Table 18. Summary of Baseline and Residual Risks Neutrino

	Risk Tables Description	Baseline Risk	Residual Risk
18.1	Radiological – Onsite-1 Facility Worker	R:I	R:III, IV
18.2	Radiological – Onsite-2 Co-located Worker	R:I	R:III, IV
18.3	Radiological – MOI Offsite	R:I	R:III, IV
18.4	Toxic Materials – Onsite 1 Facility Worker	R:*	R:*
18.5	Toxic Materials – Onsite 2 Co-located Worker	R:*	R:*
18.6	Toxic Materials – MOI Offsite	R:*	R:*
18.7	Flammable & Combustible Materials – Onsite-1 Facility Worker	R:*	R:*
18.8	Flammable & Combustible Materials – Onsite-2 Co-located worker	R:*	R:*
18.9	Flammable & Combustible Materials – MOI Offsite	R:*	R:*
18.10	Electrical Energy – Onsite-1 Facility Worker	R:*	R:*
18.11	Electrical Energy – Onsite-2 Co-located Worker	R:*	R:*
18.12	Electrical Energy – MOI Offsite	R:*	R:*
18.13	Thermal Energy – Onsite-1 Facility Worker	R:*	R:*
18.14	Thermal Energy – Onsite-2 Co-located Worker	R:*	R:*
18.15	Thermal Energy – MOI Offsite	R:*	R:*
18.16	Kinetic Energy – Onsite-1 Facility Worker	R:*	R:*
18.17	Kinetic Energy – Onsite-2 Co-located Worker	R:*	R:*
18.18	Kinetic Energy – MOI Offsite	R:*	R:*
18.19	Potential Energy- Onsite-1 Facility Worker	R:*	R:*
18.20	Potential Energy – Onsite-2 Co-located Worker	R:*	R:*
18.21	Potential Energy – MOI Offsite	R:*	R:*
18.22	Magnetic Fields – Onsite-1 Facility Worker	R:*	R:*
18.23	Magnetic Fields – Onsite-2 Co-located Worker	R:*	R:*
18.24	Magnetic Fields – MOI Offsite	R:*	R:*
18.25	Other Hazards – Onsite-1 Facility Worker	R:*	R:*
18.26	Other Hazards – Onsite-2 Co-located Worker	R:*	R:*
18.27	Other Hazards – MOI Offsite	R:*	R:*
18.28	Access & Egress – Onsite-1 Facility Worker	R:*	R:*
18.29	Access & Egress – Onsite-2 Co-located Worker	R:*	R:*
18.30	Access & Egress – MOI Offsite	R:*	R:*
18.31	Environmental Hazards	R:*	R:*

^{*} See Section 1, Chapter 4

NOTE:

Per DOE-HDBK-1163-2020, Appendix C, "Risk Assessment Methodology":

"Events with an unmitigated risk value of III or IV would not require additional control assignments to provide reasonable assurance of adequate protection. Whereas, for events with an unmitigated risk value of I or II, controls would need to be assigned to either reduce the likelihood or the consequence, and therefore the overall mitigated risk. Generally, preventive controls are applied prior to a loss event – reflecting a likelihood reduction and mitigative controls are applied after a loss event – reflecting a consequence reduction. Each control is credited for a single "bin drop" either in likelihood or consequence; not both. Following a standard hierarchy of controls, controls are applied until the residual risk is acceptable – reflecting a mitigated risk value of III or IV. After controls are credited, events with a remaining unacceptable residual risk (i.e., I or II) are candidates for additional analyses and additional controls, often quantitative in nature." For Fermilab, these controls for accelerator-specific hazards are identified as Credited Controls and further summarized in the Accelerator Safety Envelope (ASE).

Table 18.1 Radiological – Onsite-1 Facility Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M) Credited Controls (CC) in Bold	Residual Qualitative Risk (with CCs)
Residual	Hazard: exposure to residual	L: A	P – General And/Or Job Specific RWP: A Radiological Work Permit is	L: BEU
activation	activation	C: H	written by ES&H that specifies the work that is permitted to be	C: N
		R: I	performed, requirements to perform the work, and limitations of radiological exposure.	R: IV
			P – Use Of A LSM: Use of a log survey monitor is specified by a RWP.	
			The LSM allows for real time monitoring of radiation levels during work.	
			P – Radiological Training: An educational system managed by ES&H that establishes basic worker knowledge through presentations and testing.	
			M – Radiological Signage And Decay Time Requirements: Signs located in various places throughout the accelerator complex warn of various	
			hazards and occupancy restrictions prior to entry. Furthermore, work may be restricted or prevented until sufficient time has passed such that radiation levels are sufficiently low to allow for safer work to	
			proceed. This mitigation has passive and active components.	
			M – Radiological Shielding: Material placed between radiation sources and the enclosure to be protected. This is a passive mitigation.	
			M – Run Conditions: Operating parameters that reduce residual activation by limiting the total amount of beam that could be delivered.	

Hazard Description		Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M) Credited Controls (CC) in Bold	Residual Qualitative Risk (with CCs)
Groundwater	Hazard: exposure to radionuclides in	L: A	P – Sump Pumps: Pumps located in the accelerator enclosure that have an	L: BEU
Activation	ground water exceed regulatory levels	C: H R: I	underdrain network. The water is pumped to the surface, so it does not stagnate in the accelerator and becomes activated prior to removing the water from the enclosure. P – Sump Monitoring Program; Sump water samples are periodically collected and measured for radiological activation. If activation is found in the sump sample, we have the ability to look for the root cause before additional water is pumped to the surface. P – Beam Loss Monitoring Electronic Beam Loss Monitors are used to convert radiation created by prompt dose due to beam loss into electrical signals. This information is then made available to the accelerator control system where the data can be logged and monitored with alarms and limits. Losses can be reduced or eliminated with adjustment to the accelerators to prevent activation of tunnel components. M – Machine Protection System: An accelerator system that monitors devices such as beam loss monitors, power supplies, vacuum valves, etc. If these devices are not within their specified limits, the beam is aborted and further injections into the accelerator are inhibited until the system is reset by an operator. M – Run Conditions: Operating parameters that reduce residual activation by limiting the total amount of beam that could be delivered.	C: L R: IV

Hazard Description		Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M) Credited Controls (CC) in Bold			
Surface Water	Hazard: exposure to radionuclides in	L: A	P – Sump Pumps: Pumps located in the accelerator enclosure that have an	L: BEU		
Activation	surface water exceed regulatory levels	C: H	underdrain network. The water is pumped to the surface, so it does not	C: N		
		R: I	stagnate in the accelerator and becomes activated prior to removing	R: IV		
			the water from the enclosure.			
			P – Sump Monitoring Program; Sump water samples are periodically			
			collected and measured for radiological activation. If activation is			
			found in the sump sample, we have the ability to look for the root			
			cause before additional water is pumped to the surface.			
			P- Beam Loss Monitoring Electronic Beam Loss Monitors are used to			
			convert radiation created by prompt dose due to beam loss into			
			electrical signals. This information is then made available to the			
			accelerator control system where the data can be logged and			
			monitored with alarms and limits. Losses can be reduced or			
			eliminated with adjustment to the accelerators to prevent activation of			
			tunnel components.			
			M – Machine Protection System: An accelerator system that monitors			
			devices such as beam loss monitors, power supplies, vacuum valves,			
			etc. If these devices are not within their specified limits, the beam is			
			aborted and further injections into the accelerator are inhibited until			
			the system is reset by an operator.			
			M – Pond Monitoring Program: Samples taken from the ponds and			
			measured for activation. Sump water from the tunnel is discharged			
			into these ponds.			
			M – Run Conditions: Operating parameters that reduce residual activation			
			by limiting the total amount of beam that could be delivered.			

Hazard	Hazard Description		Preventative (P)/ Mitigative (M) Credited Controls (CC) in Bold	Residual Qualitative Risk (with CCs)
Radioactive	Hazard: Exposure, beyond regulatory	L: A	P – Interlocked Gates: Barriers at entrances to the accelerator enclosure that	L: BEU
Water (RAW)	levels, to radioactive water	C: H	are electrically monitored through the Radiation and Electrical Safety	C: M
Systems		R: I	Systems to turn off the accelerator if the gate is opened	R: IV
			P - Interlocked Key; A key tree system that captures the keys to the	
			accelerator enclosure. These keys are electrically monitored through	
			the Radiation and Electrical Safety Systems to turn off the accelerator	
			if any key is removed from the key tree.	
			P – Key Control Program: A program that checks the worker's training	
			prior to issuing them a key to the accelerator enclosure. Also keeps	
			track of worker accountability.	
			P – Postings: Signs located in various places throughout the accelerator warning of various hazards and occupancy restrictions.	
			P – Training: An educational system managed by ES&H that establishes	
			basic worker knowledge through presentations and testing.	
			M – Engineered Containment: Containment in the area around the RAW	
			system to prevent the RAW from spreading in the case of a leak.	

Hazard Description		Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M) Credited Controls (CC) in Bold	Residual Qualitative Risk (with CCs)
Air Activation	Hazard: radionuclides in air exceed regulatory levels	L: A C: H R: I	 P – Air Monitoring: Air sampled from the enclosure for activation P – RSIS: The Radiation Safety Interlock System uses a key tree system that captures the keys to an accelerator enclosure. These keys are electrically monitored through the Radiation and Electrical Safety Systems to turn off the accelerator enclosure if any key is removed from the key tree. P – Beam loss Monitoring: Electronic Beam Loss Monitors are used to convert radiation created by prompt dose due to beam loss into electrical signals. This information is then made available to the accelerator control system where the data can be logged and monitored with alarms and limits. Losses can be reduced or eliminated with adjustment to the accelerators to prevent activation of tunnel components. M – Engineered air flow to dilute activated air and provide cool off (decay) time prior to release. Enclosure air flow design to give the activated air time to decay before exiting the enclosure. M – Run Conditions: Operating parameters that reduce residual activation by limiting the total amount of beam that could be delivered. Specifies when MCR operators are allowed to issue keys for the enclosure. Prohibits personnel access before the appropriate amount of decay time has elapsed. 	L: BEU C: L R: IV

Hazard Description		Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M) Credited Controls (CC) in Bold	Residual Qualitative Risk (with CCs)	
Soil Interactions	Hazard: radionuclides are produced by beam interactions which may contaminate ground water	L: A C: N R: IV	 P – Beam Loss Monitoring: Electronic Beam Loss Monitors are used to convert radiation created by prompt dose due to beam loss into electrical signals. This information is then made available to the accelerator control system where the data can be logged and monitored with alarms and limits. Losses can be reduced or eliminated with adjustment to the accelerators to prevent activation of tunnel components. M – Engineered Beam Dump: Design of a beam absorber that minimizes the radiological leakage through the used of shielding. M – Beamline Design: Design of beamline optics to ensure that the actual beam size is smaller than the beam pipe to prevent scraping, beam loss, prompt dose, and residual activation. M – Run Conditions: Operating parameters that reduce residual activation by limiting the total amount of beam that could be delivered. 	L: U C: N R: IV	
Radioactive waste	Hazard: persons are exposed to ionizing radiation beyond regulatory levels	L: A C: H R: I	 P – Locked Gates: Barriers to entrances of areas that contain radioactive material. Keys are required to open these gates. P – Key Control Program: A program that checks the worker's training prior to issuing them a key to the accelerator enclosure. Also keeps track of worker accountability. P – Postings: Signs located in various places throughout the accelerator warning of various hazards and occupancy restrictions M – Run Conditions: Operating parameters that reduce residual activation by limiting the total amount of beam that could be delivered. M – Distance to Stored Material: Barriers, such as ropes, that are used to increase the distance between the activated material and personnel. 	L:BEU C: L R: IV	

