method:

1. Label each cassette with sample number, usually date followed by 'DPM' followed by number: -01, -02, etc. For example if sampling performed on January 15: 011520DPM-01, -02, etc. Label and use one cassette for "calibration" only.
2. Record sample number, pump number, and worker name, location, and activity for each sample on the IH Worksheet.
3. Watch this instructional video: DPM Calibration & Sampling Video Instructions *Note: the video demonstration utilizes a rotameter (Secondary calibration device). The instructions below utilize a primary calibration device (TSI 4146).*
4. The cassette for pre-calibration will be used again for post-calibration. After calibration of the pump, place a new labeled DPM cassette that will be placed onto the worker.
5. Prepare the cassette and cyclone for calibration:
    a. Remove the 2 plugs from the cassette.
    b. Remove the thumbscrew from the cyclone.
    c. Place the cassette (impactor) onto the cyclone, re-insert, and tighten the thumbscrew.
    d. The grit pot at the end of the cyclone remains on the cyclone during calibration.
6. Place the cassette and cyclone assembly into a calibration jar, make connections and tighten the jar lid. The sampling train for calibration is as follows a) pump; b) long tubing; c) calibration jar; d) DPM cassette (no cassette holder); e) cyclone; f) long piece of tubing from jar to primary calibrator. Turn on the pump.
7. Remember to use a level, flat surface for calibration. Check flow rate is at 1.7 LPM for each pump/media assembly. If flow rate is not 1.7 LPM, adjust pump until calibrator shows 1.7 LPM. Record starting flow rate in appropriate column on General IH Worksheet.
8. Explain sampling process to employees, e.g. I will be attaching pump to belt & media to collar, you will wear pump for entire work shift including break & lunch time. If you need to remove pump to use bathroom, get assistance to remove and put back on making sure tubing is attached to pump and cassette holder tube is attached to cassette. Who to contact if pump stops, make sure not to tip cyclone upside down, when equipment will be picked up. Keep track of what you do during the day (typical tasks &/or unusual events) on the IH Worksheet.
9. Attach pump to employee's belt or top of pants. Tubing can run under or over shirt. Make sure it won't interfere with activities. Can use extra clips (if provided) or duct tape to secure tubing to back of shirt. If possible, request employees wear a belt on the day of sampling. Belts may be made out of duct tape or order a couple of adjustable belts if that is preferred.
10. Connect assembly to employee's collar in their breathing zone.
11. Start pump. **Record start time on IH worksheet**.
12. If feasible, check pumps at the end of employee break times to make sure they are operating and tubing is connected appropriately.
13. At end of sampling period, check flow rate with calibrator and **record ending flow rate on worksheet**. Stop pump and **record stop time on IH worksheet**. Ask employee if day was typical work tasks or if unusual event

occurred. **Record details in Notes section on IH worksheet**. The pre and post rates should be within 10% of each other.

14. Be careful not to tip cyclone upside down during transport or sample removal from cyclone.
15. Remove sampling assembly and cover inlets. Place the sample into the plastic bag and seal.
16. Open and close unused cassette and label “Field Blank” while in your sampling area.
17. Place field blank and samples into a plastic bag.
18. Complete IH worksheet. Crosscheck sample numbers with info on IH worksheet. Calculate total sample times and volumes.
19. Complete COC and scan/copy. Email copy of IH Worksheet & COC to: tim.jacobsen@atcgs.com. Seal COC in plastic bag with samples.
20. Ship samples via FedEx or UPS Ground to accredited laboratory.

Total Diesel Hydrocarbons (Vapor)

Analytical Method: Assay N566 Passive Badge, NIOSH 1550; GC/FID Badge

Equipment:

- Monitor **badge** (inside pack with attachment clip), Passive sampler, Assay N566 Badge for Total Hydrocarbons
- **Do Not Open Pouch with Badge Until Ready for Use**
- IH Air Sampling Record & Worksheet (IH worksheet)
- COC
- Black Sharpie

Sampling Method:

1. Before sampling, check the expiration date on the label on the outside of the pouch. Do not use after the last day of the month indicated.
2. **Do Not Open Pouch with Passive Sampler (AKA Badge) Until Ready for Use.**
3. Assign a badge to an employee.
4. Open foil pouch, remove badge and save pouch to send badge to lab.
5. Enter the date and location on the back of the badge.
6. Assign a sample ID for person being sampled.
7. There is no calibration for badge usage.
8. Open the badge cover when ready to begin sampling.
9. **Record the start time on the IH worksheet.**
10. Clip badge to pocket or lapel of person monitored near the breathing zone up to 8 hours.
11. Explain sampling process to employees, e.g. I will be attaching badge to collar, you will wear the badge for entire work shift including break & lunch. If you need to remove badge for any reason, get assistance to remove and put back on making sure it is in the breathing zone. Who to contact if you lose the monitor or damage it, when equipment will be picked up. Keep track of what you do during the day (typical tasks &/or unusual events) on the IH worksheet.
12. Record sample ID, sample number, worker name, location, and activity for each sample on the IH Worksheet.
13. Record temperature and relative humidity of the work area on the IH Worksheet.
14. At the end of the sampling time, close and seal the badge cover to stop sampling.
15. **Record stop time on IH worksheet** and back of the badge.
16. Place the badge in the original pouch immediately after sampling and seal the pouch.
17. Open and close an unused badge and label “Field Blank” while in your sampling area.
18. Place field blank and samples into a plastic bag.
19. Complete IH worksheet. Crosscheck sample numbers with info on IH worksheet. Calculate total sample times and volumes.
20. Complete COC and scan/copy. **Ensure “total hydrocarbons” is selected for analysis on the COC.** Email copy of IH Worksheet & COC to: tim.jacobsen@atcgs.com. Seal COC in plastic bag with samples.
21. Ship samples via FedEx or UPS Ground to accredited laboratory.

Respirable Crystalline Silica & Respirable Dust Sampling
PPI Method

Analytical Method: Modified NIOSH 0600/7500, modified OSHA ID-142; Gravimetric / X-Ray Diffraction. On Chain of Custody (COC) request silica, crystalline quartz, cristobalite, & tridymite (with respirable dust) using PPI.

Equipment:

- Disposable pre-weighed 2 liters per minute (LPM) Parallel Particle Impactor (PPI) samplers with tubing
- Low-flow sampling pumps calibrated to **2.0 LPM – Always maintain pumps on chargers the night before sampling for a full charge.**
- IH Air Sampling Record & Worksheet (IH worksheet)
- COC
- Black Sharpie
- Belts or duct tape to make belt
- Calibrator adaptor (Not Disposable)
- Primary calibration (TSI 4146)

Sampling Method:

1. Label each cassette with sample number, usually date followed by 'S' followed by number: -01, -02, etc. For example if sampling performed on January 15: 01152019S-01, -02, etc.
2. Record sample number, pump number, and worker name, location, and activity for each sample on the IH Worksheet.
3. Watch this video: RCS / PPI Calibration & Sampling Video Instructions
4. Remove PPI from the bag, remove the inlet cover from the PPI and connect the sample inlet to the end of the tubing connected to the pump.
5. Check flow rate is at 2.0 LPM for each pump/media assembly. If flow rate is not 2.0 LPM, adjust pump until calibrator shows 2.0 LPM. Record starting flow rate in appropriate column on General IH Worksheet.
6. Explain sampling process to employees, e.g. I will be attaching pump to belt & media to collar, you will wear pump for entire work shift including break & lunch. If you need to remove pump to use bathroom, get assistance to remove and put back on making sure tubing is attached to pump and cassette holder tube is attached to cassette. Who to contact if pump stops and when equipment will be picked up. Keep track of what you do during the day (typical tasks &/or unusual events) on the Air Monitoring Surveillance form.
7. Attach pump to employee's belt or top of pants. Tubing can run under or over shirt. Make sure it won't interfere with activities. Can use extra clips (if provided) or duct tape to secure tubing to back of shirt. If possible, request employees wear a belt on the day of sampling. Belts may be made out of duct tape or order a couple of belts if that is preferred.
8. Connect assembly to employee's collar in their breathing zone.
9. Start pump. **Record start time on IH worksheet**.
10. At end of sampling period, check flow rate with calibrator and **record ending flow rate on worksheet**. Stop pump and **record stop time on IH worksheet**. Ask employee if day was typical work tasks or if unusual event occurred. **Record details in Notes section on IH worksheet**.
11. Remove PPI assembly, cover inlet, and place the sticker over the open face of the cassette (four holes). Place the sample into the plastic bag and seal.
12. Open and close unused cassette and label "Field Blank" while in your sampling area.
13. Place field blank and samples into a plastic bag.
14. Complete IH worksheet. Crosscheck sample numbers with info on IH worksheet. Calculate total sample times and volumes.
15. Complete COC and scan/copy. Email copy of IH Worksheet & COC to: tim.jacobsen@atcgs.com. Seal COC in plastic bag with samples.
16. Ship samples FedEx or UPS Ground to accredited laboratory.

Respirable Crystalline Silica & Respirable Dust Sampling

Cyclone Method

Analytical Method: Modified NIOSH 0600/7500, modified OSHA ID-142; Gravimetric / X-Ray Diffraction. On Chain of Custody (COC) request silica, crystalline quartz, cristobalite, & tridymite (with respirable dust) using PPI.

Equipment:

- Aluminum cyclone
- Pre-weighed 37-mm filter cassette
- Filter cassette holder
- Cyclone calibration adapter
- Low-flow sampling pumps and tubing.
- Flow rate at **2.5 LPM or according to cyclone manufacturer specifications** **(Always maintain pumps on chargers the night before sampling for a full charge).**
- IH Air Sampling Record & Worksheet (IH worksheet)
- COC
- Black Sharpie
- Belts or duct tape to make belt
- Calibrator adaptor (Not Disposable)
- Primary calibration (TSI 4146)

Sampling Method:

1. Label each cassette with sample number, usually date followed by 'S' followed by number: -01, -02, etc. For example if sampling performed on January 15: 01152019S-01, -02, etc.
2. Record sample number, pump number, and worker name, location, and activity for each sample on the IH Worksheet.
3. Watch this video: RCS with Aluminum Cyclone, Calibration & Sampling Video Instructions
4. Disassemble the cassette and set aside inlet section (red). Remove plug from cassette outlet.
5. Insert cassette ring (middle section) into the cassette outlet.
6. Insert cyclone into cassette ring and press firmly. Leave the grit pit in place during calibration and sampling.
7. Insert cyclone & cassette assembly through large opening of filter cassette holder. Ensure assembly is seated firmly in holder by inserting the cyclone's side pin into the notch on the filter cassette holder.
8. Secure the cassette into the cassette holder.
9. To calibrate, push the calibration adapter over the cyclone stem until it fits snugly. Connect tubing to the inlet of the calibration adapter and connect to rotameter
10. Check flow rate is at 2.5 LPM for each pump/media assembly. If flow rate is not 2.5 LPM, adjust pump until calibrator shows 2.5 LPM. Record starting flow rate in appropriate column on General IH Worksheet.
11. Once calibrated, remove the calibration adapter and remove the cassette from the cyclone. Install a new & unused cassette for sample collection.
12. Explain sampling process to employees, e.g. I will be attaching pump to belt & media to collar, you will wear pump for entire work shift including break & lunch. If you need to remove pump to use bathroom, get assistance to remove and put back on making sure tubing is attached to pump and cassette holder tube is attached to cassette. Who to contact if pump stops and when equipment will be picked up. Keep track of what you do during the day (typical tasks &/or unusual events) on the Air Monitoring Surveillance form.
13. Attach pump to employee's belt or top of pants. Tubing can run under or over shirt. Make sure it won't interfere with activities. Can use extra clips (if provided) or duct tape to secure tubing to back of shirt. If possible, request employees wear a belt on the day of sampling. Belts may be made out of duct tape or order a couple of belts if that is preferred.
14. Connect assembly to employee's collar in their breathing zone.
15. Let the employee know that once sampling begins, do not allow particles collecting in the red grit pot to fall back towards the sampling cassette or the sample will be void.

16. Start pump. **Record start time on IH worksheet**.
17. At end of sampling period, check flow rate with calibrator and **record ending flow rate on worksheet**. Stop pump and **record stop time on IH worksheet**. Ask employee if day was typical work tasks or if unusual event occurred. **Record details in Notes section on IH worksheet**.
18. Remove cassette, reassemble cassette and close inlet/outlet with plugs.
19. Clean all parts of the cyclone with clean damp rags or isopropyl alcohol.
20. Open and close one unused cassette for the day and label "Field Blank" while in your sampling area.
21. Place field blank and samples into a plastic bag.
22. Complete IH worksheet. Crosscheck sample numbers with info on IH worksheet. Calculate total sample times and volumes.
23. Complete COC and scan/copy. Email copy of IH Worksheet & COC to: tim.jacobsen@atcgs.com. Seal COC in plastic bag with samples.
24. Ship samples FedEx or UPS Ground to accredited laboratory.

Metals or Welding Fumes & Total Dust Sampling

Analytical Method: OSHA ID-125G & NIOSH 0500; Antimony, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, vanadium, nickel, zinc & total particulate.

Equipment:

- Tared 37 mm PVC, 5 micron filter cassette with tubing
- Low-flow sampling pumps calibrated to **2.0 LPM – Always maintain pumps on chargers the night before sampling for a full charge.**
- IH Air Sampling Record & Worksheet (IH worksheet)
- COC
- Black Sharpie
- Belts or duct tape to make belt
- Primary calibration (TSI 4146)

Sampling Method:

1. Label each cassette with sample number, usually date followed by 'M' followed by number: -01, -02, etc. For example if sampling performed on January 15: 01152019M-01, -02, etc.
2. Record sample number, pump number, and worker name, location, and activity for each sample on the IH Worksheet.
3. Watch this video: Metal Sampling Video Instructions
4. Remove the inlet / outlet covers from the cassette and connect the sample inlet to the end of the tubing connected to the pump.
5. Check flow rate is at 2.0 LPM for each pump/media assembly. If flow rate is not 2.0 LPM, adjust pump until calibrator shows 2.0 LPM. Record starting flow rate in appropriate column on General IH Worksheet.
6. Explain sampling process to employees, e.g. I will be attaching pump to belt & media to collar, you will wear pump for entire work shift including break & lunch. If you need to remove pump to use bathroom, get assistance to remove and put back on making sure tubing is attached to pump and cassette holder tube is attached to cassette. Who to contact if pump stops and when equipment will be picked up. Keep track of what you do during the day (typical tasks &/or unusual events) on the Air Monitoring Surveillance form.
7. Attach pump to employee's belt or top of pants. Tubing can run under or over shirt. Make sure it won't interfere with activities. Can use extra clips (if provided) or duct tape to secure tubing to back of shirt. If possible, request employees wear a belt on the day of sampling. Belts may be made out of duct tape or order a couple of belts if that is preferred.
8. Connect assembly to employee's collar in their breathing zone.
9. Start pump. **Record start time on IH worksheet**.
10. At end of sampling period, check flow rate with calibrator and **record ending flow rate on worksheet**. Stop pump and **record stop time on IH worksheet**. Ask employee if day was typical work tasks or if unusual event occurred. **Record details in Notes section on IH worksheet**.
11. Remove cassette assembly, cover inlet/outlet. Place the sample into the plastic bag and seal.
12. Open and close unused cassette and label "Field Blank" while in your sampling area.
13. Place field blank and samples into a plastic bag.
14. Complete IH worksheet. Crosscheck sample numbers with info on IH worksheet. Calculate total sample times and volumes.
15. Complete COC and scan/copy. Email copy of IH Worksheet & COC to: tim.jacobsen@atcgs.com. Seal COC in plastic bag with samples.
16. Ship samples via FedEx or UPS Ground to accredited laboratory.

APPENDIX II
AIR MONITORING FORM & CHAIN OF CUSTODY

Industrial Hygiene Worksheet

Personal Air Sampling & Monitoring Data Sheet

Sampling Location:	Sample Date: Shift Hours:
Person Sampled (Name/Employee # & Job Title):	Sample Type: (Personal) (Area)
Ambient Conditions (Temp, RH, Air Movement):	Work Task #:
PPE Used (Circle Each): (Respirator) (Eye Protection) (Foot) (Gloves) (Body) (Ear) Other List Here:	Sample Numbers:

Describe below the work activities or tasks / controls used / conditions that may influence personal exposures (examples include: assisting, abrading, blasting, brazing, chipping, cleaning, cutting, drilling, driving, digging, grinding, installing, loading, mixing, monitoring, operating, removing, welding (include type), etc.**)**
6:30 (AM) or (PM)
7:00 (AM) or (PM)
7:30 (AM) or (PM)
8:00 (AM) or (PM)
8:30 (AM) or (PM)
9:00 (AM) or (PM)
9:30 (AM) or (PM)
10:00 (AM) or (PM)
10:30 (AM) or (PM)
11:00 (AM) or (PM)
11:30 (AM) or (PM)
12:00 (AM) or (PM)
1:00 (AM) or (PM)
1:30 (AM) or (PM)
2:00 (AM) or (PM)
2:30 (AM) or (PM)
3:00 (AM) or (PM)
3:30 (AM) or (PM)
4:00 (AM) or (PM)
4:30 (AM) or (PM)
5:00 (AM) or (PM)
5:30 (AM) or (PM)
6:00 (AM) or (PM)
6:30 (AM) or (PM)

Record **equipment** used by employee monitored and equipment being used by others in the work area (estimate time of use if applicable):
Document **engineering controls** used to reduce hazards (note natural ventilation, local exhaust ventilation, water, misting, enclosures, etc.)

Personal Air Sampling & Monitoring Data Sheet
(Continued)

Record up to 3 samples on this page if on same person.	Sampling for (List all types):			
	Sample #'s:			
	Sample Media:			

Sample #	Pump Manufacturer:		Model:		Pump #
Calibration Data	Date & Time	Calibrator	Measurement 1 (liters/min)	Measurement 2 (liters/min)	Measurement 3 (liters/min)
Pre-Cal		TSI-4146			
Post-Cal		TSI-4146			
Average Pre Flow Rate: _____ Liters/min or N/A Diffusion			Total Average:		
Average Post Flow Rate: ____ Liters/min or N/A Diffusion			Liters/Minute:		
Pump Start & Stop Times for Sample #_____					
Pump Time Started		Pump Time Stopped	Tips: If pump fails, record start/stop time and resume sampling.		
Total Sampling Time:			Total Sampling Volume:		

Sample #	Pump Manufacturer:		Model:		Pump #
Calibration Data	Date & Time	Calibrator	Measurement 1 (liters/min)	Measurement 2 (liters/min)	Measurement 3 (liters/min)
Pre-Cal		TSI-4146			
Post-Cal		TSI-4146			
Average Pre Flow Rate: _____ Liters/min or N/A Diffusion			Total Average:		
Average Post Flow Rate: ____ Liters/min or N/A Diffusion			Liters/Minute:		
Pump Start & Stop Times for Sample #_____					
Pump Time Started		Pump Time Stopped	Tips: If pump fails, record start/stop time and resume sampling.		
Total Sampling Time:			Total Sampling Volume:		

Personal Air Sampling & Monitoring Data Sheet
(Continued)

Sample #	Pump Manufacturer:		Model:		Pump #
Calibration Data	Date & Time	Calibrator	Measurement 1 (liters/min)	Measurement 2 (liters/min)	Measurement 3 (liters/min)
Pre-Cal		TSI-4146			
Post-Cal		TSI-4146			
Average Pre Flow Rate: _____ Liters/min or N/A Diffusion			Total Average:		
Average Post Flow Rate: ____ Liters/min or N/A Diffusion			Liters/Minute:		

Pump Start & Stop Times for Sample #_____

Pump Time Started	Pump Time Stopped	Tips: If pump fails, record start/stop time and resume sampling.

Total Sampling Time:	Total Sampling Volume:
Field Blank Sample Type & Numbers:	
Laboratory Samples Sent to:	Date Samples Collected:
Additional Comments / Diagrams / Interference / Notes:	
Collected by (Name, ID, Title)	Date Collected:

SGS GALSON LABORATORIES

6601 Kirkville Rd
East Syracuse, NY 13057
Tel: (315) 432-5227
888-432-LABS (5227)
Fax: (315) 437-0571
www.galsonlabs.com

☐ New Client?

Client Account No.*: _____

Report To* : _____

Phone No.* : _____

Cell No. : _____

Email Results to : _____

Email address : _____

Invoice To* : _____

Phone No. : _____

Email : _____

P.O. No. : _____

Credit Card : ☐ Card on File ☐ Call for Credit Card Info.

☐ Samples submitted using the FreePumpLoan™ Program ☐ Samples submitted using the FreeSamplingBadges™ Program

Need Results By:	(surcharge)
☐ Standard	0%
☐ 4 Business Days	35%
☐ 3 Business Days	50%
☐ 2 Business Days	75%
☐ Next Day by 6pm	100%
☐ Next Day by Noon	150%
☐ Same Day	200%

Site Name : Project : Sampled by :

Comments :

List description of industry or Process/interferences present in sampling area :

State samples were collected in (e.g., NY)

Please indicate which OEL this data will be used for :
☐ OSHA PEL ☐ ACGIH TLV ☐ Cal OSHA
☐ MSHA ☐ Other (specify):

Sample Identification* (Maxmium of 20 Characters)	Date Sampled	Collection Medium	Sample Volume Sample Time Sample Area*	Sample Units*: L, ml,min,in2,cm2,ft2	Analysis Requested*	Method Reference^	Hexavalent Chromium Process (e.g., welding plating, painting, etc.)*
EXAMPLE	04/24/13	2pc UW PVC	960	L	Hexavalent Chromium (Cr6)	Mod OSHA ID-215	Welding

^Galson Laboratories will subsititute our routine/preferred method if it does not match the method listed on the COC unless this box is checked: ☐ Use method(s) listed on COC

For metals analysis: if requesting an analyte with the option of a lower LOQ, please indicate if the lower LOQ is required (only available for certain analytes - see SAG) :

For crystalline silica: form(s) of silica needed must be indicated (Quartz, Cristobalite, and/or Tridymite)* :

Chain of Custody	Print Name/Signature	Date	Time		Print Name/Signature	Date	Time
Relinquished by :				Received by :			
Relinquished by :				Received by :			

Samples received after 3pm will be considered as next day's business
* Required fields, failure to complete these fields may result in a delay in your samples being processed.

APPENDIX III
EMPLOYEE NOTIFICATION

<<Insert Date>>

Mr. Michael Jordan
Insert Company Name

Re: Industrial Hygiene Monitoring Results
FERMI LBNF
201 W. Main Street
Lead, South Dakota

Dear Mr. Jordan

Personal exposure monitoring for RCS / Metals / NO2 / DPM on November 2, 2019, at the Type Site Name facility referenced above. Sample results indicate you were not exposed to ***(Select) RCS / Metals / NO2 / DPM*** above **OR** below applicable limits. If you have any questions regarding this information, please contact your supervisor.

Employee Sampling Results					Exposure Determination	
Work Task	Employee Name	Analyte	TWA Results		ACGIH TWA TLV	OSHA PEL TWA
			Concentration	Units		
GrindMaster Operator	Michael Jordan	Diesel Particulate Matter	36	µg/m^3	20 µg/m3	No limit
		Nitrogen Dioxide	< 0.40	ppm	0.2 ppm	1 ppm

< = No contaminant detected in sample, µg/m^3 = micrograms per cubic meter of air
ACGIH TWA TLV = American Conference of Governmental Industrial Hygienists Time Weighted Average Threshold Limit Value
OSHA PEL-TWA = Occupational Safety and Health Administration Permissible Exposure Limit as an 8-Hour Time-Weighted Average
Results in **BOLD Red** font exceed an applicable OSHA PEL or ACGIH TLV.

By signing below, the employee acknowledges that he/she has been notified of industrial hygiene monitoring results for the sampling conducted on November 2, 2019.

Employee Signature _____ Date _____

LBNF Representative Signature _____ Date _____

TO: **Represented Employees**

FROM: Environmental Health and Safety

SUBJECT: Industrial Hygiene Monitoring Results

DATE: <<Insert Date>>

This memo shall serve as your notification of industrial hygiene monitoring results for sampling and analyses that were conducted on November 2, 2019. Your results are presented below:

Employee Sampling Results					Exposure Determination	
Analyte	Work Task	Duration	TWA Results		ACGIH TWA TLV	OSHA PEL TWA
			Concentration	Units		
Diesel Particulate Matter	Grinder Operator	480 Min	< 0.40	ppm	0.2 ppm	1 ppm
Silica	Hauling Out	420 Min	< 0.40	ppm	0.2 ppm	1 ppm

TWA is 8-hour time weighted average assuming no additional exposure outside of monitored time

PEL is OSHA Permissible Exposure Limit

TLV is ACGIH Threshold Limit Value

Results in **BOLD Red** font exceed an applicable OSHA PEL or ACGIH TLV.

Edit as needed (Example provided):

Three of the representative results collected were **above <u>OR</u> below** the OSHA PEL, OSHA AL and ACGIH TLV and one of the samples was below the OSHA PEL and AL, but above the ACGIH TLV.

Based on these results, you will continue to be required to follow ***(edit to fit situation)*** procedures while completing similar tasks. ***(Insert recommendations here for reducing levels if above limits).***

A copy of this report is available for your review. Please contact ***(Insert Name)*** if you do not understand the significance or meaning of your results, or if you have any questions regarding testing.

_____ _____

Supervisor **Date**

Represented Employees

By signing you confirm you received a copy of results representing your potential exposure during **<<Insert work activity here>>** collected **November 2, 2019.**

Printed Name	Signature	Employee #

Area	Project Activity	# of employees	Employees Monitored	Shift Times	Exposures	Parameters / Analytes	Fegency of Testing	Media	Lab	Analytical Method	Flow Rate	Recommended Sample Time	Minimum Sample Time	Notes
1B Excavation Phase - Current Work List														
All work at the 4850L														
4850L Excavatin Work	CMa role on the porject	12 Supervisors in Cma role - 3 per shift/rotation plus 6 additional supervisors	3 Cma Supervisors/shfit	Two shifts seven days/week; shifts are 6:30 am to 6:30 pm & 6:30 pm to 6:30 am	Nitrogen Dioxide	Nitrogen Dioxide	Minimium of 6 samples as a baseline plus 1 sample per month	UMEx 200 Passive or Equivalent	SGS Galson	OSHA ID-182 IC	diffusion method	8 hours	To meet the OSHA ceiling, you need at least 5 minutes. To meet the TLV for a TWA, you need at least 104 min. 8 hours is the recommended time.	
					Silica	Quartz, Cristobalite, Tridymite, Total RCS, Respirable Dust		Parallel Particle Impactor (PPI) Or aluminum cyclone	SGS Galson	NIOSH 0600/7500 Grav/XRD on COC, request silica, crstyalline quartz, cristobalite, & trydymite, respirable dust	PPI is 2 LPM & Aluminum Cyclone is 2.5 LPM	8 hours Minimum	240 Minutes	
					Diesel Particulate (DPM) & Vapor	Elemental Carbon, Organic Carbon, Total Carbon & Vapor		SKC 225-317 Jeweled Impactor with Cyclone for DPM & Assay Badge N566 for vapor	SGS Galson	NIOSH 5040 (DPM) & NIOSH 1550 (Vapor)	DPM 1.7 liters per minute & passive badge	8 hours Minimum	Minimum sample time 240 minutes; ensure cyclone has respirable cut point at 1.7 lpm	
					Carbon Monoxide	Carbon Monoxide		UMEx 200 Real-Time Monitor	n/a	Sensor real-time data collection/ no lab analysis	Pre-Set by Manufacturer	8 hours Minimum		
					Noise	Decibels (dBA)		TSI Quest the Edge or equivelant dosimeter	n/a	ACGIH: A-weighting, slow response, 80 dBA threshold, 85 dBA criterion level, 3 dBA exchange rate, and meeting or exceeding the requirements for a Type 2 dosimeter per the ANSI S1.25.	1-minute intervals	8 hours Minimum		
					Oil Mist	Oil Mist (hydraulic oils, heat-treating oils, etc.)		PVC Cassette with Mateched Weight Filter	SGS Galson	NIOSH 5026	1 to 3 liters per minute		20 L minimum and 500 L maximum	

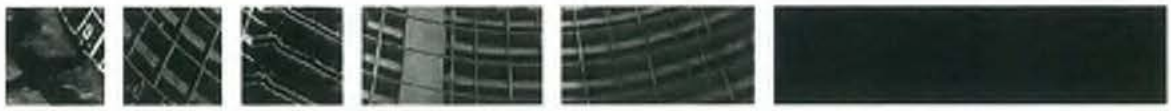
NOTE 1 If tasks vary we will need to repeat sampling on different/additional days.

NOTE 2 Not expected to be present

NOTE 3 This plan is intended to provide media and method specification for those analytes of frequent interest. It is not intended to be exhaustive listing of all possible exposures or agents for which sampling may be appropriate.

NOTE 4 Sampling of the three elements of exposure will be taken once per month.

Appendix I - TMI Specific sections related to WPC



THYSSEN MINING

local challenges | **GLOBAL SOLUTIONS**

Far Site Conventional Facilities (FSCF) Excavation Project

LBNF SITE SPECIFIC SAFETY AND HEALTH PLAN

* SECTION PROVIDED

REVISION HISTORY			
Revision Number	**Revision Description**	**Effective Date**	**Name**
0	Issued for Submittal	January 15, 2021	James Brown
1	Revision issued for Submittal	February 16, 2021	James Brown
2	Revision issued for Submittal	March 6, 2021	James Brown

DISCLAIMER

Thyssen Mining is constantly engaged in developing best practices related to Safety, Engineering and Methodology; accordingly, Thyssen Mining reserves the right to modify the document contained herein at any time.

All technical data, specifications and other information contained within this document are deemed to be the intellectual property of Thyssen Mining.

SAFETY AND ENVIRONMENTAL MANAGEMENT PLAN

TABLE OF CONTENTS

List of Appendices

Element 6 - Hazard Assessment and Control

6.0 Introduction

The hazard assessment and control process is the cornerstone to our Safety Program. Thyssen Mining will conduct hazard assessments as part of our job planning to identify, assess, and control risks that may present exposures to people, property or the environment. In many cases, the Hazard Assessment will be performed by the Site project team. Supervisors are to receive training from Corporate Safety and general workers are to receive training from their supervisor.

The optimum control measure of workplace hazards is through design and engineering to eliminate the hazard. When this is not possible or it is not feasible, administrative methods will be employed—control the hazard. The use of PPE is considered as a last resort after the consideration of engineering and administrative controls—protect from the hazard.

