

Table 2. Summary of Baseline and Residual Risks (VERTICAL TEST STAND (VTS) ACCELERATOR)

Risk Tables Description		Baseline Risk	Residual Risk
2.1	Radiological – Onsite-1 Facility Worker	R: I	R: IV
2.2	Radiological – Onsite-2 Co-located Worker	R: I	R: IV
2.3	Radiological – MOI Offsite	R: N/A	R: N/A
2.4	Toxic Materials – Onsite 1 Facility Worker	R: N/A	R: N/A
2.5	Toxic Materials – Onsite 2 Co-located Worker	R: N/A	R: N/A
2.6	Toxic Materials – MOI Offsite	R: N/A	R: N/A
2.7	Flammable & Combustible Materials – Onsite-1 Facility Worker	R: *	R: *
2.8	Flammable & Combustible Materials – Onsite-2 Co-located worker	R: *	R: *
2.9	Flammable & Combustible Materials – MOI Offsite	R: *	R: *
2.10	Electrical Energy – Onsite-1 Facility Worker	R: *	R: *
2.11	Electrical Energy – Onsite-2 Co-located Worker	R: *	R: *
2.12	Electrical Energy – MOI Offsite	R: *	R: *
2.13	Thermal Energy – Onsite-1 Facility Worker	R: *	R: *
2.14	Thermal Energy – Onsite-2 Co-located Worker	R: *	R: *
2.15	Thermal Energy – MOI Offsite	R: *	R: *
2.16	Kinetic Energy – Onsite-1 Facility Worker	R: *	R: *
2.17	Kinetic Energy – Onsite-2 Co-located Worker	R: *	R: *
2.18	Kinetic Energy – MOI Offsite	R: *	R: *
2.19	Potential Energy- Onsite-1 Facility Worker	R: *	R: *
2.20	Potential Energy – Onsite-2 Co-located Worker	R: *	R: *
2.21	Potential Energy – MOI Offsite	R: *	R: *
2.22	Magnetic Fields – Onsite-1 Facility Worker	R: *	R: *
2.23	Magnetic Fields – Onsite-2 Co-located Worker	R: *	R: *
2.24	Magnetic Fields – MOI Offsite	R: *	R: *
2.25	Other Hazards – Onsite-1 Facility Worker	R: *	R: *
2.26	Other Hazards – Onsite-2 Co-located Worker	R: *	R: *
2.27	Other Hazards – MOI Offsite	R: *	R: *
2.28	Access & Egress – Onsite-1 Facility Worker	R: *	R: *
2.29	Access & Egress – Onsite-2 Co-located Worker	R: *	R: *
2.30	Access & Egress – MOI Offsite	R: *	R: *
2.31	Environmental Hazards	R: N/A	R: N/A

* This hazard has been evaluated within the common Risk Matrix table included in SAD Section I Chapter 04 *Safety Analysis*. Work in the specified areas involving this hazard implements the controls specified in the common Risk Matrix table. No unique controls are in use.

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 2.1 Radiological – Onsite-1 Facility Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
<p>Prompt Ionizing Radiation</p>	<p><i>Hazard:</i> SRF cavities in VTS accelerator have no beam sources but may generate electron field emissions of sufficient energy to produce x-rays.</p>	<p>L: A C: H R: I</p>	<p>P: Cavity cleaning and particle-free assembly are performed to eliminate contaminants and particles that may generate electron field emissions and x-rays.</p> <p>P: Mobile shielding and position monitor switches are available as a part of Radiation Safety Interlock system. To turn on high-power RF, mobile shielding needs to be in position of covering the dewar that host cavity testing.</p> <p>M: Access to the space is only granted to trained personnel. Untrained personnel are escorted at all times.</p> <p>M: Radiation detectors on mobile shielding are available as a part of Radiation Safety Interlock System; if any one of them trips, high-power RF will be turned off, no more x-rays will be produced.</p> <p>M: Mobile shielding available to reduce radiation levels at outside of VTS accelerator to background levels.</p> <p>M: Radiation detectors under mobile shielding and operation procedure are available to provide test operators real-time and allowable radiation levels under the shielding. if the levels beyond allowable ones, operators will turn off RF and stop cavity testing.</p>	<p>L: EU C: N R: IV</p>

