THE NATIONAL COUNCIL OF EXAMINERS FOR ENGINEERING AND SURVEYING
PRINCIPLES AND PRACTICE OF ENGINEERING EXAMINATION

NUCLEAR

EFFECTIVE October 2004

Approximate Percentage of Examination

I. Nuclear Power Systems **30%**

A. Nuclear Engineering Science 17.5%

1. Reactor core analysis (e.g., neutron balance, diffusion calculations, fuel depletion, transient analysis, neutron reflection)
2. Reactor safety analysis (e.g., LOCA, transient thermal-hydraulic behavior, fuel-clad mechanical interactions, chemical interactions)
3. Energy release from nuclear processes (e.g., fission, fission product decay, neutron capture, prompt gamma)
4. Thermal-hydraulic analysis (e.g., heat transfer, fluid dynamics, natural circulation, critical heat flux, departure from nucleate boiling [DNB], peak centerline temperature, peak clad temperature, hot channel factor, flow oscillations)
5. Probabilistic risk assessment (PRA) (e.g., fault-tree and event-tree analysis, minimum cut sets, probability distribution functions and cumulative distribution functions, level 1-core damage, level 2-containment response, level 3-environmental effects, Bayesian statistics, common-cause failures, initiating & failure data collection and analysis, human reliability analysis, shutdown/low power, external events [e.g., floods, seismic events], quantitative risk analysis [QRA])
6. Energy generation and conversion (e.g., power cycle thermodynamics)
7. Materials (e.g., thermophysical and neutronic properties, performance, characteristics, coolants)
8. Water chemistry (e.g., corrosion control, soluble poison, radiolysis)
9. Interpretation of data from experimental measurements of key parameters in the power system (e.g., heat transfer coefficients, friction factors, power distributions, void fractions)
10. Mathematical modeling of systems and components (e.g., conservation of mass, energy and momentum; closure relationships; radiation transport)
11. Severe accident analysis (e.g., MELCOR, degraded core performance)
12. Reliability analysis (e.g., fault trees, reliability block diagrams, single failure analysis, failure modes and effects analysis [FMEA], parts count analysis [PCA], stress margin analysis, critical software reliability analysis)

B. Components and Systems 10%

1. Nuclear steam supply system (NSSS) (e.g., control rod drive mechanisms, reactors, steam generators, coolant pumps, pressurizers, natural circulation)
2. Balance of plant (BOP) (e.g., heat exchangers, valves, instrumentation and control systems)
3. Emergency core cooling systems (e.g., high-pressure injection, low-pressure injection, accumulators, emergency power, passive safety)
4. Containment systems (e.g., ice condensers, pressure suppression, containment spray, control of radionuclides, hydrogen control)
5. Mechanical and hydraulic systems (e.g., strength of materials, stress, strain, pump and turbomachinery performance, fluid-structure interactions, shock and vibration, fatigue)

6. Systems integration and interfaces (e.g., integrated plant behavior, systems interactions, coupling and feedback, steam generator level response to throttle valve, thermodynamics of a pressurizer)

C. Constructs 2.5%

1. Operational regulations (e.g., technical specifications, federal regulations [10 CFR parts 20, 50,100], plant manuals, SAR, EIS, nuclear regulatory guides and QA/QC)
2. Emergency plans (e.g., criticality alarm systems, evacuation, exclusion zone)
3. Licensing regulations (e.g., 10 CFR parts 50, 51, 52, 54, 100)
4. Codes and standards (e.g., ASME pressure vessel, ANSI/ANS)

II. Nuclear Fuel and Waste Management 17.5%

A. Nuclear Fuel 11.25%

1. Material balance (e.g., fuel enrichment)
2. Fuel design (e.g., fissile enrichment, chemical form, accommodation for fission gas release)
3. Cladding (e.g., integrity, corrosion, strength, chemical composition, neutron cross section)
4. Depletion, burnup, buildup, and source terms (e.g., transuranics, fission products, spent fuel assay)
5. Special nuclear material (SNM) regulations and licenses (e.g., 10 CFR part 70, IAEA safeguards)

B. Nuclear Waste Handling, Shipping, Treatment and Disposal 6.25%

1. Radioactive materials handling safety (dose rate, contamination, shielding)
2. Transport and storage cask design (e.g., Safety Analysis Report for Packaging [SARP], criticality, shielding, cooling, structural damage)
3. Radiological waste disposal
4. Radioactive materials storage (e.g., spent fuel)