The hazard recognition, evaluation and control process will follow the process of:

- Risk Assessment
- Build Plans and Job Hazard Analysis
- Field Level Risk Assessment/5 Point Card

The objective of the hazard assessment process is to introduce hazard controls early in the project by identifying risks associated with upcoming work.

The hazard assessment:

- Is performed as an integral part of job planning
- Ensures that hazards associated with a specific work are identified and analyzed
- Provides a preliminary safe work plan to mitigate hazards associated with the work
- Identifies which tasks will require a specific Job Hazard Analysis (JHA)

6.1 Hierarchy of Controls

The following hierarchy of controls shall be utilized and will be used when developing hazard mitigation activities:

- Eliminate the hazard
- Substitute the hazard with a lesser risk
- Isolate the hazard
- Use engineering controls

Use administrative controls

- Use personal protective equipment (PPE)

6.2 Stop Work Authority (SWA) Policy

Responsibilities

- All site personnel will comply with Thyssen Mining Stop Work Authority Policies.
- Ideas and concerns of individuals are important. Personnel are both responsible and authorized to stop any work that does not comply with the tenets. Individuals are assured that **No Repercussions** will result in the event of a work stoppage due to safety concerns.
- If anyone is discouraged from exercising the "Stop Work Authority" or if there are penalties for doing so, then affected individuals should report this action to the Thyssen Mining EHS Manager.

When to Exercise a Stop Work Authority (SWA)

- Site or project conditions that are possible reasons to stop work and to consider modifications to the LBNF Site Specific Safety and Health Plan include:
    - Loss of communications (inability to contact security or emergency services).
    - Imminent danger conditions.
    - Recognition of new or unidentified hazards.
    - Off-site activities or conditions impacting site work.
    - Site temperatures outside the range predicted in this LBNF Site Specific Safety and Health Plan (possibly resulting in greater risk of heat or cold stress).
    - PPE breakthrough or unexpected degradation.
    - Unusual odors that can't be identified.
    - Unexplained, elevated readings on an organic vapor monitor.
    - Unexpected changes in soil coloration or texture that might indicate undisclosed contamination.
    - Severe weather (lightning, tornado, hurricane, wind, etc.).
    - Potential release to environment.

This list is not comprehensive and should be used only as guidance

Restarting Work

- The responsible supervisor for the assigned work and the stop-work initiator shall evaluate and/or inspect the stop-work condition to ensure all corrective actions have been completed and determine that it is safe to proceed. A thorough hazard assessment shall be made of the work area and the JSA updated. At that time, the supervisor may authorize the restart of work and notify the effected individuals or work crew. The

supervisor will also notify the Project Manager and ESH Manager. In the event the stop work/restart involves a subcontractor, the Project Manager will notify the subcontractor representative. The SWA event will be documented.

FRA Processes, Procedures, and Standards

- Thyssen Mining will comply with FRA Processes, Procedures, and Standards as they apply to this site and scope of work.

6.3 Risk Assessments

JHAs must not be confused with Risk Assessments which are more in depth than JHAs because the work involved is of a higher degree of risk. The higher degree of risk requires more extensive control measures and planning than what is usually associated with a JHA.

Risk Assessments are commonly associated with Critical Crane lifts (see next page for example), Confined Space Entries, and High Risk Lock Out/Tag Out/Verify (LOTO) tasks. Risk Assessments (RA) require the involvement of Thyssen Mining Site Management and may involve Thyssen Mining Head Office personnel.

All training and meetings are to be documented with records kept on file at the project site.

Jobs that could require a RA may include, but are not limited to:

- High risk tasks.
- Scopes of work.
- New jobs or tasks that present unspecified or unknown hazards.
- New equipment (not a replacement in kind)
- Jobs that are identified to have a history of significant incidents, injuries, exposures, or high potential near misses.
- Jobs or tasks that in the professional judgment of the responsible Project Management and safety professionals require a formal RA.

Examples of Hazards that may be inherent in the work could be but not limited to:

- Falling objects
- Falls while working at a height
- Struck by
- Caught between
- Stored energy in lock out or similar situations
- Work near bulk storage of dangerous or toxic chemicals
- Jobs involving environmental remediation of hazardous wastes
- Jobs or tasks that, in the professional judgment of responsible Project Management and safety professionals, require a formal RA

The Site team will rank the risks based on a standard Risk Ranking Matrix and formulate action items to ensure that any hazards and/or mitigation strategies are delegated to trained, competent personal for action.

Critical Lift Plan

Date:		Total Pages: 3

Determining Factors for Critical Lift

___Load is greater than 75% of mobile crane rated capacity, or greater than 90% of rated fixed crane capacity or greater than 20 tons

___Two or more cranes/booms are required or special hoisting/rigging equipment will be used

___Potential for release of hazardous materials due to collision or upset of load

___Damage that would result in 3 weeks or 30% delay to schedule, or monetary value damages of $250 000 or greater

___Client's standards require that a Critical Lift Evaluation be performed

Supervisor _____ Crane Operator _____

Date _____

Job Description:

LIFT DATA

1. Equipment Weight	
2. Weight of Rigging	2A. Main Hoist Block _____ Secondary Block/Ball _____ Spreader Bars _____ Man Basket _____ 2B. Slings _____ Shackles _____ Total Rigging Weight: 2A _____ 2B _____
3. Total Lift Weight	3A. On Sling (1 + 2B) = _____ 3B. On Crane (1 + 2A + 2B) = _____
4. Height of Lift	Not Greater Than _____ Feet Elevation sketch showing height relation to crane attached? ❑ YES ❑ NO
5. Radius of Lift	Not Greater Than _____ Feet Plot plan showing location and orientation of crane attached? ❑ YES ❑ NO
6. Equipment Surface Area	Maximum subject to crosswind _____ Sq. Feet

CRANE DATA (for 2 crane lifts fill out second form)

1. Crane Manufacturer	_____ Manufacturer's load chart showing capacity at varying radiuses and boom lengths attached?
2. Model and Size	
3. Attachments	
4. Bumper or Auxiliary	_____ Lbs.

Counterweight Counterweight	
5. Boom Length	Not Greater Than _____ Feet
6. Jib Length	Not Greater Than _____ Feet
7. Main Block	Parts of Line _____ Capacity _____
8. Secondary Block	Parts of Line _____ Capacity _____

RIGGING DATA (use additional forms as necessary)

1. Sling(s)	Diameter _____ Length _____ Capacity _____ Diameter _____ Length _____ Capacity _____ Diameter _____ Length _____ Capacity _____ Vendor's chart showing capacity for different angles and sling configurations, type of wire rope and loop splice attached? ❑ YES ❑ NO
2. Shackle(s)	Size _ Capacity per Shackle _ Size _ Capacity per Shackle _ Size _ Capacity per Shackle _ Vendor's chart showing capacity attached? ❑ YES ❑ NO

3. Briefly describe and sketch sling and shackle connection at hook and equipment:

4. Notes:

Form 2:

LIFT COMPUTATION (use additional forms as necessary)

1. Boom Length	
2. Radius of Lift	
3. Crane Capacity	_____ (From manufacturer's chart using conditions listed in #1 and #2 of Crane Data.)
4. Initial Orientation of Lift Relative to Crane	(circle one): (a) Front (b) Side (c) Rear
5. Swing Orientation of Lift Relative to Crane	(circle one): (a) Front (b) Side (c) Rear
6. Total Lift Weight	Item 3B of Lift Data _____ Lbs.
7. Sling Capacity Required	Safe working load with hitch configuration based on three legs maximum _____
8. Shackle Capacity Required	Based on three legs maximum _____
9. Total Weight on Slings and Shackles	Item 3A on Lift Data _____
10. Mat Size (as needed)	Beneath each track or fully extended outrigger _____ Soil bearing pressure (PSF) calculated _____ Allowable _____
11. Wind Speed	Lifts to be made with wind speeds in excess of 30 KPH. Actual wind speed _____KPH Actual temperature _____C.
12. Notes	

Reviewed and Approved by: _____

Date: _____

6.4 Build Plans and Job Hazard Analysis (JHA)

A Build Plan provides a description of the task, material/tools needed, critical information and a step by step process on how to perform the task (an example Build Plan is shown on the next several pages). Job Hazard Analysis or JHA (referred to by FRA as Hazard Assessment (HA)) is a step by step analysis of a task with hazards and control measures identified on the card or paper to instruct and guide workers during the execution of a task. Build Plans (if applicable) and JHA will coincide with one another. Build Plans and JHA require review and approval from FRA ESH prior to the execution of work. If equipment or material can be rolled/placed into and out of the cage, a build plan will not be required. Workers are to perform a Filed Level Risk Assessment (FLRA) if there are hazards present. For example, if the Crete Rod is loaded on the cage, there is limited space for the operator to get out of the cage.

The JHA should be performed by the supervisor and crew involved in performing the work and should be reviewed and signed off by the superintendent directing the work, the safety coordinator, and must be approved by FRA ESH Representative to ensure that all hazards are identified and the proper control measures are in place.

A JHA uses information generated by a RA and other inputs which allow a task to be analyzed for risk so that it can be carried out safely. The JHA consists of the following five steps:

i.) Defining the task

ii.) Identifying the exposures to people, property, or the environment

iii.) Evaluating the magnitude of exposures to people, property, or the environment

iv.) Identifying the actions required to reduce or eliminate risk to acceptable levels; and

v.) Monitoring the control mitigation strategies to see if they have the desired effect.

As the job progresses, the job hazard analysis will be revisited as part of the scheduled look ahead meeting where additional details may be added. This review will allow Supervision adequate time to acquire any required tools or equipment, meet training requirements, or prepare JHA.

Hazard assessments are reviewed with crews performing the work and serve as the basis for their pre-job meetings.

If, during the execution of the task, new hazards are found, the work must be stopped and reassessed and appropriate control measures found and adopted. For significant changes, these control measures must be documented in the build plan, and the crew must review the updated build plan and sign off again before work may resume.

JHAs are meant to be for specific tasks which are not performed regularly. Repetitive and routine tasks usually involve the use of safe work procedures. The JHAs which are instituted by the work group are reviewed and approved by FRA ESH Representatives. The workers then review the JHA and sign off on it. The crew's Field Level Risk Assessment (FLRA) should reflect the content of the JHA.

Thyssen Mining – Build Plan – Page 1

THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

Thyssen Mining
Build Plan

FSCF Excavation Project
Jha Template R1

Potential or Associated Hazards

☐ Hazardous Substances	☐ Ignition Source	☐ Hand/Finger injuries	☐ Hot Surfaces	☐ Simultaneous Operations (SIMOPS)
☐ Chemical Exposure	☐ Fire/Explosion	☐ Pinch Points	☐ Cold Surfaces	☐ Working at Height
☐ Hydrogen Sulfide (H2S)	☐ Arc Flash	☐ Power Hand Tools	☐ Insect / Animal Attack	☐ Working Alone
☐ Lead (Pb)	☐ Machinery/Moving Objects	☐ Chips / Particles	☐ Inadequate Lighting	☐ Adverse Weather
☐ Benzene	☐ Overhead Hazards	☐ Excavations	☐ Slippery Working or	☐ Additional Workers
☐ Mercury (Hg)	☐ Lifting Plan Required	☐ Hazardous Atmosphere	☐ Walking Surfaces	☐ Over-the-Side Work
☐ Radiation Work	☐ Pressure	☐ Confined Space	☐ Slips/Trips/Falls	☐ Diving Operations
☐ Environmental Impact	☐ Critical protection bypass	☐ Heat Stress	☐ Open Hole	☐ Others (specify)
☐ Loss of Containment (spill/release)	☐ Noisy Area		☐ Manual Handling	

Hazard Controls & Emergency Plans

Muster Point: _____ **Emergency Contacts:** _____

☐ Permit to Work (PTW)	☐ SDS	☐ LOTO	☐ Fire Fighting/ERT Standby	☐ Work Procedure
☐ Manual Handling Assessment	☐ Eyewash	☑ Ignition Source Controls	☑ Continuous Gas Testing	☐ Hot Boiling Procedure
☐ Scaffolding	☐ Emergency Shower	☐ Non Sparking Tool	☐ Emergency Evacuation Plan	☐ Buddy System
☐ PPE	☐ Spill Control Plan	☐ Rigging Assessment	☐ Temporary Lighting	☐ TP Review
☐ Physical Barriers	☐ Ventilation	☐ Stop Work Authority (SWA) Review		☐ Others (specify)

PPE & Safety Equipment Required

☑ Hard Hats w/ lanyard	☐ Proper Tools	☐ Radio Communication	☐ Tyvek Suit	☐ Safety Cable
☑ Safety Shoes	☑ Personal Gas Monitor	☐ Signs & Lights	☐ Chemical Suit	☐ Lock Out / Tag Out Devices
☑ Safety Glasses	☐ Cotton Gloves	☑ Mask	☐ Fire Extinguisher / Fire Hose	☐ Containment Pans
☐ Face Shield	☐ Cut level 4 gloves	☑ Respirator (cartridge)	☐ Fire Blankets / Retardant Tarps	☐ Absorbent Pads
☐ Goggles	☐ Rubber/Chemical Gloves	☐ Airline Respirator	☐ Full Body Harness	☐ Spill Kit
☑ Hearing Protection	☐ Caution Tape	☐ SCBA	☐ Double Lanyard with Shock Absorber	☐ Other(specify)
☐ Double Hearing Protection	☐ Safety Barricade	☐ Chemical Advisor	☐ Life Line	

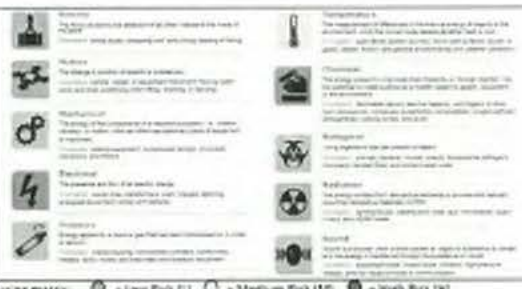
Thyssen Mining – Build Plan – Page 2

THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

Thyssen Mining
JHA for Build Plan

FSCF Excavation Project
Jha Template R1

Thyssen Mining
Job Hazard Analysis (JHA)

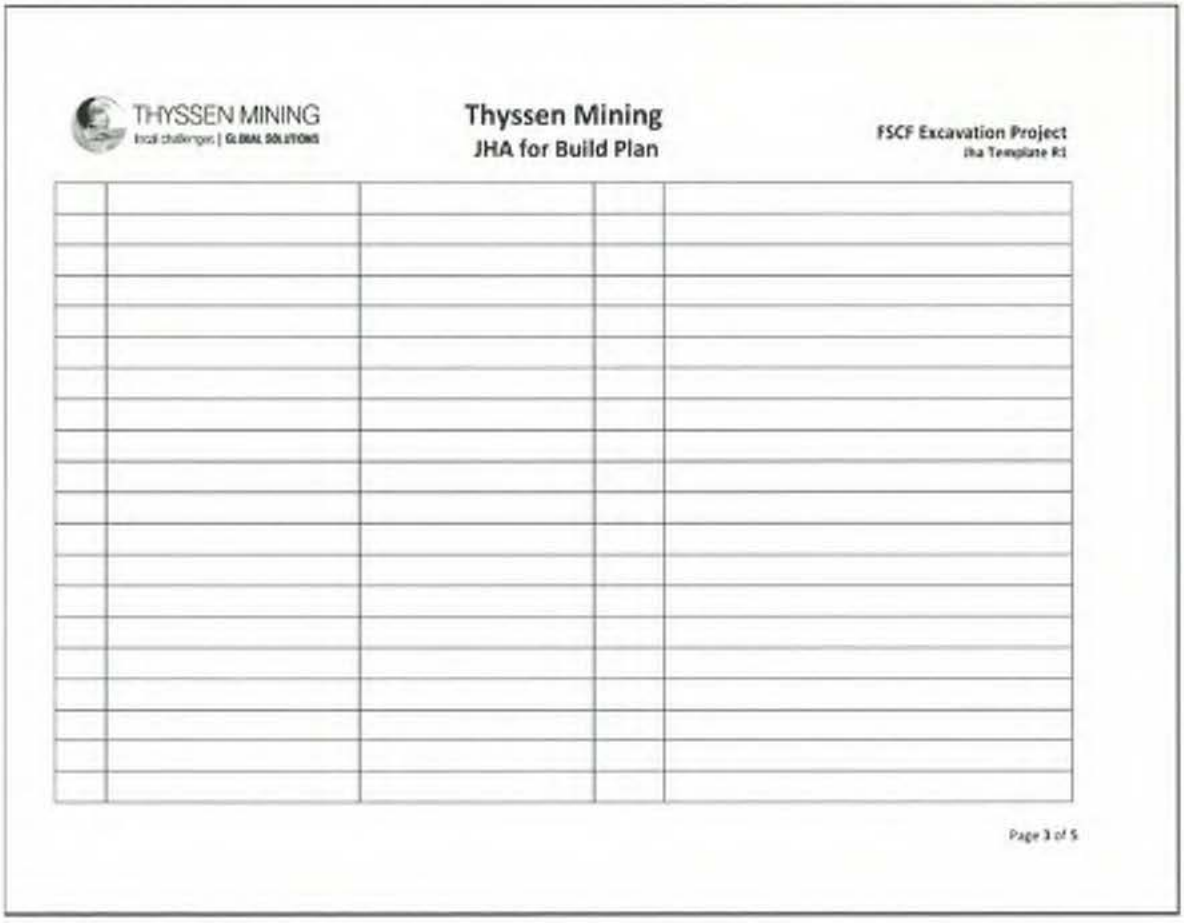


Risk Ranking is determined using matrix ● = Low Risk [L] ○ = Medium Risk [M] ● = High Risk [H]

Step #	*Basic Job Steps (tasks)*	*List the Hazards or Accidents Possible When Performing Each Task*	*Risk Ranking*	*List the Controls/Actions to Reduce or Eliminate the Hazards*

Page 2 of 5

Thyssen Mining – Build Plan – Page 3



THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

Thyssen Mining
JHA for Build Plan

FSCF Excavation Project
jha Template R1

Page 3 of 5

Thyssen Mining – JHA – Page 4

THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

Thyssen Mining
JHA for Build Plan

FSCF Excavation Project
Jha Template R1

Risk Assessment on Hazard Identification and Control List for JHA

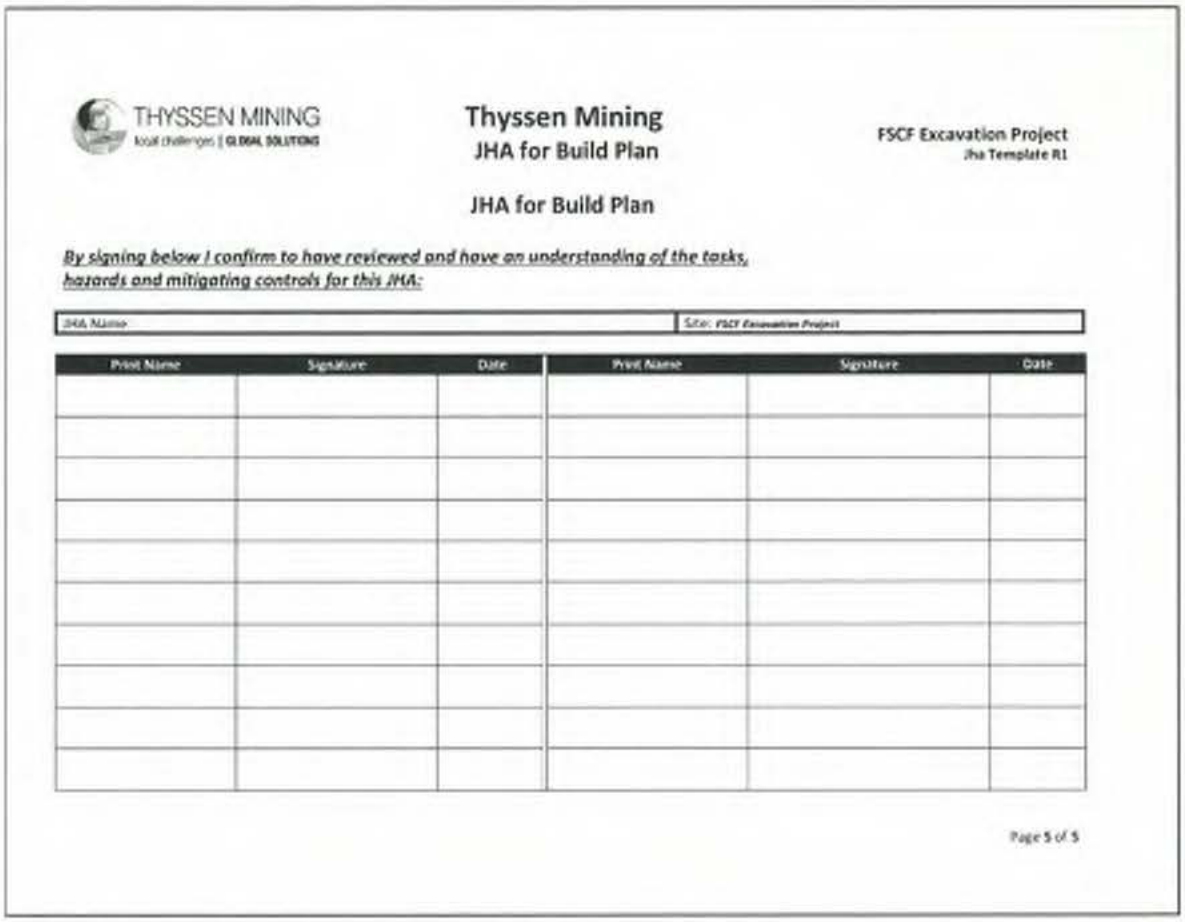
Job Title:	Site: FSCF Excavation Project		Date: Date:
Hazard Description (Basic job list steps)	*Current Risk Score of Identified Hazards Total*	*Reduced Risk Score if Controls are Implemented Total*	*Potential Risk Score Reduction*
Total Risk Score			

Divide the 'Total Potential Risk Score Reduction' by the 'Total Current Risk Score of Identified Hazards' and multiply by 100 to calculate the 'Percentage Risk Reduction' possible if all 'Controls' are implemented.

Potential Risk Reduction for the Controls in this JHA = xx%

Page 4 of 5

Thyssen Mining – JHA – Page 5



THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

Thyssen Mining
JHA for Build Plan

FSCF Excavation Project
Jha Template R1

JHA for Build Plan

By signing below I confirm to have reviewed and have an understanding of the tasks, hazards and mitigating controls for this JHA:

JHA Name	Site: FSCF Excavation Project

Print Name	Signature	Date	Print Name	Signature	Date

Page 5 of 5

6.5 Field Level Risk Assessments (FLRAs)

The Field Level Risk Assessments (FLRAs) are used by workers to recognize, evaluate and control hazards. The document used will be reviewed by supervisors, managers, safety personnel and others to ensure that the worker risk assessment strategy is having the desired effect of identifying and controlling hazards.

FLRAs shall be developed during the preparation phase for each definable feature of work. A FLRA is a procedure that integrates accepted health and safety principles and practices into a particular operation. In a FLRA, each basic step of the overall task is examined to identify potential hazards and to determine the safest way to do the job.

Four basic stages in conducting a FLRA are:

- Selecting the task to be analyzed
- Breaking the task down into a sequence of steps
- Identifying potential hazards

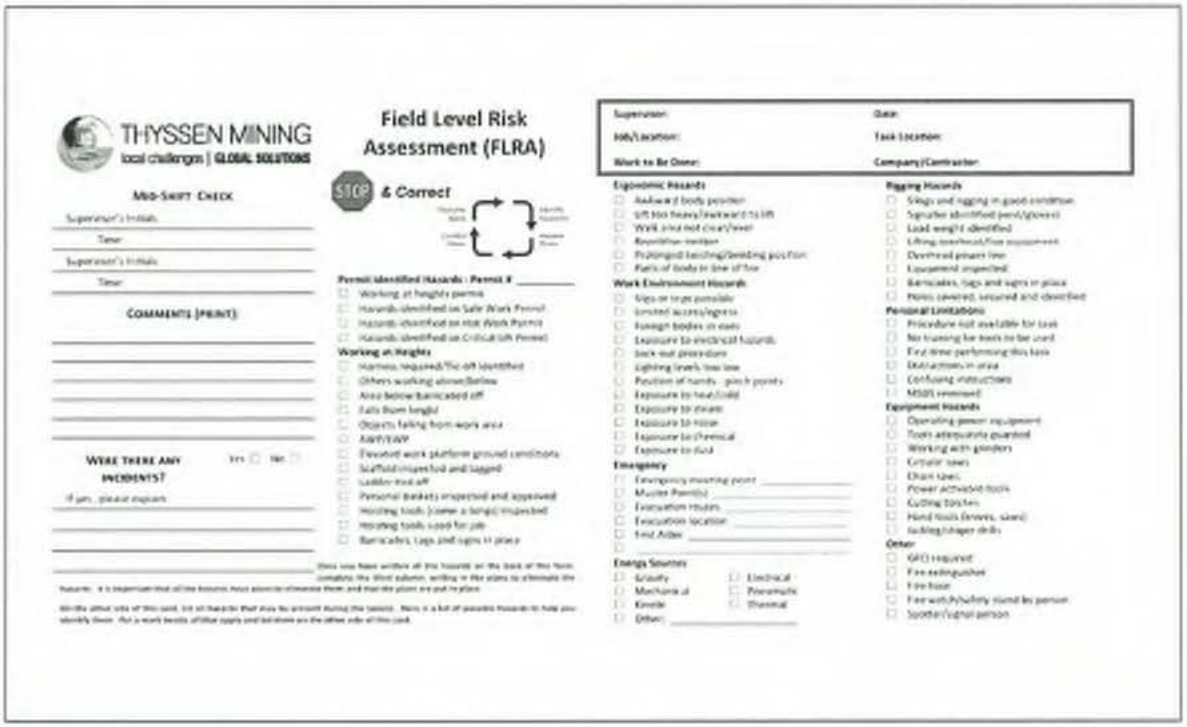
- Determining preventive measures to overcome these hazards

FLRA's are intended to be a starting point and must be reviewed and performed (modified as appropriate) by each crew prior to conducting the task. FLRAs are only good for the shift they are completed on. FLRAs are to be filled out when two (2) or more workers perform the same task together. As an individual joins the task being performed, the FLRA will be reviewed and signed by the new employee assisting in the task.

The FLRA process will identify previously undetected hazards and increase the job knowledge of those participating. Safety and health awareness is raised, communication between workers and supervisors is improved, and acceptance of safe work procedures is promoted.

The completed FLRA will be the basis for regular contact between supervisors and workers on health and safety. It will serve as a teaching aid for initial job training. The FLRA will also be used as a standard for health and safety observations and it will assist in completing comprehensive accident investigations.

All FLRA's will be documented and submitted to the Safety Department and will be maintained onsite.



THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

Field Level Risk Assessment (FLRA)

STOP & Correct

Mid-Shift Check

Supervisor's Initials
Time
Supervisor's Initials
Time

Comments (Print)

Were there any incidents?

Supervisor:
Date:
Job/Location:
Task Location:
Work to Be Done:
Company/Contractor:

Ergonomic Hazards
Awkward body position
Lift too heavy/awkward to lift
Work area not clear/level
Repetitive motion
Prolonged bending/kneeling position
Parts of body in line of fire

Work Environment Hazards
Slips or trips possible
Limited access/egress
Foreign bodies in eyes
Exposure to electrical hazards
Lock-out procedure
Lighting levels too low
Position of hands - pinch points
Exposure to heat/cold
Exposure to steam
Exposure to noise
Exposure to chemical
Exposure to dust

Emergency
Emergency meeting point
Muster Point(s)
Evacuation routes
Evacuation location
First Aider

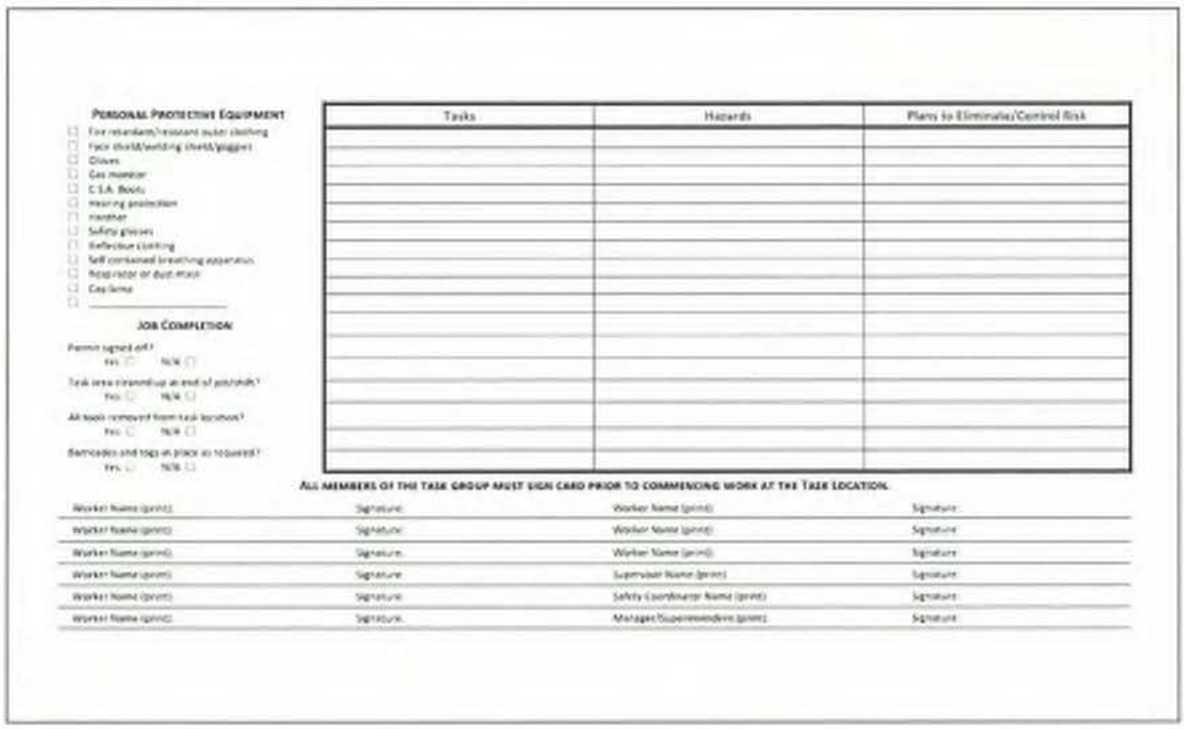
Energy Sources
Gravity
Electrical
Mechanical
Pneumatic
Kinetic
Thermal
Other:

Rigging Hazards
Slings and rigging in good condition
Signaller identified (vest/gloves)
Load weight identified
Lifting overhead/line assessment
Overhead power line
Equipment inspected
Barricades, tags and signs in place
Holes covered, secured and identified

Personal Limitations
Procedure not available for task
No training for tools to be used
First time performing this task
Distractions in area
Confusing instructions
MSDS reviewed

Equipment Hazards
Operating power equipment
Tools adequately guarded
Working with grinders
Circular saws
Chain saws
Power activated tools
Cutting torches
Hand tools (knives, saws)
Jacking/shaper drills

Other
SPO required
Fire extinguisher
Fire hose
Fire watch/safety stand by person
Spotter/signal person



PERSONAL PROTECTIVE EQUIPMENT

- ☐ Fire retardant/resistant outer clothing
- ☐ Face shield/welding shield/goggles
- ☐ Gloves
- ☐ Gas monitor
- ☐ C.S.A. Boots
- ☐ Hearing protection
- ☐ Hardhat
- ☐ Safety glasses
- ☐ Reflective clothing
- ☐ Self contained breathing apparatus
- ☐ Respirator or dust mask
- ☐ Coveralls
- ☐ _____

JOB COMPLETION

Permit signed off?
Yes ☐ N/A ☐

Task area cleaned up at end of job/shift?
Yes ☐ N/A ☐

All tools removed from task location?
Yes ☐ N/A ☐

Barricades and tags in place as required?
Yes ☐ N/A ☐

Tasks	Hazards	Plans to Eliminate/Control Risk

ALL MEMBERS OF THE TASK GROUP MUST SIGN CARD PRIOR TO COMMENCING WORK AT THE TASK LOCATION.