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M) Credited Controls (CC) in Bold	Residual Qualitative Risk (with CCs) L:BEU C: N R: IV	
Contamination	Hazard: persons are exposed to ionizing radiation beyond regulatory levels	L: A C: H R: I	 P – Locked Gates: Barriers to entrances of areas that contain radioactive material. Keys are required to open these gates. P – Key Control Program: A program that checks the worker's training prior to issuing them a key to the accelerator enclosure. Also keeps track of worker accountability. P – Postings and Fencing: Signs located in various places throughout the accelerator warning of various hazards and occupancy restrictions M – Radiological Work Permit: A permit written by Safety that specifies the work that is permitted to be performed, requirements to perform the work, and limitations of radiological exposure. M – Training: An educational system managed by ES&H that establishes basic worker knowledge through presentations and testing. M – Run Conditions: Operating parameters that reduce residual activation by limiting the total amount of beam that could be delivered. 		
⁷ Be	Hazard: Potential radiation exposure to 7Be (uptake/committed dose).	L: A C: N R: IV	No prevention or mitigation is required. ⁷ Be isn't hazardous in this pattern of use by facility.	L: A C: N R: IV	
Radioactive Sources	Hazard: Persons exposed to ionizing radiation beyond regulatory levels	L: A C: H R: I	 P – Radiological Signage On Or Near Source Cabinets: Signs give warning of the presence of radioactive sources. P – Radiological Training: An educational system managed by ES&H that establishes basic worker knowledge through presentations and testing. P – Kept Under Lock-and-key: Radioactive sources are kept in locked storage, where key issuance is a controlled process. M – Kept In Storage: Unused radioactive sources are kept in storage, which prevents the close proximity of these sources and people. M – Shielded Containers: Unused high activity sources are stored within shielded containers. 	L: BEU C: L R: IV	

Likelihood (L, of event)/year	Cor	sequence (C, of event)/	year (Risk (R, Qualitative R	anking)	Risk	Matri	X			
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (event)	t) of major concern				Like	lihood	
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		$\mathbf{H} = \text{situation (event) of concern}$				Α	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		L = Low		III = situation (eve	ent) of minor concern	es	Н	I	I	II	III
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (eve	ent) of minimal concern	enc	M	II	II	III	IV
Control(s) Type	C	Offsite (MOI)	Onsi	te-2 (co-located worker)	Onsite-1 (facility worker)	edn	_		TIT	17.7	13.7
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ 25.0 rem		C ≥ 100 rem	C ≥ 100 rem	ous	L	III	III	IV	IV
$\mathbf{M} = \mathbf{Mitigative}$ (reduces event consequences)	M	$25.0 \text{ rem} > \mathbf{C} \ge 5 \text{ rem}$	10	$00 \text{ rem} > \mathbf{C} \ge 25 \text{ rem}$	$100 \text{ rem} > \mathbf{C} \ge 25 \text{ rem}$		N	IV	IV	IV	IV
Acronyms MOI - Maximally averaged Offsite Individual	L	5 rem > C		25 rem > C	25 rem > C						
MOI = Maximally-exposed Offsite Individual rem = Roentgen equivalent man	N	0.5 rem > C		5 rem > C	5 rem > C						

Table 18.2 Radiological – Onsite-2 Co-located Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M) Credited Controls (CC) in Bold	Residual Qualitative Risk (with CCs)
Residual	Hazard: exposure to residual	L: A	P – General And/Or Job Specific RWP: A Radiological Work Permit is written by	L: BEU
activation	activation	C: H	ES&H that specifies the work that is permitted to be performed, requirements	C: N
		R: I	to perform the work, and limitations of radiological exposure.	R: IV
			P – Use Of A LSM: Use of a log survey monitor is specified by a RWP. The LSM allows for real time monitoring of radiation levels during work.	
			P – Radiological Training: An educational system managed by ES&H that establishes basic worker knowledge through presentations and testing.	
			M – Radiological Signage, Fencing And Decay Time Requirements: Signs located	
			in various places throughout the accelerator complex warn of various hazards and occupancy restrictions prior to entry. Furthermore, work may be	
			restricted or prevented until sufficient time has passed such that radiation	
			levels are sufficiently low to allow for safer work to proceed. This mitigation has passive and active components.	
			M – Radiological Shielding: Material placed between radiation sources and the enclosure to be protected. This is a passive mitigation.	
			M – Run Conditions: Operating parameters that reduce residual activation by	
			limiting the total amount of beam that could be delivered.	

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M) Credited Controls (CC) in Bold	Residual Qualitative Risk (with CCs)
Groundwater	Hazard: exposure to	L: A	P – Sump Pumps: Pumps located in the accelerator enclosure that have an	L: BEU
Activation	radionuclides in ground water	C: H	underdrain network. The water is pumped to the surface, so it does not	C: L
	exceed regulatory levels	R: I	stagnate in the accelerator and becomes activated prior to removing the water from the enclosure.	R: IV
			P – Sump Monitoring Program; Sump water samples are periodically collected and measured for radiological activation. If activation is found in the sump sample, we have the ability to look for the root cause before additional water is pumped to the surface.	
			P—Beam Loss Monitoring Electronic Beam Loss Monitors are used to convert radiation created by prompt dose due to beam loss into electrical signals. This information is then made available to the accelerator control system where the data can be logged and monitored with alarms and limits. Losses can be reduced or eliminated with adjustment to the accelerators to prevent activation of tunnel components.	
			 M – Machine Protection System: An accelerator system that monitors devices such as beam loss monitors, power supplies, vacuum valves, etc. If these devices are not within their specified limits, the beam is aborted and further injections into the accelerator are inhibited until the system is reset by an operator. M – Run Conditions: Operating parameters that reduce residual activation by limiting the total amount of beam that could be delivered. 	

Hazard	(without controls)		Preventative (P)/ Mitigative (M) Credited Controls (CC) in Bold	Residual Qualitative Risk (with CCs)	
Surface Water	Hazard: exposure to	L: A	P – Sump Pumps: Pumps located in the accelerator enclosure that have an	L: BEU	
Activation	radionuclides in surface water	C: H	underdrain network. The water is pumped to the surface, so it does not	C: N	
	exceed regulatory levels	R: I	stagnate in the accelerator and becomes activated prior to removing the water	R: IV	
			from the enclosure.		
			P – Sump Monitoring Program; Sump water samples are periodically collected		
			and measured for radiological activation. If activation is found in the sump		
			sample, we have the ability to look for the root cause before additional water		
			is pumped to the surface.		
			P- Beam Loss Monitoring Electronic Beam Loss Monitors are used to convert		
			radiation created by prompt dose due to beam loss into electrical signals.		
			This information is then made available to the accelerator control system		
			where the data can be logged and monitored with alarms and limits. Losses		
			can be reduced or eliminated with adjustment to the accelerators to prevent		
			activation of tunnel components.		
			M – Machine Protection System: An accelerator system that monitors devices		
			such as beam loss monitors, power supplies, vacuum valves, etc. If these		
			devices are not within their specified limits, the beam is aborted and further		
			injections into the accelerator are inhibited until the system is reset by an		
			operator.		
			M – Pond Monitoring Program: Samples taken from the ponds and measured for		
			activation. Sump water from the tunnel is discharged into these ponds.		
			M – Run Conditions: Operating parameters that reduce residual activation by		
			limiting the total amount of beam that could be delivered.		

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M) Credited Controls (CC) in Bold	Residual Qualitative Risk (with CCs)
Radioactive	Hazard: Exposure, beyond	L: A	P – Interlocked Gates: Barriers at entrances to the accelerator enclosure that are	L: BEU
Water (RAW)	regulatory levels, to radioactive	C: L	electrically monitored through the Radiation and Electrical Safety Systems to	C: M
Systems	water	R: III	turn off the accelerator if the gate is opened	R: IV
	b		 P - Interlocked Key; A key tree system that captures the keys to the accelerator enclosure. These keys are electrically monitored through the Radiation and Electrical Safety Systems to turn off the accelerator if any key is removed from the key tree. P - Key Control Program: A program that checks the worker's training prior to issuing them a key to the accelerator enclosure. Also keeps track of worker accountability. 	
			 P – Postings: Signs located in various places throughout the accelerator warning of various hazards and occupancy restrictions. P – Training: An educational system managed by ES&H that establishes basic worker knowledge through presentations and testing. M – Engineered Containment: Containment in the area around the RAW system to prevent the RAW from spreading in the case of a leak. 	

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M) Credited Controls (CC) in Bold	Residual Qualitative Risk (with CCs)
Air Activation	Hazard: • Radionuclides in air exceed regulatory levels	L: A C: H R: I	 P – Air Monitoring: Air sampled from the enclosure for activation P – RSIS: The Radiation Safety Interlock System uses a key tree system that captures the keys to an accelerator enclosure. These keys are electrically monitored through the Radiation and Electrical Safety Systems to turn off the accelerator enclosure if any key is removed from the key tree. P – Beam loss Monitoring: Electronic Beam Loss Monitors are used to convert radiation created by prompt dose due to beam loss into electrical signals. This information is then made available to the accelerator control system where the data can be logged and monitored with alarms and limits. Losses can be reduced or eliminated with adjustment to the accelerators to prevent activation of tunnel components. M – Engineered air flow to dilute activated air and provide cool off (decay) time prior to release. Enclosure air flow design to give the activated air time to decay before exiting the enclosure. M – Run Conditions: Operating parameters that reduce residual activation by limiting the total amount of beam that could be delivered. Specifies when MCR operators are allowed to issue keys for the enclosure. Prohibits personnel access before the appropriate amount of decay time has elapsed. 	L: BEU C: N R: IV

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M) Credited Controls (CC) in Bold	Residual Qualitative Risk (with CCs)
Soil Interactions	Hazard: radionuclides are produced which may contaminate ground water	L: A C: H R: I	 P – Beam Loss Monitoring: Electronic Beam Loss Monitors are used to convert radiation created by prompt dose due to beam loss into electrical signals. This information is then made available to the accelerator control system where the data can be logged and monitored with alarms and limits. Losses can be reduced or eliminated with adjustment to the accelerators to prevent activation of tunnel components. M – Engineered Beam Dump: Design of a beam absorber that minimizes the radiological leakage through the used of shielding. M – Beamline Design: Design of beamline optics to ensure that the actual beam size is smaller than the beam pipe to prevent scraping, beam loss, prompt dose, and residual activation. M – Run Conditions: Operating parameters that reduce residual activation by limiting the total amount of beam that could be delivered. 	L: U C: N R: IV
Radioactive waste	Hazard: persons are exposed to ionizing radiation beyond regulatory levels	L: A C: H R: I	 P – Locked Gates: Barriers to entrances of areas that contain radioactive material. Keys are required to open these gates. P – Key Control Program: A program that checks the worker's training prior to issuing them a key to the accelerator enclosure. Also keeps track of worker accountability. P – Postings: Signs located in various places throughout the accelerator warning of various hazards and occupancy restrictions M – Run Conditions: Operating parameters that reduce residual activation by limiting the total amount of beam that could be delivered. M – Distance to Stored Material: Barriers, such as ropes, that are used to increase the distance between the activated material and personnel. 	L: BEU C: L R: IV

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M) Credited Controls (CC) in Bold					
ionizing radiation beyond C: N regulatory levels R: IV		L: BEU C: N	 P – Locked Gates: Barriers to entrances of areas that contain radioactive material. Keys are required to open these gates. P – Key Control Program: A program that checks the worker's training prior to issuing them a key to the accelerator enclosure. Also keeps track of worker accountability. P – Postings and Fencing: Signs located in various places throughout the accelerator warning of various hazards and occupancy restrictions M – Radiological Work Permit: A permit written by Safety that specifies the work that is permitted to be performed, requirements to perform the work, and limitations of radiological exposure. M – Training: An educational system managed by ES&H that establishes basic worker knowledge through presentations and testing. M – Run Conditions: Operating parameters that reduce residual activation by limiting the total amount of beam that could be delivered. 	L: BEU C: N R: IV				
⁷ Be	Hazard: Potential radiation exposure to 7Be (uptake/committed dose).	L: A C: N R: IV	No prevention or mitigation is required. ⁷ Be isn't hazardous in this pattern of use by facility.	L: A C: N R: IV				
Radioactive Sources	Hazard: Persons are exposed to ionizing radiation beyond regulatory levels	L: A C: H R: I	 P – Radiological Signage On Or Near Source Cabinets: Signs give warning of the presence of radioactive sources. P – Radiological Training: An educational system managed by ES&H that establishes basic worker knowledge through presentations and testing. P – Kept Under Lock-and-key: Radioactive sources are kept in locked storage, where key issuance is a controlled process. M – Kept In Storage: Unused radioactive sources are kept in storage, which prevents the close proximity of these sources and people. M – Shielded Containers: Unused high activity sources are stored within shielded containers. 	L: BEU C: L R: IV				

