EUROPEAN SPALLATION SOURCE

Target Safety System design for the ESS Target Station

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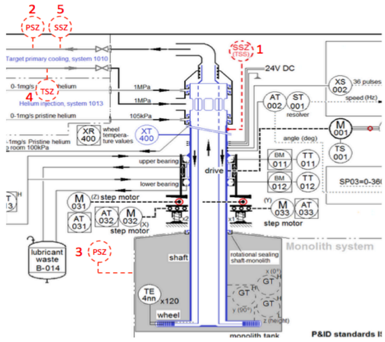
ABSTRACT

The purpose of the Target Safety System (TSS) is to protect the public from exposure to unsafe levels of radiation, prevent the release of radioactive material beyond permissible limits, and bring the neutron spallation function into a safe state. In order to fulfill the necessary safety functions, the TSS continually monitors critical parameters within target station systems. If any parameter exceeds an acceptable level, the TSS actuates contactors to cut power to components at the accelerator front end and prevent the beam from reaching the target. The TSS is classified as a safety structure, system and component, relevant for the safety of the public and the environment. As such, it requires the highest level of rigor in design and quality for interlock systems at the ESS. Standards are applied to provide a guideline for building the TSS architecture and designing in resistance to single failures and common cause failures.

TSS Safety Functions

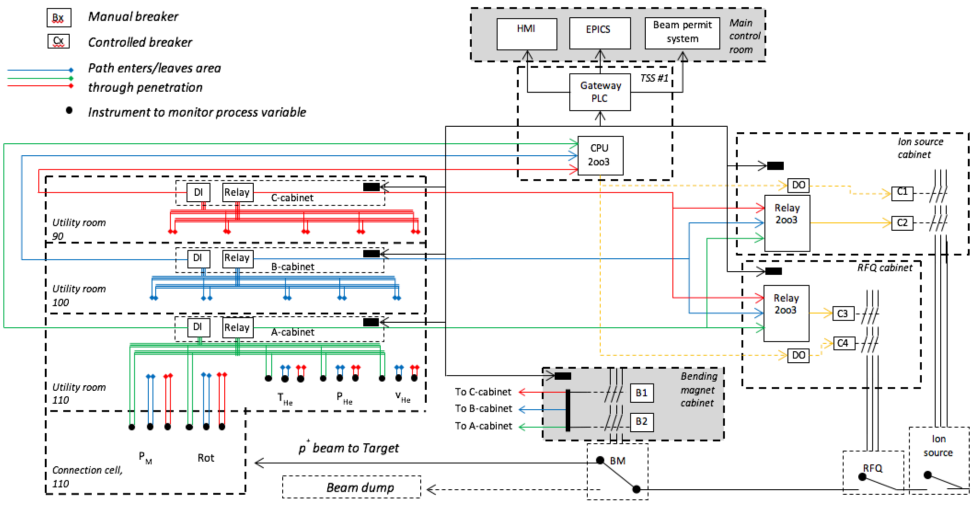
The TSS safety functions are based on results from hazard and accident analyses.
A qualitative hazard analysis was performed to identify and evaluate potential radiological accidents. To mitigate quantitatively determined consequences of the accidents, different functions were identified in different levels of defense in depth (DiD) for systems in the target station. Depending on the level, different constraints shall be applied on the design in terms of conditions from SSM (Swedish Nuclear Safety Authority) and design guidance from applicable standards.
The following safety functions are dedicated to the TSS. The TSS shall monitor process variables in the wheel, helium cooling, and monolith systems to identify if the:

- Target helium cooling outlet velocity is below a certain limit
- Target helium cooling outlet pressure is below a certain limit
- Target helium cooling inlet temperature is above a certain limit
- Target wheel rotational speed is below a certain limit
- Monolith atmosphere pressure is above a certain limit



TSS Architecture

The TSS consists of two diverse and independent trains; one train is based on hardwired relay technology and one train is based on distributed PLC technology. Each train consists of three redundant and physically separated channels (A, B and C) and performs all the safety functions independently on the other train.
Each process variable is measured by three sensors (A, B and C). All A-sensors are merged to channel A, B-sensors to channel B and C-sensors to channel C.
The 2oo3 voting in each train is performed on the three channels.
The beam is tripped by two diverse, independent and separated mechanisms; power shut-down to the Ion source and power shut-down to the RFQ. Each train acts on both trip mechanisms.



TSS Requirements

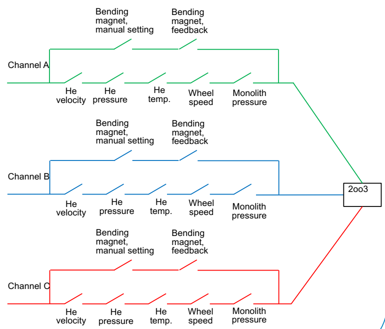
TSS is identified as a safety SSC (Structure, System, Component) in which requires TSS to survive

- **Single failure**
- **Common cause failure**
- **Internal and external initiating events and condition**

In response to these requirements, ESS safety systems shall include **redundancy, diversity, independence, and physical separation** to the extent that they can meet the SSM conditions for single failures and common cause failures.

2oo3 voting Logic

Upon receipt of a work order, the safety functions in each train can be temporarily muted by assuring that the proton beam is directed to destinations other than the target wheel (e.g. beam dump or different temporary dumps along the accelerator). The procedure to mute the safety functions is restricted by both manual settings and position feedback signals. The functionality is foreseen for the situations where the target station is not ready to receive beam (e.g. during maintenance) but the accelerator shall tune/test functionality.



Conclusion

TSS is a robust independent safety interlock system. It has dedicated equipment for monitoring, evaluation and actuation. The system architecture is built on the fail-safe concept and actuation of the safety functions is performed by passive means. Any loss of power, sensor signal or communication will be interpreted as an indication for trip (i.e. shut down of the proton beam). TSS is physically separate and independent from other control systems such as BPCS and MPS.
The TSS design includes redundancy and diversity in order to improve reliability and to fulfill SSM conditions for resistance to single failure and common cause failure.