SYSTEMIC APPROACH TO DEVELOPMENT OF RISK-INFORMED MANAGEMENT OF NPP FIRE SITUATIONS

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“Risk-informed” decision-making

Required in the management of NPP fire situations but
- Development of procedures and training is challenging
- There is only a little personal experience of severe fire situations
- A shared definition of "risk-informed" way of acting is lacking
The approach

Demands of risk-informed ways of acting are examined by focusing on the *controllability* of the management of fire situations.

Controllability is considered by finding out
- The most important *plant-specific* demands of risk-informed management
- The *actual possibilities* for fulfilling these demands at the plants

Understanding of the controllability is formed by
- *Integrating relevant expertise* at the plants
- Developing *shared conceptual models* of the management
The approach (cont.)

"Risk-informed” way of acting is regarded as the understanding of the safety-significance of one’s ways of acting

*) Risk understood here broadly, concerning not only the core damage but also, e.g., injuries and economical and environmental damages
The approach (cont.)

The safety-significance of the ways of acting is examined by taking a *systemic view* on the management

- The management is regarded as a systemic whole
- The focus is on the functional and co-operational interdependencies
The approach (cont.)

Integration of the systemic view with the core-task* approach (VTT) makes it possible to operationalize the concept of risk-informed way of acting in the management of fire situations

*) Identification of the core content of the work
Development of a method*

Interviews at Loviisa and Olkiluoto plants, concerning problems of management of fire situations (2000-2001)

Development of a method for the analysis and assessment of the management

- Phase 1 (2002-2004)
- Phase 2 (2005-2006)

A seminar for representatives from the plants, the regional rescue service authorities, the regulator (STUK) and other relevant interest groups (2005)

*) As part of The Finnish Research Programme on Nuclear Power Plant Safety (FINNUS, SAFIR)
1. Phase in the development

Consideration of the controllability of a fire situation by regarding fire management and process control as a functional whole

Analysis of the controllability of a fire situation from the control room chief supervisor’s point of view

Development of a plant-specific generic reference model that

- Describes
  - Main assessment tasks of the chief supervisor
  - Potential risks and difficulties related to assessments

- Serves as a reference in
  - Design and analysis of individual fire scenarios
  - Observation and evaluation of task performances in simulator training and fire and rescue drills
Expert collaboration

Co-operation with Loviisa and Olkiluoto plants in the form of interdisciplinary expert group work, having representatives from

- Operation
- Simulator training
- Plant fire organization
- Outside fire brigades
- Safety engineering
- Human factors research (VTT)
Expert group work

Development of the generic reference model
Development of a fire scenario on the basis of the results of fire risk analysis
Analysis of the scenario with the help of the reference model
Application of the scenario in a fire and rescue drill or in simulator training at the plant
Developed scenarios

Problems in electric rooms, difficult to extinguish the fire due to the voltages
Difficult to anticipate the consequences of the fire on the process
Application of the scenarios in fire and rescue drills

Application of the scenarios in fire and rescue drills

• Programming of the scenario for the training simulator
• Observation of the task performances during the run
• After the drill, interviews of the participating control room crew and the fire fighters
• Conclusions of identified problems of the controllability of the situation and of developmental needs concerning the support for the management
2. Phase in the development

Widening of the perspective

Consideration of the controllability of a fire situation by regarding the management not only as a functional whole but also as a *co-operational whole*

Development of conceptual tools to identify the demands and actual possibilities of *co-operating* in a risk-informed way

- The concept of the *main control tasks*, defined from the safety point of view
- A *systemic network analysis* for the analysis of the co-operational control tasks
General safety functions

"A safety function is a technical, organizational or combined function that can reduce the probability and/or consequences of accidents and other unwanted events in a system" (Harms-Ringdahl 2001)

The general safety functions of the management of fire situations are goals aiming at maintaining personal, nuclear and radiation safety and at protection of property and environment.
Main control tasks

Operational tasks / task combinations, the performance of which aims at fulfillment of the general safety functions
Not always possible to describe as procedures
Often cross the boundaries of fire management and process control and hence require co-operation of the different parties
Most important control tasks requiring co-operation

1) Initiation of the safety functions required by fire *
2) De-energization of the target room *
3) Prevention of the damages caused by smoke
4) Prevention of the damages caused by water

*) Chosen as a more detailed focus of consideration
"Risk-informed" way of co-operating

An individual participating in the management should understand the safety-significance of his/her ways of acting in the joint performance of the main control tasks.