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Residual activation	<i>Hazard:</i> x-rays produced by electron field emissions in SRF cavities may activate components of VTS accelerator.	L: A C: H R: I	<p>P: Cavity cleaning and particle-free assembly are performed to eliminate contaminants and particles that may generate electron field emissions and may cause activation.</p> <p>P: Mobile shielding is available to reduce radiation levels at outside of VTS accelerator to background levels and to avoid activation of components at outside of the shielding.</p> <p>M: Access to the space is only granted to trained personnel. Untrained personnel are escorted at all times.</p> <p>M: Radiation detectors on mobile shielding are available as a part of radiation safety interlock system; if any one of them trips, high-power RF will be turned off, no more x-rays or no more activation of the components under the shielding will happen.</p> <p>M: Radiation detectors under mobile shielding and operation procedure are available to provide test operators real-time radiation levels and potential radiation levels that may activate components of VTS accelerator under the shielding.</p> <p>M: Radiation surveys and material release plan are applied on all tested cavities and components that stay under the shielding during cavity testing</p>	L: EU C: N R: IV

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Radioactive waste	<i>Hazard:</i> x-rays produced by electron field emissions in SRF cavities may activate disposable items in the VTS accelerator (e.g., metal gasket and fasteners)	L: A C: H R: I	<p>P: Cavity cleaning and particle-free assembly are performed to eliminate contaminants and particles that may generate electron field emissions and may cause activation.</p> <p>P: Mobile shielding is available to reduce radiation levels at outside of VTS accelerator to background levels and to avoid activation of components at outside of the shielding.</p> <p>M: Access to the space is only granted to trained personnel. Untrained personnel are escorted at all times.</p> <p>M: Radiation detectors on mobile shielding are available as a part of radiation safety interlock system; if any one of them trips, high-power RF will be turned off, no more x-rays or no more activation of the components under the shielding will happen.</p> <p>M: Radiation detectors under mobile shielding and operation procedure are available to provide test operators real-time radiation levels and potential radiation levels that may activate components of VTS accelerator under the shielding.</p> <p>M: Radiation surveys and material release plan are applied on all tested cavities and components that stay under the shielding during cavity testing</p>	L: EU C: N R: IV

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Radiation Generating Devices (RDGs)	<i>Hazard:</i> SRF cavities in VTS accelerator may be operated with RGD conditions (potential energy gain per cavity is at or below 10MeV) but may have the same radiological hazards with accelerator conditions (potential energy gain per cavity is more than 10MeV).	L: A C: H R: I	<p>P: Cavity cleaning and particle-free assembly are performed to eliminate contaminants and particles that may generate electron field emissions and x-rays.</p> <p>P: Mobile shielding and position monitor switches are available as a part of radiation safety interlock system. To turn on high-power RF, mobile shielding needs to be in position of covering the dewar that host cavity testing.</p> <p>M: Access to the space is only granted to trained personnel. Untrained personnel are escorted at all times.</p> <p>M: Mobile shielding is available to reduce radiation levels at outside of VTS accelerator to background levels.</p> <p>M: Radiation detectors under mobile shielding and operation procedure are available to provide test operators real-time and allowable radiation levels under the shielding. if the levels beyond allowable ones, operators will turn off RF and stop cavity testing.</p> <p>M: Radiation surveys and material release plan are applied on all tested cavities and components that stay under the shielding during cavity testing</p>	L: EU C: N R: IV

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Non-ionizing Radiation Hazards	<i>Hazard:</i> Connections of coaxial transmission lines and SRF cavities in VTS accelerator may have leakage of hazardous level of RF power generated by RF sources (Solid State Amplifiers).	L: A C: H R: I	<p>P: All RF connectors are eye inspected before making connections to identify if any visible damages are on them.</p> <p>P: RF quality control measurements are performed at room temperature after making connections to confirm connections are properly made and see if any indications of RF leakage are there.</p> <p>M: Access to the space is only granted to trained personnel. Untrained personnel are escorted at all times.</p> <p>M: Mobile shielding is available to reduce radiation levels at outside of VTS accelerator to background levels.</p> <p>M: Radiation detectors on mobile shielding are available as a part of radiation safety interlock system; if any one of them trips, high-power RF will be turned off, no more RF leakage will happen</p> <p>M: Radiation detectors under mobile shielding and operation procedure are available to provide test operators real-time and allowable radiation levels under the shielding. if the levels beyond allowable ones, operators will turn off RF and stop cavity testing.</p>	L: EU C: N R: IV

