Draft Certification/Licensing Approaches for High Burnup Spent Fuel

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Overview

- Purpose
- Challenges with Meeting Regulatory Requirements
- Draft Storage Licensing/Certification Approach
- Draft Transportation Certification Approach
- Research and Other Activities

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Purpose

- Develop certification/licensing approaches for high burnup spent fuel storage and transportation applications while on-going research and other activities continue

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High Burnup Fuel – Hydride Reorientation

- At the high drying temperatures, the normally circumferential hydrides in the cladding will go into solution. As the fuel cools down, this soluble hydrogen may precipitate to form radial hydrides.
- When the temperature of the fuel drops below the ductile to brittle transition temperature (DBTT) the radial hydrides provide an additional embrittlement mechanism which may make it difficult to meet Part 71 and 72 with respect to the structural integrity of the fuel.

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Geometric Form – Storage

- Confinement barriers and systems
  - Maintain cladding integrity 10 CFR 72.122(h)
- Retrievability
  - Be able to readily retrieve fuel per 10 CFR 72.122(l)
- Guidance
  - ISG-11, “Cladding Considerations for the Transportation and Storage of Spent Fuel”
  - ISG-2, “Fuel Retrievability”

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Geometric Form – Transport

- Maintain criticality safety, most reactive credible configuration – 10 CFR 71.55(b),(d), and (e)
  - Package contents cannot be substantially altered during NCT - 10 CFR 71.55(d)(2).

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Draft Licensing and Certification Approaches

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Theme for approaches

- We believe that research activities will **confirm** the position that HBF which has undergone the hydride reorientation will **be able to meet** the regulatory requirements necessary for licensing

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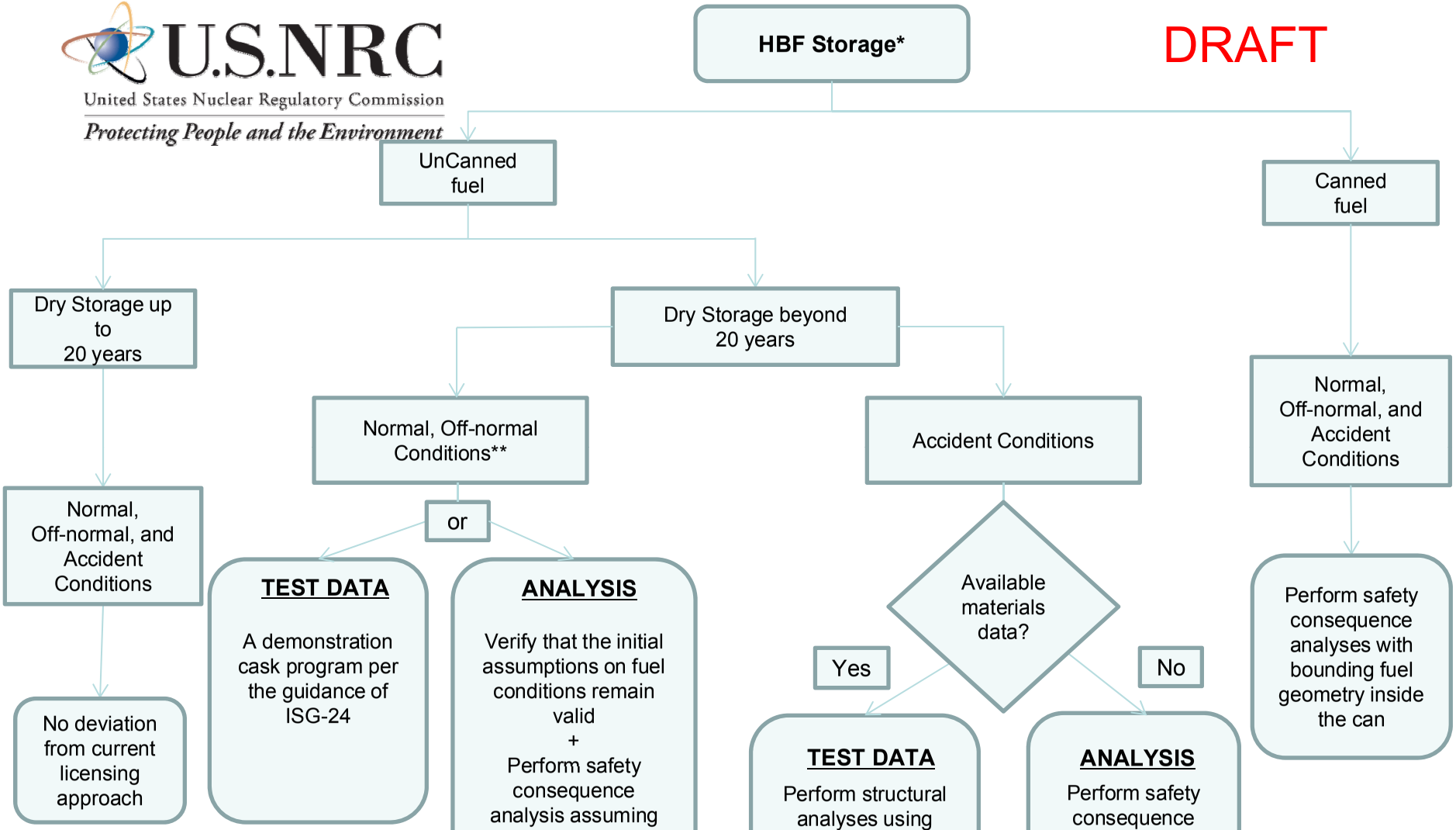

*Aging Management Program(s) is assumed to be an integral part of ISFSI operation to maintain the integrity of the confinement system and hence is not included in the flowchart.

**This strategy is valid provided that results from the demonstration cask as described confirm the original fuel condition licensing assumptions.

