

Seminar

Institute for Plasma Research

Title: Cryogenics and High-Pressure Systems at IPR: Safety, Preventive Measures, and Case Studies

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Abstract

At the Institute for Plasma Research (IPR), the Steady State Superconducting Tokamak (SST-1) utilizes advanced cryogenic systems comprising two main temperature sections 4.2 K and 77 K which are primarily used for cooling superconducting magnet coils and minimizing heat loads. Operating at such extreme temperatures and high pressures involves significant safety challenges. The behaviour of materials under these conditions differs drastically from that at room temperature, often leading to unexpected outcomes in strength and performance. Typical hazards include material embrittlement, pressure build-up from rapid vaporization, accidental leaks, and oxygen-deficient environments, any of which can result in catastrophic failures if not properly managed. The cryogenic helium plant consists of several critical subsystems that demand continuous attention and regular inspection to ensure personnel safety and prevent equipment damage. Key systems include: high pressure at 150 bar (g) in helium gas pressure vessels, safety mountings as safety valve, rupture disc and Non-Return Valve, LHe and LN2 fluid cryogenic transfer lines, Thermal and vacuum insulation, 80 K vent line, high pressure helium gas cylinders for filling and testing, low temperature lab experiments at 4.2 K and 77 K, materials testing at cryogenic temp and high pressure. A centralized alarm monitoring system developed on the Wonderware Supervisory Control and Data Acquisition System (SCADA) platform is vital for ensuring operational safety. It continuously tracks critical process parameters across various subsystems and delivers real-time notifications through both audible alarms and visual indicators whenever abnormal conditions occur. All key data are displayed in real time on a control room monitor, enabling operators to quickly identify and resolve issues without needing constant on-site supervision. This system has significantly reduced human error, helium and cryogen losses, and potential equipment failures. Recent operational challenges, such as cryogen leakage due to bellows failure, ruptured safety discs in high-pressure vessels, thermal insulation degradation, and helium leak mitigation, have been efficiently identified and rectified through systematic monitoring and timely intervention. Furthermore, comprehensive risk assessments, personnel training programs, and emergency response planning have greatly strengthened operational safety. With the increasing complexity of the SST-1 cryogenic infrastructure, the integration of advanced monitoring technologies and automated safety systems has become essential. To ensure a safe working environment and effective emergency handling capability, the Cryogenics Division has established and consistently follows robust safety practices, norms, and culture. These measures collectively minimize accident risks, ensure reliable operation of cryogenic and high-pressure systems, and foster a safety culture aimed at achieving zero accidents at IPR.

This presentation highlights the mandatory aspects of cryogenic safety, including safe handling, hazard identification, protective and preventive measures, emergency actions, and safety guidelines for cryogenic and high-pressure systems. It also shares practical experiences, case studies, and lessons learned from real operational incidents, demonstrating the continuous improvement of safety procedures, norms, and equipment within the SST-1 cryogenic and high-pressure facilities.

Keywords: Cryogenic plant, Cryogenics and high pressure systems, 4.2 K & 77 K, Helium leak tightness, Safety implementation