Worker Name (print)	Signature	Worker Name (print)	Signature
Worker Name (print)	Signature	Worker Name (print)	Signature
Worker Name (print)	Signature	Worker Name (print)	Signature
Worker Name (print)	Signature	Supervisor Name (print)	Signature
Worker Name (print)	Signature	Safety Coordinator Name (print)	Signature
Worker Name (print)	Signature	Manager/Superintendent (print)	Signature

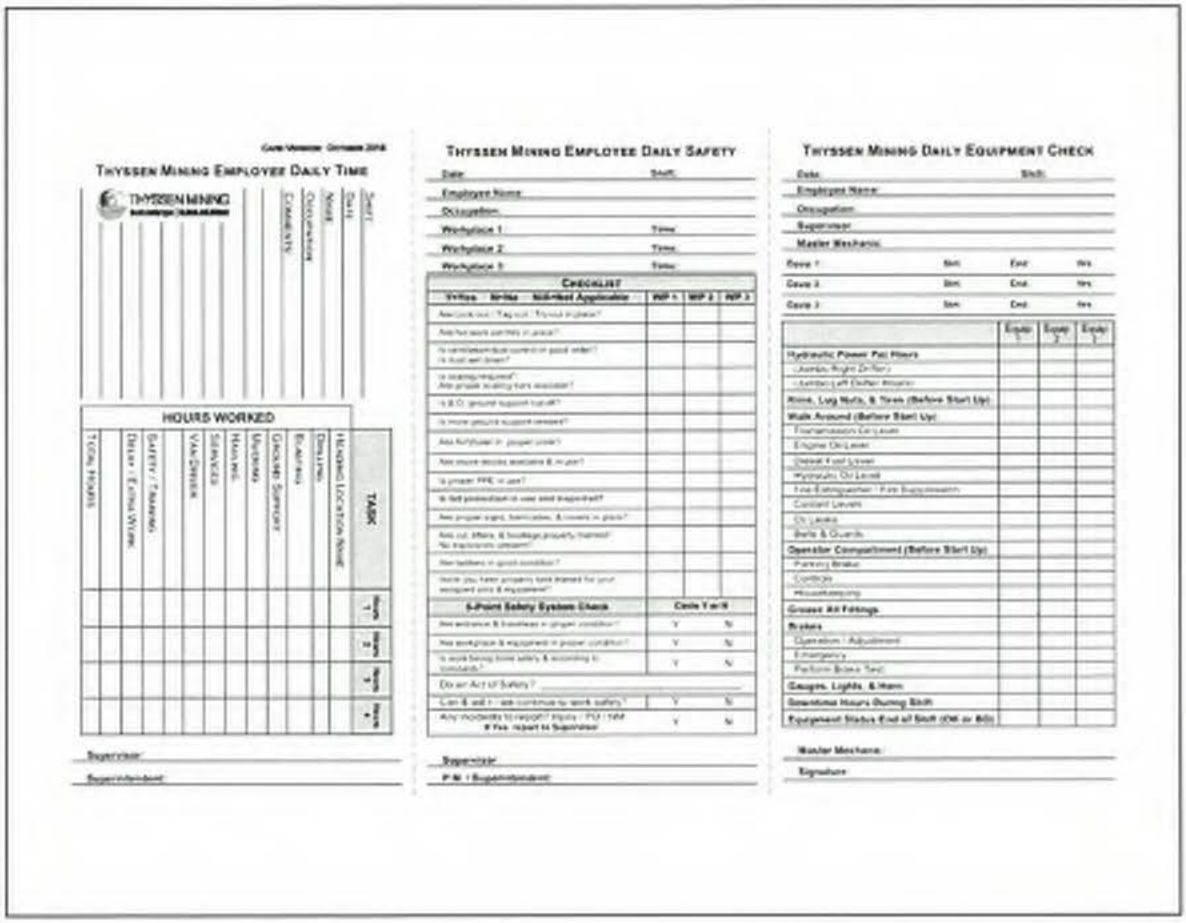
6.6 5-Point Inspection Card

Steps to properly complete a 5-Point Inspection Card are as follow:

1. Check entrance and travelway to workplace. Enroute to their workplace, workers inspect the entrance and travelway for unsafe conditions. Any problems are either corrected immediately or reported. When the supervisor arrives he or she checks the entrance and travelway again.
2. Are workplace and equipment in good working order? Before starting to work, workers will check their workplace for unsafe conditions, and their equipment to ensure it's in good working order. Substandard conditions are corrected immediately. The supervisor checks again to confirm that workers have corrected any problems.
3. Are employees working properly? Workers determine whether they are using the proper job procedures or practices, and the proper tools and equipment. They ask themselves whether they are putting themselves or their co-workers needlessly at risk. The supervisor is responsible for checking the work methods, procedures and equipment.
4. Do an act of safety. When the supervisor arrives, he or she and the workers discuss a safety topic, such as a specific hazard, work procedure, or company policy.

5. Can and will employees continue to work properly? Workers determine whether they have the knowledge, skill, and motivation to continue to work safely. They also determine whether the condition of equipment and materials will allow safe operation throughout the shift. This is confirmed by the supervisor before he or she leaves.

If each step is followed carefully, the 5-Point Safety System can become a habit for both workers and supervisors. It's a simple approach, but it can go a long way toward preventing many needless accidents in all industries.



THYSSEN MINING EMPLOYEE DAILY TIME

THYSSEN MINING

HOURS WORKED

TOTAL HOURS | DELAY / EXTRA WORK | SAFETY / TRAINING | VAN DRIVER | SERVICE | MAINTENANCE | MACHINE | CHECKING / SUPPORT | BLASTING | DRILLING | WORKING LOCATION / MINE | TASK

Supervisor

Superintendent

THYSSEN MINING EMPLOYEE DAILY SAFETY

Date | Shift

Employee Name

Occupation

Workplace 1 | Time

Workplace 2 | Time

Workplace 3 | Time

CHECKLIST

Workplace | Workplace | Task/Hazard Application | WP 1 | WP 2 | WP 3

5-Point Safety System Check | Circle Y or N

Do an Act of Safety?

Supervisor

P.M. / Superintendent

THYSSEN MINING DAILY EQUIPMENT CHECK

Date | Shift

Employee Name

Occupation

Supervisor

Master Mechanic

Hydraulic Power Pac Hours

Rims, Lug Nuts, & Tires (Before Start Up)

Walk Around (Before Start Up)

Operator Compartment (Before Start Up)

Grease All Fittings

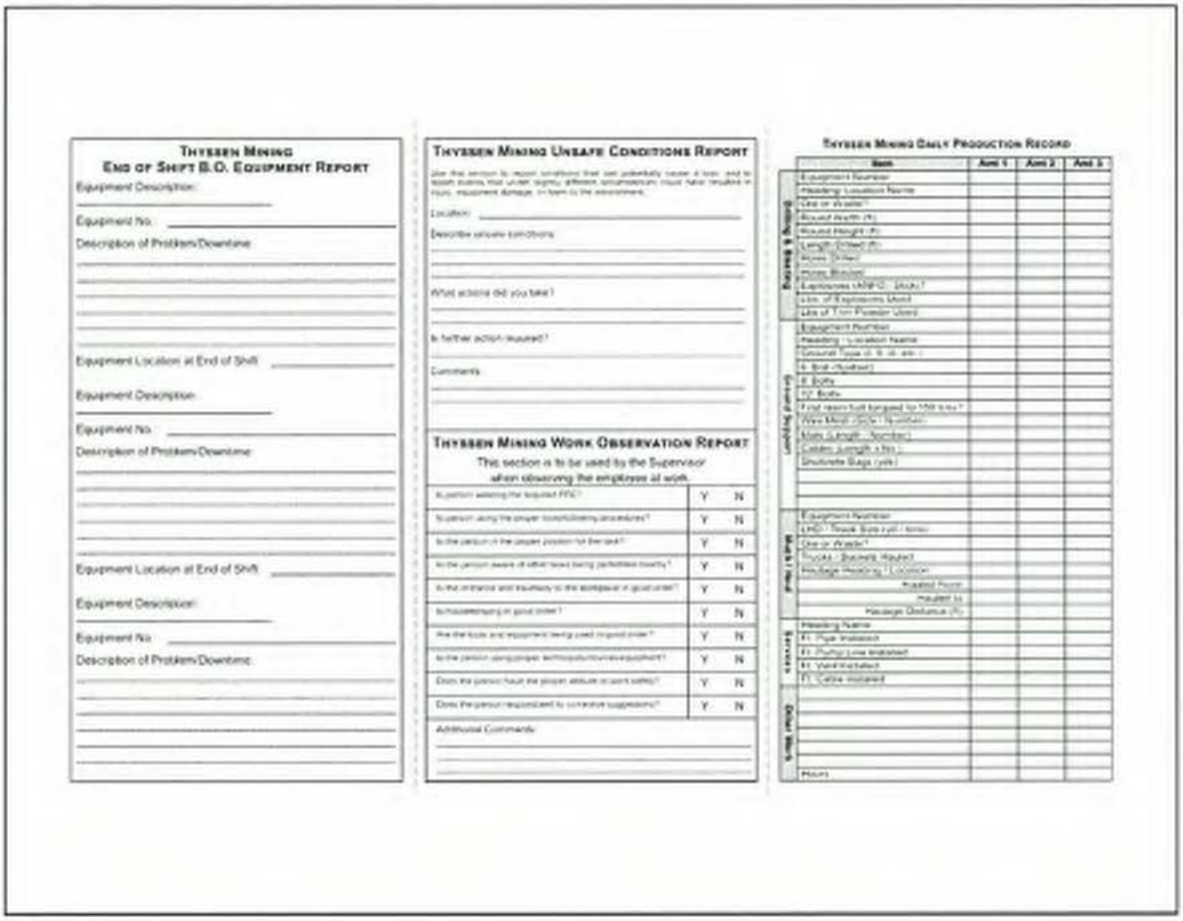
Brakes

Gauges, Lights, & Horn

Downtime Hours During Shift

Master Mechanic

Signature



THYSSEN MINING
END OF SHIFT B.O. EQUIPMENT REPORT

Equipment Description:
Equipment No.
Description of Problem/Downtime:
Equipment Location at End of Shift
Equipment Description:
Equipment No.
Description of Problem/Downtime:
Equipment Location at End of Shift
Equipment Description:
Equipment No.
Description of Problem/Downtime:

THYSSEN MINING UNSAFE CONDITIONS REPORT

Location:
Describe unsafe conditions:
What action did you take?
Is further action required?
Comments:

THYSSEN MINING WORK OBSERVATION REPORT

This section is to be used by the Supervisor when observing the employees at work.

Is person wearing the required PPE?	Y	N
Is person using the proper tools/following procedures?	Y	N
Is the person in the proper position for the task?	Y	N
Is the person aware of other tasks being performed nearby?	Y	N
Is the entrance and roadway to the workplace in good order?	Y	N
Is housekeeping in good order?	Y	N
Are the tools and equipment being used in good order?	Y	N
Is the person using proper techniques/tools/equipment?	Y	N
Does the person have the proper attitude to work safely?	Y	N
Does the person respond to corrective suggestions?	Y	N

Additional Comments:

THYSSEN MINING DAILY PRODUCTION RECORD

Item	Amt 1	Amt 2	Amt 3
Drilling & Blasting			
Equipment Number			
Heading Location Name			
Use or Waste?			
Round Width (ft)			
Round Height (ft)			
Length Drilled (ft)			
Holes Drilled			
Holes Blasted			
Explosives UNFO - (Kgs)?			
Lbs. of Explosives Used			
Lbs of T'ton Powder Used			
General Support			
Equipment Number			
Heading / Location Name			
Ground Type (I, II, III, etc.)			
6' Bolt (Number)			
8' Bolts			
10' Bolts			
First resin bolt longest for the day?			
Wire Mesh (Size / Number)			
Mats (Length - Number)			
Cables (Length x No.)			
Shotcrete Bags (yds)			
Muck & Haul			
Equipment Number			
LHD / Truck Size (yd / tons)			
Use or Waste?			
Trucks - Buckets Hauled			
Haulage Heading / Location			
Hauled From			
Hauled to			
Haulage Distance (ft)			
Services			
Heading Name			
#1 Pipe Installed			
#1 Pump Line Installed			
#1 Vent Installed			
#1 Cable Installed			
Other Items			
Hours			

6.7 Brother's Keeper

Thyssen Mining has collectively shown that a zero harm culture is not only possible but achievable as well. As a company Thyssen Mining has shown that we understand the rules and the importance of working safely. The next difficult step is broadening our view to not just what we personally do to work safely but what our coworkers and others do to in effect become "Our Brother's Keeper". This is the next step in Thyssen's safety culture. Achieving a goal is one thing, maintaining performance is another.

The Two Uses of the Cards:

1. Peer Interaction: Recognition
    a. Catch someone doing something right.
    b. If we always stress the negative, then it may generate negative performance.
    c. It is just as important to recognize good behaviors as it is to point out bad ones.
    d. It is important to communicate the message that doing things right is the goal, not just getting it done.

e. Demonstrates that doing it safely is an achievable goal.

2. Peer Interaction: Coaching (Close Call)
   a. About building a safety culture.
   b. Supervisors and management can't be everywhere; we need to look out for each other.
   c. Peers or coworkers are motivated out of genuine concern.
   d. Supervisors have a higher level of response if it's a Mission Zero rule, obligated to take firm strong action.
   e. Everyone has a legal and moral duty to correct/report an unsafe situation and not ignore it.

MY BROTHER'S KEEPER
CONTINUOUS IMPROVEMENT - *ONE DAY AT A TIME ...*

Name: _____ (optional) Location: _____ Date: _____
Supervisor: _____

HAZARD IDENTIFICATION / CONTINUOUS IMPROVEMENT SUGGESTION / POSITIVE RECOGNITION

☐ HAZARD IDENTIFICATION ☐ CONTINUOUS IMPROVEMENT ☐ POSITIVE RECOGNITION

Hazard Description: _____

Hazard Class Action:	A STOP & CORRECT	☐	B 24 hrs	☐	C 48 hrs	☐	D > 7 days	☐

What action has been taken to control or eliminate the hazard? _____

Action Required: _____

Suggestion for Improvement: _____

Positive Recognition: _____

Individual Recognized: _____ By: _____

Responsible Supervisor: _____

RUSHING FRUSTRATION FATIGUE COMPLACENCY ⟸ *STATES* ☑*SAFESTART* *ERRORS* ⟹ *EYES NOT ON TASK MIND NOT ON TASK LINE-OF-FIRE BALANCE TRACTION GRIP*

ACTION MANAGEMENT & RESPONSIBILITY

HAZARD IDENTIFICATION / CONTINUOUS IMPROVEMENT SUGGESTION / POSITIVE RECOGNITION

ACTION REQUIRED: _____

ACTION TAKEN: _____

Action owner: _____ Date to be completed: _____

ACTION COMPLETED BY: _____

I Authorize this action is complete (Supervisor/Superintendent): _____

Date Action Completed: _____

Worker Comments: _____

Supervisor/Supintendent Comments: _____

Additional Notes: _____

CA # _____

6.8 Permit to Work System

Thyssen Mining utilizes various different work permits that are applicable to specific tasks.

These permits include but are not limited to:

- Excavation Permit
- Hot Work Permit
  - All hot work underground will be communicated to the hoistman at the start of shift or as soon as the need for the hot work is to be performed during shift as this will help prepare the hoistman if someone reports smelling smoke underground.
- Working at Heights Permit
- Confined Space Permit
- Critical Lift Permit

- Lock Out Tag Out Permit
- Blasting Permit

High Hazard Permits

Additional high risk work (or high hazard work) permits may require written Thyssen Mining Safety Management acceptance for the following activities at this site:

- Excavations deeper than 4 feet (that have the potential to contact underground utilities or obstructions, or have the potential for a hazardous atmosphere).
- Excavation or drilling within 10 feet of a buried high pressure line: gas, steam, water, etc.
- Excavation or drilling within 3 feet of a buried active product line or active electrical line.
- Work involving equipment (such as a pulling unit, mast truck, backhoe or excavator) within 15 feet of active overhead electrical line or pole supporting an electric line.
- Over water work (includes dredging).
- Demolition/removal of pipelines and buried structures.
- Demolition of above ground structures.
- Energized electrical work

6.9 Daily Toolbox Meeting

The next step in the hazard control process is the daily meeting that will be held the day the work is conducted. These will be forwarded to the Safety Department daily. Led by the supervisor, the discussion will include:

- Identification of tasks being performed
- Identification of the hazards associated with work tasks that shift
- Procedures for risk assessment
- Procedures for controlling hazards to an acceptable level of risk
- Build Plans, JHA, Blast Permits, and SDSTA's Trip Action Plan (TAP)
- Toolbox meetings must be documented to identify the tasks, issues reviewed/identified and participants

6.10 Pre-Shift Exercise Routine

Each crew member will conduct a Pre-Shift Exercise Routine (see next page):

THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

PRE- SHIFT EXERCISE ROUTINE

Traditionally, athletes all warm up and stretch out before they start a game.

We are adopting this same sports medicine principle.

Warming up before any activity helps prevent muscle strains and it gets us ready to meet the demand of our daily activities, on and off the job.

Performing simple stretching and warm-up exercises before we start our work day is an easy and effective way to reduce our risks of developing strains.

Before starting our work day, let's take a few minutes to stretch our muscles and get ourselves warmed up in preparation for our daily tasks.

Please follow along as a team....

Have A Safe Productive Shift!

THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

Stretching Exercises

- **3 DEEP BREATHS** – *(Stand Tall)*
- **NECK ROLLS** – *(5 Side TO Side)*
- **EAR TO SHOULDER RT & LEFT** – *(Hold 5 sec. each)*
- **CHIN TO CHEST / CHIN TO CEILING** – *(Hold 5 sec. Each)*
- **SHOULDER ROLLS** – *(5 Back & 5 Front)*
- **ARM ACROSS BODY RT & LT** – *(Hold 5 sec. Each)*
- **STRETCH TO CEILING** – *(Hold 5 sec)*
- **LOWER BACK STRETCH** – *(Hands On Lower Back & Look To Ceiling)*
- **REACH FOR FLOOR** – *(Hold 5 sec)*
- **WAIST STRETCH** – *(Side To Side 4X – Hold for 5 sec. each side)*

Note: On these next sets of stretches hold onto something solid for support.

- **QUADRICEP STRETCH** – *(Hold for 5 sec. each leg)*
- **HAMSTRING STRETCH** – *(Hold 5 sec. Each leg)*
- **CALF STRETCH** – *(Stand on tip toes, Hold 5 Sec)*
- **STAND ON HEELS** – *(Pull Toes Up And Hold 5 sec)*
- **3 DEEP BREATHS**.....

Have A Safe Productive Shift!

6.11 Compliance Monitoring

The following criteria must be met by supervisors and safety personnel for compliance monitoring:

- Monitor compliance to established work procedures and any RAor JHAs
- Evaluate quality of RA, JHAs, or FLRAs, and any other safety documentation submitted by Thyssen Mining personnel or subcontractors
- Subcontractor area / work package hazard assessments
- Verify pre-job and JHA meetings, provide feedback to Supervisor and crew respectively on ways and means to improve
- Measure quality and quantity of pre-job and JHA documents submitted
- Field verification of compliance to permit system

Risk Assessment of Plant and Equipment

All existing structures, plant and equipment must be assessed for hazards following prolonged absence or after having been relocated.

Thyssen Mining and subcontractors must supply the tools to perform the work on the project and to maintain the tools in a state of good repair and condition.

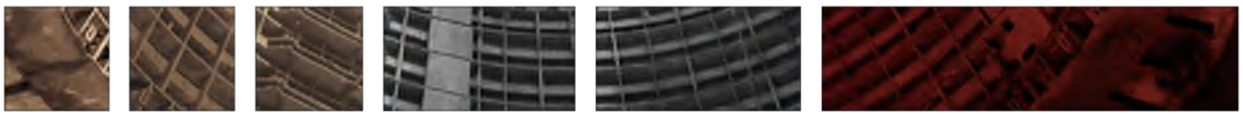
All plant, equipment, power and hand tools brought on site by Thyssen Mining and subcontractors shall be:

- Appropriate for the type of work to be performed.
- Approved, inspected, tested numbered and tagged (as required) before being brought on site.
- Logged as they are brought on site.
- Properly maintained in accordance with the manufacturer's instructions;
- Placed on a log sheet and checked at least monthly or more frequently as required by legislation or FRA procedures.

  Note:

  - Side handles must be utilized when a power tool is provided with one.
  - Trigger locks on tools are not permitted.
  - Guards on tools and machinery must be used (e.g. grinder or saw cutting guards) (Appendix 23-TM-SOP-11105-FSCF-Machine Guarding).
  - Telehandler baskets do not need to have controls as long as there is an operator in the telehandler at all times. The basket will also need to be engineered, certified, and mechanically fixed to the telehandler.

Appendix J - TMI SOP 17001 FSCF Industrial Hygiene Plan



THYSSEN MINING

local challenges | GLOBAL SOLUTIONS

Industrial Hygiene Plan

ORIGINATOR		
Name	**Signature**	**Date**
Jim Brown	Jim Brown	02/12/2021

DISCLAIMER

Thyssen Mining is constantly engaged in developing best practices related to Safety, Engineering and Methodology; accordingly, Thyssen Mining reserves the right to modify the document contained herein at any time.

All technical data, specifications and other information contained within this document are deemed to be the intellectual property of Thyssen Mining.

Industrial Hygiene Plan

1.0 PURPOSE

The purpose of this Process is to identify, minimize and control risks posed to workers by contaminants in the workplace, and ensure Industrial Hygiene monitoring is performed in accordance with national and industry standards.

2.0 SCOPE

This process applies to air, sound, and other samples collected by the Safety Coordinator for the purpose of protecting the health of Thyssen employees. The scope of this process includes:

2.1 Identification and assessment of potential workplace exposures;

2.2 Identification of engineering administrative and control measures;

2.3 Evaluation of potential exposure related health effects;

3.0 DEFINITIONS

TLV shift length adjustment

The ACGIH TLV guidelines (3.0 ppm 2005 and 0.2 ppm 2016) are based on an 8-hour workday. As TMI intends to work a 10-hour workday, these TLV must be shift adjusted. ACGIH recommends the use of the Brief and Scala Model, which is outlined below.

Adjusted TLV = Reduction Factor x TLV

Reduction Factor = (8 / daily hours worked) x ((24 - daily hours worked) / 16)

Reduction Factor (ten hour shift) = ((8 / 10) x (24 - 10) / 16)

Reduction Factor (ten hour shift) = 0.7

Therefore the 3.0 ppm and 0.2 ppm TLVs would be adjusted to 2.1 ppm and 0.14ppm respectively.

4.0 RESPONSIBILITIES

4.1 Safety Department:

4.1.1 Develop an Exposure Profile and Annual Exposure Monitoring Plan for the Thyssen Mining project/site.

4.1.2 Conduct and prepare the Exposure and Risk Assessment Report

4.1.3 Will notify employees of their IH monitoring results

4.1.4 Will evaluate the sampling results and make recommendations for further action as appropriate

4.2 Sampled Employees:

4.2.1 Employees must wear the sampling equipment as directed. The sampling media must not be tampered with or placed in an area or position that may cause a non-representative result.

5.0 PROCESS

5.1 Industrial Hygiene Risk Assessment Strategy

5.1.1 Thyssen Mining is committed to controlling exposures to chemical and physical hazards within recommended exposure guidelines or consensus standards through the development and implementation of exposure assessment strategies.

5.1.2 The overall approach links job hazard analysis (JHAs) job safety analysis (JSA), exposure assessment, and medical surveillance with prevention and control to reduce the risk of exposure and prevent adverse health effects. The Industrial Hygiene/Safety group uses pre-established and approved methods and rationale to characterize and monitor workers' potential exposures to chemical and physical hazards. The exposure assessment strategy applies to all activities (including design, construction, operation, maintenance, decontamination, decommissioning, and environmental restoration activities) performed by Thyssen Mining Personnel.

5.1.3 The goal of Thyssen Mining's exposure assessment strategy is to protect workers by controlling exposures to less than the American Conference of Governmental Industrial Hygienists (ACGIH 2016) threshold limit

values (TLVs) or OSHA PEL's, whichever is applicable to the contaminant. If both ACGIH 2016 and OSHA have contaminant values, the lower value will be used.

5.1.4 The Safety department performs risk-based evaluations of new or modified processes involving chemical and physical hazards as part of baseline exposure assessments.

5.1.5 The Safety department may review JHA's and JSA's in conjunction with baseline assessments to ensure accuracy and thoroughness.

5.1.6 The Safety Department will consider the following parameters during a risk-based industrial hygiene assessment:

a) Toxicity, Corrosively, Reactivity, Flammability

b) Quantity and form of use

c) Duration of Use

d) Past monitoring data

e) Established occupational models

f) Employee input such as expressed concern or presence of odor

g) Professional judgment and experience

5.2 Qualitative Exposure Assessments

5.2.1 Considerations

Qualitative exposure assessment is an integral part of job hazard analysis and work planning processes. This process is conducted by the Safety Department. The qualitative exposure assessment includes an evaluation of potential exposures via inhalation, ingestion, dermal contact, physiological interactions, and ergonomic factors. The predominant exposure determinants and events (such as frequency, magnitude, and variability of exposure and tasks; route of exposure; potentials for short-duration tasks and exposures [acute] and long-term or frequently repeated tasks and exposures [chronic]; and the adequacy and potential for failure of engineering and work practice controls) should be considered and documented as a part of the qualitative exposure assessment.

5.2.2 Minor or No Risk of Exposure

If the qualitative exposure assessment indicates a minor or no risk of exposure,

no further action (such as quantitative monitoring or the implementation of prevention and control measures) is required.

5.2.3 Recognition of Employee Exposure above Occupational Exposure Limits

It is the goal of Thyssen Mining that employee exposure to chemical or physical stressors are controlled and limited to safe levels as identified by regulatory requirements and industry accepted practices.

No employee shall be knowingly exposed to chemical or physical stressors exceeding the occupational exposure limit without proper controls in place that protect the employee.

Should an occupational over exposure to a chemical or physical stressor occur the following steps must be taken:

a) The Safety Department will notify the Employee within 15 days if there has been an overexposure identified in the sampled results. All Employees who have been sampled may request to see their sampling results at any time.

b) The incident is to be evaluated to determine if an investigation is to be conducted.

c) Follow site's guidelines for this determination. The investigation may identify the need for a Risk Assessment Strategy to be developed and executed. For unacceptable exposure risk, or if exposure risk is uncertain, a quantitative exposure assessment is required, and implementation of prevention and control methods may be recommended.

5.2.4 Periodic Reassessment

The Thyssen Mining Safety Department will conduct risk-based qualitative reassessments of existing operations at Thyssen Mining on a biannual basis, so that each work area will be re-evaluated at least twice a year.

5.3 Quantitative Exposure Assessment

The Safety Department performs surveys to assess potential employee exposures to hazardous materials and contaminants in the workplace. Hazard evaluation surveys often include some type of monitoring, such as air or wipe sampling, to measure the amount or concentration of the hazards. Monitoring will be performed in accordance with the standards of the ACGIH 2016 and OSHA.

5.3.1 Types of Monitoring

a) *Personal Air Sampling*

Personal Air Sampling may be used to measure personnel exposure to airborne contaminants. Workplace air is sampled over the full work shift and is representative of the individual's breathing zone. In some cases standards require 15 minute samples or short term exposure limits. The Safety Department will observe and record general information about personnel work processes. When Personal Sampling is conducted the following forms are to be completed:

- Industrial Hygiene Sampling Data Sheet
- Employee Monitoring Log
- TMI will draft and submit to FRA ESH a weekly summary report outlining all sampling activities as well as all sampling results from the week. The report will outline all alarm events and list any mitigating actions employed to reduce exposures prior to resuming operations in the area of the alarm. FRA ESH will review the weekly reports and submit them to Fermilab's industrial hygiene section for review and comment.

b) *Personal NO_2 Sampling*

- Real Time Personal Exposure Monitoring

  Personnel operating loaders will wear real time multi-gas monitors in their breathing zone. These gas monitors will be supplied by TMI and will be either Industrial Scientific iBrid MX6 units or Industrial Scientific Ventis MX4 units, both configured to monitor NO_2 levels, with an accuracy of a tenth of a part per million (0.1 ppm). Personnel being monitored shall be required to wear the multi-gas monitor for the duration of their shift.

