International Atomic Energy Agency

Practical Exercise - Suggestions and Observations

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Workshop on Safety Assessment for Decommissioning of Research Reactors

4 - 8 October 2010, Risø, Denmark

General Structure

- 3 cases:
  - dismantling of one heat exchanger as a part of primary circuit
  - dismantling of the fuel flask (fuelling machine)
  - demolition of the biological shield

- All 3 cases similar in nature:
  - workers – general public
  - normal decommissioning operation – incident / accident
  - identification of hazards as a starting point for credible scenarios
  - simple dose calculations
  - comparison of various approaches (at least two)

Objectives (1)

- The practical exercise on safety assessment had various objectives to increase awareness:
  - demonstrate that safety assessments for decommissioning are neither trivial nor witchcraft
  - make you think about what safety assessments are good for
  - help you to see that the outcomes of safety assessments are good for decision making processes
  - there is more to safety assessments than just workers and just the planned (decommissioning) operation:
    - general public
    - large number of possibilities for incidents or accidents
- This goal seems to have been accomplished

Objectives (2)

- Demonstration of the connection between working conditions and (real) doses
  - this goal has been partly accomplished

- Demonstration of various approaches for performing screening calculations
  - this goal has been partly accomplished

How the calculations could have been carried out

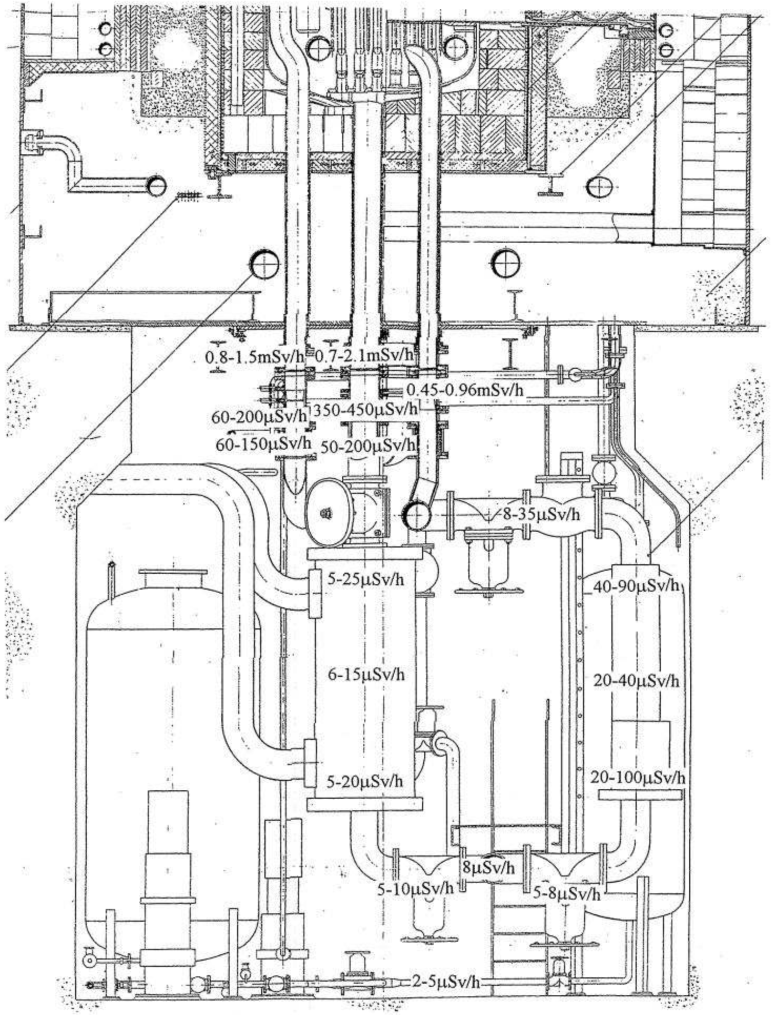
The Starting Point

- Imagine: You are a health physicist and your plant manager asks:
  - “Could we perform this particular decommissioning task without radiological problems for our workforce and for the general public in the neighbourhood? Which of the two (or three) cutting techniques would be better in your opinion from a radiological point of view? And do we need any additional shielding or other kind of protection?”
- Give him a concise yet comprehensive answer in your report.
  - And be careful: he will only be convinced by hard facts and comprehensible calculations!

Suggestions for Solutions (1)

- Approach using the example "heat exchanger"
- Workers, normal operation:
  - identify work sequence(s)
  - identify hazards
  - define working conditions using
    - plant-specific approaches where possible
    - bounding assumptions where necessary
  - build scenario(s) and calculate doses
  - draw conclusions
    - dose limits / constraints complied with?
    - which SSCs / SMs were used?
    - would a different approach have been better?

Suggestions for Solutions (1)
Example: Heat Exchanger



- Use data from DR-3 on
  - dose rates (around 10 μSv/h)
  - composition of activity (Co-60)
  - level of contamination some Bq/cm²
- Use bounding assumption on working time for all work
  - e.g. 200 h
- Individual dose 1 – 2 mSv

Suggestions for Solutions (2)

- Workers, incidents:
  - identify incident with possibly highest consequences
    - using hazard list from previous part
  - make conservative yet credible assumptions
    - what can go wrong? source term? conditions?
  - build scenario(s) and calculate doses
  - clarify whether this has been a bounding assumption or whether a different incident would have led to higher doses
    - use that scenario instead (restart)
  - draw conclusions
    - dose limits / constraints complied with?
    - which SSCs / SMs are there for potential mitigation?

