Statistics and Risk in the Nuclear Industry

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Overview

- Nuclear Power Generators
  - Background information on Nuclear Energy
  - Statistical Considerations
- Reprocessing of Nuclear Waste
  - Probabilistic Safety Assessment
- Conclusion

References

Reading: Wilson, G.T. (2006). Statistics and risk in the nuclear industry. Significance, 3 (2), 59-62.

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Yaneer Bar-Yam. "Concepts: Power Law". New England Complex Systems Institute.

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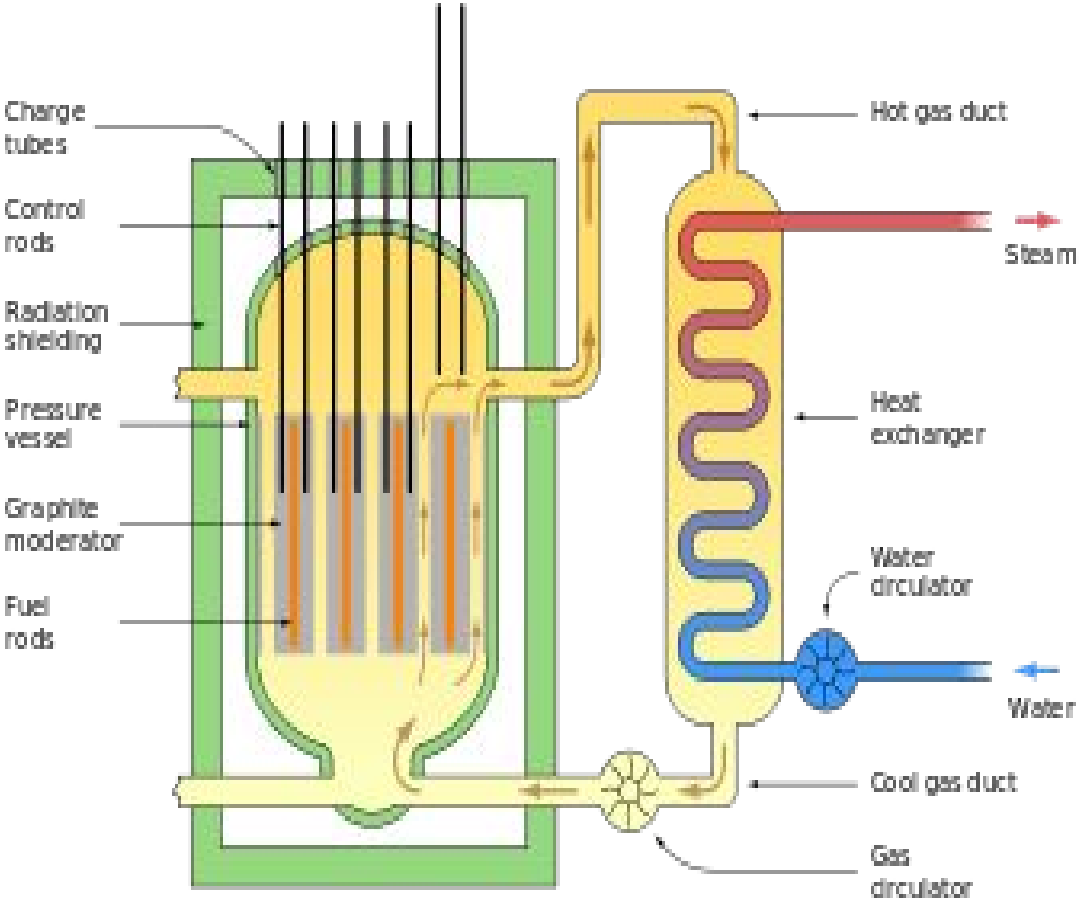
Nuclear Energy

- Production of heat energy through splitting of atoms (Uranium, Thorium, Plutonium etc.)
- Heat is carried away by a gas (CO2 in Magnox reactors)
- Hot gas is used to raise steam and generate electricity
- Sustainable, reduces carbon emissions



- Fuel enters reactor vessel with small neutron source
- Reaction Site: Rods within pressure vessel
- CO2 forced out through channel gas outlets (CGOs) on the reactor's surface at high temperatures

Temperature of CO2 at CGOs

- Key to reactor's performance
- Controlled via manipulation of rods
- Higher temperature = Greater power output over the machine's lifetime ➔ Greater economic advantages

Statistical Considerations

- Expected number of CGO temperatures exceeding 400°C to be less than 0.01
- Known temperatures at only 10% of CGOs (400 out of 4000)

➜ Upper limit of 390°C

However,

- Temperature prone to fluctuations ➜ Distribution may not be uniform across all CGOs
- Hence a need for sophisticated statistical methods to extrapolate data

Statistical Methods

- Power laws

➜ Pareto distribution on the upper tail

- Smoothed temperature measurements: Remove interferences from background signals/noise

Reprocessing of Nuclear Waste

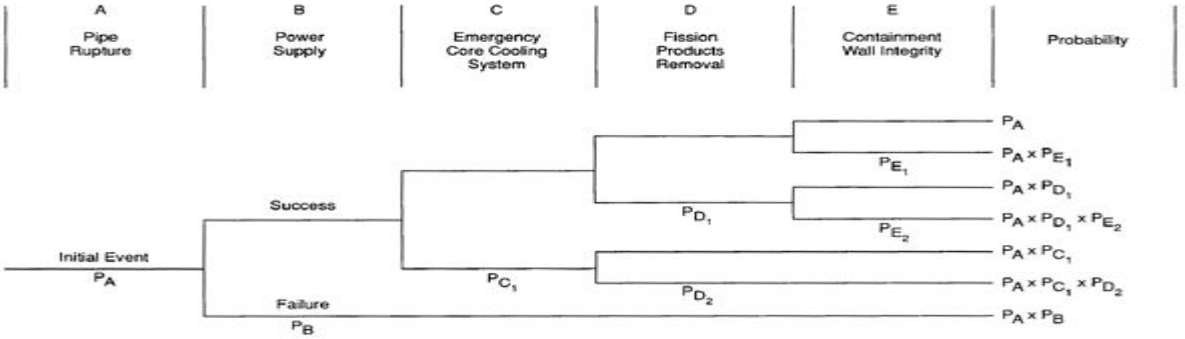
- Separating unspent uranium and manufactured plutonium from waste products for possible use as new fuel
- Theoretical computation vs Instrumental measurements: Statistical tolerance set at ± 0.45%
- Redundancy

❖ Deviations brushed off as outliers or calculation errors

❖ Unable to establish link between deviations and failure within the system

Probabilistic Safety Assessment

- Specialised examination of the system's design along with data synthesis and subjective expert judgement
- Probability diagram of external events and subsequent damage to the system
  ➜ Data prioritised according to set criteria eg. Failure of the system, hazardous levels of emissions etc
- Associated weaknesses are then subsequently addressed



Conclusion

- Textbook methods may sometimes not be good enough
- Experienced-based judgements incorporated with statistics for a more rigorous safety criteria
- Lingering problems in objective risk assessment:

❖ Failure events are rare

❖ Commercial pressures

Thank You!