  Prior to the approval of the NO_2 abatement plan, these units will be set to alarm should a monitor register a reading of 0.2 NO_2 or greater (equipment limitation). After the abatement plan is approved, these monitors will be configured to alarm should a monitor register a reading of 2.1 ppm NO_2 or greater.

  Should a monitor go into an alarm state, the operator will be required to withdraw from the heading and contact their TMI ESH representative immediately. Work will not resume in the heading until the event has been investigated by the TMI ESH representative. TMI ESH will maintain 24-hour presence in the underground mine.

  These gas monitors will be collected at end of shift and taken back to surface for the downloading of data into the TMI database. The data will be examined to determine whether the shift exposure

exceeded the set exposure limit (0.14 ppm NO_2 prior to abatement plan approval, and 2.1 ppm NO_2 after abatement plan approval) averaged over the duration of the shift. Should data from a gas monitor indicate that the average exposure over the shift exceeded the set limit, then FRA ESH shall be notified immediately, and work performed in the area sampled will be halted. Such an event shall be considered a reportable event. An investigation will then be required to determine the cause of the exceedance.

- Real Time Investigation And Mitigation Of Levels Exceeding Set Limits

  Once notified that a monitor has gone into alarm, the TMI safety representative will proceed to meet with the operator involved and to perform an investigation to determine the cause of the elevated exposure. The ESH representative will work with the operator and the TMI shift supervisor to implement any necessary mitigation measures to bring NO_2 levels back below the alarm limit. The ESH representative will record the date, time, location, contaminant reading, and operator name for the event, and these will be entered at the end of shift into a central database that TMI will maintain on surface. This database will allow for tracking of alarm events over time.

- Real Time Reporting Of Levels Exceeding Set Limits

  Once notified of a gas monitor alarm event, the TMI ESH representative will have one hour to report the event to FRA. These events shall be reported to the FRA construction coordinator who will pass the notification on to FRA ESH via email by the end of the shift.

- NO_2 TLV Shift Exposure Monitoring

  Personnel operating loaders will also be required to wear a ChemDisk NO_2 monitor badge (Item #594AT) which will be worn in their breathing zone opposite the multi-gas monitor that they will also be wearing (see above). The monitor badges will be worn for the duration of the shift. The monitor badges are accurate to 0.01 ppm NO_2. These badges will be collected by TMI ESH at the end of the shift and packaged for shipment to the AT Labs laboratory in Boardman, Ohio for analysis. If an operator's multi-gas monitor has not alarmed during the shift, then the monitor badge will be shipped per usual to the laboratory, and results would be available within 10-14 days. If an operator's multi-gas monitor has alarmed during the shift, then the monitor badge will be shipped to the laboratory for expedited analysis, and results would be available in 4-6 days.

Should the results of a monitor badge indicate that an employee was exposed to NO_2 in exceedance of the set limit over the duration of the shift (0.14 ppm prior to abatement plan approval and 2.1 ppm after abatement plan approval), then FRA ESH shall be notified immediately. Such an event shall be considered a reportable event. An investigation will then be required to determine the cause of the exceedance.

TMI will also identify other personnel, minimum one per shift, who will be assigned to wear NO_2 monitor badges while performing tasks other than mucking. This monitoring will be performed to assess background NO_2 levels in the other work areas in the project space.

c) *Area Air Sampling*

- The Safety Department will use area air sampling to define the extent of exposure or to measure the effectiveness of engineering controls. During mucking operations, the air sampler shall be placed on the Rib 50' to 75' away from the muck pile. During other operations the sampler shall be placed in a fixed location in the work area or near the suspected source of the hazard. Note: Breathing zone sampling is a better measure of effectiveness.
- Area NO_2 Exposure Monitoring

  Area sampling will also be performed in the headings where loaders are operating to remove blasted rock from the face. This area sampling will be performed utilizing either Industrial Scientific iBrid MX6 units or Industrial Scientific Ventis MX4 units, and these units will be hung some 50-75 feet from the muck pile. These units will be hung by the TMI ESH representatives, and shall be hung such that the monitors are:

  - Positioned without obstruction so that general conditions in the heading may be monitored
  - Positioned in locations that do not expose the monitors to unnecessary risk of damage
  - Positioned out of the path of the direct exhaust stream being emitted from the loader (so as not to skew the data set by exposing the monitors to undiluted equipment exhaust)

  These gas monitors will be collected at end of shift and taken back to surface for the downloading of data into the TMI database. The data will be examined to determine whether the shift exposure exceeded the set exposure limit (0.2 ppm (equipment limitation) NO_2 prior to abatement plan approval, and 2.1 ppm NO_2 after abatement plan approval) over the duration of the shift. Should data from a

gas monitor indicate that the average exposure over the shift exceeded the set limit, then FRA ESH shall be notified immediately, and work performed in the area sampled will be halted. Such an event shall be considered a reportable event. An investigation will then be required to determine the cause of the exceedance.

d) *Wipe Sampling*

The Safety Department may use wipe sampling to measure surface contamination for selected materials.

5.4 Job Rotation Strategies (if required)

Should monitoring results indicate that personnel are working near or just above the set exposure limits, TMI and FRA ESH will investigate the applicability of job rotation strategies to limit exposures to workers. Such rotation strategies would be closely monitored. All personnel involved in a job rotation for the purposes of limiting exposures shall wear the applicable monitoring equipment throughout the length of their shift and personnel shall not share these devices.

5.5 TMI shall meet the following requirements to comply with this Industrial Hygiene Process:

5.5.1 Develop an Exposure Profile and Annual Exposure Monitoring Plan for the Thyssen Mining Project/Site. Exposure profiles shall be reviewed at least once per year, and updated whenever changes in equipment, processes or environmental agents are made in the workplace.

5.5.2 Conduct and prepare an Exposure and Risk Assessment Report and issue a written report every year discussing the results of the assessment and any required actions (See Appendix 2).

5.5.3 Follow the hierarchy of controls when selecting and implementing exposure prevention and control methods.

5.5 The Safety Department shall determine the reason for sampling and complete the Workplace Exposure Monitoring Record (Attachment 7.1) properly identifying the badge number and sample number for each employee.

Lab Details:

- ALS Environmental Laboratory
  Salt Lake City 801-266-7700
  Jessica.Helland@alsglobal.com
  - Analytical request form has been received for test collection data and chain of custody requirements

5.6 The Safety Department will analyze the sampling results to determine if they are valid. Shift adjustment shall be made between these steps for TLV comparison and OSHA HCS comparison. Brief and Scala model.

5.7 When results exceed the OELs, an investigation will be conducted to determine possible corrective actions. The recommendations of the investigation must consider re-monitoring, medical surveillance, engineering controls, and modifications in PPE. Note: The 2016 ACGIH 2016 TLVs are recommended for use instead of the OSHA/MSHA PELs whichever is lower).

5.8 Record Retention

5.8.1 Personal monitoring records must be maintained for length of employment plus 30 years.

6.0 UNDERGROUND MOBILE EQUIPMENT MITIGATIONS

6.1 Utilization of emissions scrubbing technology on mobile equipment:

Where applicable, TMI mobile equipment is fitted with exhaust scrubbing equipment. This equipment works to reduce NO_2 and diesel particulate matter (DPM) content in the mobile equipment's exhaust, minimizing the contaminants emitted into the mine air and thus lowering possible exposures to workers. All muckers are Tier 3 engines fitted with scrubbing systems that deliver Tier 4 equivalent performance.

6.2 Emissions Testing

Emissions testing is performed on all equipment when it is commissioned in the underground. The purpose of this testing is to verify that the equipment is not emitting contaminants in excess of its designed emissions levels. Emissions testing is performed utilizing an ENERAC 700 Portable Compliance Level Combustion Emissions Analyzer. Thereafter, emissions testing is performed bi-annually when fire suppression checks are performed.

6.3 Enclosed Cabs

Where possible TMI have procured mobile equipment with enclosed cabs, an engineering measure that helps to limit the exposure of operators to mine air contaminants through filtering systems that ventilate the enclosed cabs.

7.0 VENTILATION

Maximizing ventilation to working areas:

Both primary ventilation and secondary ventilation will be utilized to deliver air to and flush the working places. Primary ventilation is supplied by large induced draft fans on the surface that suck air down both the Yates and Ross shafts, through the various mine levels, and back to surface via the #5 and Oro Hondo ventilation shafts. Secondary ventilation is provided by auxiliary fans hung in headings that draw air from the primary ventilation path and push it through conduit (vent bag) directly to the working places. The combination of primary and secondary ventilation, combined with strategic mine design, provides fresh air to the working places to sustain operations and to flush contaminants from those working places. TMI will perform regular ventilation checks wherein ventilation rates are measured and quantified to ensure adequate ventilation rates are maintained. Daily spot checks of ventilation flows will be performed by TMI Supervisors utilizing handheld anemometers. Weekly ventilation surveys will be performed and documented by TMI engineering staff.

When 29 CFR 1926.800(k)(3) is no longer achievable due to the dimensions of the excavation face, a localized ventilation approach will be utilized. This will require 30 fpm average localized ventilation be supplied within workers' work area. This requirement will be documented in the task specific Build Plans and Hazard Analysis. Compliance with this requirement will be validated through air flow measurements taken in the worker's local area. In addition, TMI will follow their Industrial Hygiene Monitoring Procedure to validate the compliance with ACGIH 2016.

8.0 REFERENCES

None

9.0 ATTACHMENT

9.1 – See next page

THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

IH Sampling Employee Field Notes

Name:				**Type of Sampling Being Conducted:**	**Noise** ☐
Date:		**Shift:**		**Dust** ☐ **DPM** ☐ **Other:** ☐	_____
Work Area(s):				**Suggestions to reduce exposure:**	
Equipment:					
Job/Tasks:					

PPE Worn: *(circle applicable)*

Ful-Face Respirator	Ear Muffs	Face Shield
Half-Face Respirator	Ear Plugs	Goggles
PAPR	Dual HP	Gloves *(list type)*
Tyvek	Slicker	_____

Observable Conditions:

Location:	Clear	Dust	Smoky	Foggy	Noisy
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

Weather and/or Ventilation Comments:

Typical day? Yes / No ***(If No, please explain)***

Start Time:	*End Time :*	Please Note Location,Task & Equipment	Similar Exposure Group (SEG)	Hours 1	Hours 2	Hours 3	Total Hrs.
			Bolting/Drilling Open/Outside Cab				
			Bolting/Drilling Closed Cab				
			Mucker				
			Haul Truck				
			Shotcreting				
			Utilities				
			Other				

Equipment Operator Checks ***(circle appropriate answers)***

AC Working?	Y / N / NA	Doors & Windows Closed?	Y / N / NA
Cab Clean?	Y / N / NA	Cab Seals In Good Cond.?	Y / N / NA
Traffic in Area:	Y / N / NA	Holes in Cab?	Y / N / NA

v v ***Safety Department Use Only*** *v v*

Thyssen Pump/Dos. #	Cassette #	Pre Cal.	Post Cal.	Start Time	End Time	Total Run Time (hrs/min)	Total Run Time (min)	Total Flow (L)
P-		LPM						

Safety - Supervision Visits / Observations			
Time	Location / Activity	PPE In Use	Observable Conditions / Comments

9.2 List of Agents to be Monitored

SUBSTANCE	COMPLIANCE STANDARD	LOCATION	SAMPLE TYPE	FREQUENCY	COLLECTION METHOD
CARBON MONOXIDE	2016 ACGIH TLV = 25 ppm	Maintenance Equipment Bay Underground	Grab	At Baseline and at the start of any new activity	Gas Meter or Colorimetric Tube
CARBON DIOXIDE	2016 ACGIH TLV = 5,000 ppm	Maintenance Equipment Bay Underground	Grab	At Baseline and at the start of any new activity	Gas Meter or Colorimetric Tube
DIESEL PARTICULATE MATTER Graphite (Use GS-1 Cyclone)	160 µg / m^3 Total Carbon (MSHA) TLV 2.0	Underground	Area Personal	At Baseline and at the start of any new activity	NIOSH 5040 DPM 25mm Filter 1 um Porosity
RESPIRABLE DUST (Collect simultaneously with respirable silica using plastic cyclone)	OSHA 1910.1000 Table Z-1 PEL = 5 mg/m^3 8-hour TWA	Underground	Personal	At Baseline and at the start of any new activity	NIOSH 0600 Matched Weight or Tared PVC Filter (5.0 um Porosity)

OCCUPATIONAL NOISE	OSHA 1910.95 PEL = 90 dBA as 8-hour TWA 85 dB OSHA HCS 85dB ACGIH 2016 TLV	Underground	Personal	At Baseline and at the start of any new activity	Noise Dosimeters TSI Quest THE EDGE
OIL MIST	OSHA 1910.1000 Table Z-1 PEL = 5 mg/m3	Underground	Personal	At Baseline and at the start of any new activity	NIOSH 5026 Matched Weight or Tared 5 um PVC 37mm Filter
RESPIRABLE SILICA DUST	OSHA 1910.1153(c) PEL = 50 µg/m^3 8-hour TWA ACGIH 2016 TLV = 25 µg/m^3	Underground	Personal	At Baseline and at the start of any new activity	NIOSH 7500 Matched Weight or Tared 5 um PVC 37mm Filter
NITROGEN DIOXIDE	2016 ACGIH TLV 0.2 ppm –TLV	Maintenance Equipment Bay Underground	Grab Personal	At Baseline and at the start of any new activity.	Gas Meter, Passive Monitoring Badge

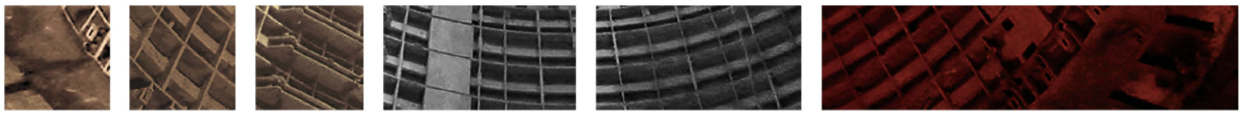
CHANGE LOG

Change Log Revision #	Document Revision Date	Description of Change	Approval(s)
0	02/12/2021	Revised for FSCF	JB
1	06/03/21	Updated	JB/CW
2	06/04/21	Updated	JB/CW
3	06/09/21	Updated	JB
4	06/14/21	Updated	JB
5	10/7/21	Updated	JB

SITE APPROVALS

Name and Title (PINT)	Signature	Date

Appendix K – TMI SOP 17010 FSCF Industrial Hygiene Sampling & Monitoring Procedure



THYSSEN MINING

local challenges | GLOBAL SOLUTIONS

Far Site Conventional Facilities (FSCF) Excavation Project Industrial Hygiene Sampling and Monitoring Procedure

ORIGINATOR		
Name	**Signature**	**Date**
Jim Brown	Jim Brown	03/18/21
Brian Gladhart, CIH, CSP BRITER Environmental, Inc.		05/15/2021

DISCLAIMER

Thyssen Mining is constantly engaged in developing best practices related to Safety, Engineering and Methodology; accordingly, Thyssen Mining reserves the right to modify the document contained herein at any time.

All technical data, specifications and other information contained within this document are deemed to be the intellectual property of Thyssen Mining.

Industrial Hygiene Monitoring Procedure

1.0 PURPOSE

The purpose of this Standard Operating Guideline (SOG) is to ensure Industrial Hygiene monitoring is performed in accordance with national regulatory standards and when possible, recognized guidance values. This procedure also provides information to establish a program that evaluates and manages risks of employee exposures to physical (i.e. heat stress or occupational noise) and commonly occurring airborne contaminants (i.e. respirable dust and its silica content, diesel particulate matter, etc.). The ultimate goal for this program is to conform with all other team members to establish and implement controls that protect using sound work practices. These work practices shall share authority by implementing both administrative and engineering practices. When these two principles fail, personal protective equipment can and will be used to safeguard workers.

2.0 SCOPE

This plan applies to the industrial hygiene activities conducted for Thyssen Mining Employees for the purpose of protecting the health of Thyssen Mining Employees.

3.0 DEFINITIONS

- **Action Level (AL):** This is a level at which action is required. Many industrial hygiene professionals use the action level to evaluate workplace exposure: It is usually identified as half the PEL or TLV.
- **Categories of Exposure Limits:** There are three important categories of exposure limits that apply to TLVs, PELs, and RELs: time-weighted average, short-term exposure limit, and ceiling:
    - *Time-Weighted Average:* This is the average concentration for an 8-hour workday or 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.
    - *Short-Term Exposure Limit (STEL):* This is a short-term TWA exposure to which workers can be continuously exposed for up to 15 minutes without suffering from

irritation, chronic or irreversible tissue damage, or narcosis of sufficient degree to increase the likelihood of accident or injury. Note: The U.S. OSHA standard for asbestos fiber exposure uses a 30 minute STEL.

- *Ceiling (C):* This is the concentration that should not be exceeded during **any** part of the work day. It is demonstrated in the standards as a PEL-C or STEL-C value.

- **Chemical Stressors:** Chemical risks such as respirable dust and its silica content, diesel particulate matter (DPM), welding fumes, solvent vapors, nitrogen dioxide, carbon monoxide, etc. which personnel may be exposed to.

- **Industrial Hygiene:** According to the American Industrial Hygiene Association (AIHA), industrial Hygiene is "that science and art devoted to the anticipation, recognition, evaluation, and control of those environmental factors or stresses arising in or from the workplace which may cause sickness, impaired health and well-being or significant discomfort among workers or among the citizens of the community."

- **NIOSH Manual of Analytical Methods (NMAM):** NMAM is a collection of methods for sampling and analysis of contaminants in workplace air. These methods have been developed or adapted by NIOSH or its partners and have been evaluated according to established experimental protocols. The NMAM can be found at NIOSH's website at <http://www.cdc.gov/niosh/nmam>. NMAM also includes chapters on quality assurance, sampling, portable instrumentation, etc.

- **Physical Stressors:** Physical risks such as noise, radiation, heat, and cold to which personnel may be exposed.

- **Recommended Exposure Limit (NIOSH – REL):** An occupational exposure limit that has been recommended by NIOSH to OSHA for adoption as a permissible exposure limit. The REL is a level that NIOSH believes would be protective of workplace safety and employee health over a working lifetime.

- **Skin Designation:** In looking up exposure limits, you may see a skin designation. This alerts you that there is a potential significant contribution to the overall exposure through the skin, eyes, and mucous membranes. This designation is an alert that air sampling alone may be insufficient to quantify exposure.

- **Threshold Limit Value (TLV – ACGIH *2016)*:** The level to which it is believed that a worker can safely be exposed day after day for a working lifetime without adverse health effects.

4.0 RESPONSIBILITIES

4.1 Safety / Occupational Hygiene Department

4.1.1 Communicate risks and concerns to both management and employees as identified.

4.1.2 Coordinate resource availability for execution of this plan.

4.1.3 Develop a monitoring schedule and select proper sampling methods.

4.1.4 Evaluate the sampling results and make recommendations for further action as appropriate.

4.1.5 Facilitate findings reviews by multi-disciplinary teams to identify and develop plans for appropriate control measures and mitigation strategies.

4.2 Employees

4.2.1 Employees must wear the sampling equipment as directed. The purpose of the sampling equipment is to represent what the employee would be exposed to throughout the work shift that is sampled. , the sampling media must not be tampered with or placed in an area or position that may cause a result that is not representative of the work being performed.

5.0 PROCESS

5.1 No employee may be exposed to concentrations exceeding the PEL, STEL or TLV without an action being implemented. The list of agents to be monitored is attached in Section 7. Personal air monitoring should be performed for 600 minutes for employees working 12-hour shifts. Employees working 10-hour shifts should be sampled for 480 - 540 minutes.

5.2 In order to comply with this Industrial Hygiene Process, Thyssen Mining shall meet the following requirements:

5.2.1 Develop an initial exposure profile for the Thyssen Mining project site. Exposure profiles shall be reviewed at least every year and updated whenever

changes in equipment, processes or environmental agents are made in the workplace.

a) Develop and implement an annual exposure monitoring plan for the Project.

b) Use the Workplace Exposure Monitoring Record to record all exposure-monitoring results.

c) Follow the hierarchy of controls when selecting and implementing exposure prevention and control methods. The hierarchy of controls states: Eliminate or replace the offending product or chemical. Engineer the hazard away using ventilation or equipment removal. Next, use administrative controls that substitute employees into hazardous locations in order to limit excess exposures. (Note: This form of administrative control cannot be implemented under some instances…) Lastly, the use of personal protective equipment (PPE). Note that PPE should always be implemented as a last resort when all else fails.

5.3 The Safety / Occupational Hygiene Department shall:

5.3.1 Determine the reason for sampling and select a method for the airborne contaminant to be sampled in accordance with **Attachment 7.2 Decision Tree for Sampling**.

5.3.2 Calibrate the sampling pumps, with the proper media, to the desired flowrate. The flowrate will be the average of at least three repetitions on a primary calibration standard or one verified reading from a secondary calibration source (namely a high quality rotometer). Documentation of calibration needs for sampling pumps and noise dosimeters to be retained showing manufacturer calibration within one year.

5.3.3 Complete the Workplace Exposure Monitoring Record properly identifying the badge number and sample number for each employee.

5.3.4 Place the sampling equipment on the selected individuals or in the selected area. Conduct the sampling according to the selected method. Deviations from the method should be carefully documented and utilized in the occupational hygienist's determination.

5.3.5 The collection device must be attached to the shirt collar in a vertical position within seven inches of the worker's breathing zone. Sampling tubes should be in a vertical position to prevent channeling of the air contaminant through air spaces in the sorbent. Membrane filters for dusts should be pointed downward and in a vertical position to prevent ambient dust from falling into the filter. NO2 badges need to be attached in a vertical position.

5.3.6 Follow up with the sampled individuals during the shift to ensure the sampling trains are being worn properly and are operating correctly. Document in the field notes what the employee is doing (ie. If operating equipment document the equipment, scaling, Check sampling trains frequently for correct operation.

5.3.7 Exercise care when changing media in the field to ensure the sample media is not contaminated.

5.3.8 Seal and identify media as soon as they are removed from the sampling train.

5.3.9 Post-calibrate the sampling pumps. A difference of more than 5% from the pre-calibration must be interpreted by th Safety Coordinator.

5.3.10 Store the sample media as required by the sampling method.

5.3.11 Select a laboratory that meets the following requirements:

5.3.12 Thyssen Mining, LLC has pre-selected ALS – Salt Lake, Utah. This lab is:

a) AIHA accredited for the constituent of concern

b) Has the capability to follow the NIOSH method selected

c) Will provide a quality assurance/quality control data package for the constituent concern, on request

Note: The sampler must be alert to special needs or procedures. For example, is the analysis required to be completed within 24 hours of sampling? Will the laboratory accept and run samples on Saturdays? Etc? Note: Saturday delivery to the lab is possible, but analysis on the weekend will be considered as cost prohibitive. None of the common sampling media noted will require special handling (blue ice shipment, etc.). Uncommon airborne contaminants

(isocyanates) not found in this document could present additional media, handling and shipment requirements.

5.3.13 Utilize chain-of-custody procedures:

a) Be sure that the sampler completes the ALS Laboratory Chain of Custody form for cassette. Specify the NIOSH method and sample numbers for each cassette shipped on the sampling form. Sign and date the ALS Laboratory Chain of Custody and place it inside the shipping container prior to tape sealing.

b) Be sure that the sampler completes the AT Labs Chain of Custody form for the NO2 badges. Sampling numbers for each badge will be shipped on the sampling form. Sign and date the AT Labs Chain of Custody and place it inside the shipping container prior to tape sealing.

5.3.14 Utilize field blanks for 10% of the sample population for each day's sampling. A minimum of one (1) field or blank will be included in each sample set.

5.4 The Safety Coordinator carefully packs the samples with plenty of padding along with the Laboratory Analysis Request/Chain of Custody form.

5.5.1 Packing material that develops or holds an electrostatic charge (such as Styrofoam or "peanuts") should not be used with particulate sampling media.

5.5.2 Bulk samples should not be shipped with air, wipe, or biological samples. If they must be shipped together place them inside one or more Ziploc-brand baggies (or similar) for added protection from sample contamination.

5.5 The Safety Department will analyze the sampling results to determine if they are valid and record the results on the Thyssen Mining Workplace Exposure Monitoring Record shown in Section 7.

5.6 Employees must receive written notification of their IH monitoring results within 15 working days of receiving the laboratory analysis report or the noise monitoring results. Thyssen Mining shall use an Employee Notification Letter that upon review by the employee shall be signed by him or her.

5.7 The results will be reported to FRA in a weekly sampling data report.

6.0 REFERENCES

None

7.0 ATTACHMENT

7.1 List of Agents to be Monitored

SUBSTANCE	COMPLIANCE STANDARD	LOCATION	SAMPLE TYPE	FREQUENCY	COLLECTION METHOD
CARBON MONOXIDE	2016 ACGIH TLV = 25 ppm	Maintenance Equipment Bay Underground	Grab	At Baseline and at the start of any new activity	Gas Meter or Colorimetric Tube
CARBON DIOXIDE	2016 ACGIH TLV = 5,000 ppm	Maintenance Equipment Bay Underground	Grab	At Baseline and at the start of any new activity	Gas Meter or Colorimetric Tube
DIESEL PARTICULATE MATTER Graphite (Use GS-1 Cyclone)	160 µg / m^3 Total Carbon (MSHA) TLV 2.0	Underground	Area Personal	At Baseline and at the start of any new activity	NIOSH 5040 DPM 25mm Filter 1 um Porosity
RESPIRABLE DUST (Collect simultaneously with respirable silica using plastic cyclone)	OSHA 1910.1000 Table Z-1 PEL = 5 mg/m^3 8-hour TWA	Underground	Personal	At Baseline and at the start of any new activity	NIOSH 0600 Matched Weight or Tared PVC Filter (5.0 um Porosity)
OCCUPATIONAL NOISE	OSHA 1910.95 PEL = 90 dBA as 8-hour TWA 85 dB OSHA HCS 85dB ACGIH 2016 TLV	Underground	Personal	At Baseline and at the start of any new activity	Noise Dosimeters TSI Quest THE EDGE
OIL MIST	OSHA 1910.1000 Table Z-1 PEL = 5 mg/m3	Underground	Personal	At Baseline and at the start of any new activity	NIOSH 5026 Matched Weight or Tared 5 um PVC 37mm Filter
RESPIRABLE SILICA DUST	OSHA 1910.1153(c) PEL = 50 µg/m^3 8-hour TWA ACGIH 2016 TLV = 25 µg/m^3	Underground	Personal	At Baseline and at the start of any new activity	NIOSH 7500 Matched Weight or Tared 5 um PVC 37mm Filter

NITROGEN DIOXIDE	2016 ACGIH TLV 0.2 ppm –TLV	Maintenance Equipment Bay Underground	Grab Personal	At Baseline and at the start of any new activity.	Gas Meter, Passive Monitoring Badge

7.2 Decision Tree for Sampling

7.2.1 What is the purpose of taking this sample?

a) Diagnostic: Select a method for sampling and analysis; determine the number of samples and sample period); know the appropriate media to use and flow rate. Know the cost of sampling and analysis.

b) Compliance: Select a method for sampling and analysis; determine the appropriate sampling campaign in accordance with regulations.

7.2.2 For the constituent of concern, analyze specific OSHA regulations for guidance or requirements on monitoring and analysis. See TED 1.15 CH-1, the U.S. OSHA Technical Manual dated 05/24/1996 or newer for specific guidance. Additional information on sampling and analysis can also be found in the NIOSH Manual of Analytical Methods (NMAM), 4th Edition or newer.

Example: The MSHA Diesel Particulate Matter (DPM) Standard, 30 CFR 57.5060, requires full shift monitoring while calculating the time weighted average using a maximum of 480 minutes (8-hours for shift length). Specific accuracy requirements for collecting and analyzing samples will also apply. The current MSHA PEL for DPM is set to not exceed 160 micrograms per cubic meter ($\mu g/m^3$) of total carbon when measured as an 8-hour time-weighted average: There is no U.S. OSHA standard for DPM.

7.2.3 Once the method is selected, read carefully for any special requirements (limitations on sampling, interferences, disassembly of equipment, storage and shipping.). Call the laboratory and verify cost of analysis and availability of sampling media.

7.3 Thyssen Mining Workplace Exposure Monitoring Record (blank-example 1 next page)

Date of Sampling:	Person Conducting Sampling:
Sample Number: MMDDYYXXX	Chemical / Contaminant:
Method:	
✓ Sample Pump Run for at least 5-minutes prior to Calibration.	