Suggestions for Solutions (2)
Example: Heat Exchanger

- Scenario development:
  - under what circumstances could a worker be forced to remain in dusty environment near heat exchanger?
  - person gets injured, cannot be moved for some time, cannot wear breathing protection
  - from this a credible and enveloping scenario for an incident can be built
    - 15 min, 1,000 Bq/m³, Co-60 → 10 µSv

Suggestions for Solutions (2)
Enveloping Assessment for Incidents

- A full safety assessment would need to include a bounding scenario for the entire plant, e.g.
  - disastrous fire causing massive release without filtration
  - destruction of containment from earthquake with subsequent release
- Safety assessment must always contain both aspects:
  - plant and conditions → possible off-site consequences
  - working environment → possible consequences to workers

Suggestions for Solutions (3)

- Public, normal operation / incidents
  - use approach from Safety Report 19
  - perform the calculations for the atmospheric release pathway as far as you can go in the allocated amount of time
  - understand the dispersion in the atmosphere
    - release rate and conditions
  - understand the different contributions of various exposure pathways
    - inhalation, external exposure from ground, vegetable consumption etc.

Suggestions for Solutions (3)
Overarching Assumption

Suggestions for Solutions (3) Overarching Assumption

- Release to the environment only from cutting of heat exchanger / fuel flask / biological shield is hard to determine
- Therefore: assumption as given in section 3.4 could have been used as a bounding approach
- Dose calculations are described step by step in Safety Report 19
  - Co-60 predominant nuclide
  - bounding assessment: < 30 μSv/a
    - ingestion of crops
    - external irradiation from the ground
- Note: this is a crude result – more refined models as used by DD for DR3 lead to much lower exposure estimates

Suggestions for Solutions (4)

- Summarise the results
- Give a clear indication
  - whether dose limits / constraints are complied with
  - what (critical) assumptions were made for this
  - which SSCs and SMs were assumed to be in place
    - which of those are critical
  - which alternatives have been analysed and why they have been rejected
- Prepare to defend your results

Suggestions for Solutions (4) Example: Heat Exchanger

- Individual doses to workers: 1 – 2 mSv ✓
  - dose limit 20 mSv/a
- Doses to workers from possible incidents: ~ 10 μSv ✓
  - acceptably low
- Doses to public: << 30 μSv/a ✓
  - using bounding assumptions on release and screening model
  - dose constraint 300 μSv/a
- SSCs / SMs:
  - work-specific condition: respiratory protection when work will create dust / aerosols
  - general condition: ventilation of building, HEPA filter

Observations

Observations on the Approaches (1)

- Approach:
  - it took some time before a convincing dismantling sequence had been agreed upon
  - discussion on technology and performance was preferred over making a bounding assumption
  - one group contemplated a first approach not within the limits of the current licence of the plant
    - additional time for obtaining extra licence / permit
    - would lead to unknown conditions
  - all 3 working groups succeeded in choosing a dismantling sequence from which scenarios could be derived

Observations on the Approaches (2)

- Parameters and calculation results:
  - one group took the bounding approach to an extreme
    - assumptions may be bounding but have to remain within physically possible limits
  - performance of techniques were generally overrated
    - time required for setup, maintenance, adjusting to next segmenting step etc.
    - performance values taken from literature (manufacturer?) and not from real case experience
  - feeling has to be developed for a sound balance between enveloping and over-conservative

Observations on the Approaches (3)

- Interdependence of assumptions:
  - if one assumption is changed in a scenario / set of scenarios, many other parameters will change as a result
    - e.g.: segmenting speed → exposure time → dose
    - e.g.: filter efficiency → dust concentration → source term → inhalation dose
  - consequence: implement calculations flexibly
  - develop a feeling for credible / dubious assumptions

Observations on the Approaches (4)

- Performance of dose calculations:
  - actual calculations required perhaps more time than envisaged
    - not all parts of the assessment could therefore be adequately covered
  - need to agree on assumptions where hard facts are not readily available
- Concepts:
  - calculation of doses to worker from accident and doses to the public were harder than normal operating conditions
  - understand that safety assessments cover all parts
    - deviations from the planned procedures
    - general public

Observations on the Presentation of Group A

- Good:
  - use of calculation results for comparison between the two techniques
  - calculations to the public done to a rather far stage
- Improve:
  - presentation of work steps not clearly defined
  - removal procedure not clear
  - rather high resulting dose, accepted result without questioning or stating what could be done to reduce these

Observations on the Presentation of Group B

- Good:
  - clearly stated dose limits / dose constraints
  - clearly stated assumptions for all calculations
  - reasonable assumptions on incidents
  - identification of binding dose values but with discussion of various measures how to reduce doses
  - presentation structured very well
- Improve:
  - work steps not clearly defined
  - no consideration of doses to public

Observations on the Presentation of Group C

- Good:
  - clear layout of work steps and of scenarios, good derivation of source term
  - good approach to waste aspects (clearance)
  - transport also completely modelled
  - incident scenario derived from good scenario analysis
  - identification of actions against these incidents
- Improve:
  - rather optimistic assumptions for work time, pessimistic on dust load
  - use of an unrealistic high dose rate (100 µSv/h)

Congratulations!
Well done!