Analyses and Evaluations for PWR Fuel Affected by Stress Corrosion Cracking in the Top Nozzle Bulge Joints

Zita Martin (TVA)
Oley Nelson (Xcel Energy)

for

The Nuclear Energy Institute

September 16, 2010

NUCLEAR ENERGY INSTITUTE

Objectives

- Discuss Analyses and Evaluations (A/E) required to demonstrate fuel susceptible to stress corrosion cracking (SCC) at the bulge joints may be stored/transported under a Part 72 and 71 license or CoC
- Start development of a mutually agreed to flow path that licensees may use
- May identify additional A/E required as NEI and NRC work through issue resolution

A/E Flow Chart

- Outlines process for identifying what A/E are required.
- May need separate Part 72 and Part 71 flow charts due to differences in regulations, e.g. retrievability, containment vs. confinement
- To be determined who will perform the A/E or what can be performed generically

A/E Flow Chart

- Approach focuses on fuel-specific and system-related functions.
  - Part 72
    - Confinement
    - Configuration
    - Retrievability
    - Prevent gross cladding rupture
  - Part 71
    - Containment
    - Configuration

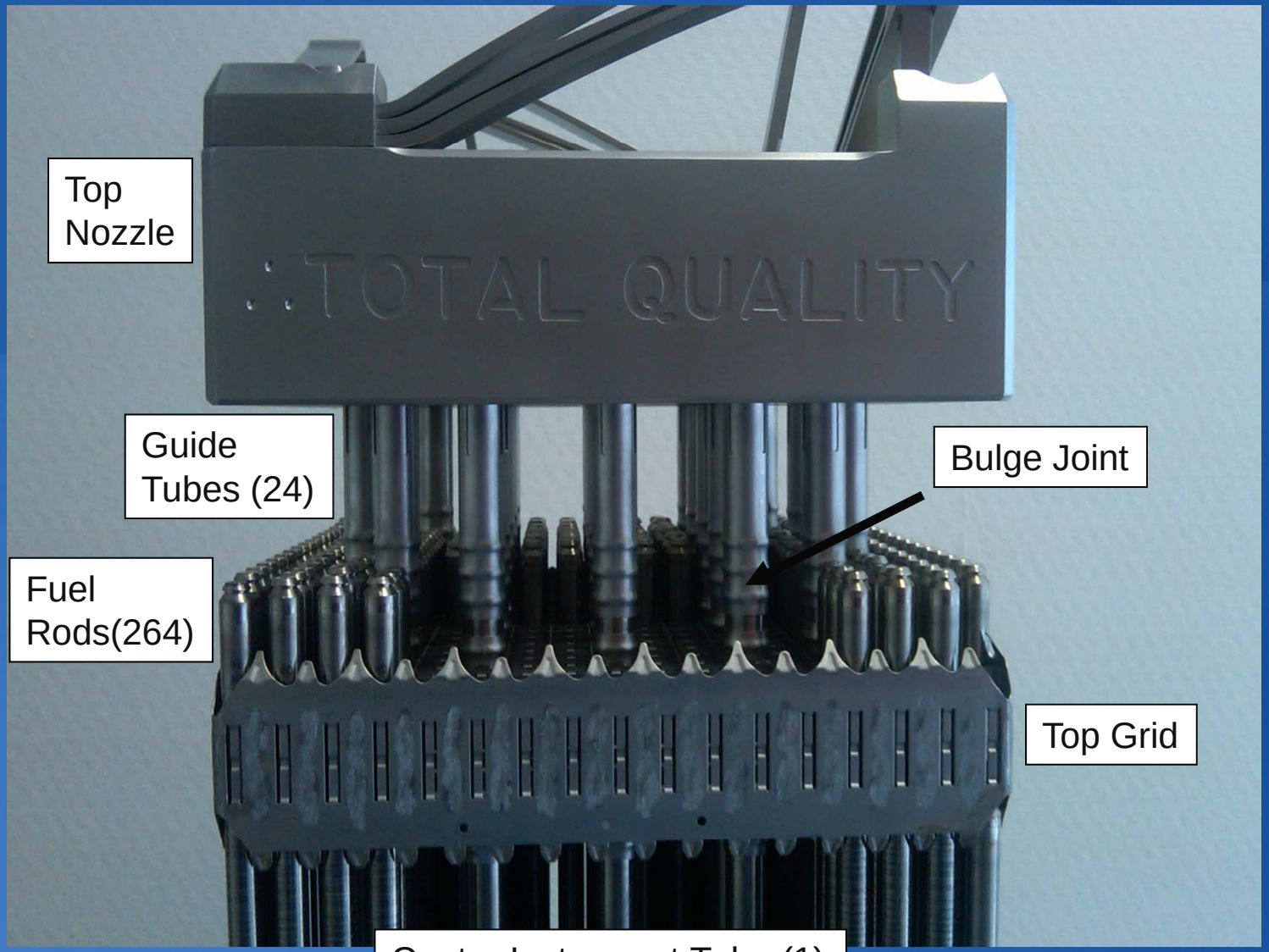
A/E Flow Chart (Part 72 Example)

