Work Planning and Control Assessment at the Fermi National Accelerator Laboratory

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Acronyms

AC	Alternating Current
AD	Accelerator Division
AHJ	Authority Having Jurisdiction
APS-TD	Applied Physics and Superconducting Technology Division
CAS	Contractor Assurance System
CFR	Code of Federal Regulations
CRAD	Criteria and Review Approach Document
DC	Direct Current
DOE	U.S. Department of Energy
EA	Office of Enterprise Assessments
ES&H	Environment, Safety, and Health
FAMIS	Facility Administration and Maintenance Information System
Fermilab	Fermi National Accelerator Laboratory
FESHM	Fermilab Environment, Safety, and Health Manual
FESS	Facilities Engineering Services Section
FRA	Fermi Research Alliance, LLC
HA	Hazard Analysis
HPI	Human Performance Improvement
IOTA	Integrable Optics Test Accelerator
ISM	Integrated Safety Management
LOTO	Lockout/Tagout
MI	Main Injector
ND	Neutrino Division
NM-4	Neutrino Muon (NM)-4 Enclosure
OFI	Opportunity for Improvement
OSHA	Occupational Safety and Health Administration
PPD	Particle Physics Division
PPE	Personal Protective Equipment
PPMS	Physical Property Measurement System
QAM	Quality Assurance Manual
SBN	Short-Baseline Neutrino
SME	Subject Matter Expert
SOP	Standard Operating Procedure
WO	Work Order
WP&C	Work Planning and Control

Work Planning and Control Assessment
at the Fermi National Accelerator Laboratory

EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) Office of Worker Safety and Health Assessments, within the independent Office of Enterprise Assessments (EA), conducted a work planning and control (WP&C) assessment at the Fermi National Accelerator Laboratory (Fermilab), which is operated by Fermi Research Alliance, LLC (FRA). The Laboratory Director requested this assessment to gain an independent perspective on the status of WP&C at Fermilab. WP&C and selected elements of the contractor assurance system (CAS) were reviewed, involving observations of research and maintenance activities within the Accelerator, Particle Physics, Neutrino, and Applied Physics and Superconducting Technical Divisions and the Facilities Engineering Services Section. This assessment was conducted within the broader context of a series of targeted assessments of WP&C at sites across the DOE complex. EA conducted the onsite portions of this assessment February 11-15 and 25-28, 2019.

FRA has implemented a single approach to WP&C across all organizations and types of work, with varying degrees of effectiveness. The institutional WP&C process, set out in Fermilab Environment, Safety, and Health Manual (FESHM) 2060, provides the program description, definitions, responsibilities, procedures, and technical appendices addressing WP&C, and Hazard Analysis Form 2060 provides a useful format for documenting the work description and the hazards and controls for research and other technical work activities. The process also allows for the use of procedures and permits instead of hazard analyses where criteria for scope, hazard assessment, and controls are met.

However, FESHM 2060 does not contain adequate requirements and guidance to effectively implement integrated safety management. The approach used is not always effective in identifying and controlling work hazards, and the quality and content of hazard analyses generally does not meet FESHM 2060 requirements. FRA has not established a workplace occupational exposure assessment program as required by 10 CFR 851.21, *Worker Safety and Health Program*, Appendix A(6), *Industrial Hygiene*, and has not fully implemented the 10 CFR 851.23(a)(3) invoked Occupational Safety and Health Administration 29 CFR 1910.269, *Electric Power Generation, Transmission, and Distribution*, requirements for working on or near high-voltage electrical distribution equipment.

Overall, the current CAS program description is adequate to guide CAS implementation, but FRA has not effectively implemented a feedback and lessons-learned program. Although FRA performs a number of documented self-assessment activities, none were scoped to evaluate and improve the WP&C process. The recently-instituted human performance improvement (HPI) review team has strengthened the HPI program. However, the integration of HPI into the graded corrective action system does not ensure the documentation of technical causes and associated corrective actions, even when technical causes are identified. Pre-job briefings did not review operating experience or information on site safety and health experience. Post-job reviews are not always conducted, and hazard analyses are not always reviewed.

Collectively, these issues reach across each of the core functions of integrated safety management. The effectiveness of FRA's WP&C program may be improved through a greater focus on rigor and accountability throughout the work planning process.

Work Planning and Control Assessment
at the Fermi National Accelerator Laboratory

1.0 PURPOSE

The U.S. Department of Energy (DOE) Office of Worker Safety and Health Assessments, within the independent Office of Enterprise Assessments (EA), conducted a work planning and control (WP&C) assessment at the Fermi National Accelerator Laboratory (Fermilab). The Fermilab Laboratory Director requested this assessment to gain an independent perspective on the status of WP&C. EA conducted the onsite portions of this assessment February 11-15 and 25-28, 2019.

2.0 SCOPE

This assessment evaluated the WP&C program and its implementation in accordance with the *Plan for the Office of Enterprise Assessments Assessment of the Work Planning and Control Program at Fermi National Accelerator Laboratory, February 2019.* This assessment evaluated the effectiveness of the implementation of the integrated safety management (ISM) core functions (define scope of work, identify and analyze hazards, identify and implement controls, perform work safely within controls, and feedback and improvement) within operations that contain physical, chemical, and radiological hazards. This assessment also evaluated elements of the contractor assurance system (CAS).

