SAFETY CONSIDERATIONS FOR SHIELD DOOR CONTROL SYSTEMS

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Abstract

The Accelerator Operations and Technology division is upgrading the control system for a 33-ton shield door that will be used when the Cathodes and RF Interactions in Extremes (CARIE) accelerator begins operations. The door was installed in the 1990's but safety standards such as ISO 13849-1 have since emerged which provide safety requirements and guidance on the principles for the design and integration of safety-related parts of a control system. Applying this standard, a safety controller, safety relays and a light curtain barrier have been added to eliminate injury and exposure of personnel to potential hazards during door operations.

"HOW we do things is as important as WHAT we do." – Thom Mason, Lab Director LANL

Overview of CARIE

Los Alamos National Lab (LANL) is starting construction of a new C-band (5.712GHz) accelerator test facility for cathode, accelerator, and material science studies. The new facility is called Cathode and RF Interactions in Extremes (CARIE). This accelerator will reside in a radiation protection vault on the Los Alamos Neutron Science Center (LANSCE) mesa. This location will house a cryo-cooled copper RF photoinjector with a high QE cathode and a high gradient accelerator section with beam power up to 20kW.

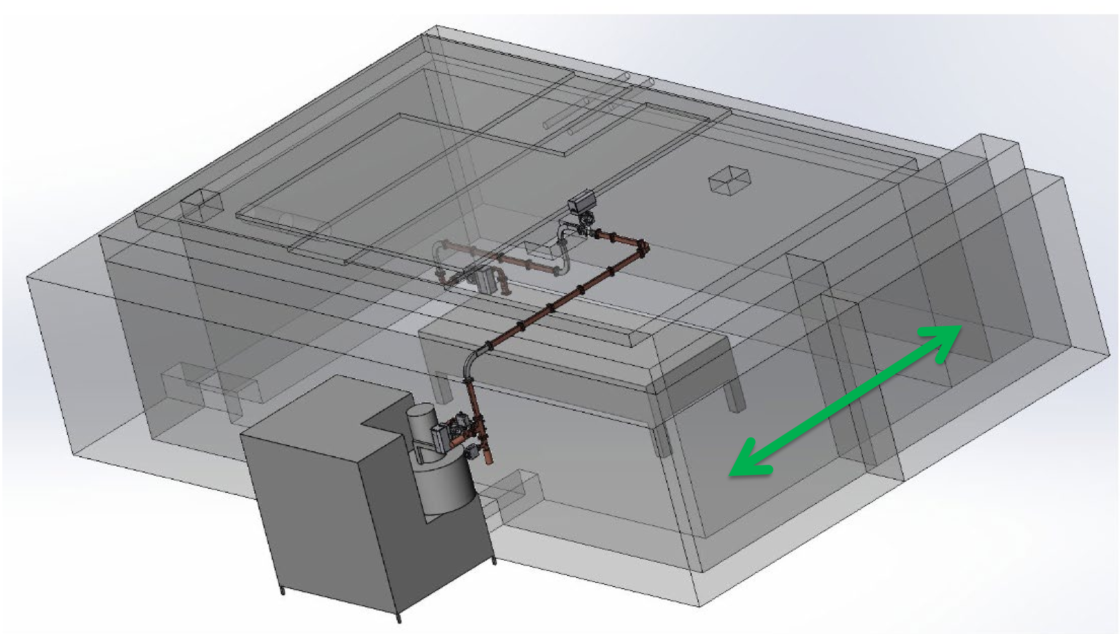

Figure 1: Radiation Shield Vault

Shield Vault

CARIE will reside in a 12 by 25-foot interior vault that uses 4-foot-thick magnetite blocks to shield the exterior control and operations areas. A 33-ton moveable shield door separates the vault from the control room. When closed during CARIE operation, the door protects personnel from neutron and bremsstrahlung radiation, activated air, and ozone. The door is constructed of 12 magnetite concrete blocks welded together on their edges and welded to a reinforced concrete base. The door is mounted on four sets of Hilman rollers and guided by tracks on the floor, the door is opened and closed by a hydraulic piston.

What is Safety? What is Risk?

Control system engineers must incorporate safety into designs to provide the protective measures needed to insure safe operations. Control system safety can be defined as "freedom of the operator from unacceptable risk." This infers that there is minimal level of risk involved even when a system is considered safe.

