NCEES
advancing licensure for engineers and surveyors

NCEES Principles and Practice of Engineering Examination
NUCLEAR Exam Specifications

Effective Beginning with the October 2012 Examinations

- The exam is an 8-hour open-book exam. It contains 40 multiple-choice questions in the 4-hour morning session, and 40 multiple-choice questions in the 4-hour afternoon session. Examinee works all questions.
- The exam uses both the International System of units (SI) and the US Customary System (USCS).
- The exam is developed with questions that will require a variety of approaches and methodologies, including design, analysis, and application.
- The knowledge areas specified as examples of kinds of knowledge are not exclusive or exhaustive categories.

	Approximate Number of Questions
I. Nuclear Power Systems	**28**
A. Design and Analysis	16

1. Energy generation and conversion
2. Application and interpretation of data from experimental measurements of key parameters in the power system (e.g., heat transfer, fluid mechanics, power distributions, void fractions, scaling)
3. Applications of conservation of mass, energy, and momentum
4. Probabilistic risk assessment (PRA) (e.g., fault trees and event trees, probability distribution functions and cumulative distribution functions, quantitative risk analysis [QRA])
5. Reactor safety analysis (e.g., LOCA, transient thermal-hydraulic behavior, fuel-clad mechanical interactions, chemical interactions)
6. Reliability analysis (e.g., reliability block diagram analysis, single failure analysis, failure modes and effects analysis [FMEA], parts count analysis [PCA], stress margin analysis)
7. Severe accident analysis (e.g., degraded core, combustible gas control, radiolysis, zirconium water reaction)
8. Systems interactions (e.g., integrated plant behavior, coupling and feedback, steam generator level response to throttle valve)
9. Thermal-hydraulic analysis (e.g., heat transfer, fluid dynamics, thermodynamics, natural circulation, critical heat flux, departure from nucleate boiling [DNB], peak centerline temperature, peak clad temperature, hot channel factor, flow oscillations)
10. Engineering decision making (e.g., cost/benefit analysis, environmental impact, economics, ALARA, alternatives analysis)
11. Treatment of measurement uncertainties in reactor protection and safety systems (e.g., error analysis)

B. Components and Systems — 10

1. Power conversion systems (e.g., turbines, heat exchangers, reactor, steam generator, pressurizer, steam dryers and separators)
2. Containment systems (e.g., ice condensers, pressure suppression, containment spray, control of radionuclides, hydrogen control)
3. Emergency core cooling systems (e.g., high-pressure injection, low-pressure injection, accumulators, emergency power, passive safety)
4. Materials (e.g., thermophysical and neutronic properties, performance characteristics)
5. Mechanical and hydraulic systems (e.g., pump and turbomachinery performance, fluid-structure interactions)
6. Instrumentation and control (e.g., pressure and temperature sensors, flow meters, interlocks and permissives, power meters, coincidence circuits)
7. Nuclear Steam Supply System (NSSS) water chemistry (e.g., corrosion control, soluble poison)

C. Regulations, Codes, and Standards — 2

1. Codes and standards (e.g., interpretation of excerpts of ASME pressure vessel, ANSI/ANS to a given situation)
2. Regulations and regulatory guidance (e.g., interpretation of excerpts of 10 CFR parts 21, 50, 51, 52, 54, 72, 100, NRC Regulatory Guides to a given situation)
3. Licensing documentation scope (e.g., interpretation of excerpts of Technical Specifications, Safety Analysis Report [SAR], Environmental Impact Study [EIS] to a given situation)

II. Nuclear Fuel Cycle — 12

A. Fuel Design and Analysis — 10

1. Cladding (e.g., integrity, corrosion, strength, chemical composition, neutron cross section)
2. Depletion, burnup, and transmutation (e.g., transuranics, fission products, spent fuel assay)
3. Fuel cycle processes (e.g., material balance, fuel enrichment, SWU, tails assay)
4. Fuel bundle design (e.g., fissile enrichment, chemical form, accommodation for fission gas release, materials behavior, thermal hydraulic analysis)
5. Conversion and enrichment processes (e.g., uranium chemistry, gaseous diffusion)