In order to promote this understanding the plant organization should develop a shared concept of risk-informed co-operation.
Systemic network analysis

Analysis of the co-operational control tasks

- Consideration of the *functional connections* between the different parties’ tasks
- Identification of the *dependencies* related to information, time and allocation of human resources
- Identification of the *difficulties and constraints* in the parties’ possibilities to
  - Form an understanding of the situation
  - Perform needed operations timely and in a correct way
De-energization of the target room

**Fire brigade**
- Protects operations in the field

**Main control room**
- Calls electrician
- Gives support to operations

**Electricians**
- Informs of voltages
- Informs of progress of work
- Informs when de-energization has been attained

**Plant emergency organization**
- Negotiations about the situation and operational alternatives

**Asks about voltages**
- Informs of progress of work
- Informs when de-energization has been attained
Systemic analysis of the co-operational control tasks

Definition of the main phases in the performance of the control task

For each phase, identification of
  - Most important assessments of the situation
  - Operations to be performed
  - "Action points" requiring co-operation
  - Dependencies at the action points, e.g.
    - information needs, needs concerning assistance to operations, coordination of operational actions, time windows
  - Difficulties and constraints related to possibilities to
    - make assessments of the situation
    - perform the operations
Example: de-energization of the target room

Important issues to be assessed
• Is de-energization necessary?
• Is it possible to carry out de-energization?
• Can the sufficiency of de-energization be ensured?
• What are the operational alternatives if it can not be ensured?
Example: de-energization of the target room

Potential difficulties
- Lack of procedures
- Lack of sufficient documentation of cables
- Complexity of steps to be taken
- Availability for experts outside the plant

Potential risks
- Health risks of the fire fighters
- Unwanted process consequences if or if not de-energized (e.g. loss of technical safety functions)
- Delayed or reduced opportunity to extinguish the fire
General factors potentially endangering the controllability of the fire situation

Possibility to make proper assessment of the situation
• Knowledge of the plant, e.g., of the cable routes
• Possibility to get information during the situation
• Sufficiency, timing and validity of the gained information
• Functioning of the communication tools
• Way of communicating in the co-operational network
• On-line risk assessment concerning injuries and plant safety

Possibility to perform operations
• Available time
• Availability and usability of the technical systems and devices
• Sufficiency of the human resources
• Availability of external help (e.g. electricians)
• Availability of guidance for reaching the target room
• Accessibility of the target area and physical circumstances in the target area
Utilization of the results at the plants

The developed fire scenarios have been used in fire and rescue drills and simulator training at both plants.
At Loviisa, handling of the alarms has been moved from the chief supervisor to the security center.
At Olkiluoto, a working group has been formed to consider the strategies of the extinction of the electric rooms.
Benefits of the approach

Provides a means to concretize the concept of risk-informed way of acting in the management of fire situations
Promotes understanding of the safety-significance of the different ways of acting and co-operating
Facilitates identification of the potential weak points in the co-operational system
Future plans

To support development of *plant-specific safety concepts* at the plants by

- Deepening the analysis of each control task
- Considering the controllability of the different control tasks as a whole from the co-operation point of view

The safety concept

- A conceptual model of the way *safety is formed* in the co-operational performance of the control tasks
- Can be developed in interdisciplinary expert collaboration
- Lays basis for the development of *integrated support* for the management (procedures, training, etc.) at the plants