Likelihood (L, of event)/year	Cor	sequence (C, of event)/	year (Risk (R, Qualitative R	anking)	Risk	Matri	X			
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (event)	t) of major concern				Like	lihood	
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		II = situation (ever)	nt) of concern			Α	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \text{Low}$		III = situation (event) of minor concern		es	Н	I	I	II	III
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible	IV = situation (eve		ent) of minimal concern	enc	M	II	II	III	IV
Control(s) Type	C	Offsite (MOI)	Onsi	te-2 (co-located worker)	Onsite-1 (facility worker)	edn	_		TIT	17.7	13.7
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ 25.0 rem		C ≥ 100 rem	C ≥ 100 rem	ous	L	III	III	IV	IV
 M = Mitigative (reduces event consequences) Acronyms MOI = Maximally-exposed Offsite Individual rem = Roentgen equivalent man 		$25.0 \text{ rem} > \mathbf{C} \ge 5 \text{ rem}$	10	$00 \text{ rem} > \mathbf{C} \ge 25 \text{ rem}$			N	IV	IV	IV	IV
		5 rem > C		25 rem > C	25 rem > C						
		0.5 rem > C	5 rem > C		5 rem > C						

Table 18.3 Radiological – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Residual	Hazard: exposure to residual	L: BEU	P – Facility is locked and not accessible to the unescorted public.	L: BEU
activation	<u> </u>		P – Shielding in place around the beam line and experiment enclosures per	C: M
		R: IV	the relevant shield assessments	R: IV
			P – Interlock system preventing access to beam enclosure while beam is present.	
			P – Enclosure keys linked to radiological and controlled access training to	
			enter enclosure	

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Groundwater	Hazard: radionuclides in ground	L: EU	P – Monitoring Wells: Wells that are drilled near accelerator enclosures in	L: BEU
Activation	water exceed regulatory levels	C: H	areas that are sensitive to potential aquifer contamination. These wells	C: L
		R: I	are periodically sampled and analyzed by ES&H to ensure the aquifer	R: IV
			is not becoming contaminated from accelerator operations.	
			P – Sump Pumps: Pumps located in the accelerator enclosure that have an	
			underdrain network. The water is pumped to the surface, so it does not	
			stagnate in the accelerator and becomes activated.	
			P – Beam loss Monitoring: Electronic Beam Loss Monitors are used to	
			convert radiation created by prompt dose due to beam loss into	
			electrical signals. This information is then made available to the	
			accelerator control system where the data can be logged and	
			monitored with alarms and limits. Losses can be reduced or	
			eliminated with adjustment to the accelerators to prevent activation of	
			tunnel components.	
			M – Machine Protection System: An accelerator system that monitors	
			devices such as beam loss monitors, power supplies, vacuum valves,	
			etc. If these devices are not within their specified limits, the beam is	
			aborted and further injections into the accelerator are inhibited until	
			the system is reset by an operator.	
			M – Run Conditions: Operating parameters that reduce residual activation	
			by limiting the total amount of beam that could be delivered	

Hazard			Hazard Description Baseline Qualitative Risk (without controls) Preventative (P)/ Mitigative (M)			
Surface Water Activation	Hazard: radionuclides in surface water exceed regulatory levels	L: U C: H R: I	 P – Sump Pumps: Pumps located in the accelerator enclosure that have an underdrain network. The water is pumped to the surface, so it does not stagnate in the accelerator and becomes activated prior to removing the water from the enclosure. P – Sump Monitoring Program; Sump water samples are periodically collected and measured for radiological activation. If activation is found in the sump sample, we have the ability to look for the root cause before additional water is pumped to the surface. P – Beam Loss Monitoring Electronic Beam Loss Monitors are used to convert radiation created by prompt dose due to beam loss into electrical signals. This information is then made available to the accelerator control system where the data can be logged and monitored with alarms and limits. Losses can be reduced or eliminated with adjustment to the accelerators to prevent activation of tunnel components. M – Machine Protection System: An accelerator system that monitors devices such as beam loss monitors, power supplies, vacuum valves, etc. If these devices are not within their specified limits, the beam is aborted and further injections into the accelerator are inhibited until the system is reset by an operator. M – Pond Monitoring Program (Procedure): Samples taken from the ponds and measured for activation. Sump water from the tunnel is discharged into these ponds. M – Run Conditions: Operating parameters that reduce residual activation by limiting the total amount of beam that could be delivered. 	L: BEU C: N R: IV		
Radioactive Water (RAW) Systems	Hazard: Exposure beyond regulatory levels, to radioactive water	L: BEU C: M R: IV	 P – Facility is locked and not accessible to the unescorted public. P – Interlock system preventing access to beam enclosure while beam is present. P – Enclosure keys linked to radiological and controlled access training to enter enclosure 	L: BEU C: M R: IV		

Hazard	Hazard Hazard Description		Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)	
Air Activation	Hazard: radionuclides in air exceed regulator levels	L: BEU C: N R: IV	 P – Facility is locked and not accessible to the unescorted public. P – Interlock system preventing access to beam enclosure while beam is present. P – Enclosure keys linked to radiological and controlled access training to enter enclosure 	L: BEU C: N R: IV	
Soil Interactions	Hazard: radionuclides are produced which may contaminate ground water	L: BEU C: N R: IV	 P – Beam Loss Monitoring: Electronic Beam Loss Monitors are used to convert radiation created by prompt dose due to beam loss into electrical signals. This information is then made available to the accelerator control system where the data can be logged and monitored with alarms and limits. Losses can be reduced or eliminated with adjustment to the accelerators to prevent activation of tunnel components. M – Beamline Design: Design of beamline optics to ensure that the actual beam size is smaller than the beam pipe to prevent scraping, beam loss, prompt dose, and residual activation. M – Run Conditions: Operating parameters that reduce residual activation by limiting the total amount of beam that could be delivered. 	L: BEU C: N R: IV	
Radioactive waste	Hazard: Persons are exposed to ionizing radiation beyond regulatory levels	L: BEU C: H R: III	P – Facility is locked and not accessible to the unescorted public. M – Radiological shielding to limit exposure to radioactive waste.	L: BEU C: M R: IV	
Contamination	Hazard: Persons are exposed to ionizing radiation beyond regulatory levels	L: BEU C:N R: IV	P – Facility is locked and not accessible to the unescorted public. P – Radiological control prescreens items with contamination potential prior to acceptance. If contamination exists the item is rejected.	L: BEU C: N R: IV	

Hazard			Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
⁷ Be	Hazard: Potential radiation exposure to 7Be (uptake/committed dose).	L: A C: N R: IV	No prevention or mitigation is required. ⁷ Be isn't hazardous in this pattern of use by facility.	L: A C: N R: IV
Radioactive Sources	Hazard: Persons are exposed to ionizing radiation beyond regulatory levels	L: BEU C: H R: III	P – Facility is locked and not accessible to the unescorted public. P – All low activity sealed sources are kept in a lock box and registered through Radiological Control. M – Radiological training is required for source handling.	L: BEU C: M R: IV

Radiological Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.											
Likelihood (L, of event)/year	ar Consequence (C, of event)/year			Risk (R, Qualitative Ranking)			Risk Matrix				
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (even)	t) of major concern				Like	lihood	
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		II = situation (ever	nt) of concern			A	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \text{Low}$		III = situation (eve	ation (event) of minor concern			I	I	II	III
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (event) of minimal concern			M	II	II	III	IV
Control(s) Type	C	Offsite (MOI)	Onsi	te-2 (co-located worker)	Onsite-1 (facility worker)	ednences		TTT	***	77.7	***
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ 25.0 rem		C ≥ 100 rem	C ≥ 100 rem	ons	L	III	III	IV	IV
M = Mitigative (reduces event consequences)	M	$25.0 \text{ rem} > \mathbf{C} \ge 5 \text{ rem}$	10	$00 \text{ rem} > \mathbf{C} \ge 25 \text{ rem}$	100 rem > C ≥ 25 rem	0	N	IV	IV	IV	IV
Acronyms MOI - Movimelly, avenued Officia Individual	L	5 rem > C		25 rem > C	25 rem > C						
MOI = Maximally-exposed Offsite Individual rem = Roentgen equivalent man	N	0.5 rem > C		5 rem > C	5 rem > C						

Table 18.4 Toxic Materials – Onsite 1 Facility Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Lead	Hazard: Potential exposure to lead dust during manual handling of unencased lead bricks, lead shot, and lead sheets.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Beryllium *	Hazard: Potential exposure to beryllium dust during manual handling of un-encased, activities.	L: C: R:	See Section 1, Chapter 4	L: C: R:

Chemical Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.												
Likelihood (L, of event)/year	C	onsequence (C, of event))/year	Risk (R, Qualitative Ranking)			Risk Matrix					
$\mathbf{A} = \text{Anticipated } (L > 1.0\text{E}-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (eve	nt) of major concern							
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		$\mathbf{II} = \text{situation (ev}$	ent) of concern			A	U	EU	BEU	
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		L = Low		Kl;kmkm;.;'/	I = situation (event) of	es	Н	I	I	II	III	
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		minor concern		enc	M	II	II	III	IV	
				IV = situation (ev	vent) of minimal concern	nba						
Control(s) Type	C	Offsite (MOI)	Onsite	e-2 (co-located worker)	Onsite-1 (facility worker)	Suc	L	III	III	IV	IV	
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ PAC-2			C ≥ IDLH	ರ	N	IV	IV	IV	IV	
M = Mitigative (reduces event consequences)	M	$PAC-2 > C \ge PAC-1$			$IDLH > C \ge PEL \text{ or } TLV_c$							
Acronyms IDI II — Immediately Dengarays to Life and Health	L	PAC-1 > C		PAC-2 > C	PEL or $TLV_c > C$							
IDLH = Immediately Dangerous to Life and Health MOI = Maximally-exposed Offsite Individual	N	Consequences less	Cor	nsequences less than	Consequences less than							
PAC = Protective Action Criteria		than those for Low	those	for Low Consequence	those for Low							
PEL = Permissible Exposure Limit		Consequence Level		Level	Consequence Level							
TLV _c = Threshold Limit Value (ceiling)												

Table 18.5 Toxic Materials – Onsite 2 Co-located Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Lead	Hazard: Potential exposure to lead dust during manual handling of unencased lead bricks, lead shot, and lead sheets.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Beryllium *	Hazard: Potential exposure to beryllium dust during manual handling of un-encased, activities.	L: C: R:	See Section 1, Chapter 4	L: C: R:

Chemical Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.												
Likelihood (L, of event)/year	Co	onsequence (C, of event)	/year	Risk (R, Qualitative	Ranking)	Risk Matrix						
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (eve	nt) of major concern							
U = Unlikely (1.0E-02 > L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		II = situation (ev	ent) of concern		1	Α	U	EU	BEU	
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \text{Low}$		III = situation (ev	vent) of minor concern	ses	Н	I	I	II	III	
BEU = Beyond Extremely Unlikely (1.0E-06> L)		\mathbf{N} = Negligible		IV = situation (ev	vent) of minimal concern	e	M	II	II	III	IV	
Control(s) Type	C	Offsite (MOI)	Onsite	e-2 (co-located worker)	Onsite-1 (facility worker)	edn	T	TIT	Ш	IV	IV	
P = Preventive (reduce event occurrence likelihood)	H $C \ge PAC-2$ M $PAC-2 > C \ge PAC-1$ PA		C ≥ PAC-3	C ≥ IDLH	ons	L	III	1111	1 V	1 V		
$\mathbf{M} = \mathbf{Mitigative}$ (reduces event consequences)			P.A	$AC-3 > C \ge PAC-2$	$IDLH > C \ge PEL \text{ or } TLV_c$	0	N	IV	IV	IV	IV	
Acronyms IDLH = Immediately Dangerous to Life and Health	L	PAC-1 > C		PAC-2 > C	PEL or TLV _c > C							
MOI = Maximally-exposed Offsite Individual PAC = Protective Action Criteria PEL = Permissible Exposure Limit TLV _c = Threshold Limit Value (ceiling)	N	Consequences less than those for Low Consequence Level		nsequences less than for Low Consequence Level	Consequences less than those for Low Consequence Level							

