

Educational/training needs of Nuclear Power Industry [NPI]

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Nuclear Energy
Renaissance Workshop
8 May 2008
Athens

Outline

- Importance of education/training for NPI.
- Brief history: The TMI lesson for the US Nuclear Industry.
- Activities of the NPI.
- Activities important for a Greek Nuclear Power Industry.
- People needed and their qualifications.
- Educational programs needed.

An ancient Greek saying

- Δει δε ανθρώπων και άνευ τούτων ουδέν εστί γενέσθαι των δεόντων

Translated:

- One needs people and nothing can be done without them

The true old saying

- Δει δε χρημάτων και άνευ τούτων ουδέν εστί γενέσθαι των δεόντων.
- (Δημοσθένης)

Translated

- One needs money and nothing can be done without them.
- (Demosthenes)

Of Course

- Both people and money are needed,
- But only people will be discussed here

Declaration

- My presentation and models discussed are based on the US Nuclear Power Industry and the US educational/training system.
- *However, I am not advocating that Greece must duplicate that system. There is more than one ways to achieve the goal of a successful NPI*

Importance of education and training

- We build well-designed machines.
- People operate them.
- If the operator is not well trained, mistakes are inevitable
- The machine will fail

The TMI lesson

- April 1979
- At the TMI nuclear plant, operators misinterpreted instruments' readings
- Core lost its water cooling cover
- Core melted
- Reactor destroyed

Why did the accident happen?

- It was not a faulty reactor design.
- It was poor training of the people running the plant that caused the accident

The nuclear Industry asked the question:

- What should we do about it?

Better training

- Better training, of course
- First big step was the creation of the Institute of Nuclear Power Operations (INPO)
- INPO set education/training standards which the industry agreed to follow.
- It also set performance objectives.
- Goal? Operational excellence

What is the result?

- 1. No other accident or even serious incident occurred since TMI
- 2. The annual capacity factors increased from $\sim 70\%$ to more than 90% today.

Capacity factor

- $\frac{\{\text{Energy generated over a time period}\}}{\{\text{Max. design energy that could have been produced over the same period}\}}$

Increase of capacity factor from 70 to 90%

- Amounts to generating additional electricity equivalent to that produced by 20 plants of a 1000 MWe size.

Activities of the NPI

- 1. Mining/milling of Uranium
- (product is U_3O_8 , yellow cake)
- 2. Conversion/enrichment (the product is UF_6 enriched to 4-5% in ^{235}U)
- 3. Fuel fabrication (UF_6 is first transformed into UO_2 which then is pressed into pellets)
- 4. Reactor operation/energy generation.

Activities, cont.

- 5. Radioactive waste storage and disposal.
- 6. Radiation protection (Health Physics activities) of the workers and the public.
- 7. Regulatory activities
- 8. Architect/engineering

Scenario for Greece

- Pay min. attention to U mining
- Stay out of conversion and enrichment
- Buy fabricated fuel from an established reliable fuel manufacturer.
- Sign an agreement to send back the spent (irradiated) fuel to the fabricator

No fuel ownership

- In a sense:
- Greece will never really own the fuel. Paying for the fuel will be like being charged a fee for the use of that fuel to generate electricity and return it to its owner upon discharge from the reactor core.

Activities to pay attention to:

- 4. Reactor operation
- 5. Radioactive waste storage and disposal (LLW)
- 6. Radiation protection
- 7. Regulatory activities
- 8. Architect/engineering

Regulation

- I will not discuss regulatory activities
- Dr. Lambros Lois will do that later today

Architect/engineering

- Very important activity; it concerns the design of the plant.
- I assume that the plant vendor will be responsible for this activity.
- Greece must have a small group that will be the liaison with the plant designer.

Reactor operation needs

- 1. Reactor operators
- 2. Engineers
- 3. Health physicists
- 4. Technicians
- 5. Security people
- 6. Administrative personnel
- (non-technical)

Typical employment numbers

- Engineers 150-200
- Operations 150-200
- Radiation protection 50-70
- Quality assurance/quality control (QC and QA) 30-40
- Maintenance 200
- Security 100-140
- Administrative 60-80

- Total (round #'s) 700-900
- (for US plants)

Reactor operators

- Operators
- Senior reactor operators
- Every plant employs at least 6 crews of operators:
 - 3 crews for the 3-8 hour shifts
 - 1 crew in training
 - 1 crew on leave
 - 1 crew on reserve

Training of Reactor Operators

- Every nuclear plant has a simulator on site in which one shift of operators is always on training.
- Using the simulators, the operators are exposed to every conceivable scenario of created risk.
- Appropriate response is learned

Qualifications for reactor operators

- A 4-year college degree is NOT required.
- Only the shift supervisor must have an engineering degree, probably a NE degree.

Engineers

- They are responsible for the safe operation of the plant
- They solve or resolve technical issues
- They collect and interpret data relative to the power production and fuel burnup.
- They prepare the fuel reload requirements. Questions that must be answered:

Engineers, cont.

- *What should be the enrichment of the new fuel?*
- *How many assemblies are needed?*
- *Any changes required, based on the experience from the previous cycle?*
- *What is the effect of any changes introduced by the fuel manufacturer?*

Engineers , cont.

- They form the liaison with the fuel manufacturer.
- They are responsible for the timely and safe refueling of the plant.
- They are responsible for plant maintenance.
- They are responsible for additions/changes/repairs of the physical plant.
- They form the liaison with the regulatory agency.

Educational qualifications and specialties

- Engineers have earned at least a 4-year degree from an Engineering College
- (accredited by ABET)
- In addition to NE's, a NPP employs many ME's, EE's, some CE's.

The Nuclear Engineering Curriculum

- Mathematics, Chemistry, Physics.
- Fluid flow and heat transfer
- Materials
- Radiation detection and measurement.
- Radiation protection/shielding
- Reactor physics
- Reactor design

Laboratories

- A nuclear reactor laboratory is desirable but not necessary.
- A radiation measurements lab is necessary.
- A fluid flow measurements lab is highly desirable.
- A materials lab is highly desirable.

Health Physicists

- They are responsible for monitoring the radiation levels everywhere inside and outside the plant.
- HP's must have a 4-year college degree.
- They take courses in physics, chemistry, biology, and mathematics including statistics.

Health Physicists (cont.)

- They must understand the operation of dosimetry instruments and be able to interpret the results of measurements correctly.
- They must implement and obey the ALARA principle.

ALARA

- The exposure to radiation must be:
- As
- Low
- As
- Reasonably
- Achievable

ALARA

- It is not enough to stay under the maximum allowed regulatory exposure limits.
- Every (reasonable) effort must be made to minimize the exposure.

Effect of ALARA

- Primarily as a result of ALARA, the exposure to radiation workers has been cut to $\frac{1}{2}$ of what it was in the 70's.
- {exposure is well below the regulatory limit of 50 mSv/year (5 rem); actual exposure in PWR's today is ~ 2 mSv (200 mrem)}

Technicians

- Most technicians have a 2-year college education beyond High school and appropriate training on the tasks they are assigned to perform

Radioactive waste (LLW)

- Every activity that utilizes ionizing radiation produces LLW.
- Examples of LLW: contaminated clothes, tools, oils, old sources etc
- In general, LLW is stored at the plant for a period of time and then is shipped to a LLW disposal site.

Summary

- A successful nuclear industry relies on well educated and trained personnel.
- Nuclear industry personnel must have a sound science and engineering foundation.
- Must also be instilled and understand their responsibility for the safe operation of the plant.