Radiological Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.																																				
Likelihood (L, of event)/year A = Anticipated ($L > 1.0E-02$) U = Unlikely ($1.0E-02 > L > 1.0E-04$) EU = Extremely Unlikely ($1.0E-04 > L > 1.0E-06$) BEU = Beyond Extremely Unlikely ($1.0E-06 > L$)	Consequence (C, of event)/year		Risk (R, Qualitative Ranking)		Risk Matrix <table border="1"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="4">Likelihood</th> </tr> <tr> <th>A</th> <th>U</th> <th>EU</th> <th>BEU</th> </tr> </thead> <tbody> <tr> <th rowspan="4">Consequences</th> <th>H</th> <td>I</td> <td>I</td> <td>II</td> <td>III</td> </tr> <tr> <th>M</th> <td>II</td> <td>II</td> <td>III</td> <td>IV</td> </tr> <tr> <th>L</th> <td>III</td> <td>III</td> <td>IV</td> <td>IV</td> </tr> <tr> <th>N</th> <td>IV</td> <td>IV</td> <td>IV</td> <td>IV</td> </tr> </tbody> </table>			Likelihood				A	U	EU	BEU	Consequences	H	I	I	II	III	M	II	II	III	IV	L	III	III	IV	IV	N	IV	IV	IV	IV
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Table 2.2 Radiological – Onsite-2 Co-located Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Prompt Ionizing Radiation	<i>Hazard:</i> SRF cavities in VTS accelerator has no beam sources but may generate electron field emissions of sufficient energy to produce x-rays.	L: A C: H R: I	<p>P: Cavity cleaning and particle-free assembly are performed to eliminate contaminants and particles that may generate electron field emissions and x-rays.</p> <p>P: Mobile shielding and position monitor switches are available as a part of radiation safety interlock system. To turn on high-power RF, mobile shielding needs to be in position of covering the dewar that host cavity testing.</p> <p>M: Access to the space is only granted to trained personnel. Untrained personnel are escorted at all times.</p> <p>M: Radiation detectors on mobile shielding are available as a part of radiation safety interlock system; if any one of them trips, high-power RF will be turned off and no more x-rays will be produced.</p> <p>M: Mobile shielding is available to reduce radiation levels at outside of VTS accelerator to background levels.</p>	L: EU C: N R: IV

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Residual activation	<i>Hazard:</i> x-rays produced by electron field emissions in SRF cavities may activate components of VTS accelerator.	L: A C: H R: I	<p>P: Cavity cleaning and particle-free assembly are performed to eliminate contaminants and particles that may generate electron field emissions and may cause activation.</p> <p>P: Mobile shielding is available to reduce radiation levels at outside of VTS accelerator to background levels and to avoid activation of components at outside of the shielding.</p> <p>M: Access to the space is only granted to trained personnel. Untrained personnel are escorted at all times.</p> <p>M: Radiation detectors on mobile shielding are available as a part of radiation safety interlock system; if any one of them trips, high-power RF will be turned off, no more x-rays or no more activation of the components under the shielding will happen.</p> <p>M: Radiation surveys and material release plan are applied on all tested cavities and components that stay under the shielding during cavity testing</p>	L: EU C: N R: IV

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Radioactive waste	<i>Hazard:</i> x-rays produced by electron field emissions in SRF cavities may activate disposable items of VTS accelerator (e.g., metal gasket and fasteners)	L: A C: H R: I	<p>P: Cavity cleaning and particle-free assembly are performed to eliminate contaminants and particles that may generate electron field emissions and may cause activation.</p> <p>P: Mobile shielding is available to reduce radiation levels at outside of VTS accelerator to background levels and to avoid activation of components at outside of the shielding.</p> <p>M: Access to the space is only granted to trained personnel. Untrained personnel are escorted at all times.</p> <p>M: Radiation detectors on mobile shielding are available as a part of radiation safety interlock system; if any one of them trips, high-power RF will be turned off, no more x-rays or no more activation of the components under the shielding will happen.</p> <p>M: Radiation surveys and material release plan are applied on all tested cavities and components that stay under the shielding during cavity testing</p>	L: EU C: N R: IV