Table 18.6 Toxic Materials – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Lead	Hazard: Potential exposure to lead dust during manual handling of unencased lead bricks, lead shot, and lead sheets.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Beryllium *	Hazard: Potential exposure to beryllium dust during manual handling of un-encased, activities.	L: C: R:	See Section 1, Chapter 4	L: C: R:

Chemical Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.												
Likelihood (L, of event)/year	Co	onsequence (C, of event)/year	Risk (R, Qualitative	Risk (R, Qualitative Ranking)			X				
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (eve	nt) of major concern				Like	lihood		
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		$\mathbf{II} = \text{situation (ev}$	ent) of concern		1	Α	U	EU	BEU	
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \text{Low}$		III = situation (ev	vent) of minor concern	es	Н	I	I	II	III	
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (ev	vent) of minimal concern	enc	M	II	II	III	IV	
Control(s) Type	C	Offsite (MOI)	Onsite	e-2 (co-located worker)	Onsite-1 (facility worker)	edn	_	TTT	TTT	TX /	***	
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ PAC-2		C ≥ PAC-3	C ≥ IDLH	ons	L	III	III	IV	IV	
M = Mitigative (reduces event consequences)	М	$PAC-2 > C \ge PAC-1$	P/	$AC-3 > C \ge PAC-2$	$IDLH > C \ge PEL \text{ or } TLV_c$	C	N	IV	IV	IV	IV	
Acronyms IDLH = Immediately Dangerous to Life and Health	L	$PAC-1 > \mathbf{C}$		PAC-2 > C	PEL or TLV _c > \mathbf{C}							
MOI = Maximally-exposed Offsite Individual PAC = Protective Action Criteria PEL = Permissible Exposure Limit	N	Consequences less than those for Low Consequence Level		nsequences less than for Low Consequence Level	Consequences less than those for Low Consequence Level							
TLV _c = Threshold Limit Value (ceiling)												

 ${\bf Table~18.7~Flammable~and~Combustible~Materials-Onsite~-1~Facility~Worker}$

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Combustible materials (cables, Boxes, Paper, wood cribbing, etc.)	Hazard: This hazard is a potential facility fire. The presence of excessive combustible materials can pose a hazard stemming from inadequate housekeeping practices. This hazard can add to the fuel load of a potential facility fire. Poor housekeeping can also lead to life safety concerns, such as egress obstructions and tripping hazards. The exposure of the hazard to the facility worker is of major concern.	L: C: R:	See Section 1, Chapter 4	L: C: R:

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Flammable Materials (e.g., flammable gas, cleaning materials, etc.)	Hazard: The presence of flammable gases in cylinders or storage containers pose an inherent hazard due to their flammability/combustibility properties. Exposure to hot work provides a dangerous situation where flammable liquids will ignite. Unmitigated this could lead to an explosion and subsequent fire. The exposure of the hazard to the facility worker is of major concern.		See Section 1, Chapter 4	L: C: R:

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.

Likelihood (L, of event)/year	C	onsequence (C, of event)/	/year	Risk (R, Qualitative	Ranking)	Risk Matrix							
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (event) of major concern					Like	lihood			
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		\mathbf{H} = situation (even	ent) of concern	_	1	Α	U	EU	BEU		
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \text{Low}$		III = situation (ev	vent) of minor concern	es	Н	I	I	II	III		
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (ev	vent) of minimal concern	enc	M	II	II	III	IV		
Control(s) Type	C	Offsite (MOI)	Offsite (MOI) Onsite-2 (co-located worker) Onsite-1 (facility worker)	Onsite-1 (facility worker)	sednences	—			***	***			
P = Preventive (reduce event occurrence likelihood)	H	C ≥ Irreversible,	C > P	rompt worker fatality	C ≥ Prompt worker	Cons	L	III	III	IV	IV		
M = Mitigative (reduces event consequences)		other serious effects,		acute injury that is	fatality or acute injury that	ŭ	N	IV	IV	IV	IV		
Acronyms		or symptoms which		mmediately life-	is immediately life-								
MOI = Maximally-exposed Offsite Individual		could impair an		ening or permanently	threatening or								
		individual's ability to	*		permanently disabling.								
		take protective		disabling.	1								
		action.											
	M	C ≥ Mild, transient	C ≥	Serious injury, no	C ≥ Serious injury, no								
		adverse effects.		ediate loss of life no	immediate loss of life no								
			peri	manent disabilities;	permanent disabilities;								
			hosp	oitalization required.	hospitalization required.								
	L	Mild, transient	N	Inor injuries; no	Minor injuries; no								
		adverse effects > C	ho	ospitalization > C	hospitalization $> \mathbf{C}$								
	N	Consequences less	Con	sequences less than	Consequences less than								
		than those for Low		for Low Consequence	those for Low								
		Consequence Level		Level	Consequence Level								

Table 18.8 Flammable and Combustible Materials – Onsite -2 Co-located Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Combustible materials (cables, Boxes, Paper, wood cribbing, etc.)	Hazard: This hazard is a potential facility fire. The presence of excessive combustible materials can pose a hazard stemming from inadequate housekeeping practices. This hazard can add to the fuel load of a potential facility fire. Poor housekeeping can also lead to life safety concerns, such as egress obstructions and tripping hazards. The exposure of the hazard to the facility worker is of major concern.	L: C: R:	See Section 1, Chapter 4	L: C: R:

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Flammable	Hazard: The presence of	L:	See Section 1, Chapter 4	L:
Materials (e.g.,	flammable gases in cylinders or	C:		C:
flammable gas,	storage containers pose an	R:		R:
cleaning	inherent hazard due to their			
materials, etc.)	flammability/combustibility			
	properties.			
	Exposure to hot work provides a dangerous situation where flammable liquids will ignite. Unmitigated this could lead to an explosion and subsequent fire. The exposure of the hazard to the facility worker is of major concern.			

Likelihood (L, of event)/year	Co	onsequence (C, of event)	/year	Risk (R, Qualitative	Ranking)	Risk Matrix						
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (eve	I = situation (event) of major concern				Like	lihood		
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		$\mathbf{II} = \text{situation (even}$	ent) of concern		-	A	U	EU	BEU	
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \mathbf{Low}$		III = situation (ev	vent) of minor concern	es	Н	I	I	II	III	
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (ev	vent) of minimal concern	ences	M	П	II	III	IV	
Control(s) Type	C	Offsite (MOI)	Onsite	-2 (co-located worker)	Onsite-1 (facility worker)	Consequ	, –	***	***	77.7	77.7	
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ Irreversible,	C > P	rompt worker fatality	C ≥ Prompt worker	suo	L	III	III	IV	IV	
M = Mitigative (reduces event consequences)		other serious effects,		acute injury that is	fatality or acute injury that	Ö	N	IV	IV	IV	IV	
Acronyms		or symptoms which		mmediately life-	is immediately life-							
MOI = Maximally-exposed Offsite Individual		could impair an	3 1		threatening or							
		individual's ability to		disabling.	permanently disabling.							
		take protective		C								
		action.										
	M	C ≥ Mild, transient	C ≥	≥ Serious injury, no	C ≥ Serious injury, no							
		adverse effects.	imm	ediate loss of life no	immediate loss of life no							
			per	manent disabilities;	permanent disabilities;							
			hosp	oitalization required.	hospitalization required.							
	L	Mild, transient	N	Ainor injuries; no	Minor injuries; no							
		adverse effects $> \mathbf{C}$			hospitalization $> \mathbf{C}$							
	N	Consequences less			Consequences less than							
		than those for Low	those	for Low Consequence	those for Low							
		Consequence Level		Level	Consequence Level							

Table 18.9 Flammable and Combustible Materials – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Combustible materials (cables, Boxes, Paper, wood cribbing, etc.)	Hazard: The presence of excessive combustible materials can pose a hazard stemming from inadequate housekeeping practices. This hazard can add to the fuel load of a potential fire. Poor housekeeping can also lead to life safety concerns, such as egress obstructions and tripping hazards. The exposure of the hazard to the public is of minimal concern.	L: C: R:	. See Section 1, Chapter 4	L: C: R:

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Flammable Materials (e.g.,	Hazard: The presence of flammable gases in cylinders or	L: C:	See Section 1, Chapter 4	L: C:
flammable gas, cleaning materials, etc.)	storage containers pose an inherent hazard due to their flammability/combustibility properties. Exposure to hot work provides a dangerous situation where flammable liquids will ignite. Unmitigated this could lead to an explosion and subsequent fire. The exposure of the hazard to the public is of minor concern.	R:		R:

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.

Likelihood (L, of event)/year	Consequence (C, of event)/year			Risk (R, Qualitative Ranking)		Risk Matrix					
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (event) of major concern					Like	lihood	
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		II = situation (event) of concern			1	A	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \text{Low}$		III = situation (event) of minor concern		es	Н	I	I	II	III
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (event) of minimal concern		enc	M	II	II	III	IV
Control(s) Type	C	Offsite (MOI)	Onsite	-2 (co-located worker)	Onsite-1 (facility worker)	M M				***	***
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ Irreversible,	C > P	rompt worker fatality	C ≥ Prompt worker	Cons	L	III	III	IV	IV
M = Mitigative (reduces event consequences)AcronymsMOI = Maximally-exposed Offsite Individual		other serious effects,		acute injury that is	fatality or acute injury that	ŭ	N	IV	IV	IV	IV
		or symptoms which		mmediately life-	is immediately life-			l			
		could impair an		ening or permanently	threatening or						
		individual's ability to		disabling.	permanently disabling.						
		take protective		8	1						
		action.									
	M	C ≥ Mild, transient	C ≥	Serious injury, no	C ≥ Serious injury, no						
		adverse effects.		ediate loss of life no	immediate loss of life no						
			peri	manent disabilities;	permanent disabilities;						
			hosp	oitalization required.	hospitalization required.						
	L N	Mild, transient	N	Ainor injuries; no	Minor injuries; no						
		adverse effects > C	ho	ospitalization > C	hospitalization $> \mathbf{C}$						
		Consequences less	Con	sequences less than	Consequences less than						
		than those for Low		for Low Consequence	those for Low						
		Consequence Level		Level	Consequence Level						

Table 18.10 Electrical Energy – Onsite-1 Facility Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Stored Energy Exposure	Hazard: Shock hazard, >50 V, Non-interlocked enclosures	L: C: R:	See Section 1, Chapter 4	L: C: R:
	Arc Flash, <u>Non-interlocked</u> <u>enclosures</u>			
Stored Energy Exposure	Hazard: Shock hazard,>50 V, <u>Interlocked</u> enclosure area	L: C: R:	See Section 1, Chapter 4	L: C: R:
High Voltage Exposure	Hazard: Shock hazard, voltage > 50 V, Non-interlocked enclosures Arc Flash, Non-interlocked enclosures	L: C: R:	See Section 1, Chapter 4	L: C: R:

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
High Voltage Exposure	Hazard: Shock hazard, voltage > 50 V, Interlocked enclosures Arc Flash, Interlocked enclosures	L: C: R:	See Section 1, Chapter 4	L: C: R:
Low Voltage, High Current Exposure.	Hazard: Arc Flash, Non- interlocked enclosures Fire hazard from high current causing smoke inhalation and burns.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Low Voltage, High Current Exposure	Hazard: Arc Flash, Interlocked enclosures Fire hazard from high current causing smoke inhalation and burns.	L: C: R:	See Section 1, Chapter 4	L: C: R:

Other Hazard Consequences, derived from Figure C-1	l, "E	Example Qualitative Conse	quence Matrix", DOE-HD	BK-1163-2020.						
Likelihood (L, of event)/year	C	onsequence (C, of event)/y	ear Risk (R, Qualitative	Ranking)	Risk	Matri	ix			
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$	I = situation (eve	ent) of major concern				Like	lihood	
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$	$\mathbf{II} = \text{situation (ev}$	ent) of concern			A	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		L = Low	III = situation (evaluation	vent) of minor concern	es	Н	I	I	II	III
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible	IV = situation (ex	vent) of minimal concern	enc	M	II	II	III	IV
Control(s) Type	C	Offsite (MOI)	Onsite-2 (co-located worker)	Onsite-1 (facility worker)	Consequences					
P = Preventive (reduce event occurrence likelihood)	H	C ≥ Irreversible,	$C \ge Prompt worker fatality$	C ≥ Prompt worker	ons	L	III	III	IV	IV
M = Mitigative (reduces event consequences)		other serious effects,	or acute injury that is	fatality or acute injury that	ರ	N	IV	IV	IV	IV
Acronyms		or symptoms which	immediately life-	is immediately life-						
MOI = Maximally-exposed Offsite Individual			hreatening or permanently	threatening or						
		individual's ability to	disabling.	permanently disabling.						
		take protective	8	1						
		action.								
	M	C ≥ Mild, transient	C ≥ Serious injury, no	C ≥ Serious injury, no						
		· ·	immediate loss of life no	immediate loss of life no						
			permanent disabilities;	permanent disabilities;						
			hospitalization required.	hospitalization required.						
	L	Mild, transient	Minor injuries; no	Minor injuries; no						
		adverse effects > C	hospitalization $> \mathbf{C}$	hospitalization $> \mathbf{C}$						
	N	Consequences less	Consequences less than	Consequences less than						
		than those for Low that	nose for Low Consequence	those for Low						
		Consequence Level	Level	Consequence Level						

Table 18.11 Electrical Energy 1 Onsite-2 Co-located Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Stored Energy Exposure	Hazard: Shock hazard, >50 V, Non-interlocked enclosures Arc Flash, Non-interlocked enclosures	L: C: R:	See Section 1, Chapter 4	L: C: R:
Stored Energy Exposure	Harard: Shock hazard, >50 V, Interlocked enclosures Arc Flash, Interlocked enclosures	L: C: R:	See Section 1, Chapter 4	L: C: R:
High Voltage Exposure	Hazard: Shock hazard, voltage > 50 V, Non-interlocked enclosures Arc Flash, Non-interlocked enclosures	L: C: R:	See Section 1, Chapter 4	L: C: R:

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
High Voltage Exposure	Hazard: Shock hazard, voltage > 50 V, <u>Interlocked enclosures</u> Arc Flash, <u>Interlocked enclosures</u>	L: C: R:	See Section 1, Chapter 4	L: C: R:
Low Voltage, High Current Exposure.	Hazard: Arc Flash Non- interlocked enclosures Fire hazard from high current causing smoke inhalation and burns service building areas.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Low Voltage, High Current Exposure.	Hazard: Arc Flash, Interlocked enclosures Fire hazard from high current causing smoke inhalation and burns, beam line enclosure areas	L: C: R:	See Section 1, Chapter 4	L: C: R:

Other Hazard Consequences, derived from Figure C-1	, "Example Qualitative Conseque	nce Matrix", DOE-HDBK-1163-2020.						
Likelihood (L, of event)/year	Consequence (C, of event)/year	Risk (R, Qualitative Ranking)	Risk	Matrix	ζ.			
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$	$\mathbf{H} = \mathbf{High}$	I = situation (event) of major concern		Ī		Like	lihood	
U = Unlikely (1.0E-02> L > 1.0E-04)	$\mathbf{M} = \mathbf{Moderate}$	II = situation (event) of concern			Α	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)	$\mathbf{L} = \text{Low}$	III = situation (event) of minor concern	C	Н	I	I	II	III

BEU = Beyond Extremely Unlikely (1.0E-06> L)		\mathbf{N} = Negligible		IV = situation (ev	vent) of minimal concern	M	II	II	III	IV
						L	III	III	IV	IV
						N	IV	IV	IV	IV
Control(s) Type	C	Offsite (MOI)	Onsite	e-2 (co-located worker)	Onsite-1 (facility worker)					
 P = Preventive (reduce event occurrence likelihood) M = Mitigative (reduces event consequences) Acronyms MOI = Maximally-exposed Offsite Individual 	H	C ≥ Irreversible, other serious effects, or symptoms which could impair an individual's ability to take protective action.	or	Prompt worker fatality acute injury that is immediately life-tening or permanently disabling.	C ≥ Prompt worker fatality or acute injury that is immediately lifethreatening or permanently disabling.					
	L N	C ≥ Mild, transient adverse effects. Mild, transient adverse effects > C Consequences less than those for Low Consequence Level	imm per hos h	≥ Serious injury, no nediate loss of life no rmanent disabilities; pitalization required. Minor injuries; no ospitalization > C nsequences less than for Low Consequence Level	C ≥ Serious injury, no immediate loss of life no permanent disabilities; hospitalization required. Minor injuries; no hospitalization > C Consequences less than those for Low Consequence Level					

Table 18.12 Electrical Energy – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Stored Energy	Hazard: Shock hazard, >50 V,	L:	See Section 1, Chapter 4	L:
Exposure	Arc flash	C:		C:
		R:		R:
High Voltage	Hazard: Shock hazard, >50 V,	L:	See Section 1, Chapter 4	L:
Exposure	Arc flash <u>outside</u>	C:		C:
-		R:		R:
Low Voltage,	Hazard: N/A	L:	No Further analysis required	L:
High Current		C:		C:
Exposure.		R:		R:

Likelihood (L, of event)/year	C	onsequence (C, of event)	/year	Risk (R, Qualitative	Ranking)	Ris	k Matr	ix			
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (ever	nt) of major concern				Like	lihood	
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		$\mathbf{II} = \text{situation (evolution } \mathbf{II} = \mathbf{II}$	ent) of concern			A	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		L = Low		III = situation (ev	vent) of minor concern	es	Н	I	I	II	III
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (ev	vent) of minimal concern	enc	M	II	II	III	IV
Control(s) Type	C	Offsite (MOI)	Onsite	-2 (co-located worker)	Onsite-1 (facility worker)	sedneuces	_			***	***
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ Irreversible,	C > P	rompt worker fatality	C ≥ Prompt worker	ous	L	III	III	IV	IV
M = Mitigative (reduces event consequences)		other serious effects,		acute injury that is	fatality or acute injury that	Coi	N	IV	IV	IV	IV
Acronyms		or symptoms which		mmediately life-	is immediately life-				•		
MOI = Maximally-exposed Offsite Individual		could impair an		ening or permanently	threatening or						
		individual's ability to		disabling.	permanently disabling.						
		take protective		S							
		action.									
	M	$C \ge Mild$, transient	C ≥	≥ Serious injury, no	C ≥ Serious injury, no						
		adverse effects.		ediate loss of life no	immediate loss of life no						
			peri	manent disabilities;	permanent disabilities;						
			hosp	oitalization required.	hospitalization required.						
	L	Mild, transient	N	Minor injuries; no	Minor injuries; no						
		adverse effects $> \mathbf{C}$	ho	ospitalization > C	hospitalization $> \mathbf{C}$						
	N	Consequences less	Con	sequences less than	Consequences less than						
		than those for Low	those	for Low Consequence	those for Low						
		Consequence Level		Level	Consequence Level						

 $Table\ 18.13\ Thermal\ Energy-Onsite-1\ Facility\ Worker$

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Hot Work	Hazard: welding, brazing, grinding, and other operations which create high temperatures which can ignite a fire	L: C: R:	See Section 1, Chapter 4	L: C: R:

Other Hazard Consequences, derived from Figure C-	1, "E	xample Qualitative Cons	equence Matrix", DOE-HD	BK-1163-2020.						
Likelihood (L, of event)/year	C	onsequence (C, of event)/y	year Risk (R, Qualitative	Ranking)	Risk	Matri	X			
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$	I = situation (eve	ent) of major concern				Like	lihood	
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$	$\mathbf{II} = \text{situation (ev}$	ent) of concern		1	Α	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \text{Low}$	III = situation (e	vent) of minor concern	ses	Н	I	I	II	III
BEU = Beyond Extremely Unlikely $(1.0E-06>L)$		N = Negligible	$IV = situation (e^{-})$	vent) of minimal concern	iences	M	II	II	III	IV
Control(s) Type	C	Offsite (MOI)	Onsite-2 (co-located worker)	Onsite-1 (facility worker)	nbəs	L	Ш	III	IV	IV
P = Preventive (reduce event occurrence likelihood) M = Mitigative (reduces event consequences)	Н	$C \ge$ Irreversible, other serious effects,	C ≥ Prompt worker fatality or acute injury that is	C ≥ Prompt worker fatality or acute injury that	Con	N	IV	IV	IV	IV
Acronyms		or symptoms which	immediately life-	is immediately life-						
MOI = Maximally-exposed Offsite Individual		could impair an	threatening or permanently	threatening or						
		individual's ability to	disabling.	permanently disabling.						
		take protective								
		action.								
	M	$C \ge Mild$, transient	$C \ge Serious injury, no$	$C \ge Serious injury, no$						
		adverse effects.	immediate loss of life no	immediate loss of life no						
			permanent disabilities;	permanent disabilities;						
			hospitalization required.	hospitalization required.						

L	,	Mild, transient	Minor injuries; no	Minor injuries; no
		adverse effects $> \mathbf{C}$	hospitalization $> \mathbf{C}$	hospitalization $> \mathbf{C}$
N	ſ	Consequences less	Consequences less than	Consequences less than
		than those for Low	those for Low Consequence	those for Low
		Consequence Level	Level	Consequence Level

Table 18.14 Thermal Energy – Onsite-2 Co-located Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Hot Work	Hazard: welding, brazing, grinding, and other operations which create high temperatures which can ignite a fire.	L: C: R:	See Section 1, Chapter 4	L: C: R:

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.												
Likelihood (L, of event)/year	C	onsequence (C, of event)/	year Risk (R, Qualit	Risk (R, Qualitative Ranking)			Risk Matrix					
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$	I = situation	n (eve	nt) of major concern				Like	lihood		
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$	$\mathbf{H} = \text{situation}$	on (eve	ent) of concern		ı	Α	U	EU	BEU	
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \text{Low}$	III = situat	ion (ev	vent) of minor concern	ses	Н	I	I	II	III	
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible	IV = situati	ion (ev	vent) of minimal concern	ences	M	II	II	III	IV	
Control(s) Type	C	Offsite (MOI)	Onsite-2 (co-located work	ker)	Onsite-1 (facility worker)	sedn	L	Ш	III	IV	IV	
P = Preventive (reduce event occurrence likelihood) M = Mitigative (reduces event consequences)	Н	C ≥ Irreversible, other serious effects,	C ≥ Prompt worker fatality or acute injury that is		C ≥ Prompt worker fatality or acute injury that	Con	N	IV	IV	IV	IV	
Acronyms		or symptoms which	immediately life-		is immediately life- threatening or							
MOI = Maximally-exposed Offsite Individual		could impair an	threatening or permane	ently								
		individual's ability to	disabling.		permanently disabling.							
		take protective										
		action.										
	M	$C \ge Mild$, transient	$C \ge Serious injury, r$	no	C ≥ Serious injury, no							
		adverse effects.	immediate loss of life	no	immediate loss of life no							
			permanent disabilitie	rmanent disabilities; permanent disabilities;								
			hospitalization requir	ed.	hospitalization required.							