III. Nuclear Radiation Protection/Radiation Shielding/Interaction of Radiation with Matter 20%

A. Protection 5%

1. Radioactive material control and monitoring (e.g., controlled areas, decontamination of clothing, handheld instrumentation, in-situ monitoring, inventory and accountability, Unaccounted Material [MUF])
2. Dose assessment and personal safety (e.g., biological effects, quality factors, acute radiation effects, chronic radiation effects)
3. Regulatory compliance (e.g., 10 CFR part 20)

B. Shielding 3.75%

1. Streaming (e.g., preferential radiation transport through penetrations, ducts, skyshine)
2. Shield materials, shape and orientation (e.g., High Z, Low Z, neutron absorbers)
3. Interaction coefficients (e.g., μa, μtr, μen)

C. Interaction of Radiation with Matter 11.25%

1. Interaction of photons with matter (e.g., Compton scattering, pair production, photoelectric effect)
2. Nuclear reaction rates (e.g., capture, scattering, charged particle production, neutron production)
3. Neutron transport (e.g., flux, current, scattering, absorption, streaming, anisotropy)

4. Energy deposition (e.g., local, distributed, thermal analysis of shields, charcoal heating)
5. Buildup factors (e.g., correction factors, energy flux)

IV. Nuclear Criticality/Kinetics/Neutronics 20%

A. Nuclear Criticality 5%

1. Analysis of critical systems (e.g., neutron balance, neutron reflection, leakage, combination of uncertainties)
2. Analysis of subcritical systems (e.g., neutron sources, neutron balance, neutron reflection, leakage)
3. Minimum critical mass (e.g., different fissile materials, bare and reflected, H/U ratio)
4. Lessons learned from case histories (e.g., SL-1, Tokai-mura, Chernobyl)

B. Kinetics 5%

1. Point kinetics (e.g., keff, beta, fission spectrum, reactivity, neutron lifetime, prompt critical and delayed critical)
2. Delayed neutrons (e.g., beta, energy spectrum)
3. Fission product poisoning (e.g., Xenon, Samarium)
4. Reactivity coefficients (e.g., temperature, power, Doppler, void)
5. Spatially dependent kinetics (e.g., Xenon oscillations, local control rod effects, impact of local detectors)

C. Neutronics 10%

1. Multidimensional analysis codes and methods (e.g., Monte Carlo, confidence intervals, deterministic)
2. Effects of strong absorbers (e.g., control rod worth, burnable poisons, self-shielding)
3. Reactivity calculations (e.g., rod drop, ATWS, differential rod worth, depletion effects)
4. Neutron transport (e.g., multigroup transport, approximations: Fick's Law, diffusion approximation, diffusion coefficients)
5. Cross sections (including macroscopic and microscopic, atomic number densities, inelastic scattering, elastic scattering, absorption, transport, fission, anisotropic effects, energy collapsing)
6. Slowing down and thermalization (e.g., lethargy, scattering kernels, logarithmic energy decrement, S [alpha, beta], Gaussian, resonance capture, Doppler broadening, unresolved resonances, 1/v behavior)
7. Characterization of neutron spectra (e.g., fast and thermal reactors, spectral shift, moderator effectiveness)
8. Chart of the nuclides (e.g., transformations, radioactive decay, energy release, half lives, fission yields, branching intensities)

V. Nuclear Measurements and Instruments 12.5%

A. Nuclear Measurements 10%

1. Radiation detection (e.g., types of detectors, types of radiation and detector selection, detector sensitivity, charge multiplication)
2. Gas-filled detectors (e.g., ionization chambers, proportional counters, G-M tubes)
3. Solid-state detectors (e.g., track detectors, thermoluminescent detectors, spectroscopy, scintillation detectors, intrinsic germanium and silicon detectors)
4. Neutron detectors (e.g., BF3, fission chambers, He-3, activation detectors and foils, Bonner spheres, in-core detectors)
5. Dosimetry (e.g., calibration, TLD, film)
6. Counting statistics (e.g., error propagation, deadtime analysis, standard deviation, LLD)

7. Treatment of measurement uncertainties in reactor protection and safety systems
8. Neutron activation analysis

B. Instruments 2.5%

1. Nuclear instrumentation and control (e.g., power meters, neutron source range, power range, intermediate range, rate circuits, coincidence circuits, interlocks and permissives, digital I & C)
2. Non-nuclear process instrumentation and control (e.g., pressure and temperature sensors, flow meters, thermocouples, interlocks and permissives)

Total 100%

Notes

1. The knowledge areas specified under A., B., C., etc., are examples of kinds of knowledge, but they are not exclusive or exhaustive categories.
2. This examination contains 80 multiple-choice questions. Examinee works all questions.