Hazard Analysis

The tritium target is an alteration of the existing Qweak Target. The alterations required for this system to function for the tritium target are associated with the motion system (low voltage stepper motors) and cryogenic piping. A number of additional hazards associated with tritium are assumed. A loss of 1100 Ci of tritium are not in fact expected to pose a serious risk to JLAB personnel, the public, or the environment under any reasonable failure scenario. However, it is assumed that any loss of tritium could expose JLAB personnel to doses above those allowed by lab policy and could impose significant decontamination costs and interrupt schedules.

A formal Failure Modes and Effects Analysis using MIL-SPEC-1629A as guidance is given in Ref  [30].

The following hazards have been identified as applicable to the tritium target:

* Pressure hazards
  + Vacuum systems (scattering chamber)
  + Cryogenic piping
  + Tritium gas cell (200 psia)
  + Other gas cells (500 psia)
* Cryogenic hazards
  + Exposure to cold fluids
  + ODH
* Radiological hazards
  + Excessive dose
  + Contamination
  + Activation of materials

The Hall A Cryogenic Target controls (with minor alterations) and scattering chamber are also being used as part of the system. Note that the overpressure protection for the scattering chamber shall remain installed as shall be vented to the tritium exhaust system (on the pump line). A hazard analysis for each of these systems has been performed and is documented in the Hall A Standard Equipment ESAD and Ref  [3]. No further consideration for these systems is given here. An ODH assessment was performed for the cryogenic target and magnets in Hall A. No appreciable hazard was found below the crane level. The ESR supply system for the tritium target system is identical to that of the Hall A cryogenic target. Therefore, no further analysis is performed here.

The following hazards are considered to have been addressed

* Cryogenic hazards (equivalent to Hall A cryogenic target)
  + Exposure to cold fluids
  + ODH
* Vacuum hazards (Equivalent to Hall A cryogenic target)
* Electrical hazards (equivalent (or lower) than Hall A target
* Material handling hazards (equivalent to Hall A target
* Chemical hazards equivalent to Hall A target
* Activation of materials equivalent to Hall A target

JLAB ESH Manual Chapter 3210 Appendix T3 describes the method required for hazard analysis. This method may be clearly applied to individual tasks but is difficult to apply to a system. The standard ANSI/GEIA-STD-0010  [4] shall be used to determine the probability of a given incident.

|  |  |  |  |
| --- | --- | --- | --- |
| Likelihood | JLAB Level | Number assigned in FMEA | Definition |
| Probable | H | 4 | Probability of occurrence per operational hour is greater than 1E-5 |
| Remote | M | 3 | Probability of occurrence per operational hour is less than 1E-5, but greater than 1E-7 |
| Extremely Remote | L | 2 | Probability of occurrence per operational hour is less than 1E-7 but greater than 1E-9 |
| Extremely Improbable | EL | 1 | Probability of occurrence per operational hour is less than 1E-9 |

Table 6: ANSI/GEIA-STD-0010 Standard likelihood of occurrence  [4].

## Pressure hazards

The pressure hazards applicable to the tritium target are given below in Table 7.

|  |  |  |  |
| --- | --- | --- | --- |
| Hazard | Unmitigated Risk Code | Mitigation | Mitigated Risk Code |
| Cell failure  Flying debris  Loud Noise/pressure wave | 2 | -Designed to Code (675 psi design pressure)  -Procedures/training  -PPE  -Shipping covers on until final step of installation  -Low stored energy in pressure from small volume. | 1 |
| Cryogenic piping:  Explosion flying debris  Exposure to cold gas  ODH  Load noise/pressure wave | 4 | -Design/fabricated/examined/tested to Code.  -Proper/adequate relief is installed.  -Procedures/training | 1 |

Table 7: Pressure hazards with mitigations

## Radiological Hazards

Tritium presents a number of atypical hazards to JLAB personnel. The unmitigated risk code associated with tritium shall be 4. This is a conservative assumption based on the potential for public exposure and elevated dose (above JLAB limits) for workers on site. Furthermore, the costs associated with decontamination may be significant if no mitigating steps are taken after a release. The table below addresses the radiological hazards associated with the target system.

|  |  |  |  |
| --- | --- | --- | --- |
| Hazard | Unmitigated Risk Code | Mitigation | Mitigated Risk Code |
| Uncontrolled release of 1100 Ci of T2:  1) Ground level release to environment  2) Worker exposure  3) public exposure  4) contamination of Surfaces in Hall A  Contamination of beam line  5) hi dose to installation team | 4 | - Design/construct the cell to Code with conservative FS  - FSD protections  - collimators  - Be isolation window  - fixed and portable T2 monitors  - Interlock system  - exhaust system with 20m stack  - Procedures/training  - simple installation  - 3 levels of containment  - Getter system | 2 |
| Uncontrolled leak of T2 from cell seals and thin sections:  1) Possible contamination of beamline  2) possible exposure of workers in Hall.  3) low level release of T2 to hall and contamination thereof. | 3 | - All above mitigations  - Seals are typically He leak tight even when cold.  - Pumps vented to exhaust system | 1 |

[1] D. Meekins, *Hall A Tritium Target FMEA* (2015).

[2] D. Stamatis, *Failure Mode and Effect Analysis: FMEA from Theory to Execution* (2003).

[3] M. Seely and D. Meekins, *Hydrogen Target Safety Assessment Document* (2004).

[4] ANSI, *ANSI/GEIA-STD-0010* (2010).