L	,	Mild, transient	Minor injuries; no	Minor injuries; no
		adverse effects $> \mathbf{C}$	hospitalization $> \mathbf{C}$	hospitalization $> \mathbf{C}$
N	ſ	Consequences less	Consequences less than	Consequences less than
		than those for Low	those for Low Consequence	those for Low
		Consequence Level	Level	Consequence Level

Table 18.15 Thermal Energy – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Hot Work	Hazard: N/A	L:	No further analysis required.	L:
		C:		C:
		R:		R:

Other Hazard Consequences, derived from Figure C-1	Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.										
Likelihood (L, of event)/year	C	onsequence (C, of event)	/year Risk (R, Qualitative	Ranking)	Risk Matrix						
$\mathbf{A} = \text{Anticipated (L} > 1.0\text{E}-02)$		$\mathbf{H} = \mathbf{High}$	$\mathbf{I} = \text{situation (eve}$	ent) of major concern							
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$	$\mathbf{II} = \text{situation (ev}$	ent) of concern			A	U	EU	BEU	
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		L = Low	III = situation (ex	vent) of minor concern	es	Н	I	I	II	III	
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible	IV = situation (ev	vent) of minimal concern	ences	M	II	II	III	IV	
Control(s) Type	C	Offsite (MOI)	Onsite-2 (co-located worker)	Onsite-1 (facility worker)	nba	_	***		***		
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ Irreversible,	$C \ge Prompt worker fatality$	C ≥ Prompt worker	Suc	L	III	III	IV	IV	
M = Mitigative (reduces event consequences)		other serious effects,	or acute injury that is	fatality or acute injury that	Co	N	IV	IV	IV	IV	
Acronyms		or symptoms which	immediately life-	is immediately life-							
MOI = Maximally-exposed Offsite Individual		could impair an	threatening or permanently	threatening or							
		individual's ability to	disabling.	permanently disabling.							
		take protective	2.2.2.6.	Francisco, asserting.							
		action.									
	M	C ≥ Mild, transient	C ≥ Serious injury, no	C ≥ Serious injury, no							
		adverse effects.	immediate loss of life no	immediate loss of life no							
			permanent disabilities;	permanent disabilities;							
			hospitalization required.	hospitalization required.							
	L	Mild, transient	Minor injuries; no	Minor injuries; no							
		adverse effects > C	hospitalization $> \mathbf{C}$	hospitalization $> \mathbf{C}$							
	N	Consequences less	Consequences less than	Consequences less than							
		than those for Low	those for Low Consequence	those for Low							
		Consequence Level	Level	Consequence Level							

Table 18.16 Kinetic Energy – Onsite-1 Facility Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Power tools	Hazard: Personnel injury due to improper use of power tools.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Pumps and Motors	Hazard: Personnel injury due to entrapment/entanglement.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Motion Tables	Hazard: Personnel injury due to pinch points, tip-overs, caught in between.	L: C: R:	See Section 1, Chapter 4	L: C: R:

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.													
Likelihood (L, of event)/year	C	onsequence (C, of event)	year Risk (R, Q	, Qualitative Ranking)			Risk Matrix						
$\mathbf{A} = \text{Anticipated } (L > 1.0\text{E}-02)$		$\mathbf{H} = \mathbf{High}$	I = situ	ation (eve	nt) of major concern								
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$	$\mathbf{II} = \mathbf{sit}$	uation (ev	ent) of concern		1	Α	U	EU	BEU		
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \text{Low}$	$\mathbf{III} = \mathbf{s}$	ituation (ev	vent) of minor concern	uces	Н	I	I	II	III		
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible	IV = si	ituation (ev	vent) of minimal concern	تة ا	M	II	II	III	IV		
Control(s) Type	C	Offsite (MOI)	Onsite-2 (co-located	worker)	Onsite-1 (facility worker)	edn				***	***		
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ Irreversible,	C ≥ Prompt worke	r fatality	C ≥ Prompt worker	Suo	L	III	III	IV	IV		
M = Mitigative (reduces event consequences)		other serious effects,	or acute injury	•	fatality or acute injury that	Co	N	IV	IV	IV	IV		
Acronyms		or symptoms which	immediately l		is immediately life-								
MOI = Maximally-exposed Offsite Individual		could impair an	threatening or peri		threatening or								
		individual's ability to	disabling.	-	permanently disabling.								
		take protective	B		Francisco, asserting.								
		action.											
	M	C ≥ Mild, transient	C ≥ Serious inju	ıry, no	C ≥ Serious injury, no								
		adverse effects.	immediate loss of	f life no	immediate loss of life no								
			permanent disab	ilities;	permanent disabilities;								
			hospitalization re	equired.	hospitalization required.								
	L	Mild, transient	Minor injuries	s; no	Minor injuries; no								
		adverse effects > C	hospitalization	1 > C	hospitalization $> \mathbf{C}$								
	N	Consequences less	Consequences le	ss than	Consequences less than								
		than those for Low	those for Low Con	sequence	those for Low								
		Consequence Level	Level		Consequence Level								

Table 18.17 Kinetic Energy – Onsite-2 Co-located Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Power tools	Hazard: Personnel injury due to power tool use (flying debris, struck by object).	L: C: R:	See Section 1, Chapter 4	L: C: R:
Pumps and Motors	Hazard: Personnel injury due to entrapment/entanglement.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Motion Tables	Hazard: Personnel injury due to tip-overs, caught in between, crushing	L: C: R:	See Section 1, Chapter 4	L: C: R:

Other Hazard Consequences, derived from Figure C-1	l, "E	xample Qualitative Con	sequen	ce Matrix", DOE-HD	BK-1163-2020.						
Likelihood (L, of event)/year	Co	onsequence (C, of event)	/year	Risk (R, Qualitative	Ranking)	Risk Matrix					
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (eve	nt) of major concern						
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		$\mathbf{II} = \text{situation (even}$	ent) of concern		1	A	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \text{Low}$		III = situation (ev	vent) of minor concern	seou	Н	I	I	II	III
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (ev	vent) of minimal concern	enc	M	II	II	III	IV
Control(s) Type	C	Offsite (MOI)	Onsite	-2 (co-located worker)	Onsite-1 (facility worker)	edn	т .	Ш	III	IV	IV
P = Preventive (reduce event occurrence likelihood)M = Mitigative (reduces event consequences)	Н	C ≥ Irreversible, other serious effects,		rompt worker fatality acute injury that is	C ≥ Prompt worker fatality or acute injury that	Cons	N	IV	IV	IV	IV
Acronyms MOI = Maximally-exposed Offsite Individual		or symptoms which could impair an individual's ability to take protective		mmediately life- ening or permanently disabling.	is immediately life- threatening or permanently disabling.						
		action. C ≥ Mild, transient adverse effects. Mild, transient	imm per hosp	≥ Serious injury, no lediate loss of life no manent disabilities; bitalization required.	C ≥ Serious injury, no immediate loss of life no permanent disabilities; hospitalization required. Minor injuries; no						
		adverse effects > C		ospitalization > C	hospitalization > C						

Table 18.18 Kinetic Energy – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Power tools	Hazard: N/A	L: C: R:	No Further analysis required	L: C: R:
Pumps and Motors	Hazard: N/A	L: C: R:	No Further analysis required	L: C: R:
Motion Tables	Hazard: N/A	L: C: R:	No Further analysis required	L: C: R:

Other Hazard Consequences, derived from Figure C-	1, "F	Example Qualitative Con	sequer	nce Matrix", DOE-HD	BK-1163-2020.						
Likelihood (L, of event)/year	Ranking)	Risk	Matri	X							
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (eve	nt) of major concern			Likelihood			
U = Unlikely (1.0E-02 > L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		II = situation (ev	ent) of concern		1	A	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		L = Low		III = situation (ev	vent) of minor concern	seou	Н	I	I	II	III
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (ev	vent) of minimal concern		M	II	II	III	IV
Control(s) Type	C	Offsite (MOI)	Onsite	e-2 (co-located worker)	Onsite-1 (facility worker)	nbəs	ī	Ш	III	IV	IV
 P = Preventive (reduce event occurrence likelihood) M = Mitigative (reduces event consequences) Acronyms MOI = Maximally-exposed Offsite Individual 		C ≥ Irreversible, other serious effects, or symptoms which could impair an individual's ability to take protective action.	or i	Prompt worker fatality acute injury that is immediately lifetening or permanently disabling.	C ≥ Prompt worker fatality or acute injury that is immediately lifethreatening or permanently disabling.	Con	N	IV	IV	IV	IV
	M L	C ≥ Mild, transient adverse effects. Mild, transient adverse effects > C	imm per hosp	≥ Serious injury, no nediate loss of life no rmanent disabilities; pitalization required. Minor injuries; no ospitalization > C	C ≥ Serious injury, no immediate loss of life no permanent disabilities; hospitalization required. Minor injuries; no hospitalization > C						

Table 18.19 Potential Energy – Onsite-1 Facility Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Crane Operations	Hazard: Personnel injury due to improper crane operations.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Compressed Gasses	Hazard: Personnel injury due to unexpected release, or unsecure tanks.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Vacuum/ Pressure Vessels/ Piping	Hazard: Personnel injury due to unexpected pressure release.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Vacuum Pumps	Hazard: Personnel injury due to interaction with existing vacuum.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Material Handling	Hazard: Personnel injury due to moving/handing material (rollovers, crush, etc.)	L: C: R:	See Section 1, Chapter 4	L: C: R:

Other Hazard Consequences, derived from Figure C-	Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.											
Likelihood (L, of event)/year	C	onsequence (C, of event)/	year	Risk (R, Qualitative	Ranking)	Ri	sk Ma	trix				
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (ever	nt) of major concern					Like	lihood	
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		$\mathbf{II} = situation (evolution (evolution for evolution $	ent) of concern	_			A	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \text{Low}$		III = situation (evolution)	vent) of minor concern	South	H H	ł	I	I	II	III
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (ev	vent) of minimal concern	1 2	5 N	1	II	II	III	IV
Control(s) Type	C	Offsite (MOI)	Onsite	-2 (co-located worker)	Onsite-1 (facility worker)	100			III	III	IV	IV
P = Preventive (reduce event occurrence likelihood) M = Mitigative (reduces event consequences) Acronyms	H	C ≥ Irreversible, other serious effects, or symptoms which	or	rompt worker fatality acute injury that is mmediately life-	C ≥ Prompt worker fatality or acute injury that is immediately life-	Con	N	1	IV	IV	IV	IV
MOI = Maximally-exposed Offsite Individual		could impair an individual's ability to take protective action.	threat	ening or permanently disabling.	threatening or permanently disabling.							
	М	C ≥ Mild, transient adverse effects.	imm peri	E Serious injury, no ediate loss of life no manent disabilities; oitalization required.	C ≥ Serious injury, no immediate loss of life no permanent disabilities; hospitalization required.							
	L	Mild, transient	N	Inor injuries; no	Minor injuries; no							

hospitalization > C

Consequences less than

those for Low Consequence

Level

hospitalization > C

Consequences less than

those for Low

Consequence Level

Mild, transient adverse effects > C

Consequences less

than those for Low Consequence Level

Table 18.20 Potential Energy – Onsite-2 Co-located Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Crane Operations	Hazard: Personnel struck by falling, swinging loads	L: C: R:	See Section 1, Chapter 4	L: C: R:
Compressed Gasses	Hazard: Collocated personnel injury due to unexpected release, or unsecure tanks	L: C: R:	See Section 1, Chapter 4	L: C: R:
Vacuum/ Pressure Vessels/ Piping	Hazard: Collocated personnel injury due to unexpected pressure release Hazard: Beam pipes under vacuum	L: C: R:	See Section 1, Chapter 4	L: C: R:
Vacuum Pumps	Hazard: Hazard: Personnel injury due to interaction with existing vacuum.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Material Handling	Hazard: Collocated personnel injury due to moving/handing material (rollovers, crush, etc.)	L: C: R:	See Section 1, Chapter 4	L: C: R:

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.										
Likelihood (L, of event)/year	C	onsequence (C, of event)	/year Risk (R, Qualitative	Ranking)	Risk	Matri	ix			
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$	$\mathbf{I} = \text{situation (eve}$	ent) of major concern				Like	lihood	
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$	$\mathbf{II} = \text{situation (ev}$	ent) of concern			A	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \mathbf{Low}$	III = situation (ex	vent) of minor concern	ses	Н	I	I	II	III
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible	IV = situation (evolution)	vent) of minimal concern	ences	M	II	II	III	IV
Control(s) Type	C	Offsite (MOI)	Onsite-2 (co-located worker)	Onsite-1 (facility worker)	sedno	_	***	777	77.7	77.7
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ Irreversible,	C ≥ Prompt worker fatality	C ≥ Prompt worker	Cons	L	III	III	IV	IV
M = Mitigative (reduces event consequences)		other serious effects,	or acute injury that is	fatality or acute injury that	5	N	IV	IV	IV	IV
Acronyms		or symptoms which	immediately life-	is immediately life-						
MOI = Maximally-exposed Offsite Individual		could impair an	threatening or permanently	threatening or						
		individual's ability to	disabling.	permanently disabling.						
		take protective	Č							
		action.								
	M	$C \ge Mild$, transient	$C \ge Serious injury, no$	C ≥ Serious injury, no						
		adverse effects.	immediate loss of life no	immediate loss of life no						
			permanent disabilities;	permanent disabilities;						
			hospitalization required.	hospitalization required.						
	L	Mild, transient	Minor injuries; no	Minor injuries; no						
		adverse effects > C	hospitalization $> \mathbf{C}$	hospitalization > C						
	N	Consequences less	Consequences less than	Consequences less than						
		than those for Low	those for Low Consequence	those for Low						
		Consequence Level	Level	Consequence Level						