Sample Pump Number	Lot or S/N	Pre-Service Calibration (Log 3 and Avg.)	Time On	Time Off	Total Run Time in Minutes	Total Volume Sampled
		1 2 3 AVG				

Description of Area to be Sampled:	Post-Service Calibration (Log 3 and Avg.)	Remarks / Comments:
Include weather conditions, ventilation velocity if observed, etc.	1 2 3 AVG	Include discussion points such as Sample Pump Difficulties, Post-Service Calibration Discrepancies, if repairs were made to equipment, etc.
	AVG of Pre and Post	

Thyssen Mining Workplace Exposure Monitoring Record (partially completed example 2)

Thyssen Mining Workplace Exposure Monitoring Record

Employee Information

Employee Name: XXXXXXXX Employee ID: XXXXXXXXXX Job Position: Miner

Exposure Group: Miner Supervisor: _____

Shift (24 hrs. HH:MM) 0600 to 1600 Shift Length in minutes: 600

Sampling Information

Sample Date: _____ Sample Number: 041215-03 Laboratory: ALS – Salt Lake

Sample Type: Personal Type of Sample: TWA

Agent: Respirable Dust / Slilica Operation Status: Normal Sampled By:_____

Sample Location

Geographic Location: City, State, Sample Location on Site: DOE Mine, Underground

Location Comments: Haulage Level, installing roof bolts

Sampling Equipment

Equipment: MSA Escort Collection Media: 37 mm PVC 5 micron – Matched Weight Filter cassette

Equipment Serial Number: 15243 Media Lot/Serial Number: PZ041114

Calibrator: Bios Defender 510 Calibrator Serial Number: 133058

Sample Time (24 Hours 00:00-24:00) **Flow Rate (L/min) and Air Volume (L)**

Start Time Stop Time Run Time (Minutes) Initial: 2.542 Final: 2.532 Average: 2.537 (round to 2,5)

0600 1600 600 Sample Air Volume: 1,500 L

Environmental Conditions (When appropriate)

Temperature: 60^0 F Pressure: 595 mm Hg Humidity: 60 % Wind Direction: NA Wind Speed: 50 fpm

Sample Results and Method

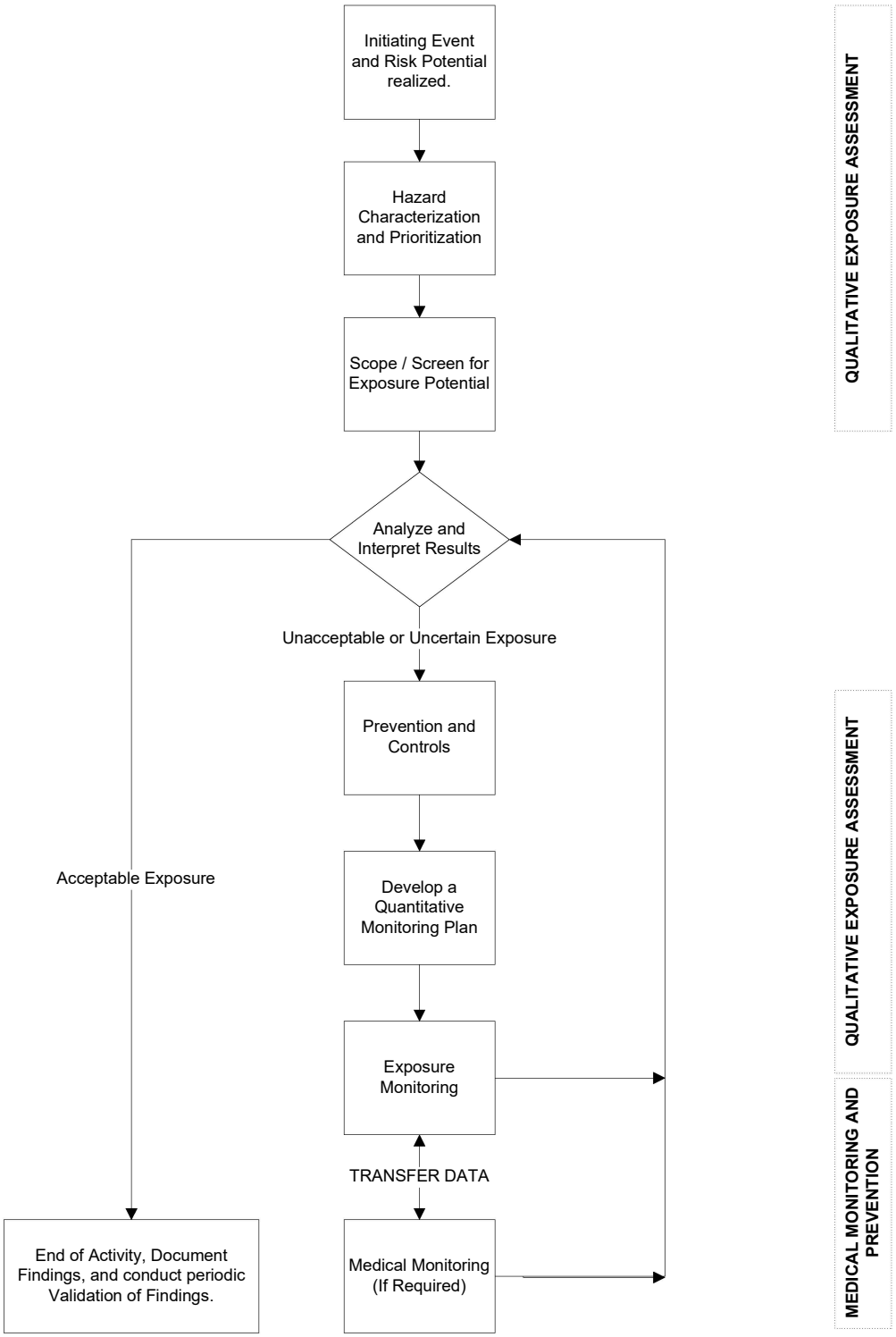
Substance		Concentration	Units	SWA/TWA/STEL	Non-Sampled Concentration
Total Dust			mg/m^3	SWA	

Method: Air samples for respirable dust were collected on a 37 mm PVC 5 micron porosity – Matched Weight Filter Cassette and the samples were analyzed for the amount of respirable dust by an AIHA-Certifed Laboratory using the NIOSH 0600 method. These samples are to be analyzed for silica content as well using the NIOSH 7500 method.

Personal Protective Equipment

Ear Plugs, Ear Muffs, Leather Gloves, Slicker Suit, Hard Hat, Metatarsal Boots, Safety Glasses

7.4 Industrial Hygiene Risk Assessment Strategy Flowchart



7.5 Continuous Gas Monitoring

TMI utilizes Industrial Scientific continuous gas monitoring to ensure that personnel who may be exposed to expected gaseous contaminants can determine what the levels of those contaminants may be in the atmosphere to which they are exposed and to ensure immediate notification of the employee should they be exposed to levels of those contaminants above recognized safe levels.

7.5.1 Any TMI employee utilizing continuous gas monitoring equipment will first be properly trained in the use and care of the equipment, including basic operation of the unit, bump testing prior to use, and appropriate responses to alarm information.

7.5.2 No TMI employee or escorted visitor shall travel the underground project spaces without at least one person in their party carrying a continuous gas detector.

7.5.3 TMI's MX4 continuous gas monitors are configured to monitor for oxygen (O2), carbon monoxide (CO), nitrogen dioxide (NO2), and concentrations of combustible gasses around their lower explosive limits (LEL). TMI's MX6 continuous gas monitors are configured to monitor for oxygen (O2), carbon monoxide (CO), nitrogen dioxide (NO2), concentrations of combustible gasses around their lower explosive limits (LEL), Hydrogen Sulfide (H2S) and carbon dioxide (CO2).

7.5.4 All continuous gas monitors must be calibrated a minimum of once per month by the ESH Coordinator.

7.5.5 All continuous gas monitors must be bump tested each shift prior to use.

7.5.6 Continuous gas monitors shall be carried upon the employee's person such that they are fully exposed to the atmosphere around the employee and do not become blocked behind any clothing or any other barrier that would impede the atmosphere from entering into the monitor.

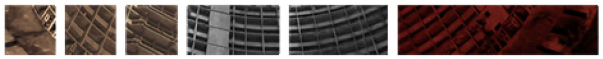
7.5.7 Upon the sounding of an oxygen alarm, whether <19.5% or >23.5%, the employee and any other personnel in the area will immediately evacuate and barricade off the area and will immediately notify the supervisor responsible for the work are and the ESH department. It will be the responsibility of the supervisor/ESH department to safely investigate the cause of the oxygen alarm condition.

7.5.8 Upon the sounding of a CO, NO2, LEL, H2S or NO2 low alarm, the employee and any other personnel in the area shall exit the area and investigate the source of the alarm condition.

7.5.9 Upon the sounding of a high CO, NO2, LEL, H2S or NO2 alarm, the employee and any personnel in the area shall evacuate the heading in which the alarm is occurring and head towards fresh air, barricade off the heading upon exiting, and will immediately notify the supervisor responsible for the work are and the ESH

department. If secondary accesses are available to the heading in question, then those secondary accesses shall also be barricaded. It will be the responsibility of the supervisor/ESH department to safely investigate the cause of the high alarm condition.

7.5.10 Personnel utilizing continuous gas monitoring equipment for confined space applications require specific confined space entry training which stipulates how the continuous gas monitoring equipment shall be used in those situations.



THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

IH Sampling Action Plan

Sampling will be conducted at a minimum monthly interval, two Dust/Silica and two DPM per crew per month, or at any change in process for DPM/Dust/Silica. A change is defined as follows; Change such as directional change in ventilation, increase of 20% of diesel mining equipment, or breakthrough in the cavern. Additional testing may be recommended by FRA subject matter expert. NO2 sampling will be conducted every shift for NO2 until a baseline has been established and then again at any change in process.

Sampling Equipment Type:

- SKC AirChek TOUCH Sample Pump 220-Series
- NO2 monitors (badges)

Lab Details:

DPM/Dust/Silica

- ALS Environmental Laboratory Salt Lake City 801-266-7700

NO2 monitors

- ASSAY Technology Livermore, Ca/Boardman, OH 800-833-1258

Cassettes used:

- Respirable Dust and Silica by NIOSH 0600/7500 Matched Weight PVC filters
- Diesel Particulate Matter by NIOSH Quartz Fiber Filters

NO2 monitors (badges)

- Nitrogen Dioxide Monitors X594AT

Prioritize tasks to be sampled (DPM)

- Loading
- Mucking
- Shotcreting
- Drilling
- Bolting

Prioritize tasks to be sampled (Respirable Dust/Silica)

- Mucking
- Drilling
- Bolting
- Loading

SEG Groups to be sampled:

Group 1

- Bolter Operator
- Jumbo Operator

Group 2

- Shifter
- Safety Coordinator

Group 3

- Mucker Operator

Group 4

- Mechanic
- Electrician

Group 5

- Shotcrete Operator

Group 6

- Rock Crusher Operator
- Tramway Operator
- Rock Handling 5000 Level

Prioritize tasks to be sampled (NO_2 badges/monitor)

- Mucking
- Drilling/Bolting on diesel
- Telehandler
- Skidsteer
- Selection of miners working in different areas

As the data is received it will be reviewed and transmitted to all parties including employees.

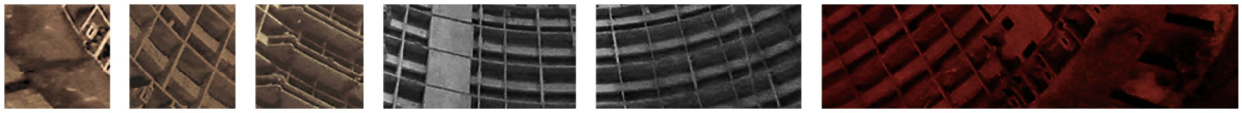
CHANGE LOG

Change Log Revision #	Document Revision Date	Description of Change	Approval(s)
1	03/18/21	Revised for FSCF	JB
2	05/15/21	Audit Review	BG
3	06/09/21	Revised	JB
4	06/14/21	Revised	JB
5	12/22/21	Revised	JB
6	02/11/22	Revised	JB

SITE APPROVALS

Name and Title (PINT)	Signature	Date

Appendix L - TMI Underground Blasting Safety Procedure



THYSSEN MINING

local challenges | GLOBAL SOLUTIONS

Far Site Conventional Facilities (FSCF) Excavation Project

FSCF Underground Blasting Safety Procedure

ORIGINATOR		
Name	**Signature**	**Date**
Jim Brown	Jim Brown	02/17/21

DISCLAIMER

Thyssen Mining is constantly engaged in developing best practices related to Safety, Engineering and Methodology; accordingly, Thyssen Mining reserves the right to modify the document contained herein at any time.

All technical data, specifications and other information contained within this document are deemed to be the intellectual property of Thyssen Mining.

FSCF Underground Blasting Safety Procedure

1.0 PURPOSE

To control risks related to storage, transportation, handling and use of explosives, blasting accessories and agents.

2.0 SCOPE

This procedure applies to the Long Baseline Neutrino Facility Far Site Facilities Project under the control of the COO of Thyssen Mining and the subsequent Joint Ventures or Partnerships. Sites may adopt client practices and procedures as long as they meet the requirements of the applicable Safe Work Practice as a minimum.

3.0 DEFINITIONS

- **Authorized Personnel** – Those employees that carry out blasting tasks, handle explosives, transport explosives, and who are duly authorized by the BATFE and Thyssen Mining.
- **Blasting Accessories** – Delays, detonators or blasting caps, boosters, safety fuses, detonating cord, and other explosives used for the blasting process.
- **Blasting Agent** – ANFO, emulsion, and similar products
- **Blasting Area/Zone** – The area where the blasted material or fumes from an explosion may cause personal injuries, damages to property, or losses of process.
- **Blasting Guard** – Persons assigned to block the entry of vehicles and persons to the blasting area during detonation and subsequent inspection until re-entry to the area is permitted.
- **Blasting Schedule** – Hours during which detonations are carried out in an area charged with explosions.
- **BATFE** – Bureau of Alcohol, Tobacco, Firearms and Explosives
- **Explosives** – Chemical compounds or physical mixes, susceptible to sudden decomposition that momentarily produces a large volume of gasses at high temperatures and pressures with destructive effects.
- **FLRA** – Field Level Risk Assessment

4.0 RESPONSIBILITIES

Project Staff will develop and implement a site-specific blasting plan. The Project Manager will approve site-specific blasting plan. This plan must include, but is not limited to:

- A thorough survey of nearby structures, photographs, videos, notes and vibration analysis may be needed.
- A list of authorized and qualified personnel and credentials.
- Transportation, storage, and handling requirements.
- Blasting records, including:
    - Date of blast;
    - Time of blast;
    - Number of holes;
    - Type of explosive used;
    - Number of delays;
    - Amount of charge per delay;
    - Number and type of caps;
    - A continuous inventory of all explosives.
- Warning signals.
- Traffic control.
- Employee training.
- Any other local requirements.
- RFID warning systems will be installed on all Thyssen Mining underground equipment, and are required to be inspected and functioning at all times.
- All employees are required to have corresponding RFID stickers installed in their hard hats.

All TMI personnel who will handle, transport, or store explosives will do so in accordance with all applicable regulations and the Thyssen Safe Work Practice (SWP) 007 Handling, Transporting, & Storage of Explosives and Detonators.

5.0 PROCESS

Obtain written approval from the FRA and SURF Director's or their designee prior to using explosives. Obtain a SURF blasting permit. A blank copy of the SURF blasting permit is provided as an example at the end of this SOP. Blast permits are required for each blast including the timing for development and review.

An explosives information packet must be sent to the Corporate Safety Director or U.S. Safety Manager of explosive work when storing explosives onsite. This must be completed and given to the Corporate Safety Director for filing with the ATF in a timely manner. Refer to the ATF guide to assist.

The job will be required to complete ATF Form 5400.13/5400.16 for each magazine as well as provide:

- Contact persons
- Phone numbers
- Directions to the Job
- Estimated start and end dates of explosive work
- Employee Possessor Questionnaire at least submitted/approved, prior to individuals handling or accessing explosives. Utilize the ATF Employee Possessor Log to track status of individuals on the job.

5.1 Prior to Using Explosives

The proper explosives permit will be obtained, and notification to local authorities including the Fire Marshal and/or Governing Agency will occur.

The blast plan format will be submitted forty five days (45) prior to commencing blasting activities. Individual blasts shall be submitted at least twenty four (24) hours prior to drilling any holes.

Important Note: Blast plan shall be submitted for each blast and the blast shall occur during the blast window. Blasts are not allowed outside of specified window.

The project must determine who will be the Employee Possessors for the Explosives License. An employee possessor is an individual who has actual or constructive possession of explosive materials during the course of their employment. Copies of permits will be filed in the project office and posted where applicable. Copies of the license must contain an original "wet ink" signature from a responsible person. A separate inventory record book must be kept for each powder and cap magazine on the job refer to Explosive Record Keeping Binder Cover and Spline and Daily Transaction Log. A magazine

inspection and check must be completed at least once every seven days. When the blasting is completed all records will be forwarded to the Corporate office. Warning signs, which read “Blasting Zone 1000 feet” and “Turn off Two-Way Radios” will be used in all blasting areas.

5.2 Inspections

TMI shall maintain, complete and accurate documentation of all explosive products used on the jobsite.

This includes but is not limited to the following:

- Blasting agents - ANFO, emulsion, and similar products
- Blasting Accessories – Delays, detonators or blasting caps, boosters, safety fuses, detonating cord, and other explosives used for the blasting process
- Explosives – Stick powder, trim powder and similar products

Magazine Inspection Schedules shall be initialed every seven days to verify the magazine was inspected for stolen explosives, break-ins, etc. Refer to the Independent Weekly Inventory Sheet.

5.3 Daily Explosive Transaction Inventory Logs

All job /magazine identification should be completed thoroughly on each log. Each material located in a magazine should have its own individual log and only represent one type of explosive. (i.e. caps with numbers 0-18 will require a separate sheet per delay, varying types of powder Dyno AP, Dyno Split “trim powder” need their own sheet, etc.) All measurements (lbs, ft, etc.) must be consistent between invoices, bill of lading and log sheets. Inventory needs to be recorded on the daily logs within one day of invoice date. Magazine balance is correctly calculated. Any balance discrepancies should be investigated immediately to ensure all explosives are accounted for physically and in the logs. Upon completion of the job and return of all unused explosives to the manufacturer, logs should show a zero balance.

5.4 Invoices

All invoices must have ATF license number on them.

All invoices pertaining to the job are included in the file.

5.5 Annual Inventory Log

Complete inventory (physical count) is taken once a year.

Annual inventory log ties to daily inventories and invoices/credit memos.

5.6 Records of Reporting Stolen Explosives

If applicable, stolen explosives were reported within 24 hours of discovery of theft to the following numbers:

- 1-800-461-8841 between 8:00 a.am-5:00 p.m.,
- 1-888-283-2662 after hours and on weekends

Also ATF form 5400.5 must be completed and submitted to the following address by mail or fax:

Bureau of Alcohol, Tobacco, and Firearms,

Arson and Explosives National Repository Branch (AENRB) P.O.
Box #50980, Washington, D.C 20077-8001

Toll Free Fax: 1-866-927-4570

Beginning January 24, 2003, it became a Felony to fail to report the theft or loss of explosives to the ATF within this 24-hour time frame per the Safe Explosives Act. The penalties include being fined not more than $250,000, imprisoned not more than 10 years, or both.

The loss or theft of explosives materials must be reported to the ATF and the local authorities within 24 hours. Upon discovery of any theft or loss of any explosive material:

- Report the loss or theft to the ATF at 1-800-461-8841 between 8:00 am - 5:00 pm EST and weekends at 1-800-800-3855.
- Call your local law enforcement office to report the loss or theft. If the explosives are lost or missing, you should make it clear to the authorities that there is no evidence of a crime.
- Obtain a copy of the police report.
- Complete ATF Form atf-f-5400-5 and email to USBDC@atf.gov.
- Immediately notify FRA ESH when a loss or theft is detected, all Responsible Persons listed on the license and the US Safety Manager.

- The three Thyssen Mining Construction managers will review explosives records for accuracy and the Project Manager is then responsible to review and sign off on weekly explosives package submittals. Once explosive work is complete, submit copies of daily explosive transaction inventory logs, invoice credit memos, and any records of reporting stolen explosives (ATF Form5400.5) to Accounting Operations regardless of whether explosives were stored onsite or daily blasts were performed.

5.7 Storage Requirements (All storage of explosives must comply with ATF 555.201-555.220)

Powder/detonation cord and caps/lead line shall be stored separately at all times. Never mix these two sets of items in the same box. Location of powder and cap magazines shall be accordance with all Federal, State and Local and SURF regulations. Signs will be posted away from the magazines that read “Explosives – Keep Out”. Signs will have six-inch high red letters on a white background.

Keep smoking and open flames at least 50 feet away from magazines. The magazines will be kept clear of weeds, brush, or any combustible material for at least a 25- foot radius. No empty boxes or bags will be left by the magazines.

No explosives or blasting agents shall be permanently stored in any underground operation until the operation has been developed to the point where at least two modes of exit have been provided.

- Permanent underground storage magazines shall be at least 300 feet from any shaft, adit, or active underground working area.
- Permanent underground magazines containing detonators shall not be located closer than 50 feet to any magazine containing other explosives or blasting agents.
- Caps and powder must be stored within the original manufacturer containers.
- Artificial barricades must be a minimum of 3 feet in thickness.

5.8 Transportation of Explosives

Transportation of powder and caps will be done with 25 inches of air space or a solid wood partition 6-inch thick separating them (i.e. a typical day box). Explosive material will be transported without undue delay to the underground magazines and to the blasting areas as close to the blasting times as practical. Explosives must not be left unattended. Explosive material must never be transported inside the operator compartment.

When explosives are delivered to the mine, key FRA/KAJV/SDSTA personnel will be notified by email.

5.8.1 Surface

- Explosives signs will be hung on all four sides of vehicles carrying explosives.
- Wood or other non-conductive material shall line the metal parts of trucks used to carry explosives.
- Vehicles carrying explosives will have two fire extinguishers of not less than 10 lb.-ABC rating.
- Vehicles carrying explosives will travel with the headlights on at all times.
- No person shall smoke or carry matches or any other flame producing device while in a vehicle carrying explosives.
- The driver shall remain with the vehicle containing explosives until the vehicle has been unloaded. Explosives need to be attended at all times when not in a magazine.
- All vehicles will be required to carry shipping papers to show that the explosives being transported are properly described, classified, identified, packaged, and labeled in accordance with regulations of the U.S. Department of Transportation.

5.8.2 Underground

- Client will be informed of each blast 3 hour prior blast Initiation. Any delay in blast time will require another 3 hour warning.
- Only the operator, his helper and the powder man shall be permitted to ride on a vehicle transporting explosives.
- Radio silence will be called during blasting.
- Radio use is not allowed while working with or near explosives. All radios, in the blast area, must be turned off during loading activities.
- No personnel may ride in the cage when explosives are being transported in the shaft.
- Only trained personnel with ATF Possessor License will transfer explosives from the surface vehicle to the powder car.

- No other equipment, supplies, or personnel shall be transported on the same conveyance with explosives.

- Authorized personnel shall remain with the vehicle containing explosives until the vehicle has been unloaded. Explosives need to be attended at all times when not in a magazine.

- Detonators/lead line and powder/primer cord shall not be transported at the same time in any shaft conveyance.

5.9 Loading the Shot

To ensure the safety of personnel during the loading process all backs, faces, and ribs shall be examined for loose rock and scaled down if needed prior to the commencement of the loading process. All blasting will be done with an approved blast plan and permit. The drilling shall be verified against the blast plan prior to starting loading. Any deviations to the blast plan will be noted on the blast report. Each blast will be performed using Non-Electric or electronic detonators. Electric detonators are not permitted to be used. All explosives shall be fume class 1.

Warning signs with “Blasting – Keep Out” will be used at all approaches to blast areas. The letters will be a minimum of four inches high and will be red on a white background. Clean up the loading area of drill steel, air pipe, air hoses and equipment not being used for loading prior to unloading the powder.

Personnel not required for loading and blasting operations to be excluded from loading and blasting areas (exception ESH and supervision).

No drilling, hammering or barring down shall be done while loading the holes. Check face before starting to load. If rock heats up during drilling, allow time for it to cool before loading holes.

Only ATF submitted/approved Employee Possessors shall be in contact with explosive products!

Before starting to load a hole; run the loading stick to the bottom of the hole and mark the depth so you can tell when the primer cartridge is at the bottom of the hole. Primers will be made up at each individual hole and only after the blaster in charge has confirmed all other work has stopped and production material/equipment removed. Tamp powder with wooden or plastic poles only. Make sure tamp end is smooth. NEVER TAMP A PRIMER. Loading operations shall be conducted with non-sparking tools. Do not stand in a direct line with the hole you are tamping. Stand off to one side.

Weather bug will be used to monitor for approaching lightning storms during blasting operations. The Thyssen top lander will notify the underground shifter informing him of the lightning status (Yellow Alert 12-24 miles, Orange Alert 6-12 miles, and Red Alert 0-6 miles). Explosive deliveries will not be allowed during any lighting alert.

Powder and caps left over will be immediately returned to the powder/cap box and added back to the inventory.

Do not carry caps in your pocket, do not set caps by powder, and do not smoke while handling explosives.

Seismographs shall also be reviewed and checked.

Take all empty boxes and bags off the shot. They shall be disposed of according to regulations (generally by flattening the boxes and disposing of them in recyclable dumpsters). All garbage will be hoisted to the surface and disposed of in dumpsters located at the Ross Collar.

At a minimum the blaster-in-charge and an additional person will check the round to verify that the round is loaded, tied in and the inventory matches what is used on the blast report.

5.10 Setting off the Shot

A written clearing, guarding and shot firing will be reviewed and signed off by all effected personnel prior to loading activities.

Important Note: Blast plan shall be submitted for each blast and the blast shall occur during blast window. Blasts are not allowed outside of the specified window.

5.11 Clearing Procedures

As part of the Build Plan process, and prior to blasting in any work area, a blast clearing plan shall be documented that specifies the following information:

- The heading(s) to be blasted
- The areas that must be physically cleared
- The sequence and direction in which those areas must be cleared pre-blast
- The locations where guards will be posted prior to blasting
- The sequence for the closing of air doors and blast doors

- The communication that will take place between the guards and the shift supervisor prior to blasting
- The sequence for the opening of air doors and blast doors
- The 15-minute prescribed wait after blasting before post-blast clearance checks may commence
- The areas that must be cleared post-blast
- The sequence and direction in which post-blast clearance checks are to be made

This blast clearance plan must be reviewed and approved as part of the build plan review process.

A detailed process of blast clearing is as follows:

5.11.1 Detailed Clearing Procedures

5.11.1.1 The shift supervisor will assign specific personnel to blasting or blast clearing duties. These personnel shall be familiar with the blast clearing plan, and they will have been properly trained to perform these duties. Personnel performing the physical post-blast clearing checks will be equipped with appropriate continuous gas detection equipment and shall have been properly trained in the use of that equipment.

5.11.1.2 Prior to blasting, the TMI ESH Coordinator or their designate will attend the brass board at the 4850 Ross station and document those personnel who are brassed onto the level. The ESH Coordinator or his designate will record the names of those personnel on a pre-blast check-in sheet. The ESH Coordinator or their designate will compare the personnel on the pre-blast check-in sheet to those personnel brassed in at the Ross Ramp by communicating with a TMI surface employee tasked to check the Ross Ramp brass board. If discrepancies between those personnel brassed in at surface and those brassed in on the 4850 level exist, blasting may not proceed until the discrepancy has been resolved.

5.11.1.3 15 minutes prior to the blast, all personnel not immediately involved in the blasting or pre-blast clearance process will remove their tags from the 4850-tag board and will proceed to the West drift north of the #5 Blast Door.

5.11.1.4 Personnel involved in blasting or blast clearing duties will also remove their brass from the tag board at this time.

5.11.1.5 The ESH Coordinator or their designate will then travel to the north side of the #5 Blast Door and will begin the process of having personnel behind in this area sign beside their names to verify that they are clear of the areas affected by the blast. These personnel shall stay behind the #5 Blast Door until post-blast clearing is complete.

5.11.1.6 Personnel performing pre-blast clearing shall then follow the instructions in the blast clearing plan and will physically walk the route prescribed in the plan, looking to ensure all personnel are cleared from the work areas as they pass. Upon reaching the end of their prescribed clearing routes, these personnel will either remain in place as guards as designated in the plan or they shall proceed through the # 5 Blast Door and shall sign the pre-blast check-in sheet. Personnel remaining in other specified locations as guards shall communicate to the shift supervisor by radio or mine phone once they are in place, and their names shall be checked off on the check-in sheet.

5.11.1.7 Once all required personnel are safely behind the #5 Blast Door and the ESH Coordinator or their designate has verified their presence with the pre-blast check in sheet, then the #5 Blast Door shall be closed, and the rest of the blasting procedure can be completed. The #5 Blast Door will not be closed, and blasting may not take place if the verification sheet indicates any discrepancy.

5.11.1.8 Once the blast has gone off, the TMI shift supervisor will initiate opening of the air doors and blast doors in the sequence designated in the blast clearing plan.

5.11.1.9 The shift supervisor will ensure a minimum 15 minutes has passed from the time the #5 Blast Door has been opened before the assigned personnel may begin post-blast clearance of the work areas.

5.11.1.10 Note: If the blast plan indicates that blast gasses will travel up the vent raise to the 3650 level and back down the Ross shaft to the 4850 level, then the supervisor will wait for an all clear from SDSTA personnel monitoring the SDSTA stationary gas detectors to verify that the blast gases coming down the shaft have passed out towards the 17 Ledge before allowing post-blast clearing checks to commence.

5.11.1.11 Personnel performing post-blast clearance of the work areas shall physically walk the work areas in the direction and sequence specified in the blast clearance plan. These personnel shall carry and utilize the continuous gas monitors to ensure that post-blast gas concentrations are at or below safe limits. If these personnel encounter gas readings above safe levels, they shall barricade off the area and retreat back to a location where the gas levels are at or below safe levels. This information shall be communicated

by radio or in person to the shift supervisor, who will determine next steps.

5.11.1.12 Once all areas have been physically cleared or barricaded, then the shift supervisor will confirm that the blast has been cleared. He or she will communicate to the crew any areas that may be barricaded due to high gas levels, and he or she will then allow personnel back into the work areas as appropriate. All personnel will then proceed to the Ross station tag board and return their brass on the board before returning to other work duties.

5.12 Misfires

A site specific plan is to be developed on removing misfired holes. When misfires occur the KAJV/LBNF/SDSTA/ and TMI ESH Managers need to be notified.

When a misfire hole is identified, a FLRA will be performed by The Blaster in Charge and his designee. The FLRA will be used to identify the hazards that will be encountered and a plan to control the risks The Blaster in Charge and his designee will be the only ones allowed to enter the area of a misfire. No one else should return to work or start work in the area of a misfire, except to remove it. The charge of explosive in a misfired hole should not be drilled, picked, or dug at. The safest way to deal with a misfire is to reshoot it. Each misfire will be re-shot with the appropriate amount of explosives as determined by the Blaster in Charge and the FLRA. If no misfires are apparent upon inspecting the face the Blaster in Charge should inspect the muck pile for large shot rock, intact blast holes in the rock, or explosive material. During the mucking operation the muck pile should be monitored for the presence of explosive materials by the operator/crew. If intact powder is found contact the shift supervisor.

All misfires must be recorded in a log book.

No one should return for at least 30 minutes.