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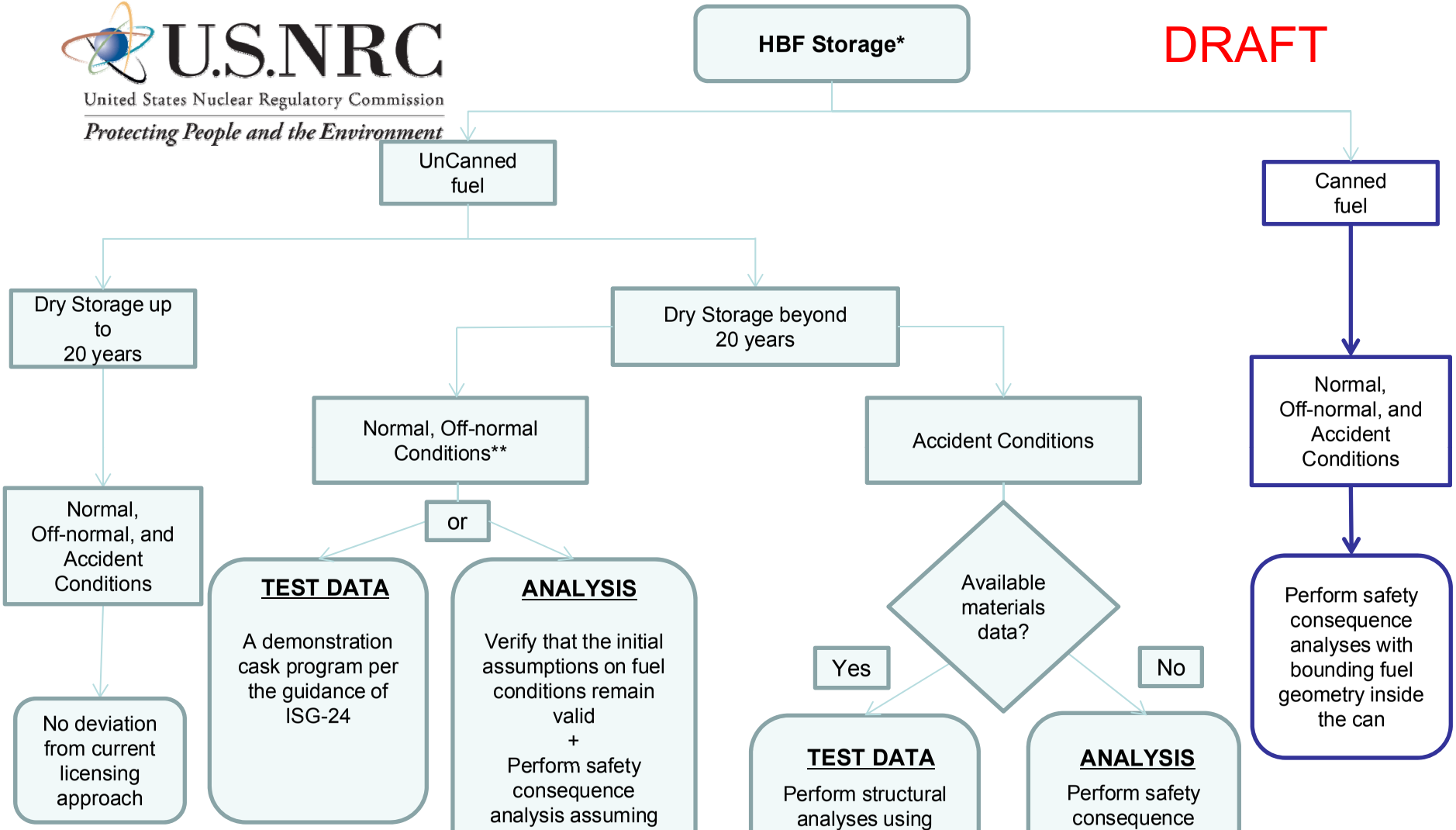

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Canned Fuel

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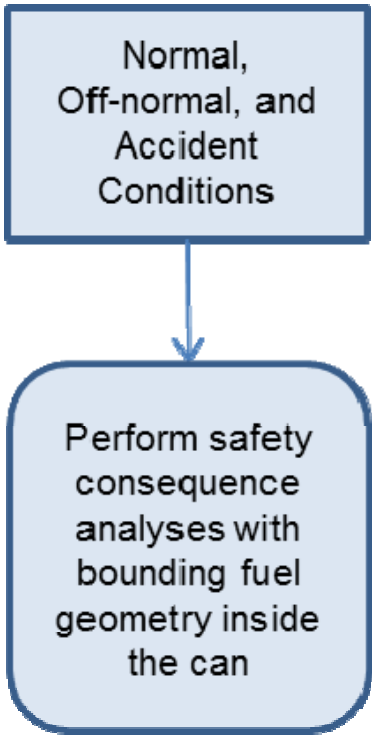

Canned fuel will require safety consequence analyses to be completed with bounding fuel geometry inside the can

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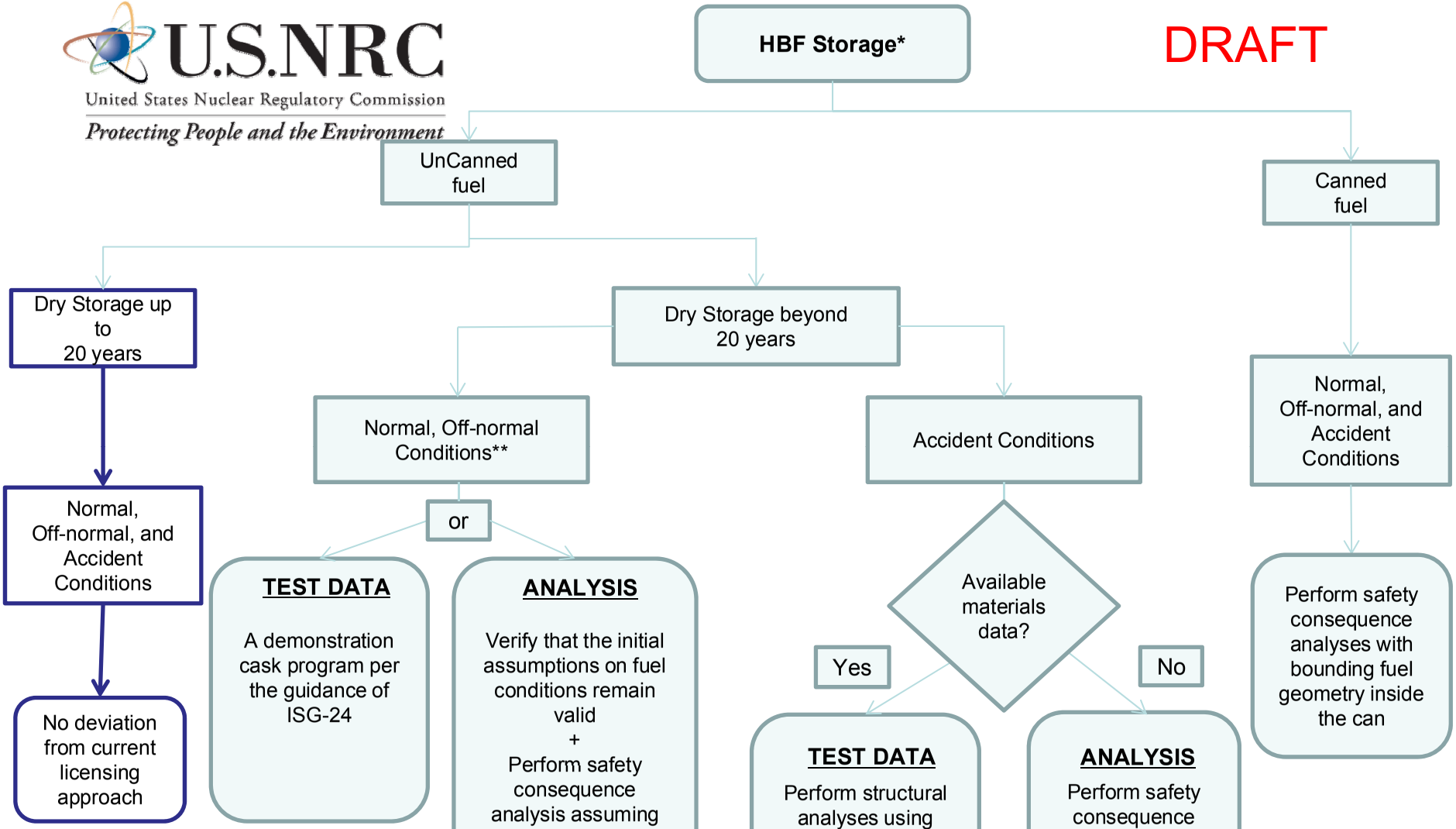