3.0 BACKGROUND

Fermilab's 6,800-acre site is located in Batavia, Illinois, and is managed by Fermi Research Alliance, LLC (FRA) for DOE's Office of Science. FRA is a partnership of the University of Chicago and Universities Research Association Inc., a consortium of 89 research universities. Fermilab is an accelerator complex specializing in particle physics and accelerator science and technology utilizing large-scale user facilities and advanced instrumentation. Fermilab has approximately 1,750 employees, including scientists and engineers from around the world.

4.0 METHODOLOGY

The DOE independent oversight program is described in and governed by DOE Order 227.1A, *Independent Oversight Program*. EA implements the independent oversight program through a comprehensive set of internal protocols, operating practices, assessment guides, and process guides. Organizations and programs within DOE use varying terms to document specific assessment results. In this report, EA uses the terms "deficiencies, findings, and opportunities for improvement (OFIs)" as defined in DOE Order 227.1A. In accordance with DOE Order 227.1A, DOE line management and/or contractor organizations must develop and implement corrective action plans for deficiencies identified as findings. Other important deficiencies not meeting the criteria for a finding are also highlighted in the report and summarized in Appendix B. These deficiencies should be addressed consistent with site-specific issues management procedures.

This assessment considered requirements related to WP&C and the CAS included in DOE Contract Number DE-AC02-07CH11359 with FRA. As outlined in the assessment plan, the assessment team selected objectives and criteria from DOE Guide 226.1-2A, *Federal Line Management Oversight of Department of Energy Nuclear Facilities*, Appendix D, *Activity-Level Work Planning and Control*

Criterion Review and Approach Documents with Lines of Inquiry. EA also selected objectives and criteria from Criteria and Review Approach Document (CRAD) EA-32-03, *Industrial Hygiene Program Criteria and Review Approach Document*; CRAD EA-45-35, *Occupational Radiation Protection Criteria Review and Approach Document*; and CRAD EA-30-01, *Contractor Assurance System*, as well as selected feedback and improvement criteria from DOE Guide 226.1-2A.

The assessment team examined key documents, such as system descriptions, work packages, procedures, manuals, analyses, policies, and training and qualification records; interviewed key personnel responsible for developing and executing the associated programs; and observed over 50 activities. The assessment team also assessed significant portions of selected Divisions – Accelerator (AD), Particle Physics (PPD), Neutrino (ND), and Applied Physics and Superconducting Technical Division (APS-TD) – and the Facilities Engineering Services Section (FESS) facilities and work areas, focusing on the effectiveness of FRA's WP&C program. The members of the assessment team, the Quality Review Board, and EA management responsible for this assessment are listed in Appendix A.

EA previously assessed subcontracted construction safety at the request of the Laboratory Director in December 2015. Follow-up on implementation of the specific actions taken in response to the recommendations from that assessment was not within the scope of this assessment; however, the assessment team did review FRA's approach to making improvements in contracted construction safety as discussed in Section 5.5 of this report.

5.0 RESULTS

Objective:

The contractor shall manage and perform work in accordance with a documented Safety Management System that describes how the contractor will (1) Define the scope of work; (2) Identify and analyze hazards associated with the work; (3) Develop and implement hazard controls; (4) Perform work within controls; and (5) Provide feedback on adequacy of controls and continue to improve safety management. (48 CFR 970.5223-1(c) and DOE Contract Number DE-AC02-07CH11359, Clause I.98, Integration of Environment, Safety, and Health into Work Planning and Execution)

5.1 Institutional Work Planning and Control Program

The Fermilab Environment, Safety, and Health (ES&H) Manual (FESHM) 2060, *Work Planning and Hazard Analysis*, provides the program description, definitions, responsibilities, procedures, and technical appendices addressing WP&C. Hazard Analysis (HA) Form 2060 provides a useful format for documenting the scope of work and establishing hazards and controls for research and other technical work activities.

The assessment team identified some institutional WP&C issues through review of FESHM 2060 and discussions with ES&H organization and line management. FESHM 2060, the only institutional document addressing WP&C, does not contain adequate requirements and guidance to effectively implement ISM: (See **OFI-FRA-1**.)

- FESHM 2060 allows the use of permits, such as electrical work permits, instead of HAs but does not provide requirements for defining the scope of work in permits, and there is no requirement to identify potential hazards before users and collaborators bring equipment and materials into Fermilab.

- FESHM 2060 does not address the level of line management responsible for authorizing work packages that contain more than one HA, or that contain multiple permits or procedures. Also, FESHM 2060 does not specify review of work activities by Authorities Having Jurisdiction (AHJs), and AHJs are not always consulted for activities under their jurisdiction before work starts.

- Section 5.4.2 of FESHM 2060 does not identify employee-initiated stop-work as a reason for cessation of a work activity, nor does it provide for a less rigorous process (e.g., pause work) to address questions arising from miscommunication or safety-related issues before resuming work. Nevertheless, employee interviews indicated that employees understand that they can stop work.

- Section 5.5 of FESHM 2060 specifies that "the HA should be updated to include improvements that were identified while performing the work." However, there is no requirement to record feedback and lessons learned needed to update the HA as noted in Section 5.3 of this report.

Additionally, FRA has not established a workplace occupational exposure assessment program as required by 10 CFR 851.21, *Worker Safety and Health Program*, Appendix A(6), *Industrial Hygiene*. (See **Finding F-FRA-1**.) The regulation requires contractors "initially to obtain baseline information and as often thereafter as necessary to ensure compliance." The ES&H organization conducts industrial hygiene workplace occupational exposure assessments to support new work or respond to issues/events that arise but has not developed a formal program to collect baseline information and subsequently update exposure assessment information, as required by the regulation.

