

Advancing Vulnerability Assessment for Nuclear Material Transport Security

The protection of nuclear material in transport against acts of sabotage is a fundamental element of a State's nuclear security regime. Ensuring that such transports are adequately protected against credible threats is essential to prevent unacceptable radiological consequences resulting from sabotage. International guidance, as set out in the IAEA Nuclear Security Series, emphasises the importance of taking a graded approach to transport security based on the potential consequences of sabotage and informed by the Design Basis Threat. Vulnerability assessments are therefore pivotal in determining whether existing protective measures are sufficient, or whether additional security measures are required.

In Germany, approximately 400 transports of nuclear material are conducted annually. These transports are categorized not only with respect to the risk of unauthorized removal, as set forth in the CPPNM, but also with respect to sabotage. The latter requires a comprehensive vulnerability assessment that considers the potential release of radioactive material and the resulting radiological consequences. Such assessments rely on analytical and numerical models, supported by an evolving experimental basis. Recent research undertaken by the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH and funded by the Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety (BMUKN) aims to strengthen this capability by providing new experimental data and simulation tools.

The research addresses the internal processes that occur within a transport package during an attack with advanced weapon systems, particularly shaped charges. Key phenomena in such scenarios include the generation of overpressure inside the transport package, material fragmentation leading to particle production, and the ejection of particle-laden gas jets through penetration caused by impact. Although the fundamental physics of gas dynamics and particle dispersion are well documented, their direct application to the highly transient and complex processes relevant in this context is limited. The specific conditions arising from shaped charge impacts and subsequent release mechanisms are too dynamic and complex to be captured by established models alone. This complexity highlights the need for experimental research to establish a reliable empirical basis for application-oriented modelling. Within its research programme, GRS has therefore conducted dedicated experiments on pressure evolution in transport packages subjected to shaped charge impacts, complemented by studies of the transient two-phase free jets resulting from overpressure-driven release. These experiments, together with associated numerical simulations, provide essential insights into the dynamics of such events and contribute to the development of validated models that can be applied in vulnerability assessments of nuclear transports.

The findings support the ongoing enhancement of vulnerability assessments for nuclear transport. They provide a robust experimental basis and flexible simulation capabilities for evaluating sabotage scenarios, in line with IAEA recommendations in NSS No. 13 and NSS No. 26-G. The results show that such an approach significantly improves the accuracy and reliability of vulnerability assessments, supporting informed decision-making on security measures.

This research directly advances the objective of strengthening nuclear security in transport by reinforcing the methodological and technical basis for vulnerability assessments. It helps to ensure that nuclear material is protected in a way that reflects the potential consequences of sabotage, thus improving the resilience of national nuclear security regimes.

Country or International Organization

Instructions

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