5.13 Training

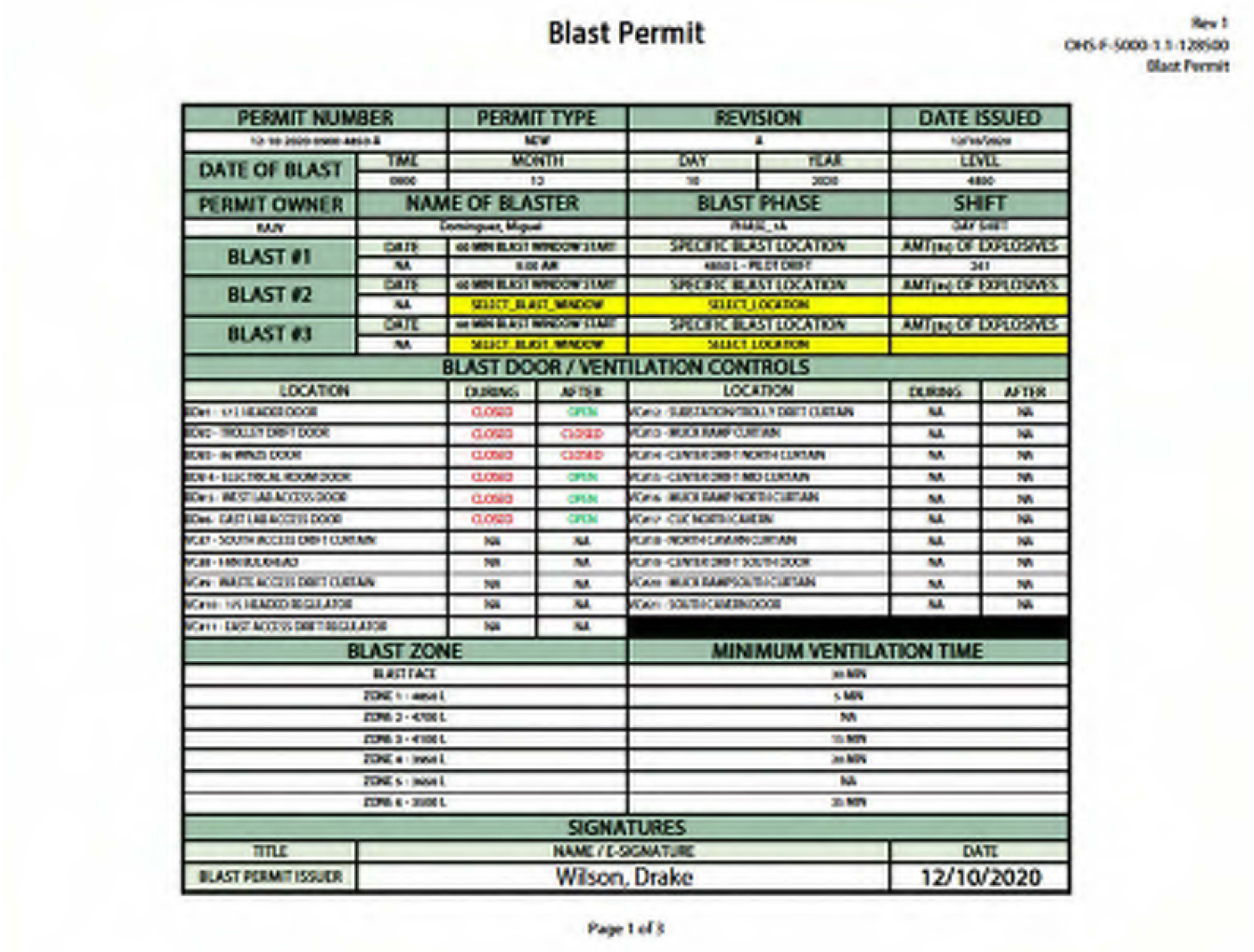
A blaster shall be qualified, by reason of training, knowledge, or experience, in the field of transporting, storing, handling, and use of explosives, and have a working knowledge of State and local laws and regulations which pertain to explosives.

A blaster shall be able to understand and give written and oral orders.

Blasters shall be required to furnish satisfactory evidence of competency in handling explosives and performing in a safe manner the type of blasting that will be required.

The blaster shall be knowledgeable and competent in the use of each type of blasting method used.

Example of the Blast Permit on next page.



Blast Permit

Rev 1
OHS-F-5000-1.1-128500
Blast Permit

PERMIT NUMBER		PERMIT TYPE		REVISION		DATE ISSUED
[illegible]		NEW		4		[illegible]
DATE OF BLAST	TIME	MONTH		DAY	YEAR	LEVEL
0800		12		10	2020	4800
PERMIT OWNER	NAME OF BLASTER			BLAST PHASE		SHIFT
RAW	Dominguez, Miguel			PHASE_4A		DAY SHIFT
BLAST #1	DATE	60 MIN BLAST WINDOW START		SPECIFIC BLAST LOCATION		AMT (kg) OF EXPLOSIVES
	NA	9:00 AM		4800 L - PILOT DRIFT		241
BLAST #2	DATE	60 MIN BLAST WINDOW START		SPECIFIC BLAST LOCATION		AMT (kg) OF EXPLOSIVES
	NA	SELECT_BLAST_WINDOW		SELECT_LOCATION		
BLAST #3	DATE	60 MIN BLAST WINDOW START		SPECIFIC BLAST LOCATION		AMT (kg) OF EXPLOSIVES
	NA	SELECT_BLAST_WINDOW		SELECT LOCATION		

BLAST DOOR / VENTILATION CONTROLS					
LOCATION	DURING	AFTER	LOCATION	DURING	AFTER
5Det - 5+1 HEADED DOOR	CLOSED	OPEN	4Cen - SUBSTATION/TROLLY DRIFT CURTAIN	NA	NA
5D#2 - TROLLEY DRIFT DOOR	CLOSED	CLOSED	4Cen - MUCK RAMP CURTAIN	NA	NA
5D#3 - 6N RAISES DOOR	CLOSED	CLOSED	4Cen - CENTER DRIFT NORTH CURTAIN	NA	NA
5D#4 - ELECTRICAL ROOM DOOR	CLOSED	OPEN	4Cen - CENTER DRIFT MID CURTAIN	NA	NA
5Des - WEST LAB ACCESS DOOR	CLOSED	OPEN	4Cen - MUCK RAMP NORTH CURTAIN	NA	NA
5Des - EAST LAB ACCESS DOOR	CLOSED	OPEN	4Cen - CUC NORTH CAMERIN	NA	NA
4Cen - SOUTH ACCESS DRIFT CURTAIN	NA	NA	4Cen - NORTH CAMARIN CURTAIN	NA	NA
4Cen - [illegible]	NA	NA	4Cen - CENTER DRIFT SOUTH DOOR	NA	NA
4Cen - WASTE ACCESS DRIFT CURTAIN	NA	NA	4Cen - MUCK RAMP SOUTH CURTAIN	NA	NA
4Cen - 5+1 HEADED REGULATOR	NA	NA	4Cen - SOUTH CAMERIN DOOR	NA	NA
4Cen - EAST ACCESS DRIFT REGULATOR	NA	NA			

BLAST ZONE	MINIMUM VENTILATION TIME
BLAST FACE	30 MIN
ZONE 1 - 4800 L	5 MIN
ZONE 2 - 4700 L	NA
ZONE 3 - 4100 L	15 MIN
ZONE 4 - 3900 L	20 MIN
ZONE 5 - 3800 L	NA
ZONE 6 - 3500 L	30 MIN

SIGNATURES		
TITLE	NAME / E-SIGNATURE	DATE
BLAST PERMIT ISSUER	Wilson, Drake	12/10/2020

Page 1 of 3

2.0 REFERENCES

- SURF's Explosive Materials Management Chapter
- Blast Permit

3.0 ATTACHMENT

None

CHANGE LOG

Change Log Revision #	Document Revision Date	Description of Change	Approval(s)
0	01/27/21	Revise for FSCF	WC
1	01/27/21	Formatting	CS
2	02/08/21	Updated	JB
3	03/08/21	Updated	JB
4	07/02/21	Updated	JB
5	02/11/22	Updated	JB

SITE APPROVALS

Name and Title (PRINT)	Signature	Date

Appendix M – TMI LBNF FSCF Ventilation Plan Excavation Series Three

LBNF – FSCF – EXCAVATION
VENTILATION PLAN
PHASE – EXCAVATION SERIES THREE – NORTH CAVERN PILOT DRIFT
TIMING: 45 DAYS, OCTOBER 15 – DECEMBER 31, 2021

DOCUMENT HISTORY:

VERSION	DATE	AUTHOR	CHANGE STATUS
0	26 October 2021	TMI	Initial Draft

SUBMITTED BY

THYSSEN MINING INC.

TO DISTRIBUTION:

NAME	TITLE	REVIEWED/ APPROVAL	DATE

ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
AOR	Area of Refuge
CFR	Code of Federal Regulations
DPM	Diesel Particulate Matter
ft	foot/feet
fpm	feet per minute
FRA	Fermi Research Alliance
FSCF	Far Site Conventional Facilities
HP	horsepower
kcfm	kilo-cubic feet per minute
HVAC	heating, ventilation, and air conditioning
LBNF	Long Baseline Neutrino Facility
MSHA	Mine Safety and Health Administration
SDSTA	South Dakota Science and Technology Authority
TLV	Threshold Limit Values
TMI	Thyssen Mining Inc.
vol%	volume percent

LBNF – FSCF – EXCAVATION
VENTILATION PLAN
PHASE – EXCAVATION SERIES THREE – NORTH CAVERN PILOT DRIFT
TIMING: 45 DAYS, OCTOBER 15, 2021 – DECEMBER 31, 2021

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

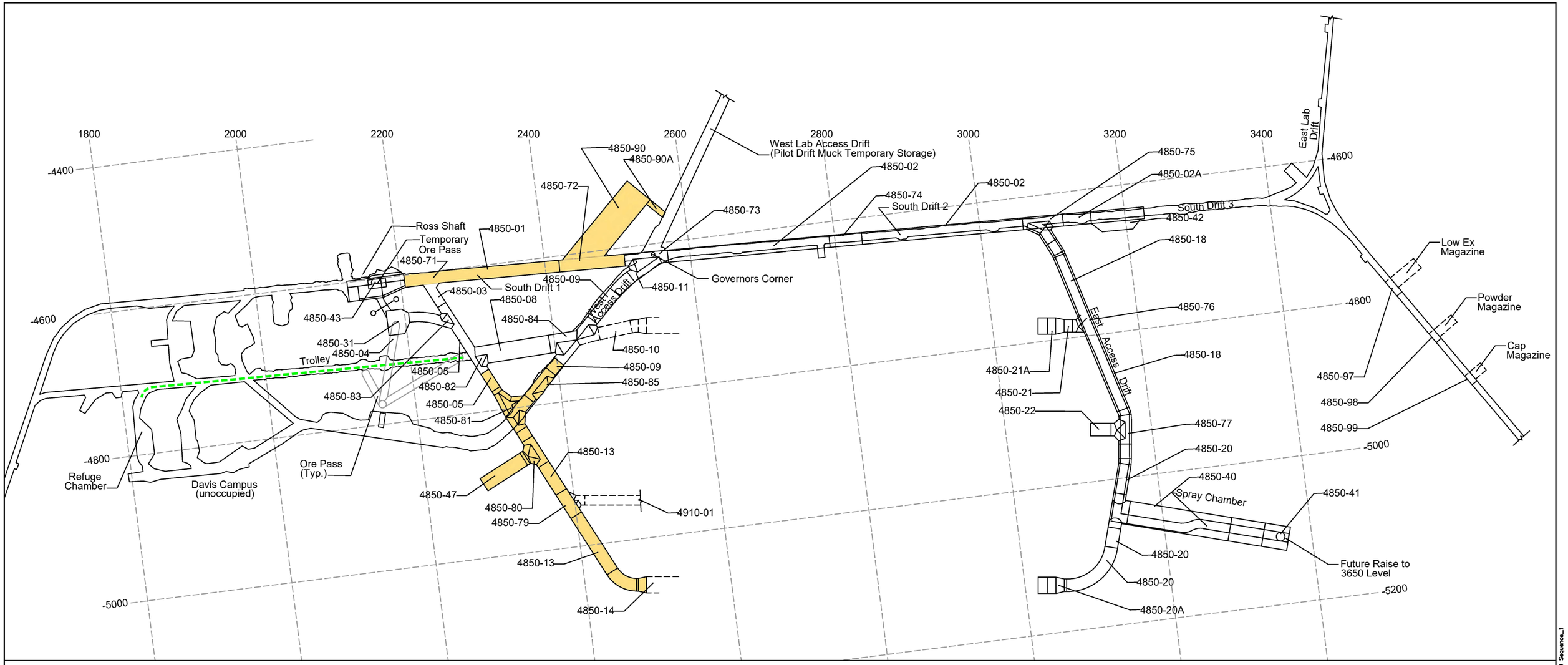
This plan describes the ventilation system proposed by Thyssen Mining Inc. (TMI) to provide the required quantity of air to maintain air quality for excavation activities. This ventilation plan contains the maps for the current direction and quantity of principal air flows, locations of air control devices (regulators, doors, curtains, etc.), areas not covered by the ventilation system, and locations of all auxiliary fans and tubing. The maps show how the required quantity of ventilation is to be provided in each typical type of working place, including the typical size and type of auxiliary fans used, and changes planned for the various activities proposed under each phase. Also included is the number and type of internal combustion engine units used underground, including make and model of unit, type of engine, make and model of engine, brake horsepower (HP) rating of engine, and Mine Safety & Health Administration (MSHA) approval number, if available.

EXCAVATION SERIES THREE: NORTH CAVERN PILOT DESCRIPTION

The excavation work of the caverns for the Long Baseline Neutrino Facility-Far Site Conventional Facilities (LBNF-FSCF) includes three broad phases: Mobilization, Pre-Development (or breakout prior to the completion of the Raise Bore connection to the 3650L), and Full Production. This ventilation plan covers the Excavation Series phase from October 15, 2021, through December 31, 2021. During this phase, work will continue on both the 3650L and 4850L. On the 4850L, excavation is anticipated for the Mucking Ramp (4910-01, -02, -03, and -86), the West Access Drift (4850-09), West Entrances of the South, Central, and North Caverns (4850-14, -12, -10, and -11), Magazines (4850-97, -98, and -99), and the Pilot Drift through the North Cavern (4850-33.0) as shown in Figure 1. Parallel to this Excavation Series, the Raise Bore equipment will be de-mobilized and shotcrete installed on the Ventilation Raise. Raise Bore muck will continue to be transported from the East Access Drift (Pilot Hole Drift) to the Temporary Grizzly. Equipment to be utilized on the 4850L and the 3650L during this Excavation Series is listed in Tables 1 and 2, respectively.

OVERVIEW OF EXISTING VENTILATION

Schematics of the current ventilation for 4850L and 3650L are shown in Figures 2 and 3, respectively. Quantities noted on the drawings are based on Ventsim™ modeling and field measurements. The main ventilation system is negative pressure with fresh air drawn down both the Yates and Ross Shafts to the 4850L and exhausting out the #4 Winze and the Oro Hondo. The #6 Winze is effectively mucked off in preparation for sealing. Fresh air is drawn down the Ross Shaft and exhausted out the Oro Hondo on the 3650L. Now that the Raise Bore is at full diameter, the airflow is upcast from the 4850L Yates Shaft intake to the Oro Hondo on the 3650L.



PROJECT NORTH

0 130

Scale (ft)

Legend

- Route to Area of Refuge
- Ducting (exhaust/dirty)
- Ducting (fresh)
- Blast Door (with or without valve)
- R — Regulator
- C — Curtain
- Kennedy Stopping
- 4910 Level (below 4850 Level)
- Current Excavation
- XX — Fresh Air Flow, XX, KCFM
- YY — Exhaust Flow, YY, KCFM

LBNF - FSCF - EXCAVATION

EXCAVATION SERIES THREE

NORTH CAVERN PILOT VENTILATION PLAN 4850L—

SEQUENCE OF EXCAVATION

DATE: 10–13–2021
SCALE: -S SHOWN

THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

Figure 1

Agapito Associates, Inc.
ENGINEERS & GEOLOGISTS

ACAD FILE: Fermilab Base Map_Phase Exc Series 3.dwg Layout: Exc Series 3_4850 Sequence_1

JOB NO.: 799–06

Table 1. Excavation Series Three - Access Drifts Central Utility and South 4850L Caverns: Diesel Equipment List

Quantity	Equipment	Model	Power (bhp)	Schedule (Hrs/day)	Usage (%)	Engine Model	Tier	MSHA #
1	Telehandler 5,500 lb	Cat TH 255	74	6.0	25%	TD 2.9L L4	US EPA Tier 4 Interim	Qualified
1	Telehandler 8,000 lb	Cat TH 408 D	124	6.0	25%	Cat C4.4 ACERT	US EPA Tier 4 Interim	
1	Mechanized Wheelbarrow	Creterod	23	13.0	54%	Yanmar 3TNM74F-NHGE	US EPA Tier 4	Qualified
1	Bobcat	5600 Toolcat	61	5.0	20%	Kubota V2003-M-DI-T	US EPA Tier 4	Qualified
1	Single Boom Jumbo	Quasar	41	3.0	13%	Deutz F3L 912 W	No Tier 4 Option	7E-B026
1	Dual Boom Jumbo	Atlas Copco 282 Boomer	78	3.0	13%	Deutz D914 L04 2V	Tier 3, No tier 4 Option	07-ENA100005
1	Dual Boom Smart Jumbo	Sandvik DD422i	163	3.0	13%	Cummins QSB4.5	US EPA Tier 4 Final	07-ENA100006
2	Bolter	Sandvik DS311 DE	134	3.0	13%	Deutz BF4M2012C	No Tier 4 Option, Tier 3	07-ENA040003
1	Large Bolter	Sandvik DS512i	220	3.0	13%	TC8	US EPA Tier 4 Interim	
1	Scoop 4 yard	Sandvik LH307	218	10.0	42%	Volvo TAD850VE	No Tier 4 Option, Tier 3	07-ENA150019
2	Scoop 4 yard	Sandvik LH307	218	10.0	42%	Mercedes Benz OM906LA E3A/4-01	No Tier 4 Option, Tier 3	7E-B084
2	Scoop 2 yard	MTI LT270	99	10.0	42%	Cummins QSB 3.3	No Tier 4 Option, Tier 3	07-ENA110017
1	Mini Excavator	Cat 301 7D CR	24	4.0	17%	Yanmar 3TNV76	US EPA Tier 4 Final	
1	Skid Steer	Cat 232D	66	10.0	42%	Cat C2.2 CRDI	US EPA Tier 4 Final	07-ENA160015
2	Scissor Lift	Normet Utililift SF 330	129	4.0	17%	Deutz TCD 2012 L4	US EPA Tier 3	07-ENA100001
2	Transmixer	Normet Utimec SF 300	129	4.0	17%	Deutz TCD 2012 L5	US EPA Tier 3	07-ENA100002
2	Shotcrete Sprayer	Normet Minimec 2	5	4.0	4%	Cat C1.1I OPU	US EPA Tier 4F	
3	UTV	Cat CUV 105	25	10.0	42%	Kholer 1.37	US EPA Tier 4F	
1	High Reach Manlift	JLG X1000AJ	22	4.0	17%	Kubota D902	US EPA Tier 4	07-ENA110010
1	Welder	Miller Trailblazer	25	3.0	13%	Kubota D902	US EPA Tier 4	07-ENA110010

Table 2. Excavation Series Three - Access Drifts Central Utility and South Caverns: 3650L Diesel Equipment List

Quantity	Equipment	Model	Power (bhp)	Schedule (Hrs/day)	Usage (%)	Engine Model	Tier	MSHA #
1	Scoop, 1 CY	MTI 100M	55	10.0	42%	Deutz F4L-912W	No Tier 4 Option	7E-B025
2	Mechanized Wheelbarrow	Creterod	23	13.0	54%	Yanmar 3TNM74F-NHGE	US EPA Tier 4	Qualified
1	Skid Steer	Cat 226D	66	4.0	17%	Cat C2.2 CRDI	US EPA Tier 4F	Qualified

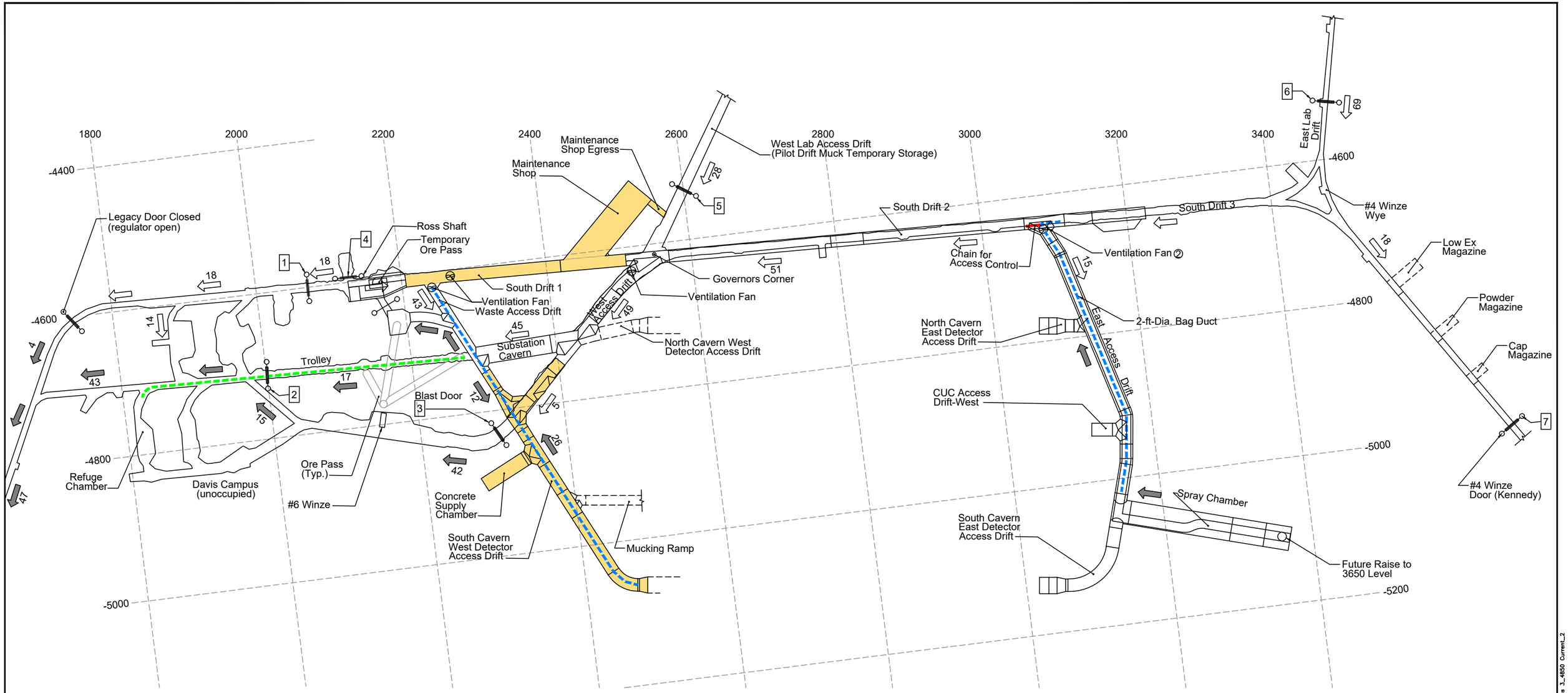
APPLICABLE AIR QUALITY REQUIREMENTS AND REGULATIONS

The project falls under the Department of Energy and, therefore, the rules and regulations of 10 Code of Federal Regulations (CFR) Part 851.23[1]. The 10 CFR Part 851.23 requires contractors to comply with a series of safety and health standards by reference. Standards by reference applicable to ventilation include American Conference of Governmental Industrial Hygienists (ACGIH®) Threshold Limit Values (TLV) for Chemical Substances and Physical Agents and Biological Exposure Indices and 29 CFR Part 1910[2] and Part 1926[3]. The 29 CFR Part 1926, Safety and Health Regulations for Construction, includes the safety and health standards for ventilation specific to underground construction. Air quality, ventilation, and diesel particulate

[1] Office of the Federal Register (2021), "Energy; Worker Safety and Health Program, 10 CFR Part 851," https://www.energy.gov/gc/10-cfr-851-worker-safety-and-health-program.

[2] US Dept of Labor (2021), "Occupational Safety and Health Standards, 29 CFR Part 1910," https://www.osha.gov/laws-regs/regulations/standardnumber/1910.

[3] Office of the Federal Register (2021), "Safety and Health Regulations for Construction, 29 CFR Part 1926," https://www.osha.gov/laws-regs/regulations/standardnumber/1926.



PROJECT NORTH

0 130

Scale (ft)

Legend

- Route to Area of Refuge
- Ducting (exhaust/dirty)
- Ducting (fresh)
- Blast Door (with or without valve)
- Regulator
- Curtain
- Kennedy Stopping
- 4910 Level (below 4850 Level)
- Current Excavation
- XX — Fresh Air Flow, XX, KCFM
- YY — Exhaust Flow, YY, KCFM

Schedule of Blast Doors and Curtains

Door No.	Door Name	Door Size	During Construction	During Blasting	Ducting or Blast Valve
1	17L Header Door	36x89	Open	Open	Valve (wall install)
2	Trolley Drift Blast Door	36x89	Open	Open	No
3	#6 Winze Door	108x108	Open	Open	No
4	Electrical Room Door	36x89	Closed	Closed	No
5	West Lab Access Door	108x108	Open	Open	No
6	East Lab Access Door	60x89	Open	Closed	Valve (wall install)

Note: All fans are the SMJ-AFS-97 30 HP 3500 RPM setting 0 connected to 2-ft-diameter ventilation bag unless otherwise noted.

LBNF - FSCF - EXCAVATION

EXCAVATION SERIES THREE

NORTH CAVERN ROUTE PLAN

VENTILATION PLAN, 4850L—CURRENT

DATE: 10–15–2021
SCALE: -S SHOWN

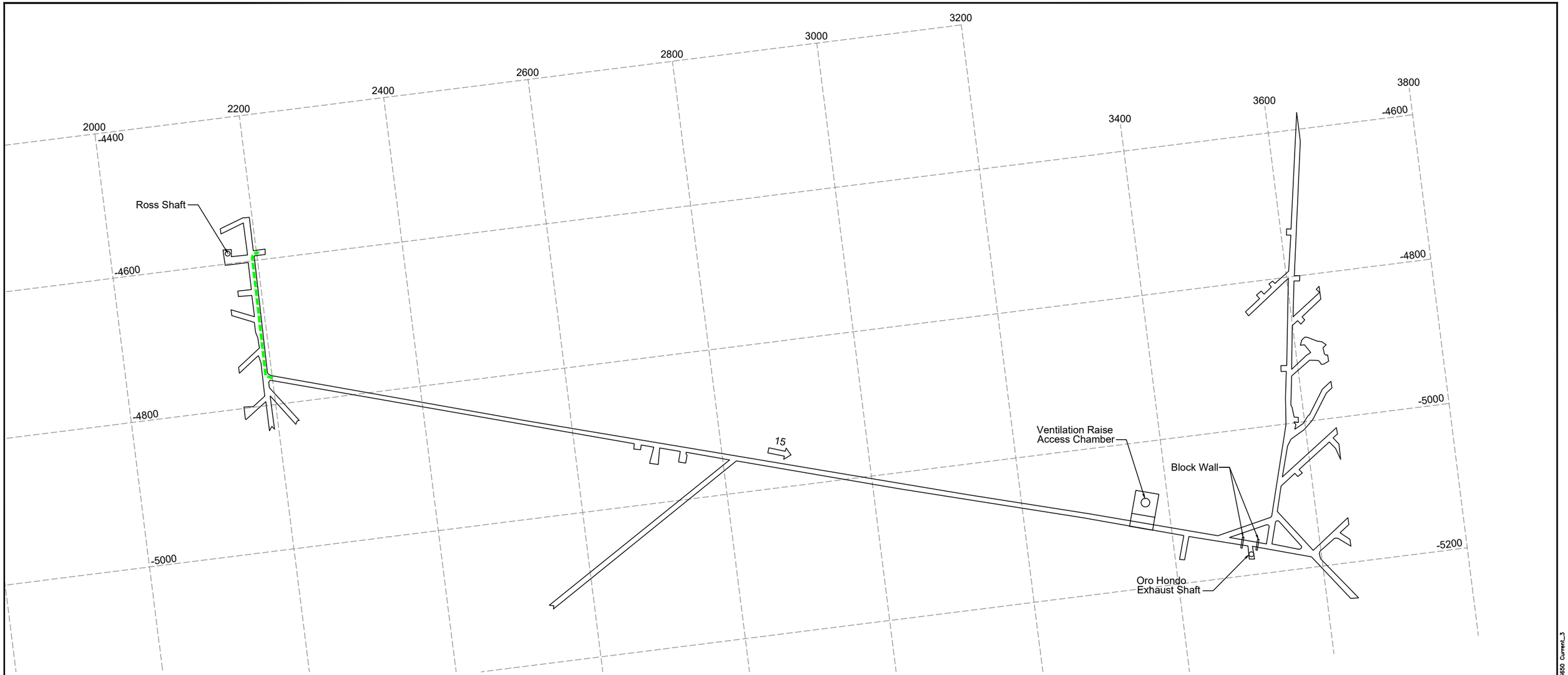
THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

Figure 2

Agapito Associates, Inc.
ENGINEERS & GEOLOGISTS

ACAD FILE: Fermilab Base Map_Phase Exc Series 3.dwg Layout: Exc Series 3_4850 Current_2

JOB NO.: 799–06



PROJECT NORTH

0 130

Scale (ft)

Legend

- Route to Area of Refuge
- Ducting (exhaust/dirty)
- Ducting (fresh)
- Blast Door (with or without valve)
- Regulator (R)
- Curtain (C)
- Kennedy Stopping
- 4910 Level (below 4850 Level)
- Current Excavation
- XX — Fresh Air Flow, XX, KCFM
- YY — Exhaust Flow, YY, KCFM

LBNF - FSCF - EXCAVATION

EXCAVATION SERIES THREE

NORTH CAVERN ROUTE PLAN

VENTILATION PLAN, 3650L—CURRENT

DATE: 10-13-2021
SCALE: -S SHOWN

THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

Figure 3

Agapito Associates, Inc.
ENGINEERS & GEOLOGISTS

ACAD FILE: Fermilab Base Map_Phase Exc Series 3.dwg Layout: Exc Series 3_3650 Current_3

JOB NO.: 799-06

matter (DPM) requirements are based on MSHA in 30 CFR Part 57[4] with ACGIH® modifications as stated in the general requirements. LBNF Construction EH&S Plan requires adherence to 2016 ACGIH TLVs. When the ACGIH® TLVs are more protective than permissible exposure limits in 29 CFR Part 1910 for general industry and/or Part 1926 for construction, the ACGIH® apply. The 2016 ACGIH TLVs are used as exposure limits only; all other safety and health standards of 29 CFR Part 1910 remain applicable. Part 1926.800 (k) is not applicable and is replaced by 30 CFR 57.5001 – Exposure limits for airborne contaminants, 30 CFR 57.5060 – Limit on exposure to diesel particulate matter, and 30 CFR 57.8518 – Main and booster fans as it applies to TMI installed ventilation and fans and not to SDSTA's main exhaust fans.