Institutional Work Planning and Control Program Conclusions

FESHM 2060 describes the WP&C program elements, and HA Form 2060 is useful for documenting the scope of work and establishing hazards and controls. However, FESHM 2060 does not contain adequate requirements and guidance to effectively implement ISM. Additionally, FRA has not established a workplace occupational exposure assessment program, as required by 10 CFR 851.21, Appendix A(6).

5.2 Work Planning and Control Implementation

This section discusses the assessment of FRA's implementation of its institutional WP&C program within research divisions and FESS.

5.2.1 Research Divisions

The assessment team observed 22 ongoing technical support and research activities within the FRA research divisions – AD, APS-TD, PPD, and ND – and participated in research facility walkdowns with division safety officers.

Defining the Scope of Work

Section 5.2 of FESHM 2060 requires that the documented HAs include a detailed scope of work, including how the person/team intends to complete the work. Examples of observed work performed under documented HAs with adequately described work scopes included work within the upgrade to "Install SLAC Undulator into the IOTA [Integrable Optics Test Accelerator] Ring" and the Short Baseline Neutrino (SBN)-FD Filter Cartridge Transport & Filling activity.

Section 5.2.1.a of FESHM 2060 states an exception that procedures or permits may be used instead of HAs "where all hazards are identified and addressed." AD uses procedures, and APS-TD uses "travelers" (the term APS-TD uses for technical work instructions), which adequately define the scope of work. However, the HAs used for most activity-level work within PPD and ND do not sufficiently describe the work scopes, and these divisions instead rely on verbal communications between project engineers and first line supervisors or technicians. **(Deficiency-FRA-1)**

For example, HAs prepared by PPD for moving shield blocks to build a shield wall in the Neutrino Muon (NM)-4 Enclosure (NM-4), by ND for installing cryogenic piping, and by PPD for assembling a cleanroom at the D-Zero facility did not sufficiently describe the activities. The HAs did not discuss rigging methods for horizontal moving of shield blocks at NM-4 and/or describe tasks in enough detail to identify some significant hazards associated with the SBN activities, such as welding on stainless steel. In these cases, the tasks described in the HA did not specify how the person/team intended to complete the work or what materials were to be used, as required by FESHM 2060. This information could have triggered further AHJ or subject matter expert (SME) review.

Identifying and Analyzing Hazards Associated with the Work

The assessment team evaluated 11 technical work activities bound by HAs and 2 work activities covered by procedures in the research divisions. HAs and procedures were typically constructed by a team including the project engineer, the facility manager, and the division safety officer, sometimes supported by other SMEs (for example, AHJs). Examples of HAs and procedures that adequately analyze hazards and controls include the following:

- In the HA at the IOTA for the upgrade to "Install SLAC Undulator into the IOTA Ring," the hazards and their potential consequences for workers were well defined, analyzed, and documented.

- The HA for SBN-FD Filter Cartridge Transport & Filling included not only the standard industrial hazards, such as heavy lifting, but also hazards associated with the potential inhalation of carcinogenic materials (e.g., emulsified copper filter media), as well as the establishment of controls based on the results of prior monitoring conducted by an industrial hygienist.

- The Electropolish Tool Operating Procedure for cavity removal identified physical and chemical hazards, including hazards requiring lockout/tagout (LOTO) and potential exposure to corrosive chemicals. The technicians performing the work demonstrated a thorough understanding of the procedure and their roles within the process, and they executed the work in accordance with the procedure.

- The Liquid Helium Refilling Procedure for Physical Property Measurement System (PPMS) Magnetometer Dewar included such potential hazards as handling of cryogen, oxygen deficiency hazard, and working at elevated heights.

However, in seven of the observed activities, the HAs or procedures did not adequately identify, quantify, or document all the applicable hazards as required by both FESHM 2060 and the directions on the HA form itself, which states: "The purpose of the Job Safety Analysis is to identify ALL hazards." (See **Finding F-FRA-2**.) Three examples are listed below, and additional examples were provided to FRA for disposition:

- The HA for installing cryogenic piping at SBN did not describe the welding of stainless steel and potential generation of hexavalent chromium. Additionally, industrial hygiene staff was not informed of a potential sampling opportunity for foreign-origin materials, which could contain greater concentrations of chromium than previously analyzed.

- The NM-4 HA for the crew moving 60,000 pounds of shield blocks on rollers with an electric forklift did not analyze the use of this equipment to pull and/or push this weight by means of slings tied off to the mast of the fork lift. No manufacturer's manual was referenced or available to determine the rated capacity of the equipment as required by FESHM 10120, *Powered Industrial Trucks*.

- For the Main Injector (MI)-60 technician work to update the modulator oscillator, the assessment team observed two workers accessing the internal components to upgrade electrical insulation and provide additional isolation of internal 750V direct current (DC) circuits from the cabinet. No HA was in use, and the AD department procedure ADDP-RF-2016-003, which specifically applies to LOTO of this unit, does not include the 750V DC hazard or requisite controls as required by FESHM 2060. Following this observation, the AHJ for Electrical Safety at Fermilab reviewed this procedure and determined it deficient and required AD to initiate revision.

Additionally, travelers for five observed work activities in APS-TD did not contain HA information.

Developing and Implementing Hazard Controls

FRA has implemented a hierarchy of controls to mitigate some hazards. For example, engineering controls are robust and used extensively to mitigate radiological and non-radiological hazards. Oxygen deficiency sensors are installed or personnel monitors are issued in locations where needed, primarily where research work with cryogenic materials is performed. Access control devices, such as interlocks, are used extensively to restrict entry into active accelerator areas and to minimize personnel radiological exposures.

