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## *What the NCS World Offers to Young Professionals*

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# What is a Criticality Accident?

- A criticality accident is an unplanned nuclear chain reaction outside a reactor.
- It results in a sudden release of radiation that has a lethal radius of about 15 feet.
- There have been 22 process criticality accidents reported in the world
  - ▶ 21 have occurred in solutions or slurries
  - ▶ 1 occurred with metal ingots
  - ▶ 18 were in unshielded and manned facilities
  - ▶ 9 fatalities resulted
  - ▶ 3 survivors lost limbs

## Common Questions

- Who has degree in Nuclear Criticality Safety?
- Do you have to have a Nuclear Engineering degree?
  - ▶ No, some of the best did not
  - ▶ About 1/3 of our staff does not
- What college classes should you have?
  - ▶ Nuclear Reactor Analysis is recommended
  - ▶ Chemistry and physics
  - ▶ Various engineering courses (fluid dynamics, materials, electrical, etc.) are helpful

# Common Questions

- How do you learn to be a NCS engineer?
  - OJT (On the Job Training)
    - Deskwork
      - Facility Safety Analyses and procedures
      - Regulatory documents and guides
      - ANSI/ANS-8 Standards
    - Footwork
      - Walking down processes
      - Talking to operators
      - Conducting audits and inspections

# Common Questions

- How do you learn to be a NCS engineer?
  - Professional Development
    - Technical conferences like this one
    - Writing technical papers
    - Reviewing technical papers (NCSD Program Committee)
    - Involvement in governance (NCSD Executive Committee)
    - Involvement in outreach (NCSD Education Committee)
    - Working on ANSI/ANS standards writing groups

# Aspects of NCS

- Audits and Inspection
- Code Development
- Code Validation
- Critical Experiments
- Criticality Accident Alarms
- New and revised process design support
- Emergency response support
- Field inspection of safety controls
- Investigation of safety-related incidents
- NCS evaluations of new or revised processes
- NCS evaluation of unusual conditions
- NCS training of emergency responders
- NCS mentorship
- NCS training of operators
- Non-destructive assay
- Peer review of NCS evaluations
- Regulatory interface
- Review of operating procedures
- Shipping container analysis



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# *Nuclear Operations Group Facility*