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Radiation Generating Devices (RDGs)	<i>Hazard:</i> SRF cavities in VTS accelerator may be operated with RGD conditions (potential energy gain per cavity is at or below 10MeV) but may have the same radiological hazards with accelerator conditions (potential energy gain per cavity is more than 10MeV).	L: A C: H R: I	<p>P: Cavity cleaning and particle-free assembly are performed to eliminate contaminants and particles that may generate electron field emissions and x-rays.</p> <p>P: Mobile shielding and position monitor switches are available as a part of radiation safety interlock system. To turn on high-power RF, mobile shielding needs to be in position of covering the dewar that host cavity testing.</p> <p>M: Access to the space is only granted to trained personnel. Untrained personnel are escorted at all times.</p> <p>M: Mobile shielding is available to reduce radiation levels at outside of VTS accelerator to background levels.</p> <p>M: Radiation surveys and material release plan are applied on all tested cavities and components that stay under the shielding during cavity testing</p>	L: EU C: N R: IV
Non-ionizing Radiation Hazards	<i>Hazard:</i> Connections of coaxial transmission lines and SRF cavities in VTS accelerator may have leakage of hazardous level of RF power generated by RF sources (Solid State Amplifiers).	L: A C: H R: I	<p>P: All RF connectors are eye inspected before making connections to identify if any visible damages are on them.</p> <p>P: RF quality control measurements are performed at room temperature after making connections to confirm connections are properly made and see if any indications of RF leakage are there.</p> <p>M: Mobile shielding is available to reduce radiation levels at outside of VTS accelerator to background levels.</p> <p>M: Radiation detectors on mobile shielding are available as a part of radiation safety interlock system; if any one of them trips, high-power RF will be turned off, no more RF leakage will happen</p> <p>M: Access to the space is only granted to trained personnel. Untrained personnel are escorted at all times.</p>	L: EU C: N R: IV

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

Likelihood (L, of event)/year A = Anticipated ($L > 1.0E-02$) U = Unlikely ($1.0E-02 > L > 1.0E-04$) EU = Extremely Unlikely ($1.0E-04 > L > 1.0E-06$) BEU = Beyond Extremely Unlikely ($1.0E-06 > L$)	Consequence (C, of event)/year H = High M = Moderate L = Low N = Negligible		Risk (R, Qualitative Ranking) I = situation (event) of major concern II = situation (event) of concern III = situation (event) of minor concern IV = situation (event) of minimal concern		Risk Matrix <table border="1"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="4">Likelihood</th> </tr> <tr> <th>A</th> <th>U</th> <th>EU</th> <th>BEU</th> </tr> </thead> <tbody> <tr> <th rowspan="4">Consequences</th> <th>H</th> <td>I</td> <td>I</td> <td>II</td> <td>III</td> </tr> <tr> <th>M</th> <td>II</td> <td>II</td> <td>III</td> <td>IV</td> </tr> <tr> <th>L</th> <td>III</td> <td>III</td> <td>IV</td> <td>IV</td> </tr> <tr> <th>N</th> <td>IV</td> <td>IV</td> <td>IV</td> <td>IV</td> </tr> </tbody> </table>			Likelihood				A	U	EU	BEU	Consequences	H	I	I	II	III	M	II	II	III	IV	L	III	III	IV	IV	N	IV	IV	IV	IV
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Table 2.3 Radiological – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Prompt Ionizing Radiation	<i>Hazard: N/A</i>	L: C: R:	Member of the public cannot access the VTS facility and are not exposed to this hazard	L: C: R:
Residual activation	<i>Hazard: N/A</i>	L: C: R:	Member of the public cannot access the VTS facility and are not exposed to this hazard	L: C: R:
Radioactive waste	<i>Hazard: N/A</i>	L: C: R:	Member of the public cannot access the VTS facility and are not exposed to this hazard	L: C: R:
Radiation Generating Devices (RDGs)	<i>Hazard: N/A</i>	L: C: R:	Member of the public cannot access the VTS facility and are not exposed to this hazard	L: C: R:
Non-ionizing Radiation Hazards	<i>Hazard: N/A</i>	L: C: R:	Member of the public cannot access the VTS facility and are not exposed to this hazard	L: C: R:

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Table 2.7 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.)	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Flammable Materials (Flammable gas, cleaning materials, etc.)	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.																																				
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	N	Consequences less than those for Low Consequence Level	Consequences less than those for Low Consequence Level	Consequences less than those for Low Consequence Level																																