For radiological exposures, shielding is installed in various beam-associated locations to reduce dose rates from beta-gamma and x-rays. Administrative controls effectively aid in controlling radiological external exposures, including tracking and effectively managing external radiation exposures, and the radiological postings and boundary controls in use were appropriate for the observed radiological hazards. Additionally, the radiological work permits in use were sufficient to cover day-to-day activities in a given facility. Radiological control technicians are assigned to specific work scopes to provide coverage where there is the potential for worker exposure.

However, seven of the observed work activities under HAs or SOPs, and five conducted under travelers, were conducted with inadequate controls, contrary to the requirements of FESHM 2060, Sections 3.2 and 5.4.2. **(Deficiency-FRA-2)** Three examples are listed below, and additional examples were provided to FRA for disposition:

- The NM-4 shield block construction and placement activity used only verbal communications and a drawing. The absence of written technical work instructions contributed to the shield wall being too short, resulting in a changed scope of work; workers had to place an additional level of shield blocks on the already-placed wall by hand at elevation, and also had to use a forklift, pallet, and scissors lift that were not included in the HA. When workers discovered that the wall was not constructed correctly, verbal coordination between the engineer and the field work supervisor revised how the work was performed, placing workers closer to radiologically activated beam

components. When the field work supervisor and engineer decided to add blocks to the top of the shield wall, As Low As Reasonably Achievable (ALARA) considerations were not reevaluated or discussed with the radiological control technician covering the job as required by FESHM 2060, Appendix B.

- For the work observed at the MI Modulator at the MI-60 test stand, the written LOTO procedure for the modulator was in use as required by AD departmental procedure. However, the procedure does not mention the 750V DC capacitor, the use of grounding sticks, or the need (and method) to verify the absence of voltage as required by FESHM 5042, *Electrical HA/WP*.

- A traveler containing no hazard analysis or control information was used for cavity packing in APS-TD.

Performing Work Within Controls

The process for authorizing and releasing research work is documented in FESHM 2060 and research division-specific procedures. FESHM 2060 requires pre-job briefings and sets out expectations for content. It states: "All who review the written HA will document the review by signing the form. Only then can the supervisor allow the work to begin. The section on performance of work requires the work plan/hazard analysis to be posted in the work area or be readily available to those performing the work."

Technicians and researchers who are or could be exposed to hazards receive appropriate training and information on hazards. For the technical and research-related activities observed, when HAs were in use to document hazards or activity specific SOPs included were used, the identified controls were followed in most cases. For example, in the IOTA upgrade to "Install SLAC Undulator into the IOTA Ring," workers used appropriate personal protective equipment (PPE) for fall protection and good hoisting and rigging practices; the work under HAs for discrete work activities, such as SBN-FD Filter Cartridge Transport & Filling, was conducted in accordance with the controls specified by an industrial hygienist; and in technical divisions, when hazards and their mitigation requirements were identified in procedures, workers followed them.

However, eight work activities observed were not performed as written in HAs or SOPs, and compliance with these controls was not enforced by supervision as required by FESHM Sections 3.2 and 5.4.2. **(Deficiency-FRA-2)** Three examples are listed below, and additional examples were provided to FRA for disposition:

- When interviewed, the MI-60 technician updating the modulator oscillator stated that a plug-and-cord LOTO was used for the alternating current (AC) power supply. He confirmed the absence of energy for the 750V DC capacitor, by meter; however, when asked, he stated that no voltage-rated PPE was used and that the test did not include steps to verify meter operability. National Fire Protection Association 70E-2018 and Occupational Safety and Health Administration (OSHA) 1910.335 as invoked by 10 CFR 851 require workers to wear rubber insulating gloves when they could be exposed to electrical hazards of 50V or more, AC or DC.

- The NM-4 shield wall required stacking an additional level of cement blocks by hand. The workers used a pallet and scissors lift, but they did not wear leather gloves as required by the HA, *Installing handstack shield assembly for E1039*, while retrieving and stacking blocks onto the pallet.

- For work observed in the Superconducting Radio-Frequency research and development lab, the compressed gas method described in the *Liquid Helium Refilling Procedure for PPMS Magnetometer Dewar* was not used. Contrary to the procedure, an electrically heated supply Dewar was used to transfer liquid helium. There was no HA for this alternate transfer process, and the employees did not don a face shield over safety glasses, safety shoes, or a personal oxygen monitor.

5.2.2 Facilities Engineering Services Section

FESS provides maintenance services for many of the laboratory's facilities, including the Planning and Scheduling, Operations and Maintenance, Utilities and Engineering, and Roads and Grounds organizations. Observed work included activities to repair or replace pumps, motors, air handlers, and piping; handling and transportation of materials; and grounds maintenance. The assessment team did not observe electric utilities work but did evaluate high-voltage distribution line work planning documentation and work procedures.

Defining the Scope of Work

FRA uses its Facility Administration and Maintenance Information System (FAMIS) computerized maintenance management system to plan and schedule work activities and create work orders (WOs) for maintenance. For the observed maintenance work, WOs adequately described the scope of work, generally defined the work scope boundaries well, and provided sufficient detail on boundaries to troubleshoot the equipment. For example, WO 737752 to "check & repair/replace noisy motor" lists the troubleshooting steps that electricians were specifically authorized to conduct. FESS uses generic HAs per Section 5.2.7 of FESHM 2060 as an activity-level work control document, which adequately define the scopes of work.