*Lynchburg, Virginia*

# Types of Processes of Interest to NCS

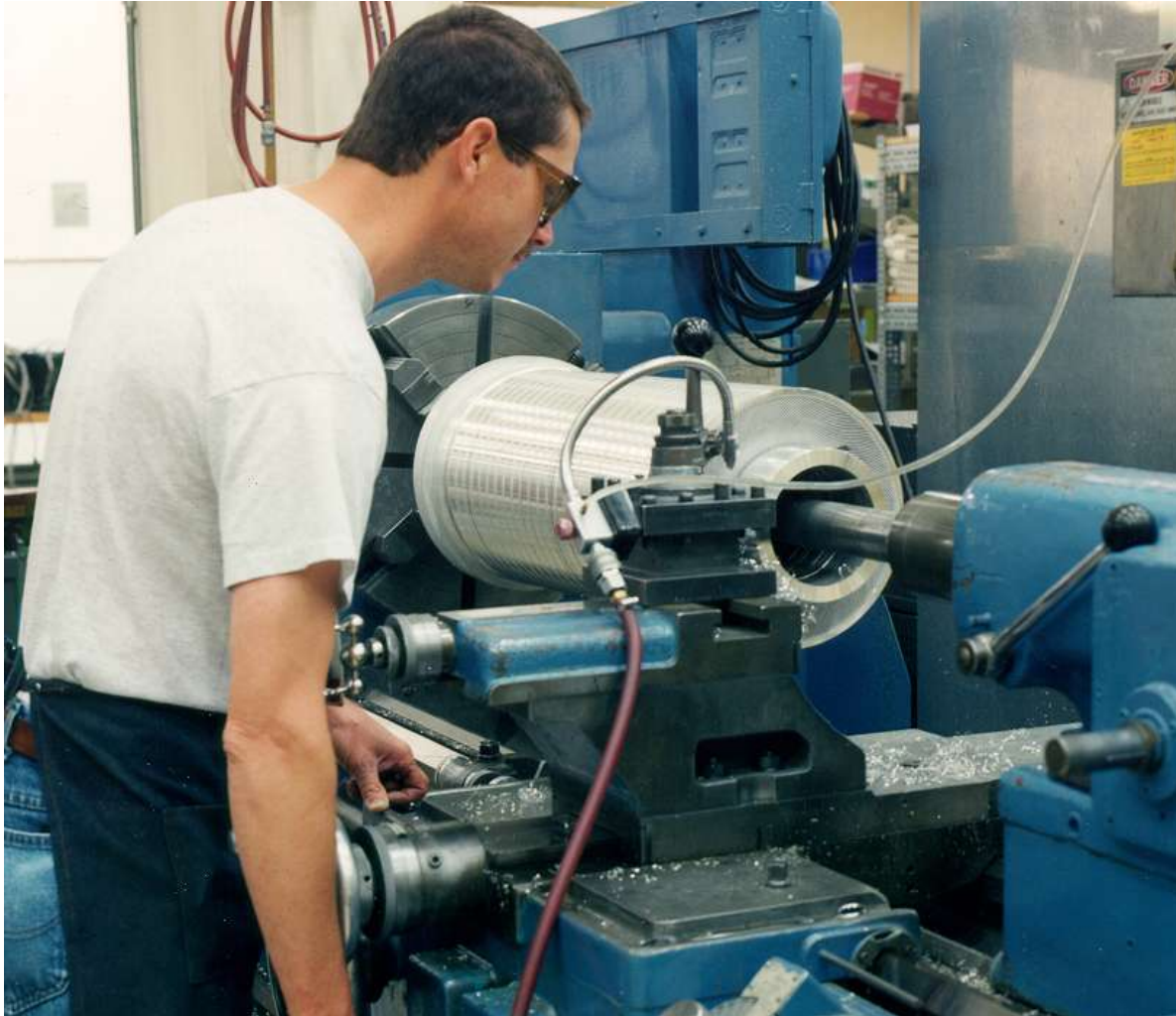
- Processes at NOG-Lynchburg
  - ▶ Receipt and storage of unencapsulated fuel
  - ▶ Processing of solid unencapsulated fuel
  - ▶ Encapsulating of the fuel
  - ▶ Production of assemblies
  - ▶ Shipment of assemblies
  - ▶ Chemical recovery of uranium from scrap material
  - ▶ Production of specialty fuel type like AGR
  - ▶ Some handling of spent fuel in water pits and hot cells
  - ▶ R&D operations
  - ▶ Waste handling and disposal



# Process Knowledge

- Understanding of the manufacturing process
- Understanding how support systems (steam, water and ventilation) interface with the process
- Understanding of uranium chemistry and how it can go wrong (aqueous and organic exchanges)
- Determination of uranium content in containers via NDA
  - Understanding of accuracy and uncertainty in the measurements.

# HFIR Element Machining



# Uranium Recovery Facility





# Uranium Recovery Facility



# Necessary Engineering Knowledge

- Neutronics, both static and dynamic
  - $k_{\text{eff}}$  calculations and excursion analysis
- Radiation transport
  - Criticality accident alarms, hot cell shielding
- Fluid dynamics
  - liquid, steam and ventilation systems
- Chemistry
  - Uranium solutions
- Physics
  - Newtonian and non-Newtonian

# Liberal Arts Knowledge

- English
  - Technical Writing!
- Psychology
  - Understanding how an operator views his work and controls
  - Human nature
- Human Factors
  - What influences the actions of an operator
  - What is the operators expected responses and likelihood of success for different conditions



# Summary

- Is NCS “boring as hell?”
  - ▶ Only if you think it is!
  - ▶ You will have a very good understanding of the entire fuel manufacturing and support processes.
  - ▶ If I didn’t like it, I would not be here.
- Nuclear Criticality Safety is:
  - ▶ “The art and science of not creating a reactor without shielding, coolant and control.”

*F. M. Alcorn*