Final exercise of R&S - Closed questions

19th June, 2014

Name:

6/10 1. Safety Variables and Safety Limits. Definition and examples (2 at least). Explain its usefulness in the "grouping and bounding process"

- Safety variables are variables, like the temperature and pressure, of different system of the plant during operation which are related with the integrity of the physical safety barriers (cladding and fuel Matrix, RCS boundaries, containment). The neutron flux, the rate of chang of the flux, the temperature average of the primary are for example related with fuel and cladding integrity, like the DNBR; the pressure of RCS is related with primary integrity (and also DNBR for lower limit); the containment pressure is linked to containment integrity.

- Then, to guarantee the integrity of these barriers, we must fix higher limits (lower for DNBR) that the variables must never exceed. In normal operation we are really far from those limits (within the operational margin), and in case of accident we should do everything possible to avoid violating those limits. Those limits give a certain margin, the "safety margin", before the failure of the barrier. For instance, the failure of RCS boundaries occurs at a pressure of more than 206 bars, but the safety limit is at around 188 bars. The safety limit for DNBR is a lower limit, at 1.17

- "Grouping and bounding process" is a technique used to minimize the number of Design Basis Transient that we will have to check: the sequences of events are grouped according to their similirarties. The nature of initiating event, the severity of the damages or the frequency (less used) are possible filters. Then, we define the most limiting transient of the group, the one with biggest damage, which will represent, "envelop" the group.

2. Among the 10 detailed identified causes of Three Mile Island Accident, at least one of them was recognized as a design deficiency:

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- Select the most significant (if there is more than one)
- Describe it
- Why is it considered a cause?
- How was it corrected by the nuclear industry after the accident?

Several consecutive failures occured during the accident of TMI : loss of FW, AFW failure because of valve misplacement after maintenance, PRZ relief valve stuck opened, desactivation of SI and of RCP ...

One of the main design related causes was that there was no display of the current state of the valve : no indicator telling if the PRZ relief valve was opened or closed (same for AFW valve and AFW flow). Worse, the operators thought the valve was closed because of the signal sent, since there was no feedback to know if the operation was successful or not. It is considered like a cause because it is partly responsible for the misdiagnosis of the operators, who were not able to assess after that a SBLOCA through the relief valve (even if there was a high T in relief line signal alarm...).

The nuclear industry made a lot of corrections after that. Now, all the state of components are clearly visible in the display of the control room : breakers connected or not, valves opened or closed, pumps active or not, alignment of different systems. Also, the flows and pressures / temperatures are available and easily visible for the operators.

3. Conservative methodologies for licensing analysis. Define and characterize. Use properly, among others, the words: pessimistic, initial and boundary conditions, safety-grade equipment, single failure...

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A licensing analysis with conservative methodology aims at insuring that, in the real operation, any sequence of accident will have enough severity to overpass the safety limits set by the regulator. The studies are generally made with conservative codes, and all the possible transients must be checked. Different technics are used.

- First the codes are very conservative, it means that they suppose the worst configurations possible in their calculations. Unlike BE codes, the user cannot change a lot of parameters in the nodalization, in order to avoid uncertainty due to certain local sensitivities in the design.
- Then, the initial and boundary conditions must be chosen in a pessimistic way: highest T allowed in operation, lowest DNBR, etc for initial conditions. The uncertainty of parameters is taken into account in final margin definition.
- Not all the transients are checked, only the most representative, i.e the most limiting of each group. In that transient, we always suppose the single failure of the most critical component (for instance in case of total loss of FW, we suppose that one PRZ relief valve out of 2 fail).
- The actuation of automatic controls is disabled, except in cases where they induce a bad evolution of the transient.
- The actuation of automatic protections is delayed as much as possible (SCRAM, AFW, etc.). Human actions are not considered unless the time required is really long (no error supposed).
- According to the results, a new large margin is define: the design limit must be right below the safety limit, but is also largely above the final operational value.

4. Consider the following organizations: Nuclear Energy Agency (NEA), EURATOM and International Atomic Energy Agency (IAEA). Describe briefly how they deal with nuclear safety.

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- NEA is an agency in charge of fixing the legal framework around the nuclear field in the world. They fix the rules and the limitation for operation, and also the responsibility in case of event.

- EURATOM is a European council, depending on the UE, which aims at enhancing a regulating the nuclear activity of the member states. They provide some regulatory limits for operation, some design basis for the utilities that are potentially interested, and encourage all the nuclear projects. Through the supply agency, they want to stabilize the access to uranium fuel, by acting like a big regulator of the market.

- IAEA is an internial agency which provides regulations for the nuclear field. They emit some documents: the general requirements, that all the regulatory bodies of each country should follow, along with complete guidelines to achieve this requirements, in all kind of nuclear activities. They can make reviews of the national regulatory plans, and help them to complete the requirements. In a certain way, all the national regulatory councils (like CSN) must prove that they comply with these requirements.