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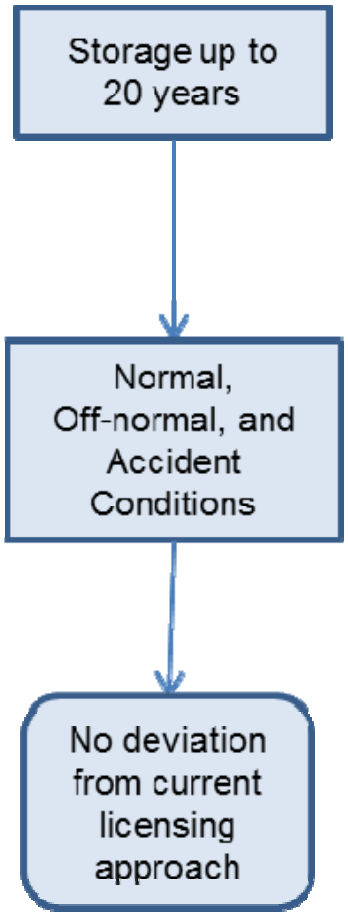
UnCanned Fuel



Fuel that is not canned and will be in dry storage for a period below 20 years will follow the current licensing approach (currently fuel is licensed up to 20 years)

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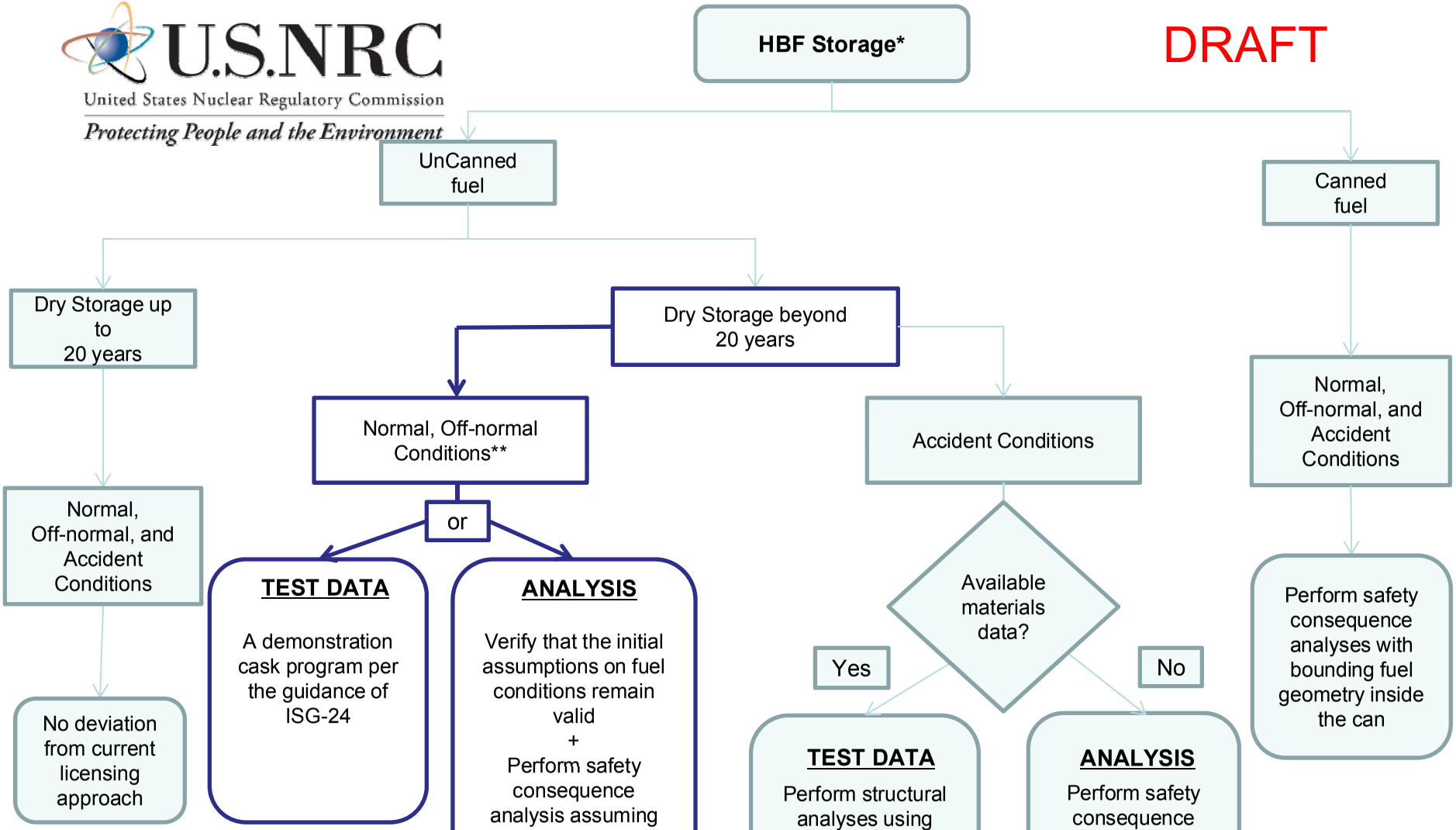

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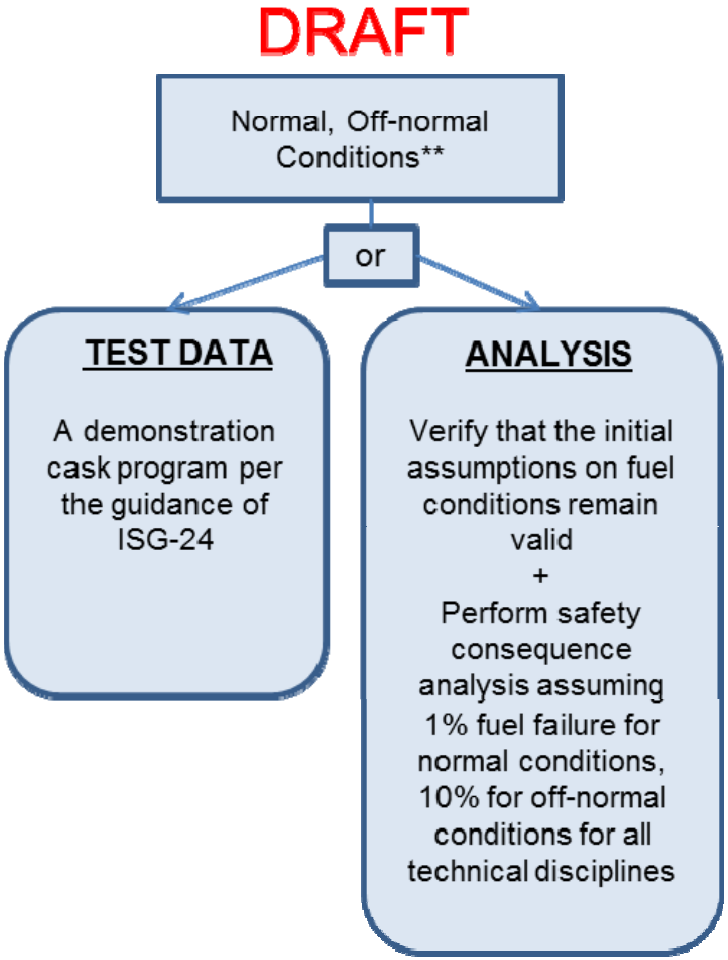
UnCanned Fuel – beyond 20 years, Normal and Off-normal Conditions



