Ideas for Projects 2022

These examples give you an idea of the typical scope and difficulty of a course project. You can use one but you are encouraged to adapt them or develop your own. Some may require permission from, or support from, your organization. Some require access to industry documentation (e.g. safety report) whereas others do not.

1. Event sequences
   a) Develop event sequence diagrams for a specific CANDU reactor (Pickering A or B, or Bruce A or B, or Darlington, or a CANDU 6) for the following initiating events: i) Loss of main feedwater flow; ii) small LOCA; iii) large LOCA.
   b) Suppose your CANDU has a LOCA + LOECC + loss of moderator cooling. Calculate the demand availability of emergency makeup to the moderator. You will need access to the technical description of your chosen CANDU plant. Do *not* copy existing safety analysis.

2. Assume a partial flow blockage in a CANDU fuel channel (your choice which CANDU and which channel).
   a) Calculate the pressure tube temperature near the channel exit for a range of *steady-state* flow reductions.
   b) What percentage reduction of the flow is required for the pressure tube to fail (assuming steady-state)? Justify this in terms of pressure-tube behaviour at high temperatures.
   c) Calculate the *steady-state* flow that will just lead to central melting of a fuel rod. You will need a fuel model and a sheath-to-coolant heat transfer model. You may need to simplify: e.g. divide the channel up into discrete bundles for calculation purposes.
   d) What conclusions can you draw from these answers re the likelihood of fuel melting before pressure-tube failure for a flow blockage that occurs gradually?

3. Consider an uncontrolled severe core damage accident in a CANDU resulting from loss of all heat sinks. Develop and describe the sequence of events up to failure of the shield tank or reactor vault and calculate (by hand, or write your own code) the approximate timing of each major event. Include containment behaviour. *Hint: Use energy balances.*

4. Compare a large LOCA and a main steam line break inside containment. Use a CANDU safety report and develop a list of symptoms which the operator can see; use them to show how he can determine the accident that has occurred and what he should do. You will need to understand what signals are available and roughly how they would behave. Repeat this assessment for a PWR and compare the symptoms and signals for a CANDU with those for a PWR. (You can access PWR safety reports through the USNRC web site).

5. Using the diagram of the SDS1 trip logic from a Safety Report, construct and evaluate the

fault tree for initiation of a reactor trip on any one signal. Include all system components from the sensor signal to the clutch release. Include failure probabilities (e.g. IAEA-TECDOC-478) of each component and give reasons for any estimates. You may need to simplify the number of components you consider.

6. Calculate the pressure in a CANDU 6 containment building 5 seconds after a large LOCA, from scratch. You will need to calculate the steam discharge rate and enthalpy after a main steam line break. You will need access to the station data. Do *not* copy existing safety analysis.

7. A CANDU station is trying to decide whether or not to put in filtered containment venting for severe accident (assume loss of all on-site AC power). Develop the cost/benefit case to help them make this decision. You will need to calculate or research the severe accident consequences in terms of health effects and economic loss, the reduction in severe accident frequency and/or consequences from the filtered venting, and the cost of the back-fit in terms of money and radiation exposure. You can choose either a multi-unit vacuum station or a single-unit CANDU (the accident behaviour and time-scales are somewhat different)

8. Assemble all the information you can find on the numerous incidents in Japan, between 1978 and 2000, of inadvertent criticality in BWRs. Analyze one of the accidents (using a root cause technique, for example) in terms of defence in depth, operator response, and design/operator interaction. Discuss if the accidents reveal any weaknesses in the BWR design. Discuss the lack of reporting of these accidents (until recently) in terms of safety culture.

9. Compare a catastrophic accident in nuclear power with those in other energy industries. Consider both real and potential accidents, and discuss such aspects as cost, health effects, environmental effects, psychological effects, and probability.

10. Compare and contrast the safety characteristics of LWRs and CANDU – e.g. safety aspects of physics, fuel, thermohydraulics, pressure boundary, control/shutdown/ design, containment design etc. Explain which differences are inherent to the design versus engineering choices. Develop the comparison **in depth**. A simple collection of ideas from other sources is not sufficient. You can choose a specific CANDU or PWR design if you wish.

11. Using publicly available data on the Fukushima accident sequence, calculate the transient water level in the vessel, the transient fuel temperature up to the onset of gross melting, and the hydrogen produced over the same period. You can do the calculations by hand or use a computer code or spreadsheet.

12. Using publicly available information on the Fukushima accident sequence, analyze in

depth the institutional failures which contributed to the event. Look closely at the behaviour of the utility, the designer, and the regulator. Contrast the organizational setup and mandates with other countries such as Canada, the U.S. and/or the U.K.; and compare with IAEA guides on industry organization. What changes would you make (and why) to the institutions and their mandates (not just in Japan)?

13. Research the technical issues behind the recent discovery of high hydrogen levels in CANDU pressure tubes. Explain the safety issue and summarize and assess the measures being taken to deal with the finding.

14. Choose a Small Modular Reactor design for which there is decent objective documentation (e.g. USNRC review) and assess how the safety functions of control/cool/contain are achieved – compared to a conventional design. Explain if and how any accidents are “eliminated” by the design.

15. Review the open literature and discuss techniques as to how one would ascribe a demand failure frequency to a passive safety system (e.g. one that relies on natural circulation). You should look at both academic papers and USNRC safety reports on advanced designs. Discuss strengths and weaknesses of the approaches taken.

...or any other project requiring similar levels of originality and of similar difficulty. You will need my prior agreement. Note that some projects have been removed from the list as they have been extensively worked over by previous classes (e.g. Pickering pressure-tube failures).

You are encouraged to interview experts in your organization as needed.

Teams can be one person, two or (exceptionally) three. More will be expected of larger teams.