Table 2.8 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.)	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Flammable Materials (Flammable gas, cleaning materials, etc.)	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	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 ($L > 1.0E-02$) U = Unlikely ($1.0E-02 > L > 1.0E-04$) EU = Extremely Unlikely ($1.0E-04 > L > 1.0E-06$) BEU = Beyond Extremely Unlikely ($1.0E-06 > L$)	Consequence (C, of event)/year H = High M = Moderate L = Low N = Negligible		Risk (R, Qualitative Ranking) I = situation (event) of major concern II = situation (event) of concern III = situation (event) of minor concern IV = situation (event) of minimal concern		Risk Matrix <table border="1"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="4">Likelihood</th> </tr> <tr> <th>A</th> <th>U</th> <th>EU</th> <th>BEU</th> </tr> </thead> <tbody> <tr> <th rowspan="4">Consequences</th> <th>H</th> <td>I</td> <td>I</td> <td>II</td> <td>III</td> </tr> <tr> <th>M</th> <td>II</td> <td>II</td> <td>III</td> <td>IV</td> </tr> <tr> <th>L</th> <td>III</td> <td>III</td> <td>IV</td> <td>IV</td> </tr> <tr> <th>N</th> <td>IV</td> <td>IV</td> <td>IV</td> <td>IV</td> </tr> </tbody> </table>			Likelihood				A	U	EU	BEU	Consequences	H	I	I	II	III	M	II	II	III	IV	L	III	III	IV	IV	N	IV	IV	IV	IV
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Table 2.9 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.)	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Flammable Materials (Flammable gas, cleaning materials, etc.)	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.																																			
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	N	Consequences less than those for Low Consequence Level	Consequences less than those for Low Consequence Level	Consequences less than those for Low Consequence Level																															

Table 2.10 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	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
High Voltage Exposure	<i>Hazard</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Low Voltage, High Current Exposure.	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	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 ($L > 1.0E-02$) U = Unlikely ($1.0E-02 > L > 1.0E-04$) EU = Extremely Unlikely ($1.0E-04 > L > 1.0E-06$) BEU = Beyond Extremely Unlikely ($1.0E-06 > L$)	Consequence (C, of event)/year H = High M = Moderate L = Low N = Negligible		Risk (R, Qualitative Ranking) I = situation (event) of major concern II = situation (event) of concern III = situation (event) of minor concern IV = situation (event) of minimal concern		Risk Matrix <table border="1"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="4">Likelihood</th> </tr> <tr> <th>A</th> <th>U</th> <th>EU</th> <th>BEU</th> </tr> </thead> <tbody> <tr> <th rowspan="4">Consequences</th> <th>H</th> <td>I</td> <td>I</td> <td>II</td> <td>III</td> </tr> <tr> <th>M</th> <td>II</td> <td>II</td> <td>III</td> <td>IV</td> </tr> <tr> <th>L</th> <td>III</td> <td>III</td> <td>IV</td> <td>IV</td> </tr> <tr> <th>N</th> <td>IV</td> <td>IV</td> <td>IV</td> <td>IV</td> </tr> </tbody> </table>			Likelihood				A	U	EU	BEU	Consequences	H	I	I	II	III	M	II	II	III	IV	L	III	III	IV	IV	N	IV	IV	IV	IV
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Table 2.11 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	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
High Voltage Exposure	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Low Voltage, High Current Exposure.	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.																																				
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Table 2.12 Electrical Energy – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Stored Energy Exposure	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
High Voltage Exposure	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Low Voltage, High Current Exposure.	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

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Table 2.13 Thermal Energy – Onsite-1 Facility Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Cryogenic Liquids	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

Other Hazard Consequences, derived from Figure C-1, “Example Qualitative Consequence Matrix”, DOE-HDBK-1163-2020.																																				
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Table 2.14 Thermal Energy – Onsite-2 Co-located Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Cryogenic Liquids	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

Other Hazard Consequences, derived from Figure C-1, “Example Qualitative Consequence Matrix”, DOE-HDBK-1163-2020.																																				
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Table 2.15 Thermal Energy – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Cryogenic Liquids	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

Other Hazard Consequences, derived from Figure C-1, “Example Qualitative Consequence Matrix”, DOE-HDBK-1163-2020.																																				
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Table 2.16 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	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Mobile Shielding	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	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 ($L > 1.0E-02$) U = Unlikely ($1.0E-02 > L > 1.0E-04$) EU = Extremely Unlikely ($1.0E-04 > L > 1.0E-06$) BEU = Beyond Extremely Unlikely ($1.0E-06 > L$)	Consequence (C, of event)/year H = High M = Moderate L = Low N = Negligible		Risk (R, Qualitative Ranking) I = situation (event) of major concern II = situation (event) of concern III = situation (event) of minor concern IV = situation (event) of minimal concern		Risk Matrix <table border="1"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="4">Likelihood</th> </tr> <tr> <th>A</th> <th>U</th> <th>EU</th> <th>BEU</th> </tr> </thead> <tbody> <tr> <th rowspan="4">Consequences</th> <th>H</th> <td>I</td> <td>I</td> <td>II</td> <td>III</td> </tr> <tr> <th>M</th> <td>II</td> <td>II</td> <td>III</td> <td>IV</td> </tr> <tr> <th>L</th> <td>III</td> <td>III</td> <td>IV</td> <td>IV</td> </tr> <tr> <th>N</th> <td>IV</td> <td>IV</td> <td>IV</td> <td>IV</td> </tr> </tbody> </table>			Likelihood				A	U	EU	BEU	Consequences	H	I	I	II	III	M	II	II	III	IV	L	III	III	IV	IV	N	IV	IV	IV	IV
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	N	Consequences less than those for Low Consequence Level	Consequences less than those for Low Consequence Level	Consequences less than those for Low Consequence Level																																