Identifying and Analyzing Hazards Associated with the Work

FESS HAs are developed primarily by work planners and schedulers and are "accepted" by job supervisors to authorize the work after workers sign off to indicate that they understand the hazards and "precautionary actions." A sample of 12 Individual Training Summary documents for those involved in the observed work showed that FESS workers, supervisors, and work planners are trained in work planning and HA development and use through course FN000628, *Work Planning and Hazard Analysis*, which provides sufficient information to implement FESHM 2060.

The assessment team observed a work planner conducting two walkdowns for requested maintenance work to verify the location of equipment, take photos as necessary, and evaluate requested work to prepare the WO and HA. The work planner develops the HA for a specific WO, but workers are not routinely involved in the planning and preparation of the HA as required by FESHM 2060, Section 5.2.4.f. **(Deficiency-FRA-3)** (See **OFI-FRA-2**.) However, during one observed exception, the interaction between workers conducting a walkdown (WO 733949), as directed by HA 19-0031, and their supervisor was notably useful in that it resulted in the identification of a safer alternative to using a chain hoist to remove a 173-pound motor from an exhaust fan located approximately nine feet off the floor. For generic HAs used by FESS Roads and Grounds, adequate worker involvement was observed in the periodic worker review of a welding HA as part of their safety meeting.

FESS has developed over 14,000 HAs (over 1,000 per year) in a database from maintenance work conducted since 2008, with the intention of providing feedback on how work was conducted and how hazards were addressed so that improvements can be made. However, five of the six HAs for the observed work and a review of selected HAs in the FESS HA database showed that most HAs are very

similar, regardless of the work scope; they cover the same hazards (e.g., slip/trips/falls, lifting, pinch points, falls from ladders, and electric power tools) whether or not those hazards are present in a specific work scope, and they do not define activity-level tasks sufficiently to allow analysis of specific hazards associated with work tasks as required by FESHM 2060, Section 5.2. **(Deficiency-FRA-1)** For the observed work, unidentified hazards included exposure to a rotating shaft after workers removed the shaft guard and checked for noise by placing their body within inches of the rotating shaft, and the need for ventilation, chemical goggles, and available eyewash for workers applying pipe cement as required by the safety data sheet for the materials.

FESS coordinates with building managers before conducting assigned maintenance jobs to ensure that FESS maintenance work activities do not introduce hazards for co-located workers or adversely affect site operations. In the observed work, the maintenance work control documents (WO and HA) provided the points of contact for required coordination before and during work. For example, the assessment team observed FESS craft workers coordinating with the Central Utility Building manager before a motor/pump troubleshooting activity. This coordination proved beneficial by identifying the correct motor (in a series of similar motors) and the location of the proper LOTO point, preventing adverse effects on site utilities.

Developing and Implementing Hazard Controls

Hazard controls, where identified, were generally appropriate for most of the observed work, particularly when many of the hazard controls were covered by FESHM requirements and through training received by the FESS crafts. These controls include wearing required fall protection while operating a manlift, wearing hearing protection when operating a skid loader while clearing brush, and ensuring that employees are current on required training for operating a forklift and crane.

The assessment team did not observe any high-voltage work on electrical distribution equipment but did review how FRA controls hazards for this type of work, with respect to OSHA Standard 29 CFR 1910.269, *Electric Power Generation, Transmission, and Distribution*. FRA has not fully implemented this OSHA standard as required by 10 CFR 851.23(a)(3) to protect electricians working on the site's high-voltage electrical power distribution equipment, as demonstrated by the following examples: (See **Finding F-FRA-3**.)

- FESS electricians, by job description and procedure (e.g., FESS Standard Policy and Procedure No. 5303.0, *AC Electrical Power Distribution Safety for Utility Level Distribution System Operation Above 600 VAC*), work on electrical distribution equipment up to 345 kV. Interviews with four electricians and their union steward indicated that they had not received training for their work on high-voltage electrical distribution lines and equipment. FRA uses an individual training needs assessment to identify the training a worker needs, based on the hazards they are exposed to in the work environment. The individual training needs assessment for electricians does not indicate their exposure to high-voltage distribution equipment hazards and the need for training required by the OSHA standard, Section 1910.269(a)(2), and the Individual Training Summary documentation did not identify whether electricians' training meets the OSHA standard. In 2016, FRA provided some commercial training courses from e-Hazard on *Low Voltage Qualified* and *High Voltage Qualified*, covering some of the OSHA requirements, but did not provide the e-Hazard course specific to compliance with the OSHA standard to electricians and members of the high-voltage engineering group.

- Section 1910.269(a)(2)(viii) of the OSHA standard requires employers to "ensure that each employee has demonstrated proficiency in the work practices involved before that employee is considered as having completed the training." FESS does not qualify electricians through demonstration of proficiency in 1910.269-related work activities as required.

- FESS Procedure Number 5303.0 does not fully cover this OSHA standard, which lays out an extensive set of safety requirements to protect qualified electricians and line clearing workers for work on or around electrical power distribution equipment. Some key OSHA standard areas not fully covered include subsections (g) through (r).

Performing Work Within Controls

Work is systematically scheduled through FAMIS, and daily work assignments are made by craft supervisors. Workers generally have the appropriate training and experience in their craft areas and demonstrated a desire to work safely. For example, workers used hand tools, portable equipment, and lifting techniques properly throughout the observed work.