Risk = Severity of Harm x Probability of the Occurrence of Harm

Risk Assessment

Control system engineers should begin with a risk assessment using the flow chart in figure 2 to determine limits, hazards, risk and the protective measures needed to mitigate exposure to the hazards. This risk assessment was completed for the shield door project and resulted in a design to minimize operator exposure to identified hazards.

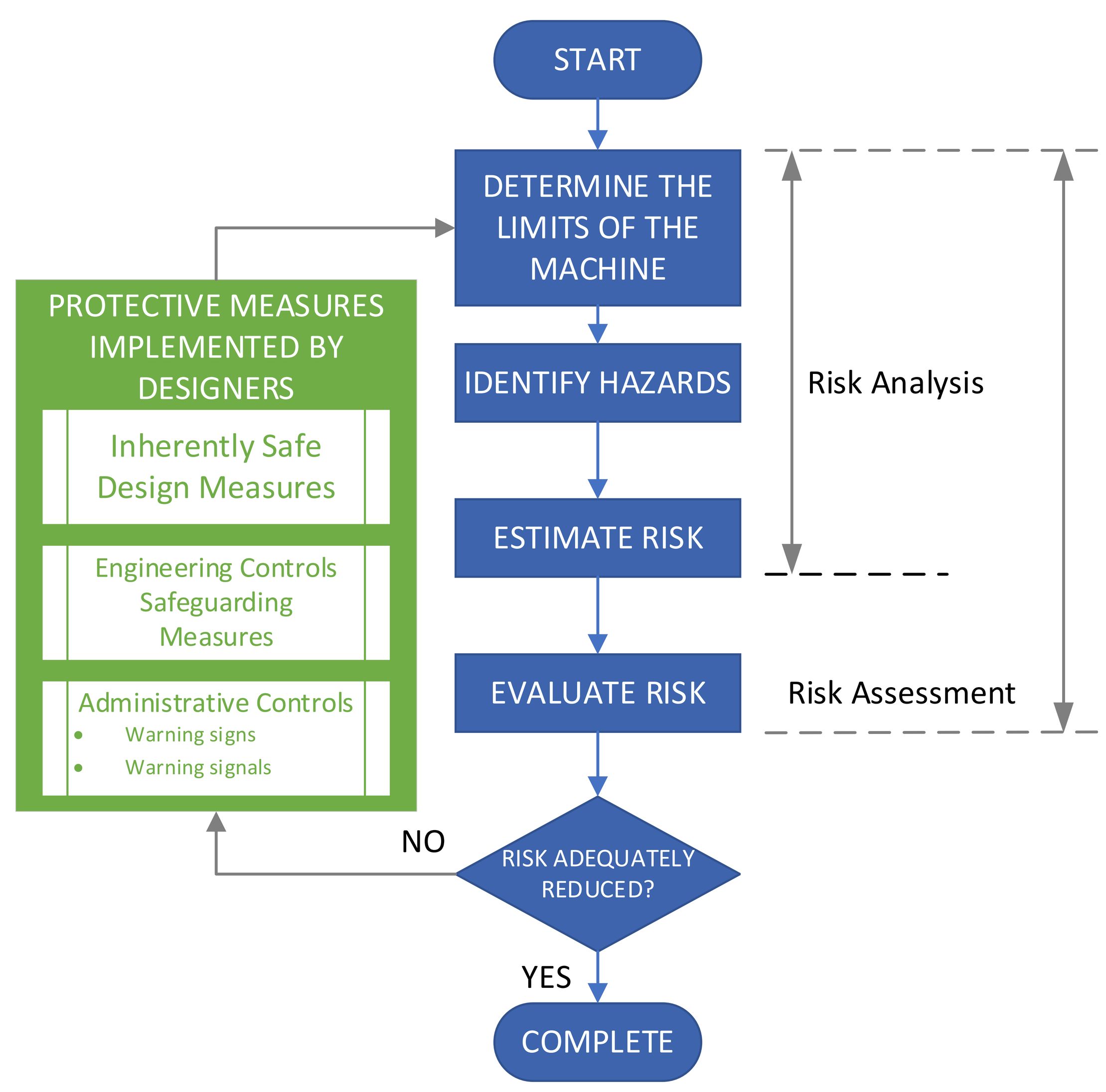

Figure 2: Risk Assessment Flowchart

Determine Limits and Identify Hazards

The shield door project determined that the limits of the shield door were based on the track structure and the stroke of the hydraulic cylinder. The shield doors specific mechanical hazard was identified as crushing.