Table 18.21 Potential Energy – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Crane Operations	Hazard: N/A	L: C: R:	No Further analysis required	L: C: R:
Compressed Gasses	Hazard: Injury due to unexpected release, or unsecure tanks outside of buildings	L: C: R:	See Section 1, Chapter 4	L: C: R:
Vacuum/ Pressure Vessels/ Piping	Hazard: Injury due to unexpected release, or unsecure tanks outside of buildings	L: C: R:	See Section 1, Chapter 4	L: C: R:
Vacuum Pumps	Hazard: N/A	L: C: R:	No Further analysis required	L: C: R:
Material Handling	Hazard: N/A	L: C: R:	No Further analysis required	L: C: R:

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.											
Likelihood (L, of event)/year A = Anticipated (L > 1.0E-02) L = Unlikely (1.0E-02) L > 1.0E-04)	Consequence (C, of event)/year H = High M = Moderate L = Low N = Negligible			,	nt) of major concern	Risk	Matri	ix A	BEU		
U = Unlikely (1.0E-02> L >1.0E-04) EU = Extremely Unlikely (1.0E-04 > L >1.0E-06) BEU = Beyond Extremely Unlikely (1.0E-06> L)					vent) of concern vent) of minor concern vent) of minimal concern	seoue	H M	I	I II	EU II III	III IV
Control(s) Type P = Preventive (reduce event occurrence likelihood)	C H	Offsite (MOI) $C \ge Irreversible,$		e-2 (co-located worker) Prompt worker fatality	Onsite-1 (facility worker) $C \ge Prompt worker$	Consequences	L	III	Ш	IV	IV
M = Mitigative (reduces event consequences) Acronyms MOI = Maximally-exposed Offsite Individual		other serious effects, or symptoms which could impair an individual's ability to take protective action.	i	acute injury that is immediately life-tening or permanently disabling.	fatality or acute injury that is immediately life- threatening or permanently disabling.		N	IV	IV	IV	IV
	М	C ≥ Mild, transient adverse effects.	imm per hosp	≥ Serious injury, no nediate loss of life no rmanent disabilities; pitalization required.	C ≥ Serious injury, no immediate loss of life no permanent disabilities; hospitalization required.						
	L	Mild, transient adverse effects $> \mathbf{C}$		Minor injuries; no ospitalization > C	Minor injuries; no hospitalization > C						
	N	Consequences less than those for Low Consequence Level		nsequences less than for Low Consequence Level	Consequences less than those for Low Consequence Level						

Table 18.22 Magnetic Fields – Onsite-1 Facility Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Fringe Fields	Hazard: Exposure to fringe fields beyond allowable limits (worker with ferromagnetic or electronic medical device(s)) Exposure to fringe fields beyond allowable limits (worker without ferromagnetic or electronic medical device(s)) Exposure to flying metallic objects causing potential injury.	L: C: R:	See Section 1, Chapter 4	L: C R:

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.												
Likelihood (L, of event)/year	Co	onsequence (C, of event)/ye	ear	Risk (R, Qualitative	Ranking)	١,	Rick	Matri	v			
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (even)	nt) of major concern	1	XI3K	wiati		Like	lihood	
U = Unlikely (1.0E-02 > L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		$\mathbf{II} = \text{situation (even}$	ent) of concern				Α	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		L = Low		III = situation (ev	vent) of minor concern		Su	Н	T	I	Ш	Ш
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (ev	vent) of minimal concern						***	
Control(s) Type	C	Offsite (MOI))nsite-	2 (co-located worker)	Onsite-1 (facility worker)	ĪL	_ •	M	II	II	III	IV

P = Preventive (reduce event occurrence likelihood) M = Mitigative (reduces event consequences) Acronyms MOI = Maximally-exposed Offsite Individual	Н	C ≥ Irreversible, other serious effects, or symptoms which could impair an	C ≥ Prompt worker fatality or acute injury that is immediately life- threatening or permanently	$C \ge Prompt$ worker fatality or acute injury that is immediately lifethreatening or	L N	III IV	III IV	IV IV	IV IV
		individual's ability to take protective action.	disabling.	permanently disabling.					
	M	$C \ge Mild$, transient	C ≥ Serious injury, no	$C \ge Serious injury, no$					
		adverse effects.	immediate loss of life no	immediate loss of life no					
			permanent disabilities;	permanent disabilities;					
			hospitalization required.	hospitalization required.					
	L	Mild, transient	Minor injuries; no	Minor injuries; no					
		adverse effects $> \mathbf{C}$	hospitalization $> \mathbf{C}$	hospitalization $> \mathbf{C}$					
	N	Consequences less	Consequences less than	Consequences less than					
		than those for Low	those for Low Consequence	those for Low					
		Consequence Level	Level	Consequence Level					

Table 18.23 Magnetic Fields – Onsite-2 Co-located Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Fringe Fields	Hazard: Exposure to fringe fields beyond allowable limits (worker with ferromagnetic or electronic medical device(s)) Exposure to fringe fields beyond allowable limits (worker without ferromagnetic or electronic medical device(s)) Exposure to flying metallic objects causing potential injury.	L: C: R:	See Section 1, Chapter 4	L: C: R:

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.												
Likelihood (L, of event)/year	Co	onsequence (C, of event)/yo	ear	Risk (R, Qualitative	Ranking)	1	Qiek	Matri	v			
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (even)	nt) of major concern		XISK	wiati		Like	lihood	
U = Unlikely (1.0E-02 > L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		$\mathbf{II} = \text{situation (even}$	ent) of concern				Α	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \mathbf{Low}$		III = situation (ev	vent) of minor concern		ns or	Н	T	I	Ш	Ш
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (ev	vent) of minimal concern						***	
Control(s) Type	C	Offsite (MOI))nsite-2	·2 (co-located worker)	Onsite-1 (facility worker)] L	_	M	II	II	III	IV

P = Preventive (reduce event occurrence likelihood) M = Mitigative (reduces event consequences) Acronyms MOI = Maximally-exposed Offsite Individual	Н	C ≥ Irreversible, other serious effects, or symptoms which could impair an	C ≥ Prompt worker fatality or acute injury that is immediately life- threatening or permanently	$C \ge Prompt$ worker fatality or acute injury that is immediately lifethreatening or	L N	III IV	III IV	IV IV	IV IV
		individual's ability to take protective action.	disabling.	permanently disabling.					
	M	$C \ge Mild$, transient	C ≥ Serious injury, no	$C \ge Serious injury, no$					
		adverse effects.	immediate loss of life no	immediate loss of life no					
			permanent disabilities;	permanent disabilities;					
			hospitalization required.	hospitalization required.					
	L	Mild, transient	Minor injuries; no	Minor injuries; no					
		adverse effects $> \mathbf{C}$	hospitalization $> \mathbf{C}$	hospitalization $> \mathbf{C}$					
	N	Consequences less	Consequences less than	Consequences less than					
		than those for Low	those for Low Consequence	those for Low					
		Consequence Level	Level	Consequence Level					

Table 18.24 Magnetic Fields – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Fringe Fields	Hazard: N/A	L:	No further analysis required	L:
		C:		C:
		R:		R:

Other Hazard Consequences, derived from Figure C-1	l, "E	xample Qualitative Con	sequen	ce Matrix", DOE-HD	BK-1163-2020.						
Likelihood (L, of event)/year	C	onsequence (C, of event)/	/year	Risk (R, Qualitative	Ranking)	Risl	Matr	ix			
$\mathbf{A} = \text{Anticipated } (L > 1.0\text{E}-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (eve	ent) of major concern				Like	lihood	
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		II = situation (ev	ent) of concern		1	A	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \text{Low}$		III = situation (evaluation	vent) of minor concern	es	Н	I	I	II	III
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (ev	vent) of minimal concern	enc	M	II	II	III	IV
Control(s) Type	C	Offsite (MOI)	Onsite	-2 (co-located worker)	Onsite-1 (facility worker)	edn	T	III	ш	IV	IV
 P = Preventive (reduce event occurrence likelihood) M = Mitigative (reduces event consequences) Acronyms MOI = Maximally-exposed Offsite Individual 		$C \ge \text{Irreversible},$ other serious effects,		Prompt worker fatality acute injury that is	C ≥ Prompt worker fatality or acute injury that	Consequences	N	IV	III	IV	IV
		or symptoms which could impair an individual's ability to take protective action.	i	mmediately life- ening or permanently disabling.	is immediately life- threatening or permanently disabling.		•		,		
	M	C ≥ Mild, transient adverse effects. Mild, transient adverse effects > C	imm per hosp	≥ Serious injury, no lediate loss of life no manent disabilities; bitalization required. Minor injuries; no lospitalization > C	C ≥ Serious injury, no immediate loss of life no permanent disabilities; hospitalization required. Minor injuries; no hospitalization > C						

N	Cor	nsequences less	Consequences less than	Consequences less than
	thar	n those for Low	those for Low Consequence	those for Low
	Con	nsequence Level	Level	Consequence Level

 $Table\ 18.25\ Other\ hazards-Onsite-1\ Facility\ Worker$

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Confined Spaces	Hazard: Exposure to toxic atmosphere, limited egress, poor quality	L: C: R:	See Section 1, Chapter 4	L: C: R:
Noise	Hazard: Exposure above OELs via use of machinery, tools, colocation w/ equipment, etc.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Silica	Hazard: Airborne exposure above OEL via concrete (or similar material) machining, moving dirt or gravel	L: C: R:	See Section 1, Chapter 4	L: C: R:
Ergonomics	Hazard: Office space, Industrial space (over lifting, repetitive motion, static posture)	L: C: R:	See Section 1, Chapter 4	L: C: R:
Asbestos	Hazard: Deteriorating building materials	L: C: R:	See Section 1, Chapter 4	L: C: R:

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Working at Heights	Hazard: Falls, dropped tools/material	L: C: R:	See Section 1, Chapter 4	L: C: R:

Likelihood (L, of event)/year	Co	onsequence (C, of event))/year	Risk (R, Qualitative	Ranking)	Risk	Matri	X			
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (eve	nt) of major concern				Like	lihood	
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		\mathbf{H} = situation (ev	ent) of concern			Α	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \text{Low}$		III = situation (ev	vent) of minor concern	es	Н	I	I	II	III
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (ev	vent) of minimal concern	Consequences	M	II	II	III	IV
Control(s) Type	C	C Offsite (MOI) Onsite-2		e-2 (co-located worker)	Onsite-1 (facility worker)	edn		***		***	***
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ Irreversible.	C > F	Prompt worker fatality	C ≥ Prompt worker fatality or acute injury that	ons	L	III	III	IV	IV
M = Mitigative (reduces event consequences)		other serious effects,		acute injury that is		Č	N	IV	IV	IV	IV
Acronyms		or symptoms which	immediately life-		is immediately life-						
MOI = Maximally-exposed Offsite Individual		could impair an		eatening or permanently threatening or							
		individual's ability to		disabling.	permanently disabling.						
		take protective									
		action.									
		C ≥ Mild, transient	C	≥ Serious injury, no	C ≥ Serious injury, no						
		adverse effects.	imm	nediate loss of life no	immediate loss of life no						

			permanent disabilities;	permanent disabilities;
			hospitalization required.	hospitalization required.
I	L	Mild, transient	Minor injuries; no	Minor injuries; no
		adverse effects $> \mathbf{C}$	hospitalization $> C$	hospitalization $> \mathbf{C}$
N	N	Consequences less	Consequences less than	Consequences less than
		than those for Low	those for Low Consequence	those for Low
		Consequence Level	Level	Consequence Level