B. Handling, Shipping, and Storage — 2

1. Nuclear material accountability and control (e.g., inventory and accountability, Material Unaccounted For [MUF], special nuclear material [SNM] regulations)
2. Radioactive materials storage (e.g., spent fuel pool, independent spent fuel storage installation [ISFSI])
3. Transport and storage cask design (e.g., Safety Analysis Report for Packaging [SARP], criticality, shielding, cooling, structural integrity)

III. Interaction of Radiation with Matter — 20

A. Analysis — 16

1. Buildup factors (e.g., correction factors, energy flux)
2. Chart of the nuclides (e.g., radioactive decay, energy release, half lives, branching, neutron activation)
3. Counting statistics (e.g., error propagation, deadtime analysis, standard deviation, lower limit of detection [LLD])
4. Energy deposition (e.g., local, distributed, thermal analysis of shields, charcoal heating)
5. Interaction coefficients (e.g., μ_a, μ_{tr}, μ_e)
6. Interaction of photons with matter (e.g., interaction coefficients [μ_a, μ_{tr}, μ_e], Compton scattering, pair production, photoelectric effect)
7. Radiation effects on materials (e.g., swelling, creep, radiolytic decomposition, embrittlement)
8. Neutron activation analysis
9. Neutron transport (e.g., flux, current, scattering, absorption, streaming)
10. Nuclear reaction rates (e.g., capture, scattering, charged particle, neutron production)
11. Shield design (e.g., materials, shape and orientation, High Z, Low Z, neutron absorbers, streaming, skyshine)
12. Source terms (e.g., transuranics, fission products, spent fuel, coolant, radwaste)

B. Protection — 4

1. Dose assessment and personnel safety (e.g., biological effects, quality factors, acute radiation effects, chronic radiation effects)
2. Dosimetry (e.g., calibration, thermoluminescent dosimeter [TLD], film)
3. Emergency plans (e.g., criticality alarm systems, evacuation, exclusion zone, emergency declarations)
4. Radiation detection (e.g., types, selection, detector sensitivity, charge multiplication)
5. Radioactive material monitoring (e.g., controlled areas, in-situ monitoring)
6. Regulatory requirements (e.g., interpretations of excerpts of 10 CFR part 20 to a given situation)

IV. Nuclear Criticality/Kinetics/Neutronics — 20

A. Criticality — 5

1. Criticality analysis (e.g., neutron balance, neutron reflection, leakage, combination of uncertainties, subcritical multiplication)
2. Subcritical systems analysis (e.g., neutron sources, neutron balance, neutron reflection, leakage, new fuel handling)
3. Lessons learned from case histories (e.g., criticality safety practices, double contingency, SL-1, Tokai-mura)
4. Minimum critical mass (e.g., different fissile materials, bare and reflected, H/U ratio)

B. Kinetics — 5

1. Delayed neutrons (e.g., beta, energy spectrum)
2. Fission product poisoning (e.g., xenon, samarium)

3. Point kinetics (e.g., k_{eff}, delayed neutron fraction, fission spectrum, reactivity, neutron lifetime, prompt critical, delayed critical)
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. Characterization of neutron spectra (e.g., fast and thermal reactors, spectral shift, moderator effectiveness)
2. Chart of the nuclides (e.g., transformations, half lives, fission yields)
3. Cross sections (e.g., macroscopic and microscopic, atomic number densities, inelastic scattering, elastic scattering, absorption, transport, fission, energy collapsing)
4. Effects of strong absorbers (e.g., control rod worth, burnable poisons, self-shielding)
5. Energy release from nuclear processes (e.g., fission, fission product decay, prompt gamma, fusion)
6. Reactor core analysis (e.g., multigroup transport, approximations: Fick's Law, diffusion approximation, diffusion coefficients, perturbation theory, Monte Carlo methods)
7. Reactivity transients (e.g., rod drop, anticipated transient without scram [ATWS], differential rod worth)
8. Slowing down and thermalization (e.g., lethargy, scattering kernels, logarithmic energy decrement, Maxwellian distribution, resonance capture, Doppler broadening, unresolved resonances, 1/v)