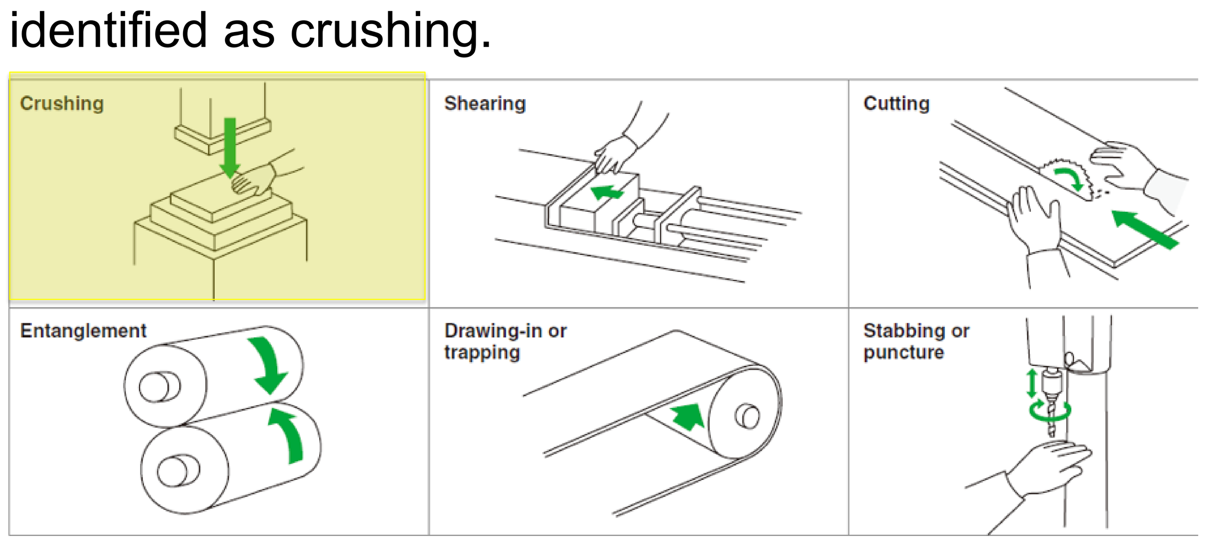

Figure 3: Mechanical Safety Hazards

Estimate Risk

The risk estimation chart (see Fig. 4) allows an engineer to determine the degree of risk as a performance level requirement (PLr) given the severity of injury, frequency of exposure to the hazard and the possibility of avoiding the hazard.

