Asian Nuclear Safety Network
ANSN Workshop on Fire Safety for Research Reactors

Argonne National Laboratory, Illinois, USA
8-12 December 2014

Syllabus (Rev 7, 1 Dec 2014)

Background and Purpose of the Workshop:

Fire safety and protection are important considerations in research reactors and the associated laboratories and experimental activities. However, the results of INSARR missions indicate that many research reactors have no systematic fire hazard analysis (FHA) and that internal events, especially fire, are not adequately addressed in the safety analysis reports. This workshop will address fire safety programs, including the FHA, fire protection measures in design and operation, and analysis of internal fire events. It will provide the participating countries with information on the IAEA safety standards and guidance on fire safety, practical knowledge and examples of fire safety programs, as well as an opportunity for exchange of related information and experience.

Principal IAEA Standards and Guidance Documents for Fire Safety

- IAEA Requirements and guidance for research reactors:
  - Safety Requirements NS-R-4, *Safety of Research Reactors*, paras. 6.22-6.25 and 7.71;
  - Draft Standard DS476 (revision of NS-R-4, in preparation), requirements 61 and 79.
  - Specific Safety Guide SSG-22, *Use of a Graded Approach in the Application of the Safety Requirements for Research Reactors,* paras.7.37-7.40.

- IAEA Requirements and guidance for nuclear power plants (as applicable to research reactors):
  - Safety Requirements SSR 2/1, *Safety of Nuclear Power Plants: Design,* requirement 74;
  - Safety Guide NS-G-1.7, *Protection against Internal Fires and Explosions in the Design of Nuclear Power Plants,* Sections 2 and 3;
  - Safety Requirements SSR 2/2, *Safety of Nuclear Power Plants: Commissioning and Operation,* Requirement 22;
  - Safety Guide NS-G-2.1, *Fire Safety in the Operation of Nuclear Power Plants;*
  - Safety Reports Series No. 8, *Preparation of the Fire Hazard Analyses for Nuclear Power Plants.*

Content of the Course:

Module 0: Administration (5-1/2 hours)

L.0.1: Welcome and introductory remarks (20 min) (LW Deitrich, ANL, D Sears, IAEA);

L.0.2: Introduction of participants and faculty (20 min) (Deitrich);
L.0.3: Site Safety Briefing (20 min) (ANL EQO);
L.0.4: Introduction to the workshop program (½ hr) (Deitrich);
D.0.5a,b: Visit to ANL/NE historical exhibit and ANL site visit (2-1/2 hr) (Deitrich, guide + all);
D.0.6: Final discussion and participants' feedback (1 hr) (Deitrich, moderator + all);
D.0.7: Closing ceremony and presentation of certificates (½ hr) (Deitrich, Sears + all).

Module 1: Basic considerations in fire safety (3 hours)

L.1.1. The IAEA Research Reactor Safety Program and Overview of IAEA Fire Safety Guidance (1 hr) (Sears, IAEA)

- Suggested fire safety documents to be included are listed at the end of the syllabus.

L.1.2. Basic Concepts in Fire Safety (NS-G-1.7 and NS-G-2.1) (1 hr) (Deitrich)

- Part 1: Fire safety objectives and defence-in-depth (paras. 2.1-2.5, NS-G-2.1)
    - Prevent fires from starting;
    - Detect and extinguish quickly fires that do start;
    - Prevent the spread of fires that are not extinguished; and
    - Protect SSCs important to safety from the effects of fire;
    - Assumptions in deterministic analysis of fire protection (para 2.5, NS-G-1.7);
    - Use of PSA in fire hazard analysis (para 3.27, NS-G-1.7).
- Part 2: Implementation of defence-in-depth in design
    - The fire containment approach and the fire influence approach. (paras. 3.8-3.19, NS-G-1.7);
    - Design measures intended to minimize the likelihood of a fire starting (Section 4, NS-G-1.7);
    - Active and passive fire protection elements;
    - Fire protection systems, including fire detection and a combination of active (automatic and manual) fire extinguishing techniques (Section 5, NS-G-1.7);
    - Mitigation of secondary fire effects (Section 6, NS-G-1.7).
- Part 3: Implementation of defence-in-depth in operation (Sect. 2, NS-G-2.1)
    - Design, installation and operation of fire prevention and protection systems;
    - Fire safety management;
    - Fire prevention and fire protection: control of fire load and ignition sources; inspection, maintenance and testing; the fire hazard analysis;
    - Quality assurance;
    - Emergency arrangements
- Part 4: Application of a graded approach in application of fire safety guidance (SSG-22, paras. 7.37-7.40)

L.1.3. Fire safety considerations in operations (Sects. 3, 6, 7, 8 and 9, NS-G-2.1) (1 hr) (Sears):

- Organization and responsibilities;
- Control of combustible materials and ignition sources;
- Inspection, maintenance and testing of fire protection systems;
- Manual fire-fighting capability;
- Training of plant personnel.