- Test Data
  - Relies on ISG-24 guidance to use a cask demonstration as confirmation of integrity for continued dry storage of HBF beyond 20 years
  - The ** highlights that this strategy is valid provided that results from the demonstration cask as described confirm the original fuel condition licensing assumptions
- Analysis
  - Confirmation that initial assumptions on the fuel condition are still valid
  - Consequence analyses assuming 1% and 10% fuel failure
    - Values taken from confinement analysis
    - Previous studies completed regarding fuel failures of all fuel types consider 1% to be a bounding value

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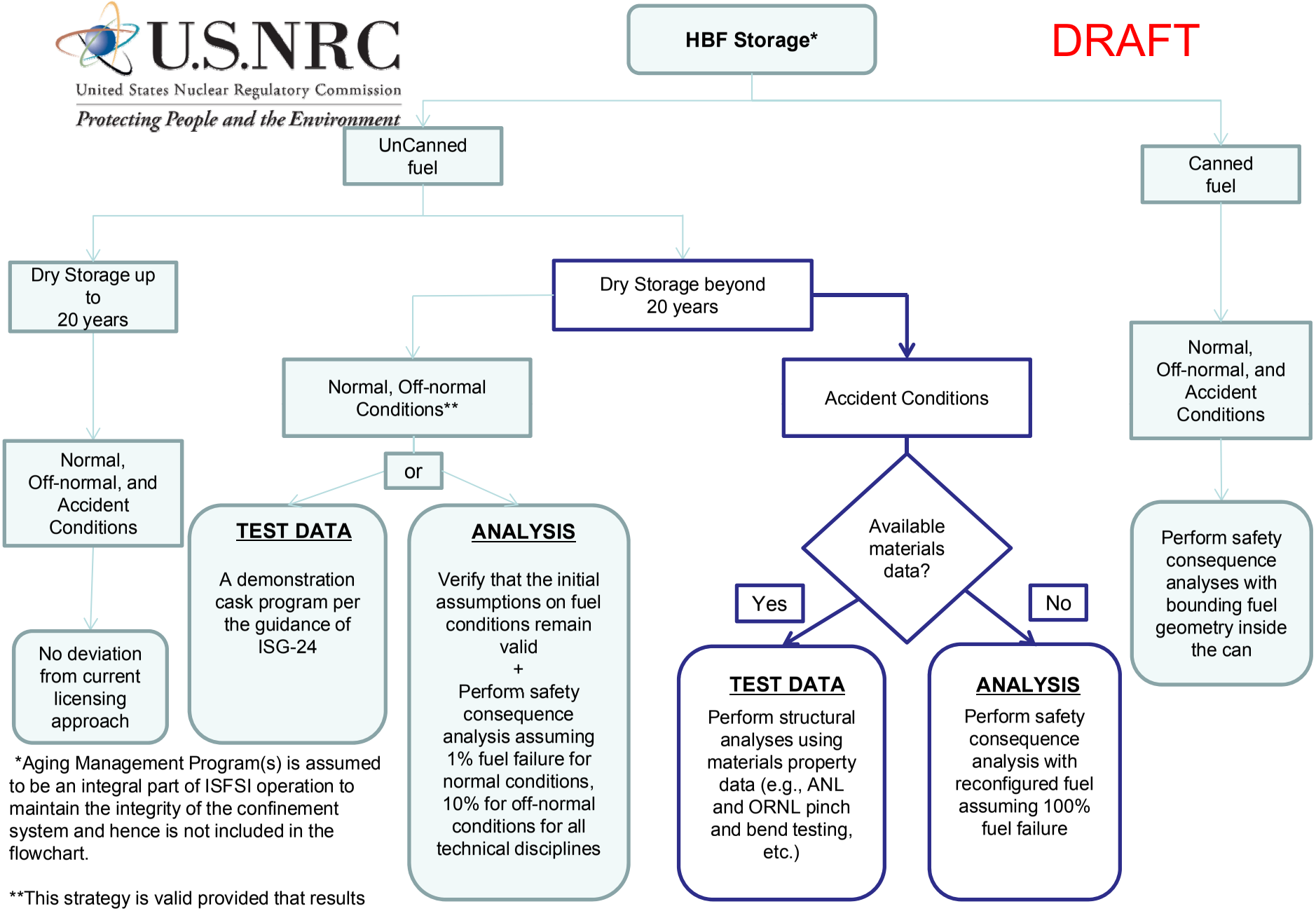

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UnCanned Fuel – beyond 20 years, Accident Conditions

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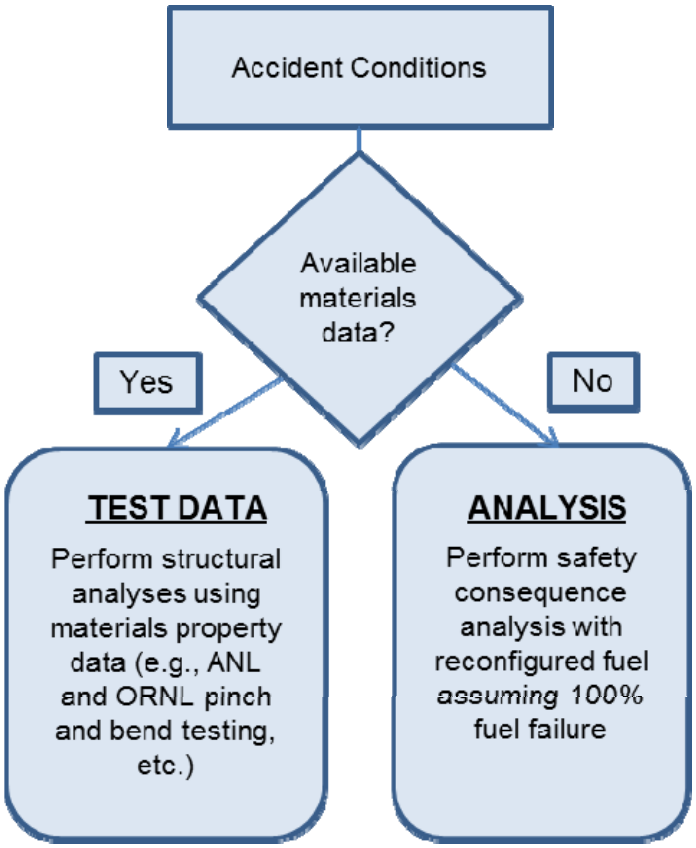

- Test Data
  - Relies on available and applicable cladding materials data
  - Possible data that can be used are results from ANL and ORNL pinch and bend tests, or applicant provides own data
- Analysis
  - Perform consequence analysis assuming 100% fuel failure

