

# Human and Organizational Factors in Defence in Depth of Nuclear Installations

Abstract

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Defence in depth concept based on hierarchical deployment of multiple physical barriers against releases of radioactive substances and several levels of complementary means to protect the barriers for protection of the workers, public and the environment against radiation harm is and should remain an essential strategy for ensuring safety of all kinds of nuclear installations, in particular research reactors and nuclear power plants.

The concept of defence in depth is often oversimplified and misinterpreted as a set of physical barriers, whose integrity is ensured by safety provisions in the form of the systems implemented independently at various levels of defence. However, the provisions established at each level of defence should in general terms include not only hardware components (active and passive systems), but more comprehensively also inherent safety characteristics, safety margins, operating procedures and guidelines, quality assurance, staff availability and staff training, operator actions and all other organizational measures.

Many of above-mentioned provisions belong to the category of human and organizational factors. While various hardware components are typically specific for different levels of defence, human and organizational factors have impact on several levels of defence at the same time. These factors are also associated with large uncertainties and deficiencies in their implementation can negatively affect all levels of defence in depth at the same time.

The paper underlines the need of a more comprehensive view of the defence in depth. The paper consists of two main parts. First part introduces a screening method facilitating the assessment of the comprehensiveness of defence in depth. The method uses screening of safety provisions at five levels of defence, aimed at preventing the mechanisms and challenges to safety functions to take place so that to ensure integrity of physical barriers and achieving safety objectives at each level of defence. So-called objective trees are used by the method as a graphical representation of interrelations between safety provisions and safety objectives. The method has been published by the IAEA in 2005 and recently significantly extended and updated by UJV Rez, a.s. reflecting all lessons learned and IAEA Safety Standards issued after the Fukushima Daiichi accident.

Second part of the paper focuses on human and organizational factors considered as provisions for reliable performance of safety functions. Specific features of these provisions (such as affecting several levels of defence, large uncertainties and difficulties in predictability in human behaviour, sensitivity and vulnerability to psychological and societal influences, etc) are summarized. Examples of the objective trees with focus on provisions, mechanisms and challenges relevant for human and organizational factors are presented and discussed.