Table 18.26 Other hazards – Onsite-2 Co-located Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Confined Spaces	Hazard: Exposure to toxic atmosphere, limited egress, poor quality	L: C: R:	See Section 1, Chapter 4	L: C: R:
Noise	Hazard: Exposure above OELs via use of machinery, tools, colocation w/ equipment, etc.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Silica	Hazard: Airborne exposure above OEL via concrete (or similar material) machining, moving dirt or gravel	L: C: R:	See Section 1, Chapter 4	L: C: R:
Ergonomics	Hazard: Office space, Industrial space (over lifting, repetitive motion, static posture)	L: C: R:	No Further analysis required	L: C: R:
Asbestos	Hazard: Deteriorating building materials	L: C: R:	See Section 1, Chapter 4	L: C: R:

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Working at Heights	Hazard: Struck by dropped tools/material	L: C: R:	See Section 1, Chapter 4	L: C: R:

Other Hazard Consequences, derived from Figure C-	Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.											
Likelihood (L, of event)/year	C	onsequence (C, of event)/y	year	Risk (R, Qualitative	Ranking)	Risk Matrix						
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \text{High}$		I = situation (ever	(event) of major concern				Likelihood			
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		II = situation (evolution)	ent) of concern	l		A	U	EU	BEU	
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		L = Low	L = Low		vent) of minor concern	જ	Н	I	I	II	III	
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (ev	vent) of minimal concern		M	II	II	III	IV	
Control(s) Type	C	Offsite (MOI)	Onsite-2	2 (co-located worker)	Onsite-1 (facility worker)	edn	,	TTT	777	13.7	13.7	
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ Irreversible,	$C \ge Pro$	ompt worker fatality	C ≥ Prompt worker	ons	L	III	III	IV	IV	
M = Mitigative (reduces event consequences)		other serious effects,		cute injury that is	fatality or acute injury that	Č	N	IV	IV	IV	IV	

Acronyms		or symptoms which	immediately life-	is immediately life-
MOI = Maximally-exposed Offsite Individual		could impair an	threatening or permanently	threatening or
		individual's ability to	disabling.	permanently disabling.
		take protective		
		action.		
	M	$C \ge Mild$, transient	$C \ge Serious injury, no$	$C \ge Serious injury, no$
		adverse effects.	immediate loss of life no	immediate loss of life no
			permanent disabilities;	permanent disabilities;
			hospitalization required.	hospitalization required.
	L	Mild, transient	Minor injuries; no	Minor injuries; no
		adverse effects $> \mathbf{C}$	hospitalization $> C$	hospitalization $> \mathbf{C}$
	N	Consequences less	Consequences less than	Consequences less than
		than those for Low	those for Low Consequence	those for Low
		Consequence Level	Level	Consequence Level

Table 18.27 Other hazards – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Confined Spaces	Hazard: Exposure to toxic atmosphere, limited egress, poor quality	L: C: R:	See Section 1, Chapter 4	L: C: R:
Noise	Hazard: Exposure above OELs via use of machinery, tools, colocation w/ equipment, etc.	L: C: R:	See Section 1, Chapter 4	L: C: R:
Silica	Hazard: Airborne exposure above OEL via concrete (or similar material) machining, moving dirt or gravel	L: C: R:	See Section 1, Chapter 4	L: C: R:
Ergonomics	Hazard: N/A	L: C: R:	No Further analysis required	L: C: R:
Asbestos	Hazard: N/A	L: C: R:	No Further analysis required	L: C: R:
Working at Heights	Hazard: Struck by dropped tools/material.	L: C: R:	See Section 1, Chapter 4	L: C: R:

Other Hazard Consequences, derived from Figure C-1	l, "E	xample Qualitative Cor	isequei	nce Matrix", DOE-HD	BK-1163-2020.						
Likelihood (L, of event)/year	Co	onsequence (C, of event))/year	Risk (R, Qualitative	Ranking)	Risl	Matri	ix			
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (eve	ent) of major concern				Like	lihood	
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		II = situation (ev	ent) of concern	_	1	A	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		L = Low		III = situation (e	vent) of minor concern	es	Н	I	I	II	III
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (ev	event) of minimal concern	enc	M	II	II	III	IV
Control(s) Type	C	Offsite (MOI)	Onsite	e-2 (co-located worker)	Onsite-1 (facility worker)	Consequences	L	III	III	IV	IV
P = Preventive (reduce event occurrence likelihood) M = Mitigative (reduces event consequences) Acronyms	Н	C ≥ Irreversible, other serious effects,	or	Prompt worker fatality acute injury that is	C ≥ Prompt worker fatality or acute injury that	Com	N	IV	IV	IV	IV
MOI = Maximally-exposed Offsite Individual		or symptoms which could impair an		immediately life- atening or permanently is immediately life- threatening or							
		individual's ability to take protective action.	to disabling. permanently disabling.								
	M	C ≥ Mild, transient adverse effects.		≥ Serious injury, no nediate loss of life no	C ≥ Serious injury, no immediate loss of life no						

		permanent disabilities;	permanent disabilities;
		hospitalization required.	hospitalization required.
L	Mild, transient	Minor injuries; no	Minor injuries; no
	adverse effects > C	hospitalization $> \mathbf{C}$	hospitalization $> \mathbf{C}$
N	Consequences less	Consequences less than	Consequences less than
	than those for Low	those for Low Consequence	those for Low
	Consequence Level	Level	Consequence Level

Table 18.28 Access & Egress – Onsite-1 Facility Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Life Safety	Hazard: blocked egress would be	L:	See Section 1, Chapter 4	L:
Egress	of major life safety concern.	C:		C:
		R:		R:
	An egress might be blocked due to			
	construction work, poor			
	housekeeping, or faulty doors.			
	In the event of a fire or other life-			
	threatening event, a blocked			
	egress would be life threatening.			
	The exposure of the hazard to the			
	facility worker is of major concern.			

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.											
Likelihood (L, of event)/year	Consequence (C, of event)/year Risk (R, Qualitative Ranking)										
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$		$\mathbf{H} = \mathbf{High}$		I = situation (event) of major concern			SK IVI	au ix	Lib	elihood	
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		\mathbf{II} = situation (event) of concern				A	U	EU	BEU
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		L = Low		III = situation (event) of minor concern		·	1	1 I	T	II	Ш
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (event) of minimal concern		Suo			-		
Control(s) Type	C	Offsite (MOI)	nsite-	nsite-2 (co-located worker) Onsite-1 (facility worker)		∟ ا	, a 1	M II	II	III	IV

P = Preventive (reduce event occurrence likelihood) M = Mitigative (reduces event consequences) Acronyms MOI = Maximally-exposed Offsite Individual	Н	C ≥ Irreversible, other serious effects, or symptoms which could impair an	C ≥ Prompt worker fatality or acute injury that is immediately life- threatening or permanently	$C \ge Prompt worker$ fatality or acute injury that is immediately lifethreatening or	L N	III IV	III IV	IV IV	IV IV
		individual's ability to take protective action.	disabling.	permanently disabling.					
	M	$C \ge Mild$, transient	$C \ge Serious injury, no$	$C \ge Serious injury, no$					
		adverse effects.	immediate loss of life no	immediate loss of life no					
			permanent disabilities;	permanent disabilities;					
			hospitalization required.	hospitalization required.					
	L	Mild, transient	Minor injuries; no	Minor injuries; no					
		adverse effects $> \mathbf{C}$	hospitalization $> \mathbf{C}$	hospitalization $> \mathbf{C}$					
	N	Consequences less	Consequences less than	Consequences less than					
		than those for Low	those for Low Consequence	those for Low					
		Consequence Level	Level	Consequence Level					

Table 18.29 Access & Egress – Onsite-2 Co-located Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Life Safety	Hazard: A blocked egress would	L:	See Section 1, Chapter 4	L:
Egress	be of major life safety concern.	C: R:		C: R:
	An egress might be blocked due to			
	construction work, poor			
	housekeeping, or faulty doors.			
	In the event of a fire, a blocked			
	egress would be life threatening.			
	The exposure of the hazard to the			
	co-located worker is of concern.			

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.

Likelihood (L, of event)/year	Consequence (C, of event)/year			Risk (R, Qualitative	Risk (R, Qualitative Ranking)				Risk Matrix							
$\mathbf{A} = \text{Anticipated } (L > 1.0E-02)$	$\mathbf{H} = \mathbf{High}$			I = situation (event) of major concern					lihood							
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$		$\mathbf{II} = situation (evolution (evolution for evolution $	ent) of concern			A	U	EU	BEU					
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		$\mathbf{L} = \text{Low}$		III = situation (ev	vent) of minor concern	es	Н	I	I	II	III					
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible		IV = situation (ev	vent) of minimal concern	enc	M	II	II	III	IV					
Control(s) Type	C	Offsite (MOI)	Onsite	-2 (co-located worker)	Onsite-1 (facility worker)	sedneuces	_			***	***					
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ Irreversible,	C > P	rompt worker fatality	C ≥ Prompt worker	suo	L	III	III	IV	IV					
M = Mitigative (reduces event consequences)		other serious effects,		acute injury that is	fatality or acute injury that	Cor	N	IV	IV	IV	IV					
Acronyms		or symptoms which		mmediately life-	is immediately life-											
MOI = Maximally-exposed Offsite Individual		could impair an		ening or permanently	threatening or											
		individual's ability to		disabling.	permanently disabling.											
		take protective		8												
		action.														
	M	$C \ge Mild$, transient	C ≥	Serious injury, no	C ≥ Serious injury, no											
		adverse effects.		ediate loss of life no	immediate loss of life no											
			peri	manent disabilities;	permanent disabilities;											
			hosp	oitalization required.	hospitalization required.											
	L	Mild, transient	N	Ainor injuries; no	Minor injuries; no											
		· · · · · · · · · · · · · · · · · · ·		ospitalization > C	hospitalization > C											
	N	Consequences less	Con	sequences less than	Consequences less than											
		than those for Low	those	for Low Consequence	those for Low											
		Consequence Level		Level	Consequence Level											

Table 18.30 Access & Egress – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Life Safety Egress	Hazard: N/A	L: C: R:	No Further analysis required	L: C: R:

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.											
Likelihood (L, of event)/year	C	onsequence (C, of event)	/year Risk (R, Qualitative	Ranking)	Risk Matrix						
$\mathbf{A} = \text{Anticipated (L} > 1.0\text{E}-02)$		$\mathbf{H} = \mathbf{High}$	I = situation (eve	ent) of major concern							
U = Unlikely (1.0E-02> L > 1.0E-04)		$\mathbf{M} = \mathbf{Moderate}$	$\mathbf{II} = \text{situation (ev}$	ent) of concern			Α	U	EU	BEU	
EU = Extremely Unlikely (1.0E-04 > L > 1.0E-06)		L = Low	III = situation (e	vent) of minor concern	es	Н	I	I	II	III	
BEU = Beyond Extremely Unlikely (1.0E-06> L)		N = Negligible	IV = situation (e	vent) of minimal concern	ences	M	II	II	III	IV	
Control(s) Type	C	Offsite (MOI)	Onsite-2 (co-located worker)	Onsite-1 (facility worker)	nbəs	_	***	***	77.7	77.7	
P = Preventive (reduce event occurrence likelihood)	Н	C ≥ Irreversible,	$C \ge Prompt$ worker fatality	C ≥ Prompt worker	Cons	L	III	III	IV	IV	
M = Mitigative (reduces event consequences)		other serious effects,	or acute injury that is	fatality or acute injury that	5	N	IV	IV	IV	IV	
Acronyms		or symptoms which	immediately life-	is immediately life-							
MOI = Maximally-exposed Offsite Individual		could impair an	threatening or permanently	threatening or							
		individual's ability to	disabling.	permanently disabling.							
		take protective	e								
		action.									
	M	C ≥ Mild, transient	C ≥ Serious injury, no	C ≥ Serious injury, no							
		adverse effects.	immediate loss of life no	immediate loss of life no							
			permanent disabilities;	permanent disabilities;							
			hospitalization required.	hospitalization required.							
	L	Mild, transient	Minor injuries; no	Minor injuries; no							
		adverse effects > C	hospitalization $> C$	hospitalization $> \mathbf{C}$							
	N	Consequences less	Consequences less than	Consequences less than							
		than those for Low	those for Low Consequence	those for Low							
		Consequence Level	Level	Consequence Level							