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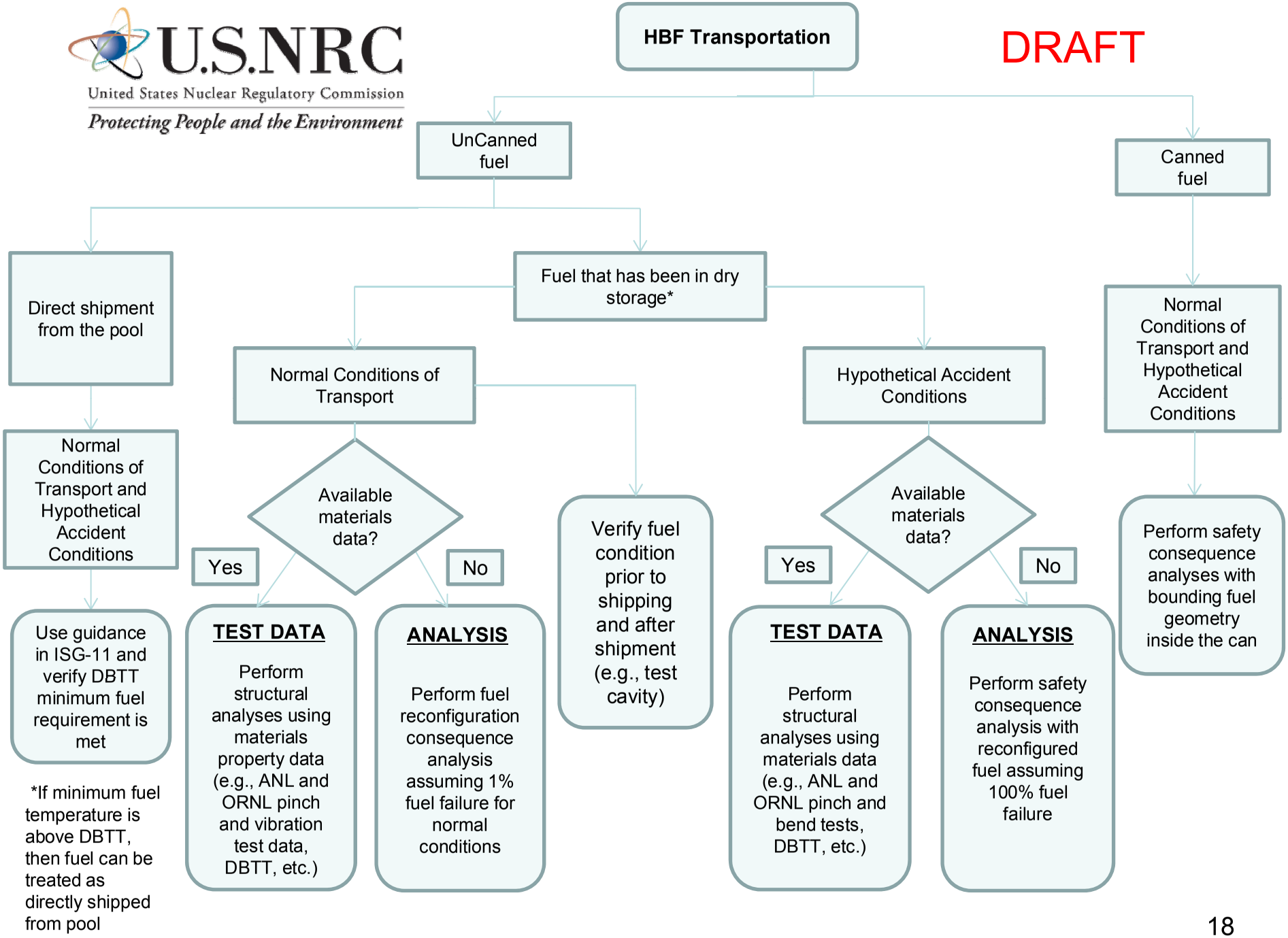

*If minimum fuel temperature is above DBTT, then fuel can be treated as directly shipped from pool

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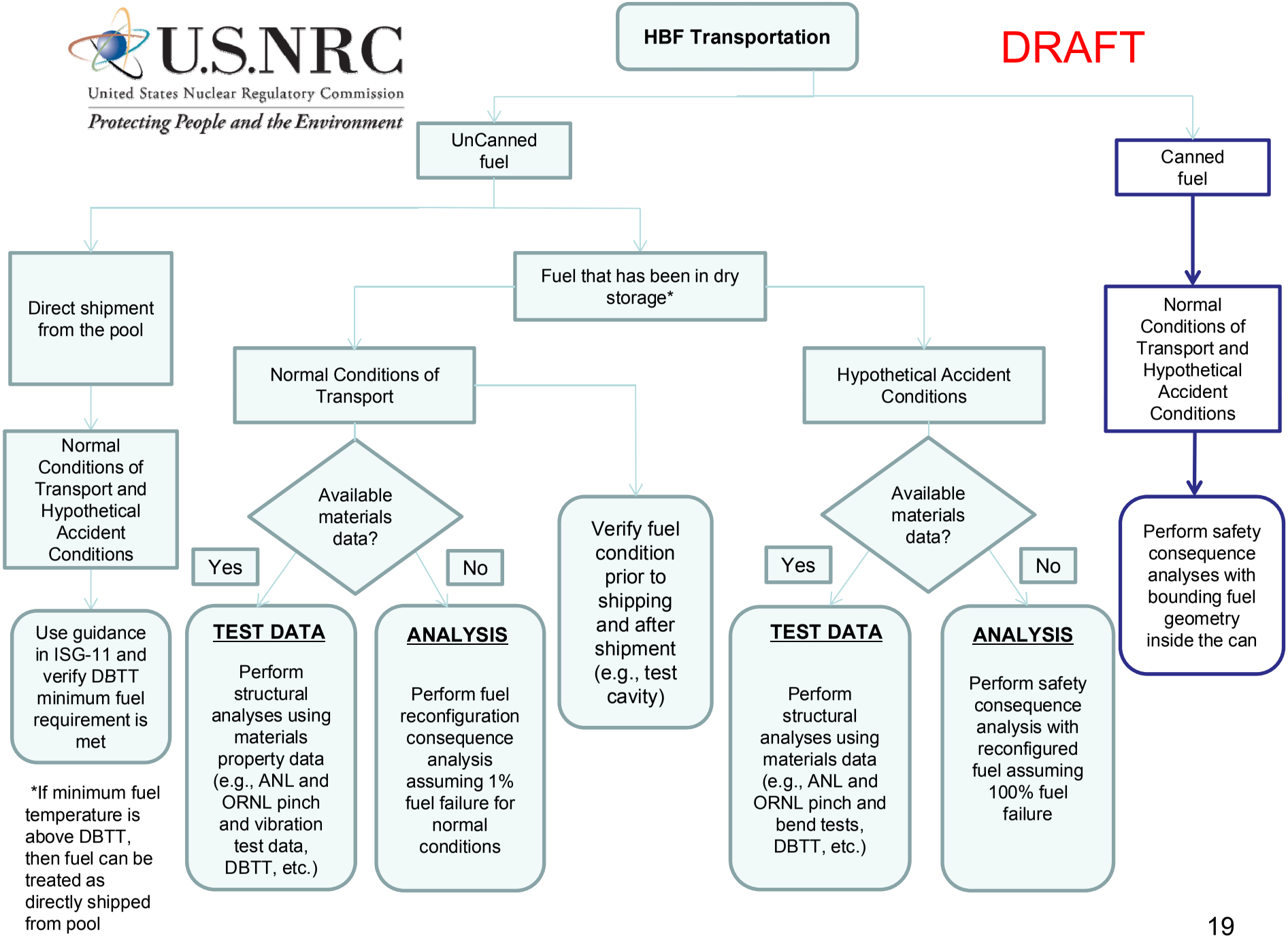