Table 2.17 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	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Mobile Shielding	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

Other Hazard Consequences, derived from Figure C-1, “Example Qualitative Consequence Matrix”, DOE-HDBK-1163-2020.																																				
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Table 2.18 Kinetic Energy – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Power tools	<i>Hazard: N/A</i>	L: C: R:	Public is prevented from having access to work areas	L: C: R:
Mobile Shielding	<i>Hazard: N/A</i>	L: C: R:	Public is prevented from having access to work areas	L: C: R:

Other Hazard Consequences, derived from Figure C-1, “Example Qualitative Consequence Matrix”, DOE-HDBK-1163-2020.																																				
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Table 2.19 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	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Compressed Gasses	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Vacuum/ Pressure Vessels/Piping	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Vacuum Pumps	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Material Handling	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

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

<p>Likelihood (L, of event)/year A = Anticipated ($L > 1.0E-02$) U = Unlikely ($1.0E-02 > L > 1.0E-04$) EU = Extremely Unlikely ($1.0E-04 > L > 1.0E-06$) BEU = Beyond Extremely Unlikely ($1.0E-06 > L$)</p>	<p>Consequence (C, of event)/year H = High M = Moderate L = Low N = Negligible</p>		<p>Risk (R, Qualitative Ranking) I = situation (event) of major concern II = situation (event) of concern III = situation (event) of minor concern IV = situation (event) of minimal concern</p>		<p>Risk Matrix</p> <table border="1"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="4">Likelihood</th> </tr> <tr> <th>A</th> <th>U</th> <th>EU</th> <th>BEU</th> </tr> </thead> <tbody> <tr> <th rowspan="4">Consequences</th> <th>H</th> <td>I</td> <td>I</td> <td>II</td> <td>III</td> </tr> <tr> <th>M</th> <td>II</td> <td>II</td> <td>III</td> <td>IV</td> </tr> <tr> <th>L</th> <td>III</td> <td>III</td> <td>IV</td> <td>IV</td> </tr> <tr> <th>N</th> <td>IV</td> <td>IV</td> <td>IV</td> <td>IV</td> </tr> </tbody> </table>			Likelihood				A	U	EU	BEU	Consequences	H	I	I	II	III	M	II	II	III	IV	L	III	III	IV	IV	N	IV	IV	IV	IV
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	<p>N</p>	<p>Consequences less than those for Low Consequence Level</p>	<p>Consequences less than those for Low Consequence Level</p>	<p>Consequences less than those for Low Consequence Level</p>																																

Table 2.20 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	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Compressed Gasses	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Vacuum/ Pressure Vessels	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Vacuum Pumps	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Material Handling	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	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 ($L > 1.0E-02$) U = Unlikely ($1.0E-02 > L > 1.0E-04$) EU = Extremely Unlikely ($1.0E-04 > L > 1.0E-06$) BEU = Beyond Extremely Unlikely ($1.0E-06 > L$)	Consequence (C, of event)/year H = High M = Moderate L = Low N = Negligible		Risk (R, Qualitative Ranking) I = situation (event) of major concern II = situation (event) of concern III = situation (event) of minor concern IV = situation (event) of minimal concern		Risk Matrix <table border="1"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="4">Likelihood</th> </tr> <tr> <th>A</th> <th>U</th> <th>EU</th> <th>BEU</th> </tr> </thead> <tbody> <tr> <th rowspan="4">Consequences</th> <th>H</th> <td>I</td> <td>I</td> <td>II</td> <td>III</td> </tr> <tr> <th>M</th> <td>II</td> <td>II</td> <td>III</td> <td>IV</td> </tr> <tr> <th>L</th> <td>III</td> <td>III</td> <td>IV</td> <td>IV</td> </tr> <tr> <th>N</th> <td>IV</td> <td>IV</td> <td>IV</td> <td>IV</td> </tr> </tbody> </table>			Likelihood				A	U	EU	BEU	Consequences	H	I	I	II	III	M	II	II	III	IV	L	III	III	IV	IV	N	IV	IV	IV	IV
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Table 2.21 Potential Energy – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Crane Operations	<i>Hazard: N/A</i>	L: C: R:		L: C: R:
Compressed Gasses	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Vacuum/ Pressure Vessels	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Vacuum Pumps	<i>Hazard: N/A</i>	L: C: R:		L: C: R:
Material Handling	<i>Hazard: N/A</i>	L: C: R:		L: C: R:

Other Hazard Consequences, derived from Figure C-1, "Example Qualitative Consequence Matrix", DOE-HDBK-1163-2020.																																				
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Table 2.22 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	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

Other Hazard Consequences, derived from Figure C-1, “Example Qualitative Consequence Matrix”, DOE-HDBK-1163-2020.																																				
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	N Consequences less than those for Low Consequence Level	Consequences less than those for Low Consequence Level	Consequences less than those for Low Consequence Level																																	

Table 2.23 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	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

Other Hazard Consequences, derived from Figure C-1, “Example Qualitative Consequence Matrix”, DOE-HDBK-1163-2020.																																				
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Table 2.24 Magnetic Fields – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Fringe Fields	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

Other Hazard Consequences, derived from Figure C-1, “Example Qualitative Consequence Matrix”, DOE-HDBK-1163-2020.																																				
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Table 2.25 Other hazards – Onsite-1 Facility Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Ergonomics	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:
Working at Heights	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	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 ($L > 1.0E-02$) U = Unlikely ($1.0E-02 > L > 1.0E-04$) EU = Extremely Unlikely ($1.0E-04 > L > 1.0E-06$) BEU = Beyond Extremely Unlikely ($1.0E-06 > L$)	Consequence (C, of event)/year H = High M = Moderate L = Low N = Negligible		Risk (R, Qualitative Ranking) I = situation (event) of major concern II = situation (event) of concern III = situation (event) of minor concern IV = situation (event) of minimal concern		Risk Matrix <table border="1"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="4">Likelihood</th> </tr> <tr> <th>A</th> <th>U</th> <th>EU</th> <th>BEU</th> </tr> </thead> <tbody> <tr> <th rowspan="4">Consequences</th> <th>H</th> <td>I</td> <td>I</td> <td>II</td> <td>III</td> </tr> <tr> <th>M</th> <td>II</td> <td>II</td> <td>III</td> <td>IV</td> </tr> <tr> <th>L</th> <td>III</td> <td>III</td> <td>IV</td> <td>IV</td> </tr> <tr> <th>N</th> <td>IV</td> <td>IV</td> <td>IV</td> <td>IV</td> </tr> </tbody> </table>			Likelihood				A	U	EU	BEU	Consequences	H	I	I	II	III	M	II	II	III	IV	L	III	III	IV	IV	N	IV	IV	IV	IV
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	N	Consequences less than those for Low Consequence Level	Consequences less than those for Low Consequence Level	Consequences less than those for Low Consequence Level																																

Table 2.26 Other hazards – Onsite-2 Co-located Worker

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Ergonomics	<i>Hazard: N/A</i>	L: C: R:		L: C: R:
Working at Heights	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

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

<p>Likelihood (L, of event)/year A = Anticipated ($L > 1.0E-02$) U = Unlikely ($1.0E-02 > L > 1.0E-04$) EU = Extremely Unlikely ($1.0E-04 > L > 1.0E-06$) BEU = Beyond Extremely Unlikely ($1.0E-06 > L$)</p>	<p>Consequence (C, of event)/year H = High M = Moderate L = Low N = Negligible</p>		<p>Risk (R, Qualitative Ranking) I = situation (event) of major concern II = situation (event) of concern III = situation (event) of minor concern IV = situation (event) of minimal concern</p>		<p>Risk Matrix</p> <table border="1"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="4">Likelihood</th> </tr> <tr> <th>A</th> <th>U</th> <th>EU</th> <th>BEU</th> </tr> </thead> <tbody> <tr> <th rowspan="4">Consequences</th> <th>H</th> <td>I</td> <td>I</td> <td>II</td> <td>III</td> </tr> <tr> <th>M</th> <td>II</td> <td>II</td> <td>III</td> <td>IV</td> </tr> <tr> <th>L</th> <td>III</td> <td>III</td> <td>IV</td> <td>IV</td> </tr> <tr> <th>N</th> <td>IV</td> <td>IV</td> <td>IV</td> <td>IV</td> </tr> </tbody> </table>			Likelihood				A	U	EU	BEU	Consequences	H	I	I	II	III	M	II	II	III	IV	L	III	III	IV	IV	N	IV	IV	IV	IV
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<p>Control(s) Type P = Preventive (reduce event occurrence likelihood) M = Mitigative (reduces event consequences) Acronyms MOI = Maximally-exposed Offsite Individual</p>	<p>C</p>	<p>Offsite (MOI)</p>	<p>Onsite-2 (co-located worker)</p>	<p>Onsite-1 (facility worker)</p>																																
	<p>H</p>	<p>C ≥ Irreversible, other serious effects, or symptoms which could impair an individual's ability to take protective action.</p>	<p>C ≥ Prompt worker fatality or acute injury that is immediately life-threatening or permanently disabling.</p>	<p>C ≥ Prompt worker fatality or acute injury that is immediately life-threatening or permanently disabling.</p>																																
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Table 2.27 Other hazards – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Ergonomics	<i>Hazard: N/A</i>	L: C: R:		L: C: R:

Other Hazard Consequences, derived from Figure C-1, “Example Qualitative Consequence Matrix”, DOE-HDBK-1163-2020.																																
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Table 2.28 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 Egress	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

Other Hazard Consequences, derived from Figure C-1, “Example Qualitative Consequence Matrix”, DOE-HDBK-1163-2020.																																				
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Table 2.29 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 Egress	<i>Hazard:</i>	L: C: R:	* See Section I Chapter 04	L: C: R:

Other Hazard Consequences, derived from Figure C-1, “Example Qualitative Consequence Matrix”, DOE-HDBK-1163-2020.																																				
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Table 2.30 Access & Egress – MOI Offsite

Hazard	Hazard Description	Baseline Qualitative Risk (without controls)	Preventative (P)/ Mitigative (M)	Residual Qualitative Risk (with controls)
Life Safety Egress	<i>Hazard: N/A</i>	L: C: R:		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 ($L > 1.0E-02$) U = Unlikely ($1.0E-02 > L > 1.0E-04$) EU = Extremely Unlikely ($1.0E-04 > L > 1.0E-06$) BEU = Beyond Extremely Unlikely ($1.0E-06 > L$)	Consequence (C, of event)/year H = High M = Moderate L = Low N = Negligible		Risk (R, Qualitative Ranking) I = situation (event) of major concern II = situation (event) of concern III = situation (event) of minor concern IV = situation (event) of minimal concern		Risk Matrix <table border="1"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="4">Likelihood</th> </tr> <tr> <th>A</th> <th>U</th> <th>EU</th> <th>BEU</th> </tr> </thead> <tbody> <tr> <th rowspan="4">Consequences</th> <th>H</th> <td>I</td> <td>I</td> <td>II</td> <td>III</td> </tr> <tr> <th>M</th> <td>II</td> <td>II</td> <td>III</td> <td>IV</td> </tr> <tr> <th>L</th> <td>III</td> <td>III</td> <td>IV</td> <td>IV</td> </tr> <tr> <th>N</th> <td>IV</td> <td>IV</td> <td>IV</td> <td>IV</td> </tr> </tbody> </table>			Likelihood				A	U	EU	BEU	Consequences	H	I	I	II	III	M	II	II	III	IV	L	III	III	IV	IV	N	IV	IV	IV	IV
			Likelihood																																	
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	M	II	II	III	IV																															
	L	III	III	IV	IV																															
	N	IV	IV	IV	IV																															
Control(s) Type P = Preventive (reduce event occurrence likelihood) M = Mitigative (reduces event consequences) Acronyms MOI = Maximally-exposed Offsite Individual	C Offsite (MOI)	Onsite-2 (co-located worker)	Onsite-1 (facility worker)																																	
	H C ≥ Irreversible, other serious effects, or symptoms which could impair an individual’s ability to take protective action.	C ≥ Prompt worker fatality or acute injury that is immediately life-threatening or permanently disabling.	C ≥ Prompt worker fatality or acute injury that is immediately life-threatening or permanently disabling.																																	
	M C ≥ Mild, transient adverse effects.	C ≥ Serious injury, no immediate loss of life no permanent disabilities; hospitalization required.	C ≥ Serious injury, no immediate loss of life no permanent disabilities; hospitalization required.																																	
	L Mild, transient adverse effects > C	Minor injuries; no hospitalization > C	Minor injuries; no hospitalization > C																																	
	N Consequences less than those for Low Consequence Level	Consequences less than those for Low Consequence Level	Consequences less than those for Low Consequence Level																																	