Section 5.3 of FESHM 2060 requires pre-job briefings to cover five areas, including summarizing critical steps and materials, anticipating where errors can occur, foreseeing consequences, reviewing operating experience, and determining what PPE and controls are to be used. The observed pre-job briefings during five morning job assignment meetings did not cover any of the required areas. **(Deficiency-FRA-4)**

For some observed work, workers did not implement the controls in the HA, and supervision did not enforce compliance with these controls as required by FESHM Sections 3.2 and 5.4.2. **(Deficiency-FRA-2)** For example, four workers did not wear required side-shield safety glasses, one worker did not wear leather gloves, and a portable electric light was not plugged into a ground fault circuit interrupter protected outlet as required by the HA.

In two work observations, LOTOs for electrical equipment were not conducted as required by FESHM 2100, *Fermilab Energy Control Program (Lockout/Tagout)*, Section 5.2. FESS Procedure 5102.00, *FESS/Operations Lock Out/Tag Out Procedures, Padlocks and Tags*, allows blue locks to lock out equipment for configuration control of equipment under maintenance. FESHM 2100 and FESS Procedure 5102.00 also require workers to use personal red locks when working on the equipment. However, the assessment team observed two work activities where workers relied on only the blue lock while working on locked out equipment. For one of these work activities, the worker left the key on an uncontrolled board and did not always have control of the blue lock key as required. In addition, a multiple lockout device was not used along with the equipment blue lock to allow addition of the workers' personal red locks as required by FESS Procedure 5102.00. **(Deficiency-FRA-5)**

5.2.3 Work Planning and Control Implementation Conclusions

The FRA approach to WP&C is not always effective in identifying and controlling hazards, and where controls are identified, they are not always implemented and followed. The HAs used for most activity-level work within PPD and ND do not sufficiently describe the work scopes. FRA has not fully implemented OSHA Standard 29 CFR 1910.269 to protect electricians working on the site's high-voltage electrical power distribution equipment as required by 10 CFR 851.23(a)(3).

In FESS, most of the 14,000 HAs are generic and do not define activity-level tasks sufficiently. Workers are not routinely involved in the planning and preparation of HAs. The identified hazard controls were generally appropriate, but workers did not always implement them and compliance with these controls was not enforced by supervision as required by FESHM 2060, Sections 3.2 and 5.4.2. Observed pre-job

briefings did not cover any of the areas required by FESHM 2060. In two work observations, LOTOs for electrical equipment were not conducted as required by FESHM 2100, Section 5.2.

5.3 Contractor Assurance System

Objective:

The Contractor Assurance System produces periodic scheduled and non-scheduled evaluations (e.g., self-assessment, independent assessment, management walkthroughs, etc.) of WP&C activities that identify issues, concerns and opportunities for improvement in the WP&C program. (FRA Contract with DOE, DE-AC02-07CH11359, Clause H.13)

The CAS requirements are specified in the FRA contract with DOE, and the CAS description defines the CAS and reflects (?) most of the contract requirements. The Quality Assurance Manual (QAM) 12002, *Fermilab Quality Assurance Program*, contains most of the implementing processes and the rest are in the FESHM. QAM 12080, *Fermilab ESH&Q Self-Assessment and Inspection Program*, provides adequate direction for the management and conduct of assessments. Overall, the current (2018) program description is adequate to guide CAS implementation.

Sixteen self-assessments were conducted in 2016; 48 in 2017, including 7 human performance improvement (HPI) investigations and 16 management system maturity evaluations; and 25 in 2018, including 6 event investigations. Most of these planned assessments were properly focused on known risks. However, none of the self-assessments reviewed provided information on feedback and improvement; line management self-assessment (required by QAM 12080) of program implementation is absent in several program areas, including the AD electrical and engineering support divisions; and FRA did not use experts or other independent reviews to validate or improve their work process and implementation.

The last limited-scope external assessment of the CAS was conducted in 2009 by DOE, the last assessment by the CAS Review Committee in 2012, and the last assessment by the Board of Directors in 2015 (which was not finalized in a report, and no issues were entered into the issues management database). Although the CAS description includes the contract requirement to verify CAS effectiveness using "third-party audits, peer reviews, independent assessments, and external certifications," no recent independent/external assessment of the CAS for safety and health has been performed that meets this contract requirement. **(Deficiency-FRA-6)**

The HPI program has been strengthened through the institution of the HPI review team, a multi-disciplined group that reviews incidents or unwanted outcomes to ensure development of a comprehensive set of corrective actions to address the conditions. The HPI review team also focuses on ensuring that all applicable error precursors, latent organizational weaknesses, and causal codes are identified and that recommended actions directly address those elements. However, the integration of HPI into the graded corrective action system was not detailed enough to ensure documentation of technical causes of issues. Specifically, the corrective action system allows the use of HPI in place of causal analysis, limiting the analytical focus to human performance errors and potentially leaving other causes unaddressed. Further, the CAS description documents do not describe the proper grading of causal determination methods. (See **OFI-FRA-3**.)

Objective:

External and internal feedback and lessons learned are factored into ongoing and future WP&C activities. (48 CFR 970.5223-1(c)(5))

QAM 12010, *Fermilab Lessons Learned Program and Procedures*, establishes a workable process for identifying and disseminating lessons-learned information to all levels of the organization. A database of lessons learned from 2010 to the present is available for searching in iTrack, and older ones are archived. However, no entries have been made to the database since 2017, even though two recent Occurrence Reporting and Processing System reports for electrical shock incidents were designated "High" category events. The recording of formal lessons learned has decreased from 35 in 2016 (11 FRA-originated), to 4 in 2017 (external sources), to one external in 2018 and none in 2019. FRA has recently drafted a revision of the above procedure that references the OPEXSHARE website. (See **OFI-FRA-3**.)