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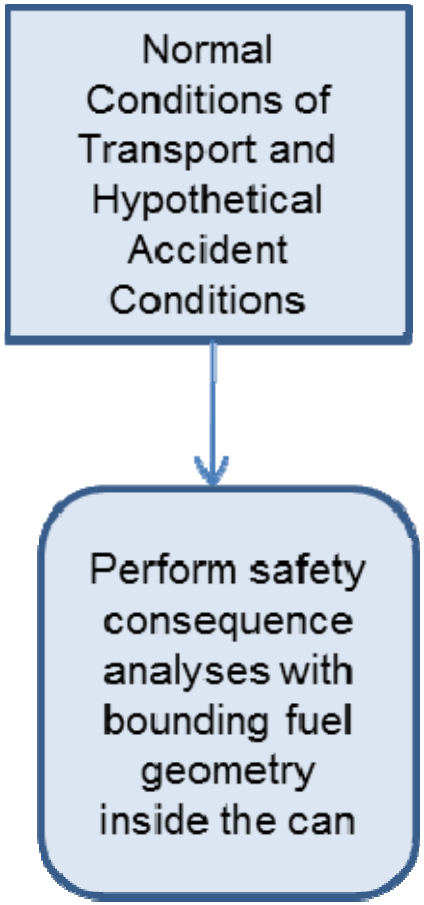
Canned Fuel



Similar to storage, if fuel is canned, safety consequence analyses are performed with bounding fuel geometry inside the can

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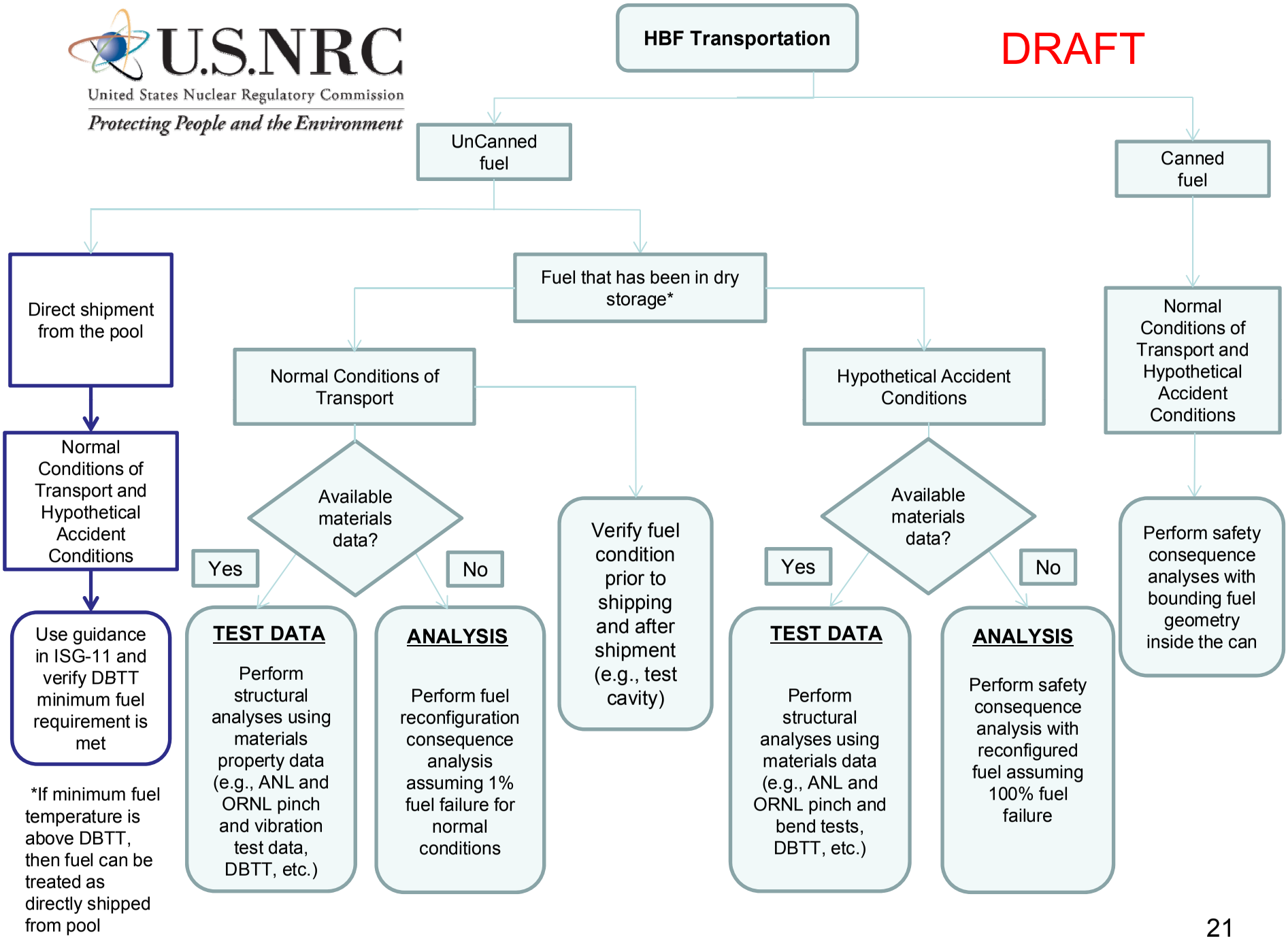

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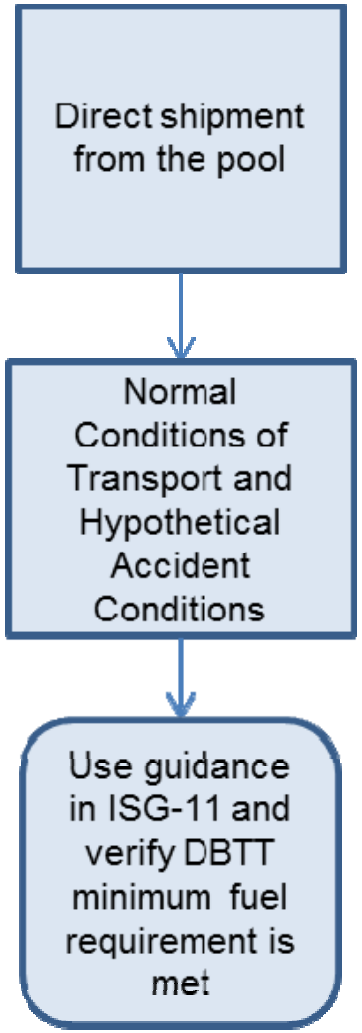
UnCanned Fuel – Directly Shipped from pool