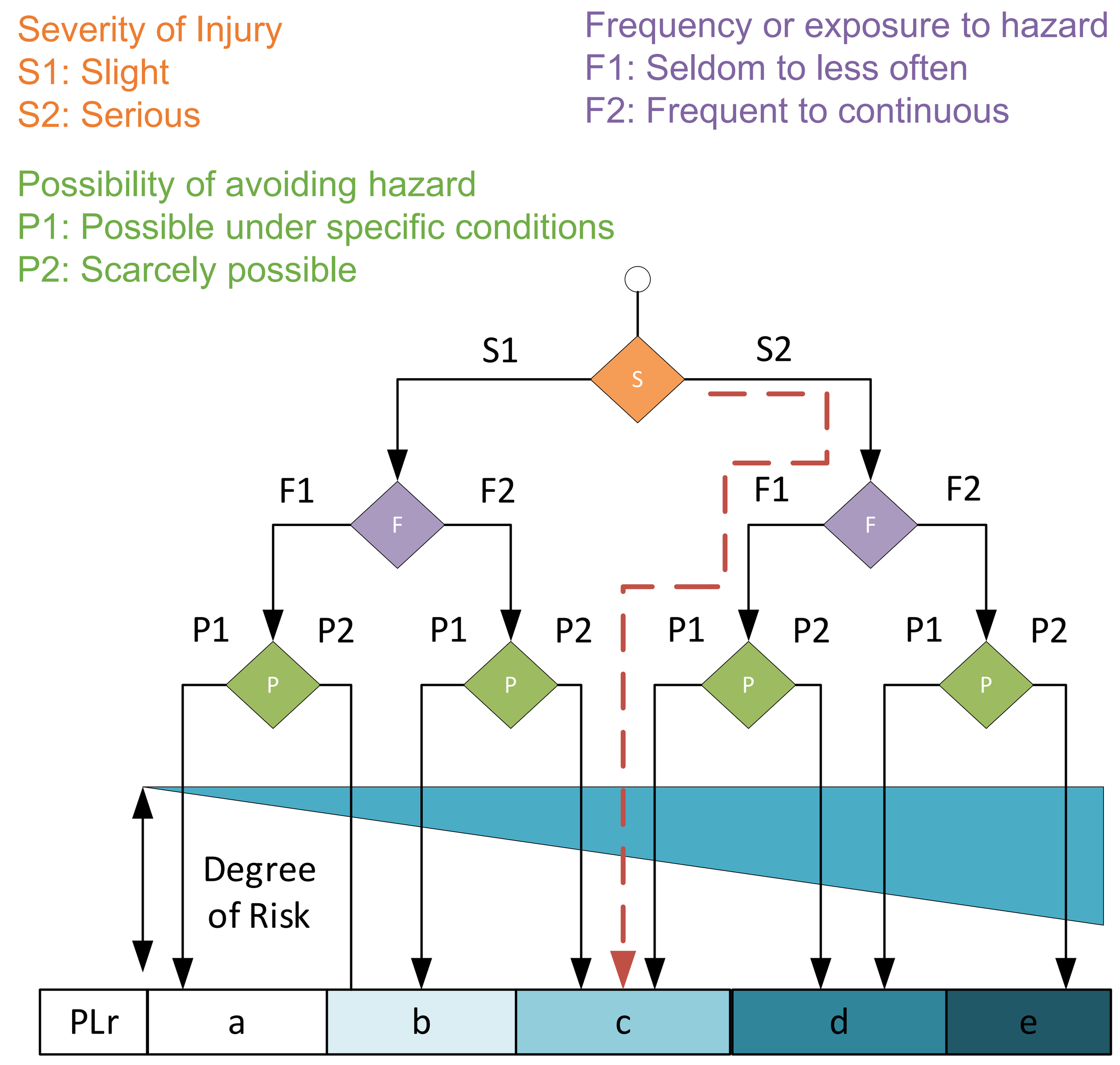

Figure 4: Risk Estimation Flow Chart

Evaluate Risk and Implement Protective Measures

Now that the hazard and PLr have been identified, it is possible to implement measures to reduce the exposure to the hazard in the form of protective measures.

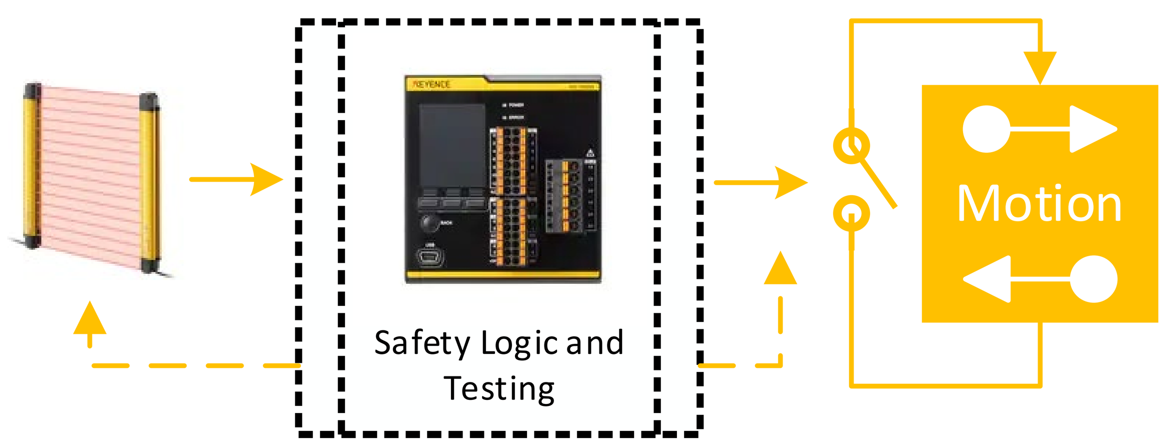

Figure 5: Light Barrier Safety Design (PLe rating)

Figure 6: Shield Door Opening and Existing Hydraulic System

Conclusion

Engineered safety controls and administrative controls were implemented to reduce the risk of hazard exposure to a minimal level for operators of the shield door. Los Alamos National Lab has instituted a new focus on disciplined operations. This focus reminds employees to use the safe conduct of research principals to cultivate a questioning attitude about safety and reminds all employees to maintain a healthy respect for what can go wrong.

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