The air contaminants expected to be encountered during the excavation project with the TLVs are listed in Table 3. In this excavation phase, the DPM in the exhaust of equipment used in excavation and dust with potential silica content is considered to be the primary contaminant of concern. Activities involving drilling and explosives will take place during this series. Blasting fumes will be created when blasting and cleared prior to resuming work. If needed, dust will be managed with the addition of moisture. As per 29 CFR Part 1926, air in all active workings shall contain at least 19.5 volume percent (vol%) oxygen. Practices are in place to keep exposure to contaminants at the lowest achievable levels. For purposes of evaluating exposure, the work is planned for 12-hour shifts.

Table 3. Applicable Air Quality Requirements and Regulations

Contaminant	TLV-TWA	TLV-STEL	Regulation
Respirable Silicates	25 µg/m^3		ACGIH 2016
Nuisance Dust*	10 mg/m^3		ACGIH 2016
DPM	160 µg/m^3		MSHA §57.5060
CO_2	0.50%	3.00%	ACGIH 2016
CO	25ppm	400 ppm	ACGIH 2016
NO	25 ppm		ACGIH 2016
NO_2	0.2 ppm		ACGIH 2016

TLV-TWA = Threshold Limit Value, Timeweighted Average
TLV-STEL = Threshold Limit Value, Short-term Exposure Level
*Guidelines only

BOUNDARY CONDITIONS

Boundary conditions have been established by Fermi Research Alliance (FRA) to maintain the current level of service. Minimum flows to maintain the current level of service include:

- Maintain approximately 60 kilo-cubic feet per minute (kcfm) airflow down the East Lab Access Drift. The airflow cannot be cut-off for longer than 30 minutes or

[4] Office of the Federal Register (2021), "Safety and Health Standards – Underground Metal and Nonmetal Mines, 30 CFR Part 57," https://www.ecfr.gov/cgi-bin/text-idx?SID=8cba7282423279e84571a7f90bba8d95&mc=true&tpl=/ecfrbrowse/Title30/30cfr57_main_02.tpl.

overheating of the Davis Campus heating, ventilation, and air conditioning (HVAC) system may occur.

- Supply 10–15 kcfm down the Ross Shaft between the 4850L and the 5000L for pump heat abatement purposes.
- Maintain unrestricted and unobstructed access to the Area of Refuge (AOR).
- The volume of air flow down the Ross Shaft is limited by the air heater.

Maximum personnel underground is 80 on the 4850L (65 TMI, 15 other).

4850L AND 3650L VENTILATION PLANS

The number of personnel, diesel equipment usage, and tasks are the basis for estimating the quantity of airflow required. Table 4 lists the estimated total minimum airflow required for personnel and equipment. The utilization of the equipment listed in Table 4 is based on the expected usage cycle. Utilizations for the equipment that use diesel for tramming and electric for other functions are reduced to reflect expected tram time. Work stops when blasting occurs and the full quantity of fresh air flow is dedicated to clear fumes.

There are two proposed ventilation plans for the Excavation Series Three North Cavern Pilot Drift, downcast, and upcast in the Ventilation Raise. For the completion of the shotcrete work for the Raise, it is necessary to maintain a downcast to effectively remove shotcrete contaminants from the work areas as efficiently as possible. To accomplish this, the Oro Hondo Shaft will be sealed off as much as possible, and the SMJ AFS-97 30-HP fan (Figure 4) in the East Access Drift will be reversed and moved to the 4850-18 area and tubing extended to exhaust out the opened #4 Winze door. The fan and tubing placement should draw the air from the Ross Shaft at the 3650L to the Raise Bore and down to the East Access Drift. If needed, the fan will be installed in a curtain bulkhead. The existing auxiliary fans with duct will be relocated to facilitate fresh air flow to the work areas in the North Cavern Pilot Drift, Central Utilities Cavern Access Drift, and the South Cavern Access Drift. An additional fan with 36-inch equivalent diameter oval tubing will be added to serve the mucking ramp (4910L). This proposed airflow direction and quantity of flow for the 4850L during downcast flow in the Raise is shown in Figure 5. Table 5 lists the estimated minimum airflow required for the planned activities on the 3650L. The proposed airflow direction and quantity for the 3650L during the downcast of the Raise is shown in Figure 6.

After the Raise lining is complete, the ventilation controls will be reconfigured to revert to upcast flow at the Ventilation Raise and provide increased fresh air flow through ventilation of the working areas. At this time, the auxiliary fan with tubing and the curtain bulkhead will be removed from the East Access Drift, and the Oro Hondo, on the 3650L, opened up to allow exhaust flow from the Raise to the surface exhaust fan. The Regulator in the West Lab Access will be adjusted to provide additional fresh air to the Maintenance Shop and the Substation Cavern. A door on the 3650L between the Ross Shaft and the Raise will be constructed to limit the direct airflow from the Ross Shaft to the Oro Hondo on the 3650L. These ventilation changes are shown in Figures 7 and 8 for the 4850L and 3650L, respectively.

Table 4. Excavation Series Three - Access Drifts Central Utility and South Caverns: Underground Air Quantity Estimated Requirements, 4850L

Number	Equipment	Power (bhp)	Quantity (cfm/unit)	Utilization (%)	Quantity (cfm)	Notes
80	Personnel		200		16,000	
1	Telehandler 5,500 lb	74	100	25%	1,850	
1	Telehandler 8,000 lb	124	100	25%	3,100	
1	Mechanized Wheelbarrow	23	100	54%	1,246	
1	Bobcat	61	100	20%	1,220	
1	Single Boom Jumbo	41	100	4%	164	Diesel tram only
1	Dual Boom Jumbo	78	100	4%	312	Diesel tram only
1	Dual Boom Smart Jumbo	163	100	4%	652	Diesel tram only
2	Bolter	134	100	4%	1,072	Diesel tram only
1	Large Bolter	220	100	4%	880	Diesel tram only
1	Scoop 4 yard	218	100	42%	9,156	
2	Scoop 4 yard	218	100	42%	18,312	
2	Scoop 2 yard	99	100	42%	8,250	
1	Mini Excavator	24	100	17%	408	
1	Skid Steer	66	100	42%	2,750	
2	Scissor Lift	129	100	17%	4,386	
2	Transmixer	129	100	17%	4,386	
2	Shotcrete Sprayer	5	100	4%	40	Diesel tram only
3	UTV	25	100	42%	3,125	
1	High Reach Manlift	22	100	17%	374	
1	Welder	25	100	13%	313	
				Total	**65,372**	

29 CFR§1926.800 - Personnel requirement 200 cfm/person

29 CFR§1926.800 - Diesel requirement of 100 cfm/bhp in addition to personnel requirement

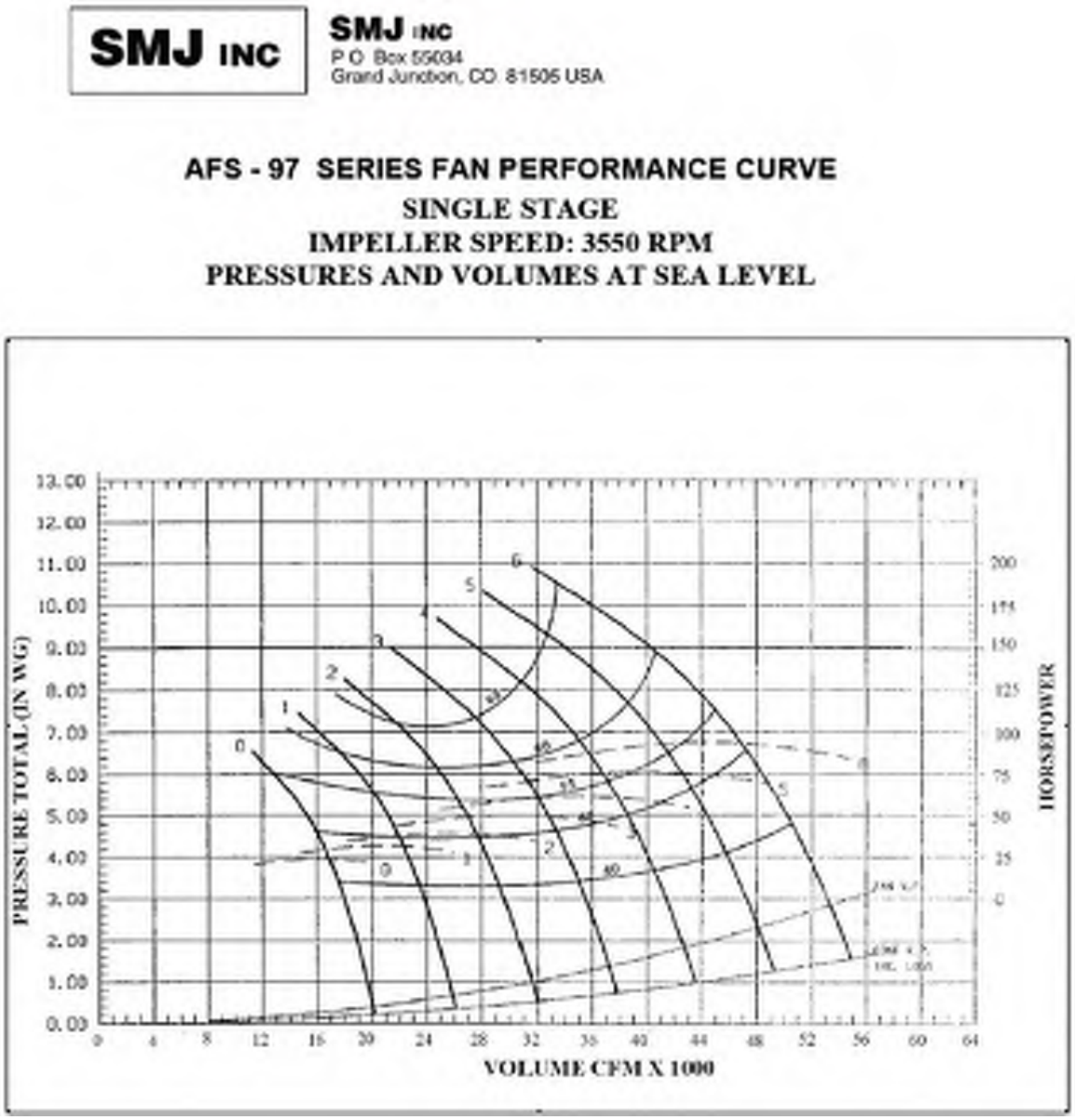
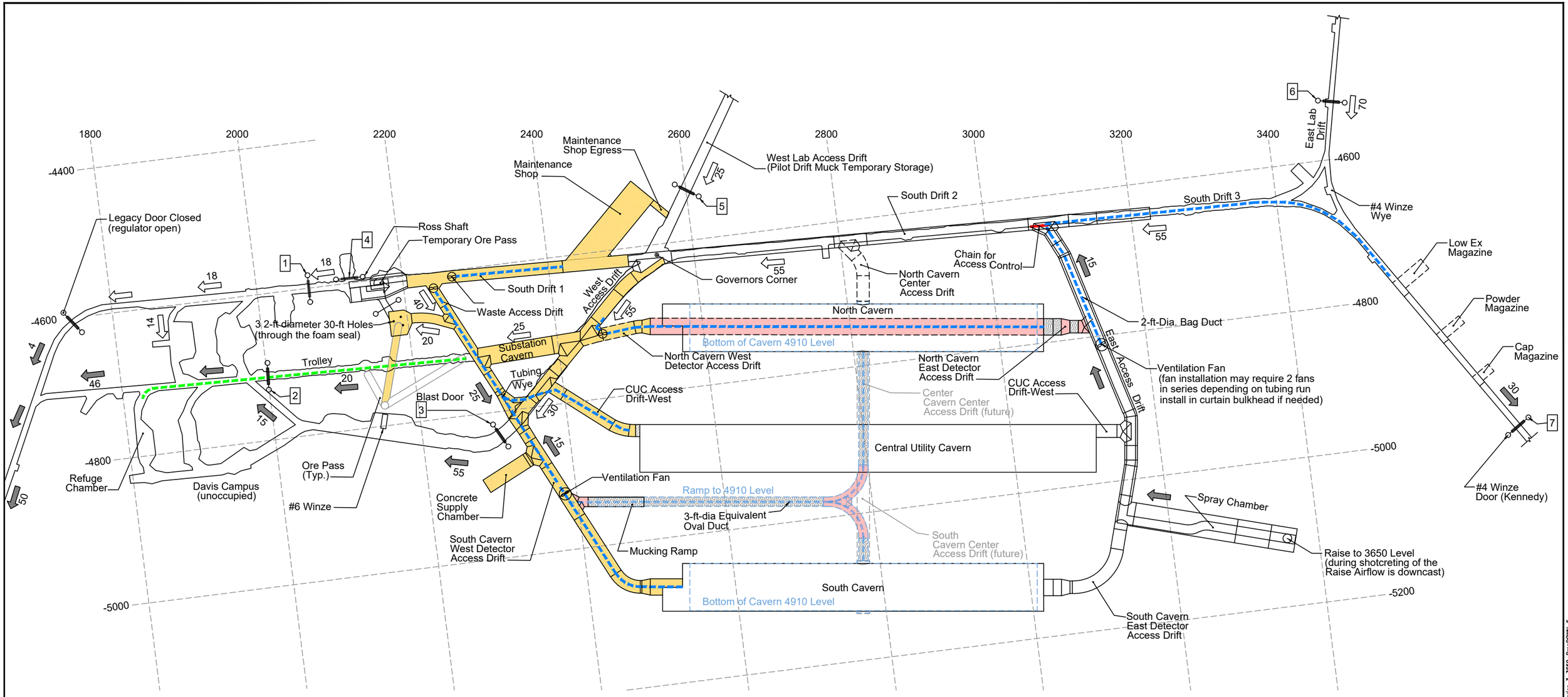


Figure 4. SMJ AFS-97 Auxiliary Fan, 30 HP



PROJECT NORTH

0 130

Scale (ft)

Legend

- Route to Area of Refuge
- Ducting (exhaust/dirty)
- Ducting (fresh)
- Blast Door (with or without valve)
- Regulator
- Curtain
- Kennedy Stopping
- 4910 Level (below 4850 Level)
- Current Excavation
- Planned Excavation
- XX — Fresh Air Flow, XX, KCFM
- YY — Exhaust Flow, YY, KCFM

Schedule of Blast Doors and Curtains

Door No.	Door Name	Door Size	During Construction	During Blasting	Ducting or Blast Valve
1	17L Header Door	36x89	Open	Open	Valve (wall install)
2	Trolley Drift Blast Door	36x89	Open	Open	No
3	#6 Winze Door	108x108	Open	Open	No
4	Electrical Room Door	36x89	Closed	Closed	No
5	West Lab Access Door	108x108	Open	Open	No
6	East Lab Access Door	60x89	Open	Closed	Valve (wall install)

Note: All fans are the SMJ-AFS-97 30 HP 3500 RPM setting 0 connected to 2-ft-diameter ventilation bag unless otherwise noted.

LBNF - FSCF - EXCAVATION

EXCAVATION SERIES THREE

NORTH CAVERN PILOT VENTILATION PLAN 4850L—PROPOSED DOWNCAST RAISE

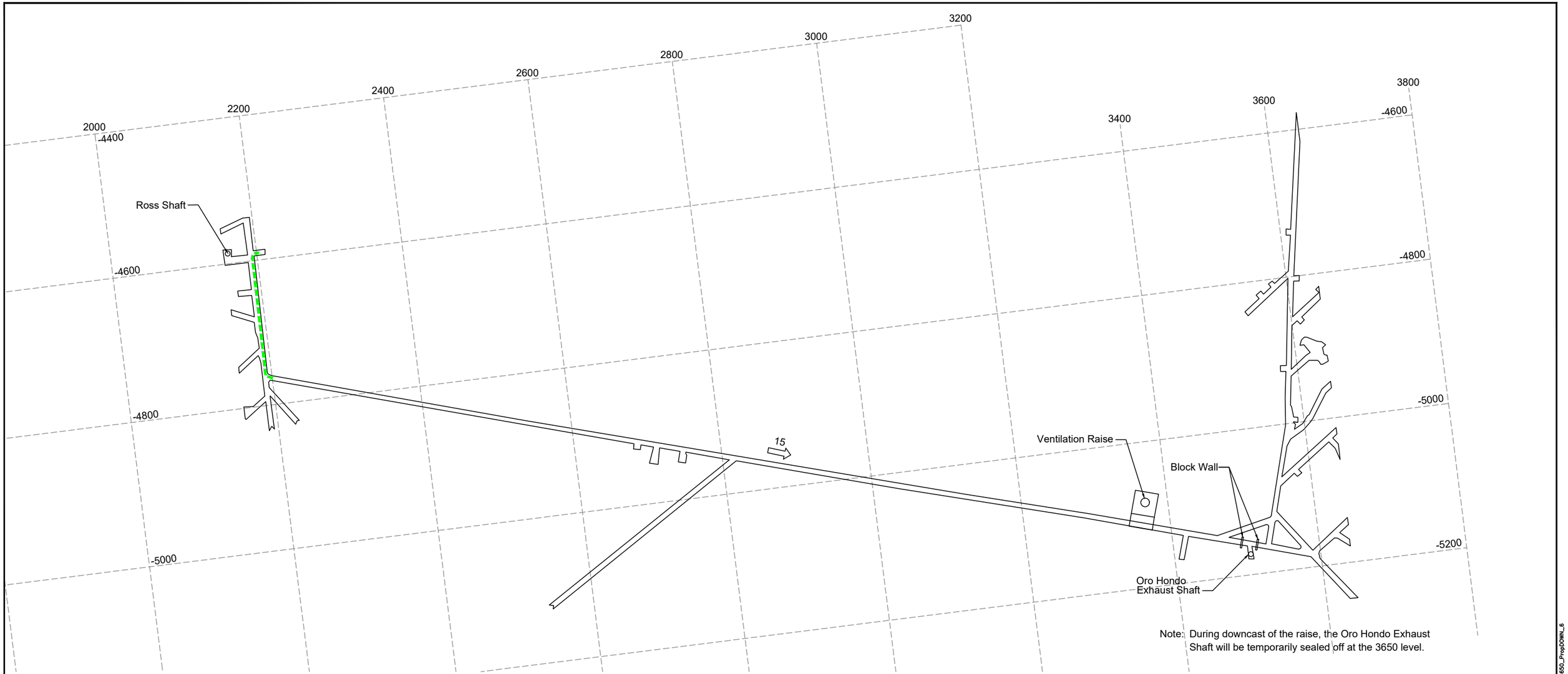
DATE: 10–15–2021
SCALE: AS SHOWN

THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

Figure 5

Agapito Associates, Inc.
ENGINEERS & GEOLOGISTS

ACAD FILE: Fermilab Base Map_4 Phase Exc Series 3.dwg Layout: Exc Series 3_3650_PropDOWN_6
JOB NO.: 799-06



Note: During downcast of the raise, the Oro Hondo Exhaust Shaft will be temporarily sealed off at the 3650 level.

PROJECT NORTH

0 130

Scale (ft)

Legend

- Route to Area of Refuge
- Ducting (exhaust/dirty)
- Ducting (fresh)
- Blast Door (with or without valve)
- R Regulator
- C Curtain
- Kennedy Stopping
- 4910 Level (below 4850 Level)
- Current Excavation
- XX Fresh Air Flow, XX, KCFM
- YY Exhaust Flow, YY, KCFM

LBNF - FSCF - EXCAVATION

EXCAVATION SERIES THREE

NORTH CAVERN PILOT VENTILATION PLAN 3650L—PROPOSED DOWNCAST RAISE

DATE: 10-14-2021
SCALE: -S SHOWN

THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

Figure 6

Agapito Associates, Inc.
ENGINEERS & GEOLOGISTS

JOB NO.: 799-06

ACAD FILE: Fermilab Base Map_Phase Exc Series 3.dwg Layout: Exc Series 3_3650_PropDOWN_6

Table 5. Excavation Series Three - Access Drifts Central Utility and South Caverns: Underground Air Quantity Estimated Requirements, 3650L

Number	Equipment	Power (bhp)	Quantity (cfm/unit)	Utilization (%)	Quantity (cfm)
12	Personnel		200		2,400
1	Scoop, 1 CY	55	100	42%	2,310
2	Mechanized Wheelbarrow	23	100	54%	2,484
1	Skid Steer	66	100	17%	1,122
				Total	**8,316**

29 CFR§1926.800 - Personnel requirement 200 cfm/person

29 CFR§1926.800 - Diesel requirement of 100 cfm/bhp in addition to personnel requirement

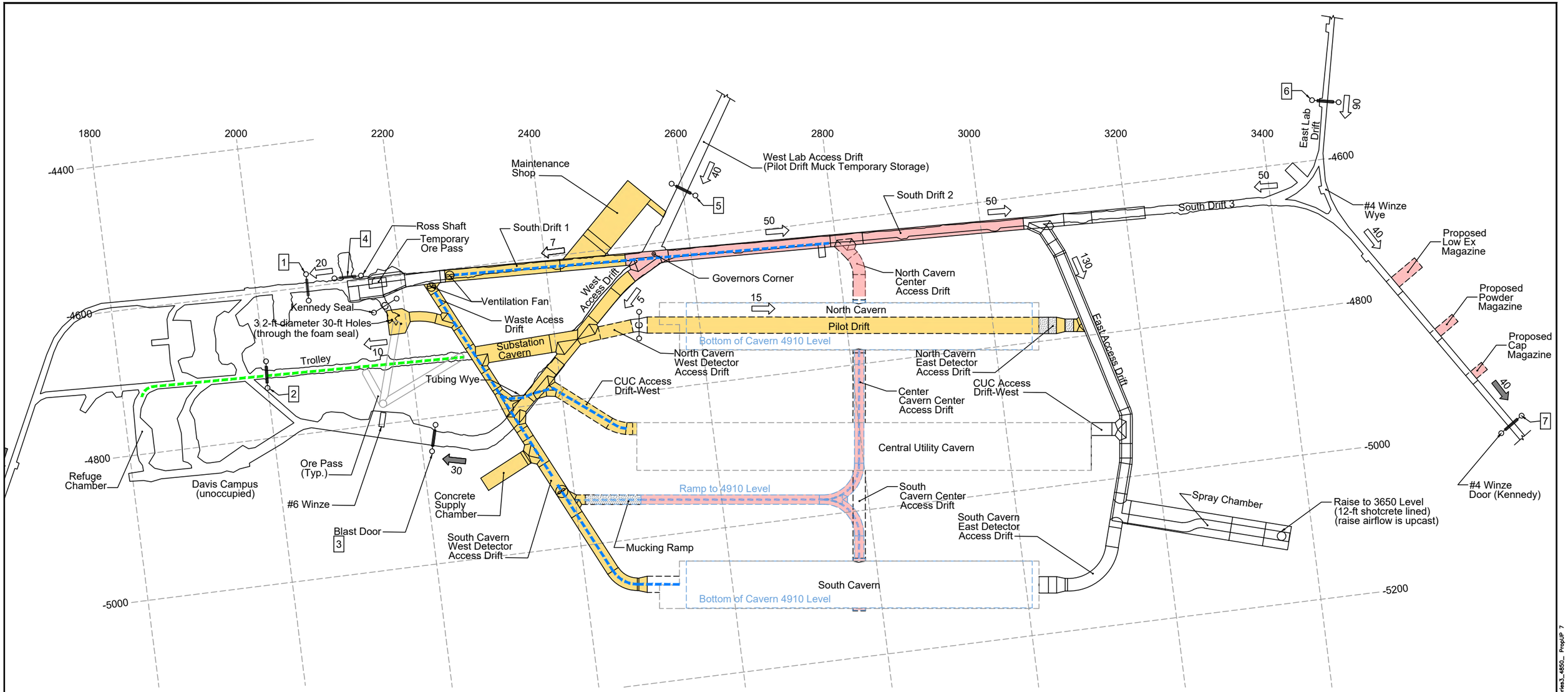
During this time, the #6 Winze will be sealed with 30 feet (ft) of foam and three 2-ft-diameter openings to an exhaust pathway. A grid mesh plate will be installed over the openings as additional protection against falling rock. The Oro Hondo fan will be ramped up to provide additional airflow in coordination with South Dakota Science and Technology Authority (SDSTA).

To the extent possible, the ore pass from the 4850L to the 5000L will continue to be kept full of muck to block the potential recirculation of air.

COMPLIANCE PLAN

Workplaces will be tested each shift before the start of underground activities for the oxygen content and gaseous contaminants. Quantity of air flow in workplaces will be measured and recorded on a weekly basis. Dust, gas, mist, and fume surveys shall be conducted as frequently as necessary to determine the adequacy of control measures. Testing and monitoring for specific contaminants will be as specified or required as in the 30 CFR Part 57[4] and the "LBNF Site Specific Safety and Health Plan."

Regular monitoring of worker airborne contaminant exposure levels will be completed to ensure compliance.



PROJECT NORTH

0 130

Scale (ft)

Legend

- Route to Area of Refuge
- Ducting (exhaust/dirty)
- Ducting (fresh)
- Blast Door (with or without valve)
- Regulator
- Curtain
- Kennedy Stopping
- 4910 Level (below 4850 Level)
- Current Excavation
- Planned Excavation
- XX — Fresh Air Flow, XX, KCFM
- YY — Exhaust Flow, YY, KCFM

Schedule of Blast Doors and Curtains

Door No.	Door Name	Door Size	During Construction	During Blasting	Ducting or Blast Valve
1	17L Header Door	36x89	Open	Open	Valve (wall install)
2	Trolley Drift Blast Door	36x89	Open	Open	No
3	#6 Winze Door	108x108	Open	Open	No
4	Electrical Room Door	36x89	Closed	Closed	No
5	West Lab Access Door	108x108	Open	Open	No
6	East Lab Access Door	60x89	Open	Closed	Valve (wall install)

Note: All fans are the SMJ-AFS-97 30 HP 3500 RPM setting 0 connected to 2-ft-diameter ventilation bag unless otherwise noted.

LBNF - FSCF - EXCAVATION

EXCAVATION SERIES THREE

NORTH CAVERN PILOT VENTILATION PLAN 4850L—PROPOSED UPCAST RAISE

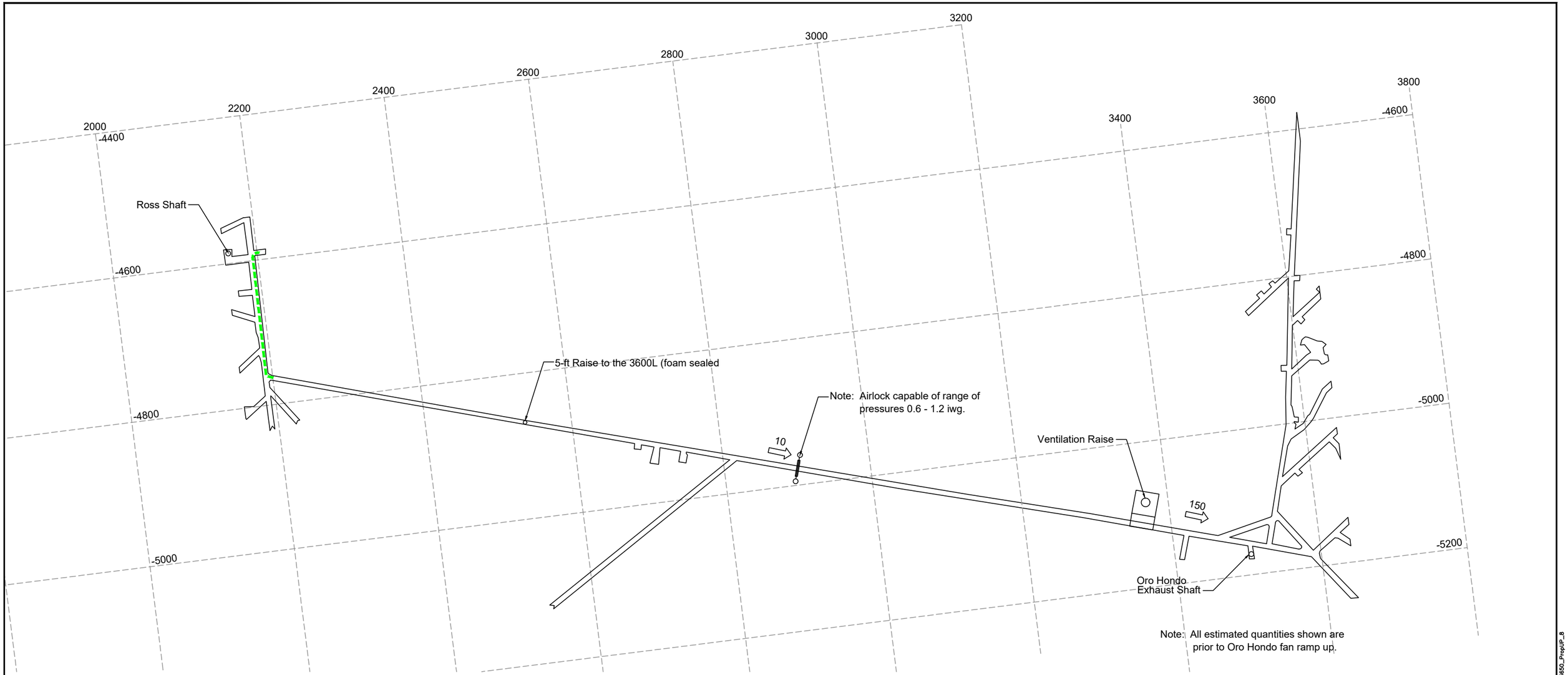
DATE: 10–15–2021
SCALE: -S SHOWN

THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

Figure 7

Agapito Associates, Inc.
ENGINEERS & GEOLOGISTS

ACAD FILE: Fermilab Base Map_4 Phase Exc Series 3.dwg Layout: Exc Series3_4850_ PropUP 7
JOB NO.: 799–06



PROJECT NORTH

N

0 130

Scale (ft)

Legend

- Route to Area of Refuge
- Ducting (exhaust/dirty)
- Ducting (fresh)
- Blast Door (with or without valve)
- R Regulator
- C Curtain
- Kennedy Stopping
- 4910 Level (below 4850 Level)
- Current Excavation
- XX Fresh Air Flow, XX, KCFM
- YY Exhaust Flow, YY, KCFM

LBNF - FSCF - EXCAVATION

EXCAVATION SERIES THREE

NORTH CAVERN PILOT VENTILATION PLAN 3650L—

PROPOSED UPCAST RAISE

DATE: 10–15–2021
SCALE: -S SHOWN

THYSSEN MINING
local challenges | GLOBAL SOLUTIONS

Figure 8

Agapito Associates, Inc.
ENGINEERS & GEOLOGISTS

ACAD FILE: Fermilab Base Map_Phase Exc Series 3.dwg Layout: Exc Series 3_3650_PropUP_8

JOB NO.: 799–06

Appendix N - SURF Ventilation Plan

Sanford Underground Research Facility Ventilation Plan – APPENDIX A to the Ventilation Chapter

Introduction:

The Sanford Underground Research Facility (SURF) is a deep level (5000 ft) underground research lab that is ventilated mechanically through exhausting fans. Ventilation is a key part in maintaining a safe and healthy work environment to ensure quality results for research projects. The ventilation system was modeled using the Howden Ventsim ventilation simulation software, which will be referenced throughout the document.

