# Chemical Engineering 374

## Nuclear Reactor Design and Analysis

Design, Licensing



Face the future with optimism. I believe we are standing on the threshold of a new era of growth, prosperity, and abundance. Barring a calamity or unexpected international crisis, I think the next few years will bring a resurgence in the economy as new discoveries are made in communication, *medicine*, *energy*, *transportation*, physics, *computer technology*, and *other fields* of endeavor.

Many of these discoveries, as in the past, will be **the result of the Spirit whispering insights into and enlightening the minds of truth-seeking individuals**. Many of these discoveries will be made for the purpose of helping to bring to pass the purposes and work of God and the quickening of the building of His kingdom on earth today. With these discoveries and advances will come new employment opportunities and prosperity <u>for those who work</u> <u>hard and especially to those who strive to keep the commandments of God</u>. This has been the case in other significant periods of national and international economic growth.

> -Elder M. Russell Ballard BYU Idaho Commencement Remarks April 6, 2012



#### Safety Requirements

- Once functional requirements are completed
- Additional requirements:
  - Operational safety
  - Accident safety
  - "What-ifs"
- Generally can be added to functional requirements



#### Example – Table Saw

• Functional Design Requirements?

Modes of Operation?



#### Table Saw Safety (Accidents)





#### Just Spam Safety?

- Safety requirements can conflict!
  - Example: three mile island
    - LOCA vs. overfill
- Cost
  - Money
  - Time
  - AP1000





#### **Class Project Decisions**

## What are you going to design?



## **Design Options**

- Active vs passive flow?
- Core outlet Temperature?
- High vs. Low pressure
- Corrosion? Protection?
- Integral or Loop?
- Baseload or Load-Follow?
- Test or Prototype?
- Licensing Basis?



### Licensing I

- Atomic Energy Act of 1946/1954 as amended
  - Fundamental organizational framework and statutory standards
  - Licensing processes all within Atomic Energy Commission
- Price-Anderson Act
  - Creates \$12.6B (as of 2011) industry-funded liability insurance
  - > \$12.6B covered by retroactive fees on industry or by feds
- Energy Reorganization Act of 1974
  - Split the weapons, energy, and regulation responsibilities.
  - DOE has energy- and weapons-related responsibilities. NRC has civilian regulatory responsibilities.
  - Established NRC structure and, through amendments, protection for employees who voice concerns.
- Reorganization Plans of 1970 & 1980
  - 1970 created EPA with broad oversight



 – 1980 – gave NRC chair broad powers in emergencies (after Three-mile Island Accident)

## Licensing II

• Two pathways:



- Old licensing pathway, 10 CFR part 50
- New licensing pathway, 10 CFR part 52
- Can actually pick which path to take
- Heavily geared towards LWR
- NRC interpretation of 50 & 52 is where complexity arises:
  - How to comply?



- How to PROVE you comply?

## 10 CFR part 50

- Required separate licenses for siting/design and operation
- The old licensing process was widely blamed as a major factor in the collapse of nuclear power in the U.S.
- It has now been "repaired"? by changes in law and regulatory policy.
- Deterministic



## 10 CFR 52

- Single COL
- Risk informed (rather than risk based)
  - Probabilistic risk assessment
  - Eliminate deterministic where available
- Still geared towards LWRs
- Still complicated by NRC interpretation
- Allowed for first 4 new reactors in a decade to be build





#### 10 CFR 53?

- <u>https://www.nrc.gov/reactors/new-</u> <u>reactors/advanced/modernizing/rulemakin</u> <u>g-and-guidance/part-53.html</u>
- NRC didn't meet time deadline
- Process was LONGER and MORE expensive than previous pathways



#### Next Lecture (1/12)

- OpenMC primer
  - Taught by Braden Clayton
  - Not full OpenMC experience
  - Learn files, modify existing, etc.
- OpenMC must be installed before class
- Link to installation guides on homework page, and here:
- <u>https://www.et.byu.edu/~mjm82/che612/Winter2024/Homework/OpenMC\_In</u> <u>stallation\_Guide.pdf</u>
- <u>https://youtu.be/18srwjXrwnE</u>