Fuel shipped from the pool must confirm that the minimum fuel DBTT is met and can use guidance in ISG-11

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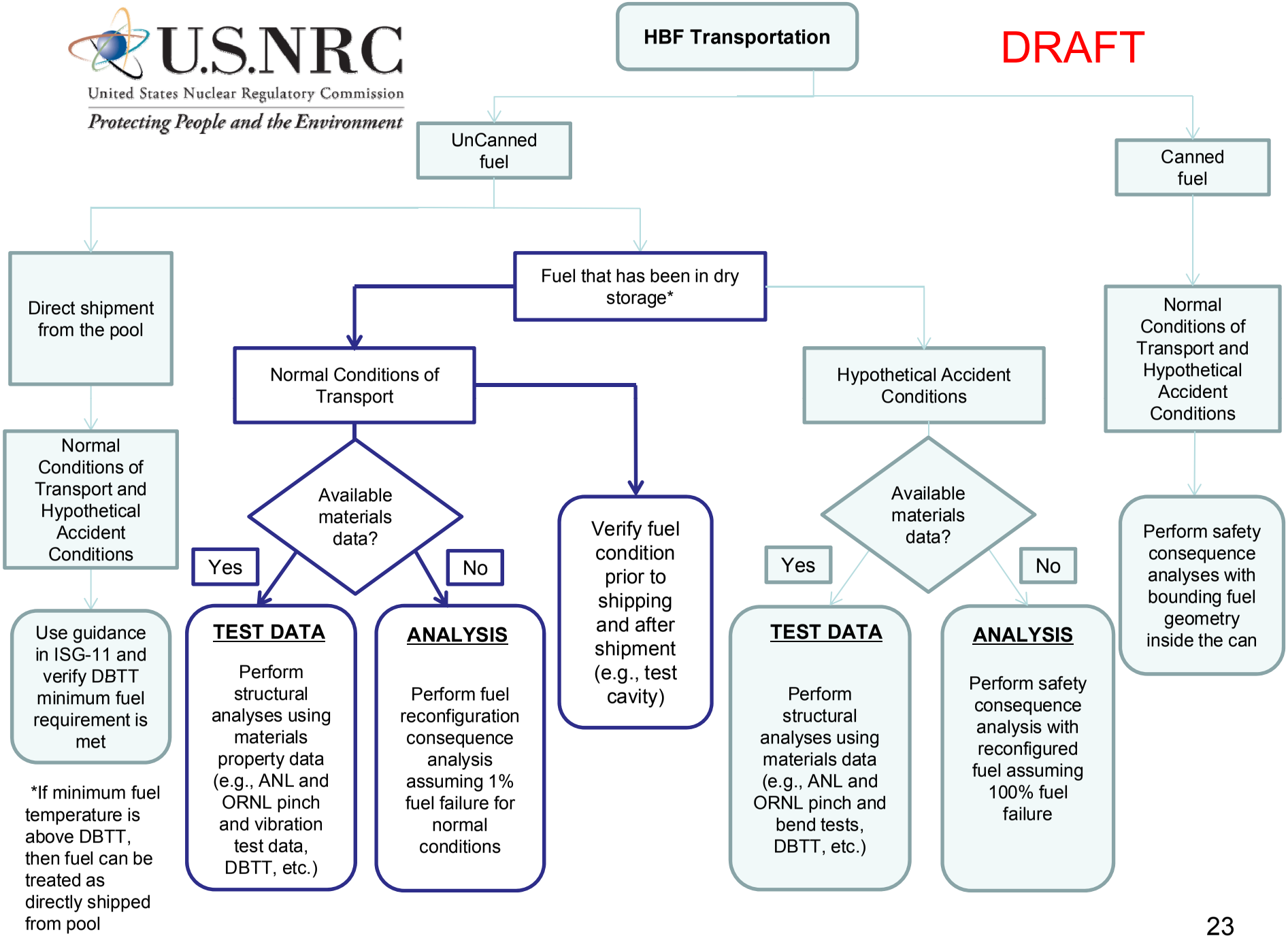

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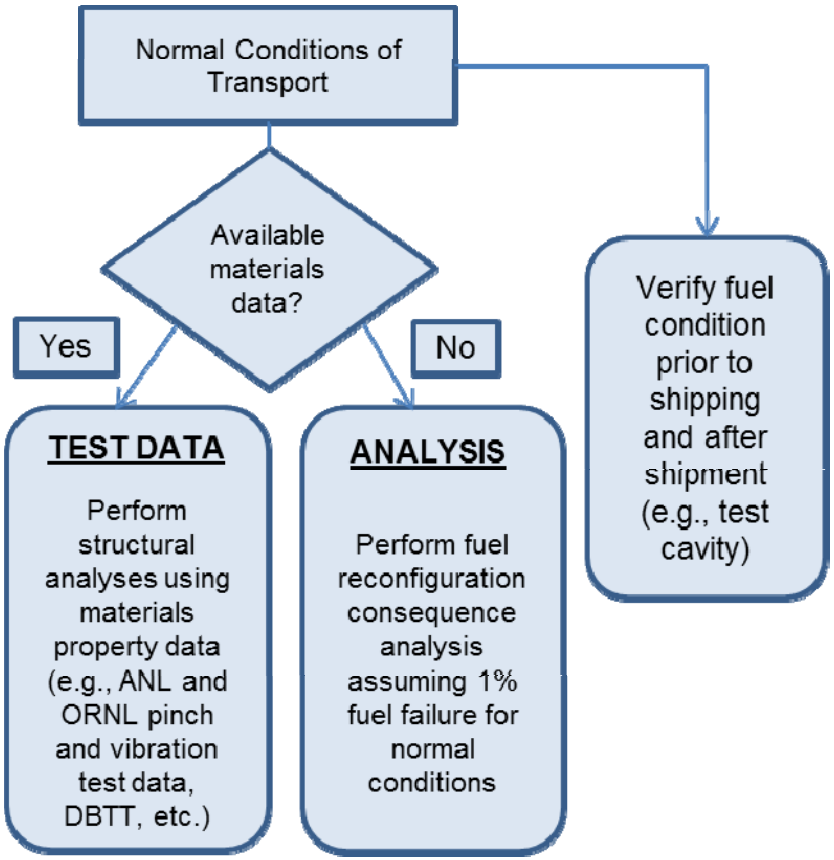
UnCanned Fuel – From Storage – Normal Conditions of Transport



- Test Data
  - Structural analysis relies on available cladding materials data
  - Possible data that can be used are results from ANL and ORNL pinch and vibration tests, or applicant provides own data
- Analysis
  - Confirmation that initial assumptions on the fuel condition are still valid
  - Consequence analyses assuming 1% fuel failure
- Fuel condition must be confirmed before and after shipment to ensure licensing assumptions are still valid