Primary Circuits:

SURF has a total accounted intake airflow of 290,000 cubic feet per minute (CFM) and a total exhaust airflow of 305,000 CFM during normal fan operation. The difference in the intake and exhaust airflow quantities represents the unaccounted airflow that leaks into the ventilation system. When the backup fan is running and the American Davidson fan is off, the total intake airflow is 193,000 CFM and the total exhaust airflow is 221,000 CFM (Measured in 2019). There are two intake shafts and two exhaust shafts that are represented in the ventilation system.

SURF's primary airflow enters down the Ross and Yates shafts and exits the levels that are open to ventilation. However, on certain levels of the facility, ventilation travels towards the shafts. This reverse movement is dependent upon leakage and pathways that enter the system.

On the 4850L, intake airflow from the Yates shaft travels through the East and West Drifts. The air from the East drift will split with most of the airflow traveling towards #4 Winze and 9 Ledge. Both courses will eventually end up in 31 Exhaust. Air that goes to #4 Winze travels down to the Deep Pool, which is currently at the 6020-foot level and exits on the 5300L and 5900L through either 26 Service Raise or 31 Exhaust. The air from 9 Ledge travels directly to 31 Exhaust.

The remaining air that splits from the East drift travels through the South Drift towards Governor's Corner, where it joins the West Drift air and continues to the Ross Campus. Combined airflow from the Yates and Ross shafts travels through the primary exhaust paths of #4 Winze, #6 Winze, 31 Exhaust Raise and 17L Incline.

Depending on door configurations in this area, air will typically go towards the Ross and #6 Winze. As the air passes by #6 Winze, we lose ~10 thousand cubic feet per minute (KCFM) down the shaft while the remainder will travel past the refuge chamber and out to 17L. Air that travels towards the Ross from Governor's Corner is usually a low flow and will join with the intake air from the Ross and travel through the #6 Winze ore pass as well as to 17L through the

Ross Campus. Air that flows through #6 Winze will end up either in the 17 Ledge ramp system or 31 Exhaust raise.

As the airflow reaches 17 Ledge, it travels up the 17 Ledge ramp incline to the 4100 Level main ventilation drift, where it meets up with the 31 Exhaust air. From there, the airflow travels across a portion of the 4100 Level, then moves through a raise, onto the 3950 Level, through the vent drift, up another raise to the 3500 Level where it enters the Oro Hondo Shaft. *Reference Diagram 1: 4850L Primary Locations*

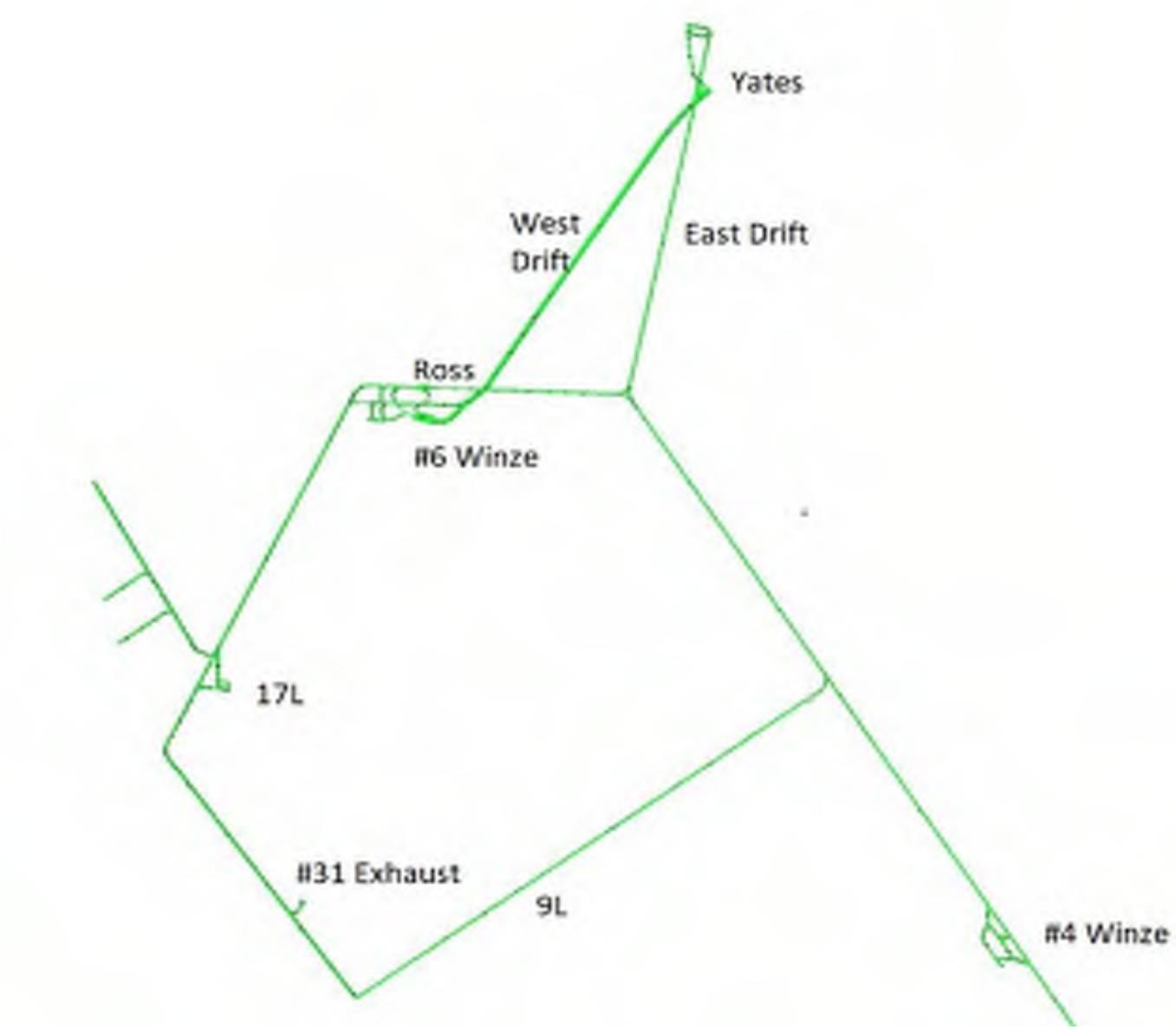


Diagram 1: *4850 Level Primary Locations*

Primary Fans:

Oro Hondo Fans

American Davidson – The American Davidson is the primary fan that exhausts air from the underground. It is a type 1400-S1BAB92-EV single-width centrifugal with backward-curved airfoil blades. The rotating wheel is 140 inches in diameter and weighs 12,700 pounds. The fan is powered by a 3,000 horsepower (HP), 720 rotations per minute (RPM) synchronous motor that is directly connected to the fan and is limited by a 1750 HP Variable Frequency Drive (VFD). The VFD provides soft-start capabilities and controls the fan speed from 50 percent to 85 percent capacity of the synchronous motor speed. The fan's normal operating point is 390 RPM, producing 305,000 CFM at 7.57 inches water column for Fan Total Pressure, with an inlet air density of 0.061 pound (lb.)/ft^3.

Spendrup 350 – The Spendrup 350 is the main backup fan in case of failure or maintenance to the American Davidson. Both fans connect to the Oro Hondo shaft through the use of ducting separated by isolation doors. The Spendrup 350 is a series 152-91-1760 vane axial fan that operates at 144,000 CFM at 3.7 inches of total water column with an inlet air density of 0.058 lb./ft^3 (measured in 2019).

#5 Shaft Fan

Spendrup 150 – The Spendrup 150 fan is the secondary main exhaust fan located at #5 Shaft. The Spendrup 150 is a series 125-07-1800-A vane axial fan that exhausts 32,000 CFM at 7.305 inches of total water gauge with an inlet air density of 0.0569 lb./ft^3. Currently, there is a blockage within #5 Shaft located 682 feet below the collar of the shaft that is exhausting an estimated 20,000 CFM from the underground, leaving 12,000 CFM of leakage through multiple areas such as the hoist room ramp, Barrick's overflow pipe, and the collar/fan housing itself.

Manager Plus ID	Fan Description	Manufacturer	Model	Serial #	Fan Details	Pressure in w.g.	CFM Capacity	Current Fan Settings	Current Location	Surface/UG	Service Area
FN-RLS05-01	Spendrup 150 150 HP Motor	Spendrup	125-70-1800	3605	Fan Diameter: 49.25" Air Density: 0.075 lbs/cu. Ft. Diffuser Diameter: 63" Diffuser Length: 60"	19	170 KCFM	Airflow: 32 KCFM Total Pressure: 7.2 in. w.g.	#5 Shaft	Surface	2000L, 4100L, and 4850L
FN-RLS05-03	Spendrup 150 150 HP Motor	Spendrup	125-70-1800	Unknown	Fan Diameter: 49.25" Air Density: 0.075 lbs/cu. Ft. Diffuser Diameter: 63" Diffuser Length: 60"	19	170 KCFM	N/A - Spare Fan	Warehouse	Surface	N/A
FN-RLS01-02	Spendrup 350 350 HP Motor	Spendrup	152-91-1760	5728	Fan Diameter: 60" Air Density: 0.075 lbs./cu. ft.	20	280	(Not in Operation) Airflow: 144 KCFM Total Pressure: 3.4 in. w.g.	Oro Hondo Shaft	Surface	Back-up
FN-RLS05-02	Spendrup 350 350 HP Motor	Spendrup	152-001-1000	5723	Fan Diameter: 60" Air Density: 0.075 lbs./cu. ft.	20	280	N/A - Spare Fan	#5 Shaft	Surface	N/A
FN-RLS01-01	2000 HP Motor	American Davidson	140.0 SI BAB92	CF 60 85085	Duct Area: 170 ft^2	26.48	478 KCFM	Airflow: 305 KCFM Total Pressure: 7.3 in. w.g. RPM: 390	Oro Hondo Shaft	Surface	All UG

Table 1: *Primary Fan Data Summary*

Auxiliary Fans:

Table 2 lists all auxiliary fans currently in inventory and summarizes each fan's data. Fan inventory will be updated with the 2021 cost report. All fan locations are listed below and are shown on the 2021 ventilation survey maps.

Manager Plus ID	Fan Description	Manufacturer	Model	Serial #	Duct Size	CFM Capacity @Max HP	Motor Horsepower	Current Level	Service Area
FN-XXB99-01	Coppus Ventair Blower 5 HP	Coppus Ventair	EM 3663T	F1112052549	10 inch	2,500	5	3650L	Pump Room
FN-XXB99-02	Coppus Ventair Blower 20 HP	Coppus Ventair	TM-8	63V1710	14 inch	7,400	20	3650L	Pump Room
FN-XXB99-03	Coppus Ventair Fan 20 HP 3 Phase	Coppus Ventair	TM-8	78V1149	14 inch	7,400	20	5000L	Pump Room
FN-XXB99-04	Coppus Ventair Fan 1 HP 24" 460V	Coppus Ventair	24K10DF	150102700	N/A	9,500	1	2450L	Pump Room
FN-XXB99-05	Coppus Ventair Fan 20 HP	Coppus Ventair	TM-8	Unknown	14 inch	7,400	20	2600L	Pump Room
FN-XXU99-01	Spendrup 20 HP	Spendrup	AMF-155-20-FPHE	3737	14 inch	10,000	20	1700L	MotorBarn (CAT)
FermiLab Owned	Tramway Fan	Jetair	J-4-B	Unknown	36 inch	45,000	50	Tramway	Conveyor Route
Thyssen Mining	Pilot Drift Fan	SMJ	AFS - 97	Unknown	24 inch	64,000	30	4850L	Pilot Drift
Thyssen Mining	Trolley Drift Fan	SMJ	AFS - 97	Unknown	24 inch	64,000	30	4850L	Governor's Corner

Table 2: *Auxiliary Fan Data Summary*

Mine Cooling:

SURF currently has two 72.47-ton chillers located on the 4850L East Lab Access Drift. The refrigerant used is R410A. These two chillers directly service the Davis Campus near the Yates Shaft on the 4850L.

Two 72-ton York chillers are in the East Drift on the 4850L, approximately 200 linear feet from the bottom of the Yates Shaft. The two chillers run in tandem, meaning only one chiller is in operation at a time. The design evaporator duty is 133.5 gallons per minute (GPM) with 10-degree Fahrenheit temperature reduction. A 15 HP Pentair Aurora 3800 series single stage end suction pump distributes the chilled water through the system.

Shaft Heating:

Shaft heaters are used at the facility to reduce the risk of freezing the shaft during winter operations. A heater is located at both the Yates and Ross shafts and are designed to work with 40,000 CFM. All heaters were manufactured by Titan and have a primary fuel source of natural gas, which can produce a maximum of 3.6 million British thermal units (BTUs) at the designed airflow.

Annual Plan

The following list includes anticipated changes to the ventilation circuits for the year **2021**. The main goal for the ventilation system improvements of **2021** is to progress the reliability of the current ventilation system by sealing unwanted leakage in areas that do not need to be ventilated. Completing the following projects will improve our main fan (American Davidson) efficiency and reduce the risk of spontaneous combustion fires.

1. Install new drive-thru Kennedy on the 4550 Level to separate #6 Winze and Ross, while removing the existing Kennedy Stopping towards 17 Ledge ramp.
    a. This will allow an efficient exhaust path utilizing the #6 Winze Ore Pass from the 4850 Level
2. Seal all x-cuts in 9 Ledge main drift
3. Seal 26 service raise by 31 Exhaust on the 4850 Level
4. Seal ramp cross over to 31 Exhaust in 17 Ledge ramp system
5. Remove/replace air door near 4 Winze towards 94 Exhaust Raise
6. Remove/replace air door in main drift towards 4 Winze
7. Seal air raise in 9 Ledge drift currently sealed with brattice wall

Once the above list is complete, open 9 Ledge drift air door, turn #5 Shaft Spendrup Fan off and seal at the surface.

If schedule and budget permits, the following installations should be completed next:

1. Install Kennedy on 800 Level near B&M #2 blocking raise
2. Install Kennedy towards Caledonia workings on the 800 Level
3. Remove existing fan house on the 1100 Level that is located on the 60 manway raise connecting 1100 Level to 1400 Level.
4. Install Kennedy blocking star shaft on the 1100 Level
5. Install Kennedy stoppings on all sump walls on the 1100 Level
6. Install Kennedy stoppings blocking Caledonia workings on 1100 Level
7. Install Kennedy stoppings blocking #1 Air Raise on 1100 Level
8. Upgrade Drive-Thru vent door on Yates Shaft Header
9. Install Kennedy blocking South Sand Raise drift
10. Install Kennedy Blocking 2150 Level decline in 9 Ledge near open stope on the 2000 Level
11. Upgrade door blocking stairway on the 2000 Level
12. Install louvered regulator on Oro Hondo Shaft wall on 2000 Level
13. Install Kennedy blocking Ellison on 2300 Level
14. Install Kennedy blocking Raise on corner near Ellison
15. Install Kennedy on 3500 Level towards Milliken
16. Install Kennedy on Yates Header on 3650 Level
17. Install Kennedy on 2/8 Ramp Front Ramp Decline on 3950 Level
18. Upgrade airlock vent doors to vent drift on 3950 Level
19. Install Kennedy Stopping to Boreholes at the top of 17 Ledge ramp on the 4100 Level
20. Install Kennedy blocking open stope near CASPAR location on the 4100 Level
21. Install Door with vent duct port between Lake Varick and Ross Shaft
22. #5 Shaft fan will be shut down and be sealed on top.
    a. There is a large blockage of steel and rubble 683 feet down. The fan is surging and not effective anymore.
    b. Need to verify the #5 shaft will not freeze without up cast warm air.
    c. Consider the overflow pipe from Grizzly Gulch (Barrick)
23. 3650 Level change ventilation to eliminate fans – is this possible with water in sump?
    a. Consider air flow over water and its impact (humidity, particulates?)

Summary

In the middle of fiscal year **2021**, KAJV operations will transition to Thyssen Mining. After the transition, the Davis Campus airflow demand will remain static, and all experiments in the Ross Campus will be decommissioned and removed. The ventilation system will stay the same during this time. Once Thyssen begins excavation, ventilation pathways will continuously change due to airflow requirements at working faces. All Davis Campus airflow requirements on the 4850L will be satisfied due to the higher CFM requirements during LBNF excavations near the Ross Shaft.

Introduction

In **2021**, the first phase of the LBNF project excavations began. New excavations for a large-scale science experiment located on the 4850 Level will be taking place and ultimately change the current state of the ventilation system. This presents a prime opportunity to evaluate the entire ventilation system, anticipating current and future demands. The analysis will be addressed in three steps:

1. Outline LBNF project airflow requirements and current science airflow requirements.
2. Undertake a remediation of the ventilation system.
3. Modify current airflow pathways.

The first step is acquiring LBNF's projected airflow requirements. After receiving their airflow requirements, the next step is to determine the means and methods of providing and routing the airflow requirements. Concurrently with the airflow pathway modifications, a plan will be submitted to decrease existing intake airflow leakage and improve the overall efficiency and reliability of the ventilation system.

Emergency Planning

In the event of an underground emergency, it is important to know some basic information and the warning system to help keep you and your group safe. When an emergency is identified and the underground needs to be evacuated, the stench warning system will be deployed. The stench system is located at the ramps of the Ross and Yates shafts. The stench warning system is a gas distinguished by its strong odor. When the stench gas is deployed, it travels within the fresh air stream by the velocity of airflow that reaches every part of the underground space that has prominent airflow. Below is the list of locations and the associated times the stench gas will reach that location after being deployed.

Underground Level	Location Description	Time to Reach Location (minutes)	Actual Time (Min.)	Remote Stench Stations Modelled Time (minutes)
1700L	Ramp to 2000L	25	No Detection	5
2000L	Water Inflow Tee	42	No Detection	6.5
3650L	Borehole Chamber	17	11	17
4100L	Main Ledge Cross Over	30	15	1
4850L	Yates Station	15	12	1
4850L	Ross Station	16	16	1
4850L	South Drift	22	16	3
4850L	Governors Corner	26	21	6
4850L	CASPAR/BHUC Drift	28	21	11
4850L	Refuge Chamber	18	18	3
5000L	Ross Station	18	17	1

During an emergency, it is important to understand your fresh air intakes and your exhaust routes for the level you are on. Always travel toward your fresh air supply. Rely on your gas tester to inform you of compromised airways and to help you understand the direction the compromised air is traveling.

Current Airflows and Monitoring

Throughout the year, the Underground Operations Department conducts quarterly ventilation audits to measure and record airflow velocities, direction, barometric pressure, dry bulb temperature and percent humidity. These measurements are completed at predefined points on twelve primary levels of the underground where ventilation plays a significant role. By conducting these measurements, SURF staff can identify notable changes to the ventilation system and can determine how it could affect the underground areas with specific requirements. It is important to know that a single air door position change (open or closed) on any level can considerably change ventilation quantity and direction on all levels. An air door should remain in the position you found it and should be brought to the Underground Operations Department's attention if you think it is in the wrong position. If you notice a change in ventilation, whether it would be an increase or decrease in airflow or direction change, notify your supervisor, or directly notify the Underground Operations Department.

For more details on recorded data, please reference the attached level maps in **Appendix F** as well as **Appendix C** *Main Ventilation Pathways*. These levels consist of the list below:

1. 300L
2. 800L
3. 1100L
4. 1550L
5. 1700L
6. 2000L
7. 3500L
8. 3650L

9. 3950L
10. 4100L
11. 4850L
12. 5000L

Along with conducting quarterly audits, SURF works with Steven Gabriel from the Spearfish High School who operates multiple airflow monitors throughout the underground. These monitors continuously record and display airflow volume in CFM, pressure in inches water, temperature in degrees Fahrenheit, relative humidity and whether each location has normal airflow direction. When changes occur within the ventilation system, programmed alerts are emailed to management personnel. These types of changes include the main fan unexpectedly turning off, certain air doors closing/opening and airflow direction changes.

Follow the link to visit Gabriel's website https://sites.google.com/a/spearfish.k12.sd.us/steve-gabriel/The-Underground/underground-environment-1-day

In conjunction with Gabriel's system, SURF has carbon monoxide (CO) sensors stationed throughout key locations in the underground to detect harmful atmosphere conditions. These sensors are stationed at the following locations:

1. Yates Ramp
2. Ross Ramp
3. 1250 Level Pump Room
4. 2000 Level Main Corridor by Crossover
5. 2450 Level Pump Room
6. 3650 Level Pump Room
7. 4100 Level near Oro Hondo
8. 4850 Level Yates Station
9. 4850 Level Ross
10. 4850 Level 9 Ledge/4 Winze Wye
11. 4850 Level 17 Ledge
12. 5000 Level Pump Room

Past Airflows

The Underground Operations Engineer measures and tracks mine airflows throughout the year at pre-determined locations on various levels across the lab underground infrastructure. The total exhaust airflows are measured directly at the fan locations at the Oro Hondo Shaft and #5 Shaft, using a pitot tube and manometer. Intake airflows are more difficult to measure directly, given the shaft size and the structure of the shaft itself. Typically, the intake airflow is estimated by measuring the airflow leaving the shaft stations and the differences that are encountered at each the Ross and Yates shaft.

YEAR	**Ross Supplied/ Required**	**Davis Supplied/ Required**			**Utilized BHP**	**CFM/ BHP**	**BHP Total KCFM**	**Avg. UG Personnel**	**CFM/Person**	**Personnel Total CFM**	**Total CFM Supplied/Required**
2020	62 / 22 KCFM	105 /42 KCFM			145	100	14.5 KCFM	80	200	16 KCFM	94.5 KCFM
YEAR	**4850L KCFM Supplied/ Required**	**4100L Supplied/ Required**	**3650L Supplied/Required**	**1700L Supplied / Required**	**Utilized BHP**	**CFM/ BHP**	**BHP Total CFM**	**Avg. UG Personnel**	**CFM/Person**	**Personnel Total CFM**	**Total UG CFM Required**
2021 (1st Half)	130 / 57 KCFM	8 / 7 KCFM	20 / 9.3 KCFM	35 / 12.3 KCFM	355 HP	100 CFM	35.5 KCFM	144	200 CFM	28.8 KCFM	149.9 KCFM
2021 (2nd Half)	130/73.4 KCFM	8 / 7 KCFM	20 / 9.3 KCFM	35 / 12.3 KCFM	676 HP	100 CFM	67.6 KCFM	144	200 CFM	28.8 KCFM	198.4 KCFM

Throughout the year, ventilation surveys are conducted to determine whether the specified equipment, airflow, and air conditioning/heating are reaching their targeted areas with the desired efficiency. Even if the defined requirements are met, an assessment should be performed to determine feasibility and efficiency of the entire ventilation system. This assessment will be developed by comparing the measured actual supplied airflow to the required airflow, along with underground personnel observations.

When completing an assessment like the one listed above, two goals are always at the forefront: reduce operating costs and provide a safe and healthy work environment. The facility's workings have provided a unique challenge in ventilating the underground science areas due to the many open drifts, stopes, boreholes, and raises throughout the entire underground; at the same time, these workings provide countless opportunities to change and adapt the ventilation system when needed. One thing is certain: leakage can be greatly reduced, and a better understanding of leakage pathways will minimize operating costs. This is a goal we work continually to solve and improve.

Future Airflows

Underground airflow specification and control is critical to the success of SURF and the success of the science experiments who call SURF home. Having a consistent database of measured airflow quantities, pressure readings and heat surveys throughout the facility helps predict and calculate existing and new airflow requirements in desired locations using the Ventsim ventilation modelling software. The Ventsim software allows us to predict available and potential airflows for future expansions with minor or major changes to the ventilation system. The Ventsim model is continuously calibrated and revised throughout the year. This is typically done by taking field measurements and adjusting the model to reflect the data by updating ventilation pathways and drift resistance.

Low airflow quantities in areas that demand certain CFM, such as the operating science experiments, can be detrimental to the success of the research itself. Areas where the Underground Mitigation Crew and other contractors are working require the proper ventilation to maintain a healthy environment and increase productivity with adequate airflow. On the flip side, too high of airflows can become expensive and can accrue large operating costs due to fan operating power and the associated pressures and CFM quantities relative to resistances throughout the underground airflow pathways. Over supply of airflow also leads to additional fans and airways needed and, in some cases, supply excessive air velocities which can be a source of dusty environments.

Airflow Specification is based on many factors associated with the underground environment such as:

- Science requirements
- Potential/upcoming excavations and the method of excavation
- Explosives usage and the blast fumes generated from the blast
- Underground diesel equipment usage
    - Utilization

- Leakage rates
- Underground gas contaminants (Radon, CO_2 , Methane, Heat, etc.)
- Air density
- New science development sites
- Regulatory requirements
- Ventilating underground areas such as:
    - Shops
    - Storage areas
    - Substations
    - Locomotive battery charging stations
    - Pump rooms
    - Refuge Chambers and escapeways

Typically, any underground environment, whether it be an operating mine or a science laboratory, will contain one overriding ventilation concern. Supplying enough airflow for that overriding concern will usually absolve other concerns. The two major ventilation design considerations currently in the SURF underground are diesel horsepower and science equipment CFM requirements. Heat is usually taken care of using chillers and HVAC systems for the research areas, so the leading ventilation concern at SURF is CFM requirements needed to properly ventilate the diesel particulate matter, or DPM, from working areas with operating mobile equipment. To determine the CFM requirements, a zero-based planning is performed to predict the equipment usage throughout a year, which is referenced in the paragraphs below.

Zero-Based Planning

The main method for specifying underground airflows at SURF is Zero-based planning. Zero-based planning is the method of charting all activities and equipment with the specific CFM requirements for each. In some cases, certain airflows can be re-used, so the summation of all individual requirements does not equal the total mine intake quantity.

Appendix A lists the diesel equipment currently used underground. It assumes that the equipment is located on one underground level and not a specific location with a utilized horsepower rating. The total predicted underground utilized diesel horsepower at SURF for 2021 is 676 HP combined for all pieces of equipment underground. In order to determine the required CFM, the airflow ratio to horsepower needs to be applied. It should be known that Mine Safety and Health Administration (MSHA) does not dictate the quantity of airflow to horsepower needed, but more so the Threshold Limit Value (TLV's) of the gas contaminants of the equipment such as CO and NO_x to be within 50 percent of their TLV. For this exercise, we will use the OSHA 29 CFR 1926.800(k)(10)(iii) referenced in **Appendix E**. The airflow ratio of 100 CFM/1 HP for the predicted horsepower utilization of all equipment will be used to determine the total CFM needed to properly ventilate the equipment exhaust. Below is a table of the predicted airflow needed for 2021.

The Future overall airflow design will be based on:

- Diesel Horsepower
- Excavation Headings
- Pump rooms & Substations
- Main Travel Ways
- Leakage
- Contingency

Design Parameter	**Quantity**	**CFM Requirement**	**Total CFM Needed**
SDSTA Diesel Horsepower	145	100	14,500
Contractor Diesel Horsepower	531	100	53,100
Personnel Underground	144	200	28,800
Excavation Headings	3	30 FPM @ 12x12 Area	12,960
Pump Rooms/Substations (5000L, 3650L, 2450L, 1250L)	4	5,000	20,000
Main Travel Ways (4100L, 3650L, 1700L)	3	5,000	15,000
Total Science Requirements	1	64,227	64,227
Leakage Rate of Subtotal	(208,587)	10%	20,859
Contingency of Subtotal	(208,587)	10%	20,859
			250,305 CFM

Conclusion

In conclusion, Sanford Underground Research Facility is slightly over ventilated, currently providing 305,000 CFM while we only need approximately 250,000 CFM. However, not all 305,000 CFM is reaching the desired areas that need to be ventilated, and a ventilation assessment report will provide the details on the overall efficiency and feasibility of the ventilation system. With new science experiments starting to call SURF their home and LBNF excavations steadily increasing, the future airflow capacities will need to be continually increased over the years with expanding CFM requirements and equipment horsepower being used. With the new American Davidson fan drive installed, we have the capability to increase the total exhaust airflow to approximately 500,000 CFM with minor changes to the current ventilation paths.

Furthermore, we can improve our ventilation system by reducing the amount of leakage outside of our main ventilation pathways to help make the overall system more reliable and have more control over changes that need to be done to the ventilation itself. By improving the leakage rate,

we can provide more airflow to areas that need it and can worry less about the areas that are of concern to start a spontaneous combustion fire.

As we currently sit today, we are able to meet the demands of the science customers and the projects that require ventilation, while also having the capability to adapt and meet the demand of future science experiments with very little to no major infrastructure improvements.

PLAN Appendix

Appendix A: Underground Diesel Equipment

2021 UG Equipment w_CFM.pdf

2021 2nd Half UG Equipment w_CFM.pdf

Appendix B: Annual Ventilation Costs

Yearly Costs.pdf

Appendix C: Main Ventilation Pathways

Quarterly Audit.pdf

Appendix D: Predicted Ventilation Changes (LBNF Excavations)

Predicted Airflows.pdf

Appendix E: Ventilation Standards Followed at SURF

Ventilation Standards.pdf

Appendix F: Primary Levels Ventilation Maps

4100L Vent 2021.pdf

3950L Vent 2021.pdf

3650L Vent 2021.pdf

3500L Vent 2021.pdf

2000L Vent 2021.pdf

1700LVent 2021.pdf

1550L Vent 2021.pdf

1100L Vent 2021.pdf

800L Vent.pdf

300LVent 2021.pdf

5000L Vent 2021.pdf

4850L Vent 2021.pdf