FESHM 2060 requires pre-job briefings to include a review of operating experience, and 10 CFR 851.21(a)(7) requires contractor hazard identification procedures to provide for "review [of] site safety and health experience information." However, the observed pre-job briefings relied only on the recall of those present at the briefing. For the observed work, no post-job reviews were conducted, and records showed no evidence of an HA revision based on performance feedback. The assessment team observed a formal post-job review for a job that was not observed as part of the assessment, the Antiproton Target Hall "Target T18 Change." The post-job review demonstrated good interaction and feedback from the workers and SMEs and produced suggestions for improving the process the next time it is performed. Overall, FRA has not effectively implemented a feedback and lessons-learned process in accordance with 48 CFR 970.5223-1(c)(5). (**Deficiency-FRA-7**)

FRA has several means for communicating employee concerns, including the internal service desk, the employee concerns program, the differing professional opinion process, and the Inspector General hotline. The assessment team verified the functionality of each of these contact methods, using a website and physical site postings. FESHM 1060, *Fermilab ES&H Concerns Program*, was updated in December 2018 to include the differing professional opinion element. The contractor notifies the employees of their rights through posters, web information, and email notifications. The FRA employee concerns programs is adequate, but historically, few FRA employees have registered complaints.

Contractor Assurance System Conclusions

Overall, the current CAS program description is adequate to guide CAS implementation, but FRA has not effectively implemented a feedback and lessons-learned process. Although FRA performs a number of documented self-assessment activities, none were scoped to evaluate and improve the WP&C process. The integration of HPI into the graded corrective action system was not detailed enough to ensure documentation of technical causes of issues. QAM 12010 establishes a workable process for identifying and disseminating lessons-learned information, but no entries have been made to the lessons-learned database since 2017. Observed pre-briefings did not include either a review of operating experience or a review of site safety and health experience information. Post-job reviews are not always conducted, and HAs are not always reviewed based on feedback. Improvement is needed in the feedback and lessons-learned process to support an effective and successful WP&C program.

5.4 Management Accountability

10 CFR 851.20, *Management Responsibilities and Worker Rights and Responsibilities*, requires contractors to be responsible for the safety of their workforce, and details a number of important management responsibilities, including the requirement to "evaluate personnel performance, and hold personnel accountable for worker safety and health performance." FESHM 2060 and other program documents, such as FESM 1010, *Laboratory Environment, Safety and Health Management System and Its Implementation*, and the *Fermilab Worker Safety and Health Program*, also discuss accountability for safety and health performance at the line-level and above. However, work activity observations, such as

those detailed in Sections 5.1 through 5.3, indicated that these requirements are not enforced at the activity level. Line management is not accountable for implementing elements of the CAS, including post-job reviews, self-assessments, and work control feedback. Interviews with managers and employees indicated that there is a general lack of accountability for safety and health performance, contrary to the requirements of 10 CFR 851.20(a)(3). (See **Finding F-FRA-4**.)

5.5 Follow-up on the Construction Safety Special Review

The assessment team reviewed FRA's status and approach in developing and implementing improvement actions to address the recommendations of the EA report *Construction Safety Special Review at the Fermi National Accelerator Laboratory – December 2015*. FRA took a cross-organizational approach to develop improvement actions to address issues, including the flowdown of applicable contract requirements to construction subcontractors, subcontractor implementation of safety requirements, and how FRA oversees day-to-day safety at subcontractor construction projects. FRA now uses the SafetyNet Predictive Solutions software for promptly notifying management when issues arise, and for tracking and trending issues to identify adverse trends and opportunities for improving construction oversight. The Predictive Solutions software has been effective in improving construction safety and has reduced occupational injuries at construction projects. A cross-organizational approach to improving the FRA WP&C program, similar to the approach FRA used in responding to the December 2015 EA report, could be applied to address the issues identified in this report. (See **OFI-FRA-4**.)

6.0 FINDINGS

Findings are deficiencies that warrant a high level of attention from management. If left uncorrected, findings could adversely affect the DOE mission, the environment, the safety or health of workers and the public, or national security. DOE line management and/or contractor organizations must develop and implement corrective action plans for EA appraisal findings. Cognizant DOE managers must use site- and program-specific issues management processes and systems developed in accordance with DOE Order 227.1A to manage these corrective action plans and track them to completion. In addition to the findings, deficiencies that did not meet the criteria for a finding are listed in Appendix B, with the expectation from DOE Order 227.1A for site managers to apply their local issues management processes for resolution.

Finding F-FRA-1: FRA has not established a workplace occupational exposure assessment program as required by 10 CFR 851.21, Appendix A(6). The ES&H organization has not established a program to collect baseline information and perform subsequent updates as required.

Finding F-FRA-2: FRA does not adequately identify, quantify, or document all the applicable hazards and controls as required by FESHM 2060, Section 5.4.

Finding F-FRA-3: FRA has not fully implemented OSHA Standard 29 CFR 1910.269 to protect electricians working on the site's high-voltage electrical power distribution equipment as required by 10 CFR 851.23(a)(3).

Finding F-FRA-4: FRA does not ensure that workers, supervisors, and managers are accountable for worker safety and health performance, as required by 10 CFR 851.20(a)(3).