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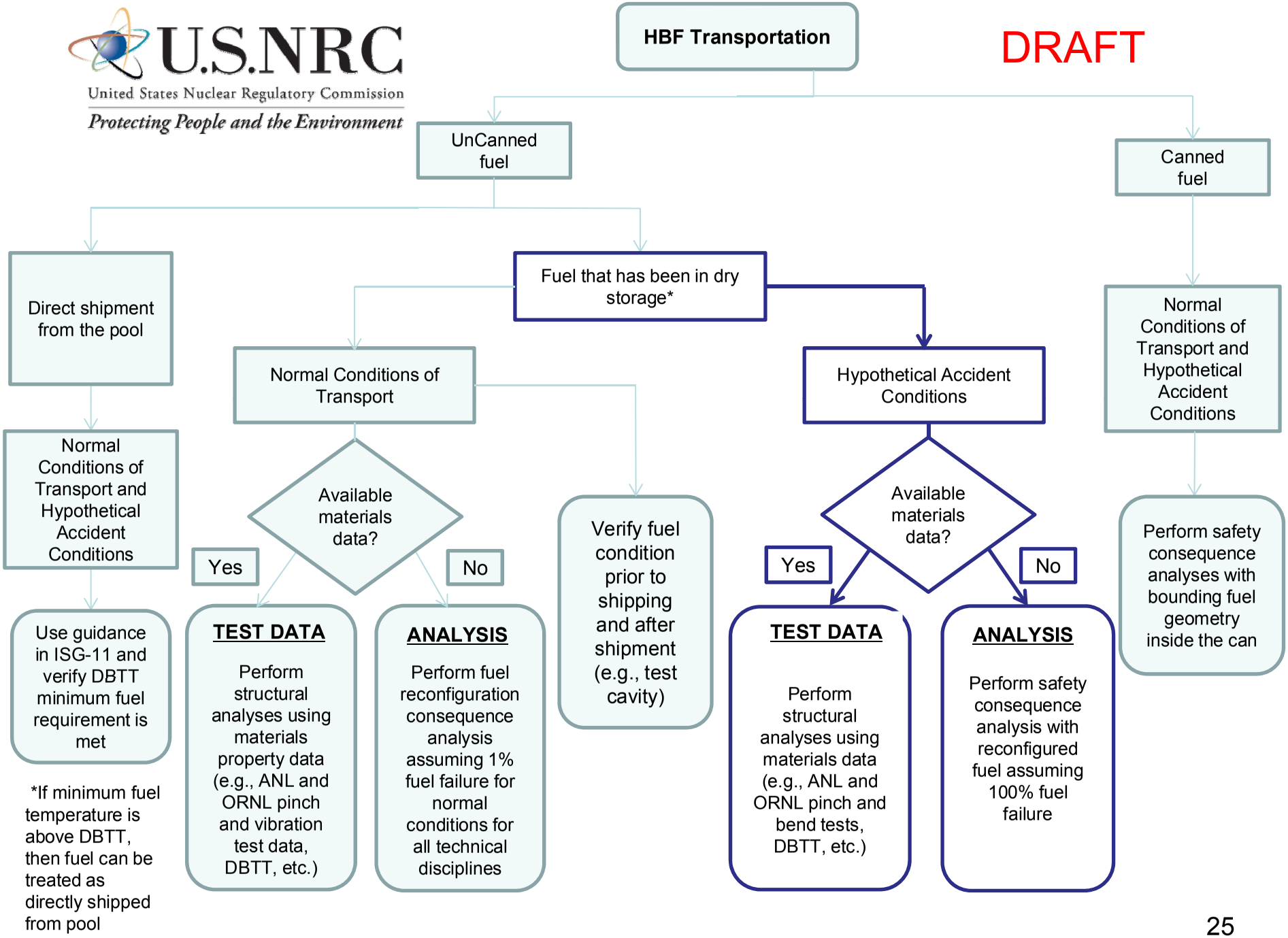

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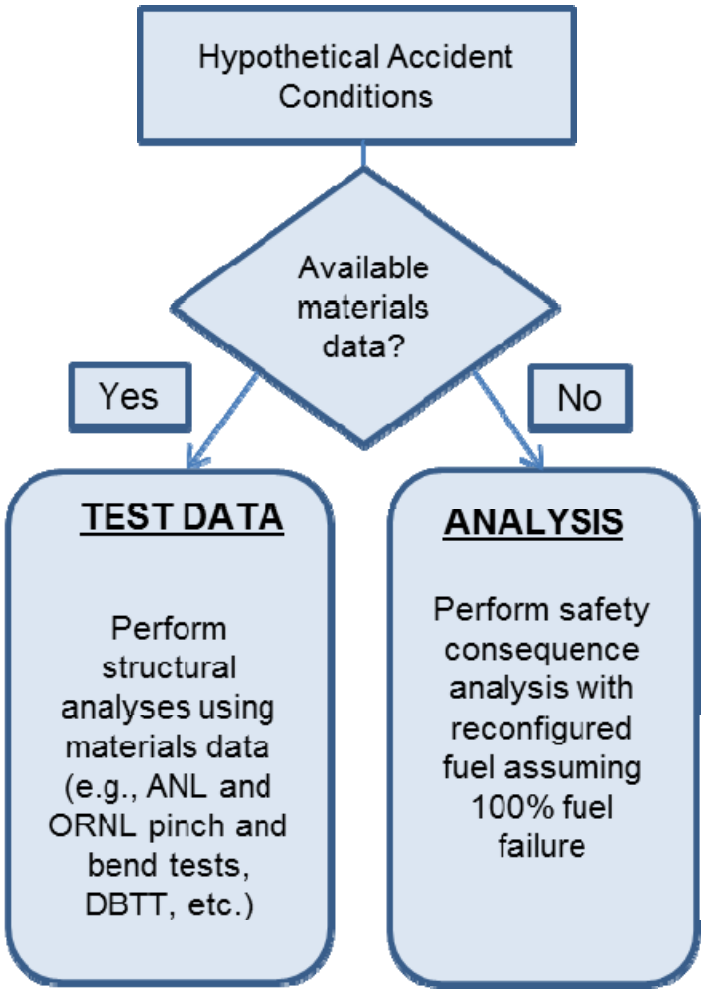
UnCanned Fuel – From Storage – Hypothetical Accident Conditions



- Test Data
  - Relies on available cladding materials data
  - Possible data that can be used are results from ANL and ORNL pinch and bend tests, or applicant provides own data
  - If fuel can reasonably be expected to reconfigure, perform safety consequence analysis
- Analysis
  - Consequence analyses assuming 100% fuel failure

Research and Other Activities on High Burnup Fuel

- Argonne National Laboratory has performed ring tests on HBF to develop stress-strain curves most appropriate for the pinch mode failure.
  - Cask tip over and HAC side drops
- Oak Ridge National Laboratory is performing vibration tests on HBF to determine the cladding endurance limit. Additionally, Oak Ridge National Laboratory has performed consequence analyses assuming different percentages of failed fuel.
- A DOE sponsored cask demonstration project will provide data on the normal conditions of storage for HBF.
- Staff believes that these research activities will validate the position that HBF which has undergone the hydride reorientation will be able to meet the regulatory requirements necessary for licensing

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