Module 2: The Fire Hazard Analysis (FHA) (3 hours)

L.2.1. Purpose and scope of the FHA (NS-G-1.7, paras. 3.20-3.27 and SR No. 8, Sect. 2) (1/2 hr) (Sears):

- To identify SSCs important to safety and their location;
- To analyse the anticipated growth of a fire, and the consequences of a fire with respect to SSCs important to safety;
- To determine the required fire resistance of the fire barriers, in particular the boundaries of fire compartments (the fire containment approach);
- To determine the active and passive fire protection measures necessary;
- To identify cases where additional fire separation or fire protection is required to protect against common cause failures and ensure SSCs important to safety remain functional during and following a credible fire, in particular, the extent of active and passive measures needed to separate the fire cells (the fire influence approach);
- To verify that SSCs performing the basic safety functions are protected against fire and capable to perform their safety function assuming a single failure;
- For existing reactors, the FHA should document the adequacy of fire detection and protection measures, or if deficiencies are found, to formulate measures to ensure safety is achieved;
- The FHA should consider all areas of the site, including non-nuclear facilities;
- The FHA should be updated periodically and in the event of modifications that affect fire safety.

L.2.2. IAEA guidance on components of the FHA (Safety Report No. 8) (1 hr) (Deitrich)

- Part 1: Data collection (Section 4, SR No. 8)
    - Inventory of safety systems;
    - Inventory of fire compartments;
    - Inventory of combustible materials;
    - Inventory of potential ignition sources;
    - Passive fire protection measures;
    - Fire detection systems;
    - Fixed fire extinguishing systems;
    - Emergency lighting;
    - Communication systems;
    - Manual firefighting arrangements.

- Part 2: Analysis of fire growth (Sect. 5, SR No. 8)
    - Physical and chemical properties of the combustible materials;
    - Physical characteristics of the fire compartments;
    - Postulated fire for each fire compartment.
- Part 3: Consequence analysis (Sect. 6, SR No. 8)
    - Determination of the adequacy of fire protection;
    - Determination of the effects of a fire;
    - Direct, indirect and secondary effects of a fire (see paras. 3.28-3.29, NS-G-1.7);
    - Other effects of a fire outside the fire compartment.

L.2.3. FHA methodology and application of a risk-graded graded approach for a large, aged research reactor (S. Kurien, AECL) (1-1/2 hr)

Module 3: Introduction to Analytical Methods for Fire Analysis (3-1/2 hours)

L.3.1. Deterministic methods (M. Bucknor, ANL) (1-1/2 hrs)

- Introduction to various calculations that are part of fire hazards analysis and available spread-sheet calculations and computer codes.

L.3.2. Fire probabilistic risk assessment (S. Shalabi, CNL Chalk River Laboratories) (2 hrs)

- Introduction to the ideas of probabilistic analysis and how they can be applied to fire hazards analysis.

Module 4: Examples of Fire Protection Programs (4-1/2 hours)

L.4.1. FPP development and implementation at an aged research reactor (S. Kurien, CNL Chalk River Laboratories) (1-1/2 hrs)

L.4.2. Fire protection programs for research and commercial reactors – US perspective (Tom McCormack, Nexus Engineering) (1-1/2 hrs)

- Covering upper-tier requirements documents, general requirements, developing the FHA, mitigation features administrative controls, inspection, testing and maintenance.

L.4.3. Fire protection programs for laboratories handling radioactive materials – DOE perspective (Alex Smith, Nexus Engineering) (1-1/2 hrs)

- Covering upper-tier requirements documents, general requirements, developing the FHA, mitigation features administrative controls, inspection, testing and maintenance.

Module 5: Participants' Presentations (4 hours)

L.5.1-5.8. Assume eight participating countries from the ANSN (Participants) (8 countries @ ½ hr.)

Module 6: Introduction to Fire Hazards Calculations (5 hours)

W.6.1. Introduction to Fire Dynamics Tools from NUREG-1805 (S. Shalabi, S. Kurien and Participants) (1-1/2 hrs, Wednesday afternoon)

W.6.2. Introduction to Fire Hazard Calculations Using the CFAST Code (S. Shalabi, S. Kurien and Participants) (3-1/2 hrs, Thursday afternoon)