7.0 OPPORTUNITIES FOR IMPROVEMENT

The assessment team identified some OFIs to assist cognizant managers in improving programs and operations. While OFIs may identify potential solutions to findings and deficiencies identified in appraisal reports, they may also address other conditions observed during the appraisal process. EA offers these OFIs only as recommendations for line management consideration; they do not require formal resolution by management through a corrective action process and are not intended to be prescriptive or mandatory. Rather, they are suggestions that may assist site management in implementing best practices or provide potential solutions to issues identified during the assessment.

OFI-FRA-1: Consider making the following changes to FESHM 2060 in order to ensure that adequate requirements and guidance are used to effectively implement ISM.

- Define the scope of work: Provide guidance on defining the scope of work when HAs are not used, such as when permits are used instead of HAs.
- Identify and analyze hazards associated with the work: Develop a formal program to collect baseline information and subsequently update exposure assessment information as required by 10 CFR 851.21, *Worker Safety and Health Program*, Appendix A(6), *Industrial Hygiene*. If SOPs are used instead of HAs, specify that the work activity-related hazards and their mitigation requirements are identified and addressed in the procedures. Add guidance on formally requesting (in advance) lists of equipment and materials that users intend to bring into Fermilab so that potential hazards can be identified as part of WP&C before the equipment and materials arrive.
- Develop and implement hazard controls: Identify line management responsibility for authorization of work (e.g., when the work package is complex and contains more than one HA, multiple permits, or multiple procedures). Specify that AHJs are to be consulted for activities within their jurisdiction before approval of the work activity.
- Perform work within controls: Include employee-initiated stop-work authority as a reason for cessation of a work activity. Add a less-rigorous process, such as "pause work," to address questions arising from miscommunication or safety-related issues before resuming work.
- Provide feedback on the adequacy of controls and continue to improve safety management: Require post-job reviews in order to record feedback and lessons learned. Provide a format for recording feedback from workers and lessons learned from the work activity.

OFI-FRA-2: Consider establishing a practice for workers to conduct walkdowns of the work areas as a first step when starting a job to validate the completeness of the HA tasks and controls when workers are not involved in planning the work or developing the HA.

OFI-FRA-3: Consider the following actions to improve the CAS and feedback processes:

- Formalizing the approach to describing the ISM-CAS relationship and highlighting the ISM guiding principles
- Revising CAS description documents to establish a proper grading of causal determination methods
- Qualifying lead assessors
- Establishing an assessment manager to provide oversight and guidance to assessors
- Developing review criteria and reviewing assessment reports to provide feedback and improvement advice to the lead assessors
- Establishing a report format that includes the criteria reviewed, signatures of the assessors, and date the report was finalized, and inserting action tracking references to iTrack as appropriate

- Revising the assessment planning process to include appropriate independent assessments and make provisions for their management in the issues management system (e.g., assessment planning, iTrack)
- Holding line managers accountable for performing a certain number of self-assessments per year
- Revising and renaming management walkthroughs as "management observations" that include work observations for feedback and improvement purposes
- Appointing a lessons-learned coordinator, providing training on use of OPEXSHARE, and reinforcing accountability for using lessons learned
- Reinforcing a lessons-learning culture by beginning meetings with safety shares and ensuring that supervisors and work planners share relevant lessons learned from past performance.

OFI-FRA-4: Consider implementing a cross-organizational approach to improve the FRA WP&C program, with an emphasis on establishing clear accountability, similar to the approach used by FRA in response to the EA report *Construction Safety Special Review at the Fermi National Accelerator Laboratory – December 2015*.

Appendix A
Supplemental Information

Dates of Assessment

Onsite Assessment: February 11-15 and February 25-28, 2019

Office of Enterprise Assessments (EA) Management

Nathan H. Martin, Director, Office of Enterprise Assessments
April G. Stephenson, Deputy Director, Office of Enterprise Assessments
Thomas R. Staker, Director, Office of Environment, Safety and Health Assessments
C.E. (Gene) Carpenter, Jr., Director, Office of Nuclear Safety and Environmental Assessments
Kevin G. Kilp, Director, Office of Worker Safety and Health Assessments
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Quality Review Board

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EA Assessors

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Roby Enge
Terry E. Krietz
Joseph Lischinsky
Nimalan Mahimaidoss
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Appendix B
Deficiencies

Deficiencies that did not meet the criteria for a finding are listed below, with the expectation from DOE Order 227.1A for site managers to apply their local issues management processes for resolution.

Deficiency-FRA-1: HAs do not include a detailed scope of work as required by FESHM 2060, Section 5.2.4.a, d, e.

Deficiency-FRA-2: Some observed work was conducted with inadequate controls, and supervisors did not ensure that work was performed in accordance with the HA, contrary to the requirements of FESHM 2060, Sections 3.2 and 5.4.2.

Deficiency-FRA-3: FESS workers are not routinely involved in the planning and preparation of HAs as required by FESHM 2060, Section 5.2.4.f.

Deficiency-FRA-4: Pre-job briefings at five morning job assignment meetings did not cover the five areas required by FESHM 2060, Section 5.3.

Deficiency-FRA-5: Two LOTOs for maintenance work on electrical equipment were not conducted as required by FESHM 2100, Section 5.2 and FESS Procedure 5102.00.

Deficiency-FRA-6: FRA has not met the contract Clause H.13(a)(2) requirement to verify effectiveness of the CAS using "third-party audits, peer reviews, independent assessments, and external certifications" by performance of independent/external assessment of the CAS for safety and health since approved in 2011.

Deficiency-FRA-7: FRA has not effectively implemented a feedback and lessons-learned process in accordance with 48 CFR 970.5223-1(c)(5).