- **Has susceptible fuel assembly been addressed via modification?**
  - **Yes**
  - **No**

Modified Fuel Assembly

- Modified means of attaching top nozzle
  - Guide tube anchors or similar
  - Instrument Tube Tie Rods or similar
- Modification reviewed under 50.59

PWR Fuel Assembly Top Region



Evaluation of Modified Fuel Assemblies

- **Confinement**
  - No breach of confinement boundary
- **Configuration**
  - Insignificant change in configuration of basket or fuel rods
  - If modification extends into fuel region, must address criticality
  - Guide tube remains within sleeve, thus no impact on structural analyses
- **Retrievability**
  - Top nozzle remains secured to fuel assembly
  - Handled by normal means
- **Cladding rupture**
  - Cladding not subjected to impacts or severe bending

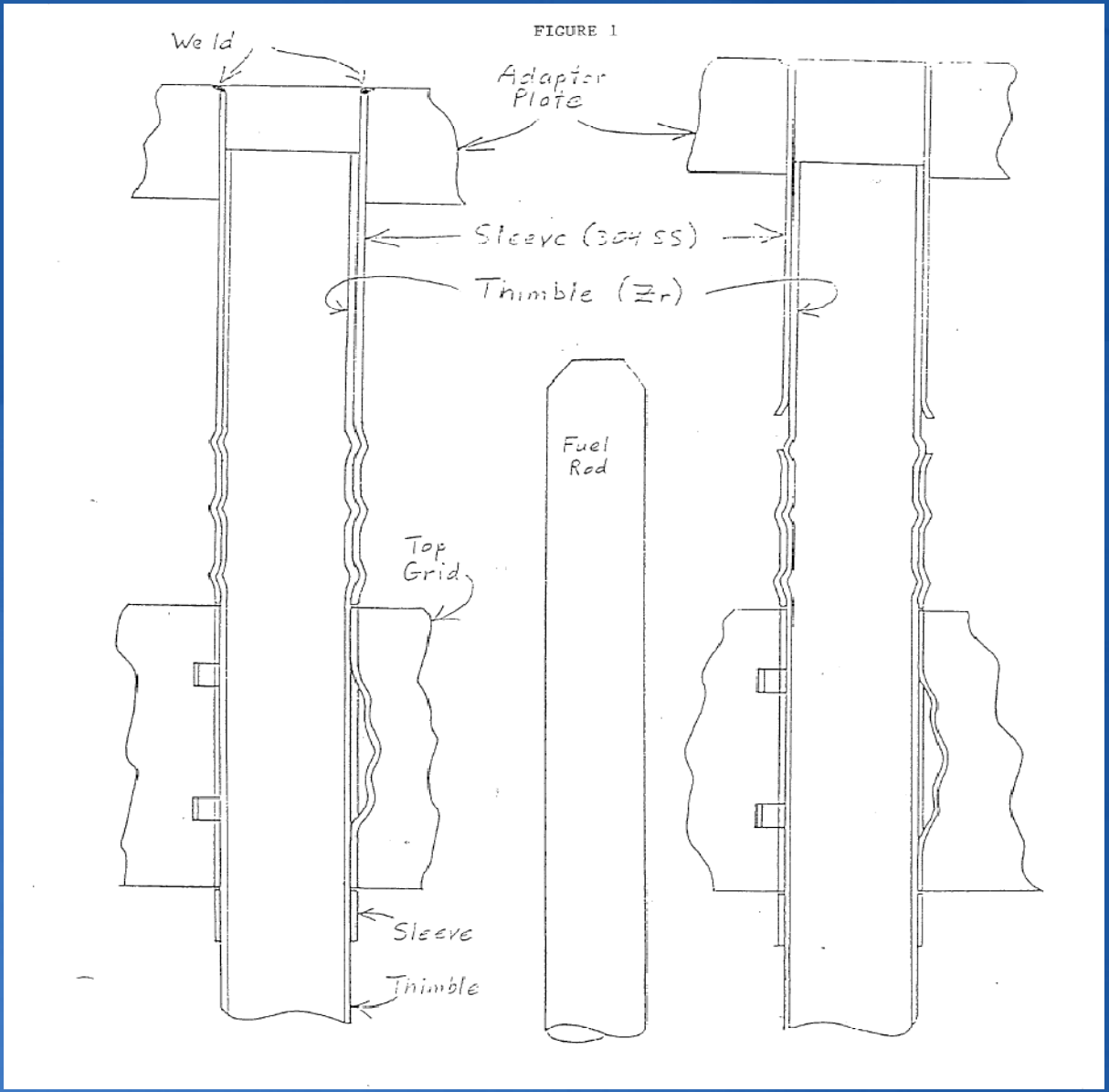
A/E Flow chart

- Has susceptible fuel assembly been addressed via modification?
  - Yes
  - No
- Assume top nozzle separates

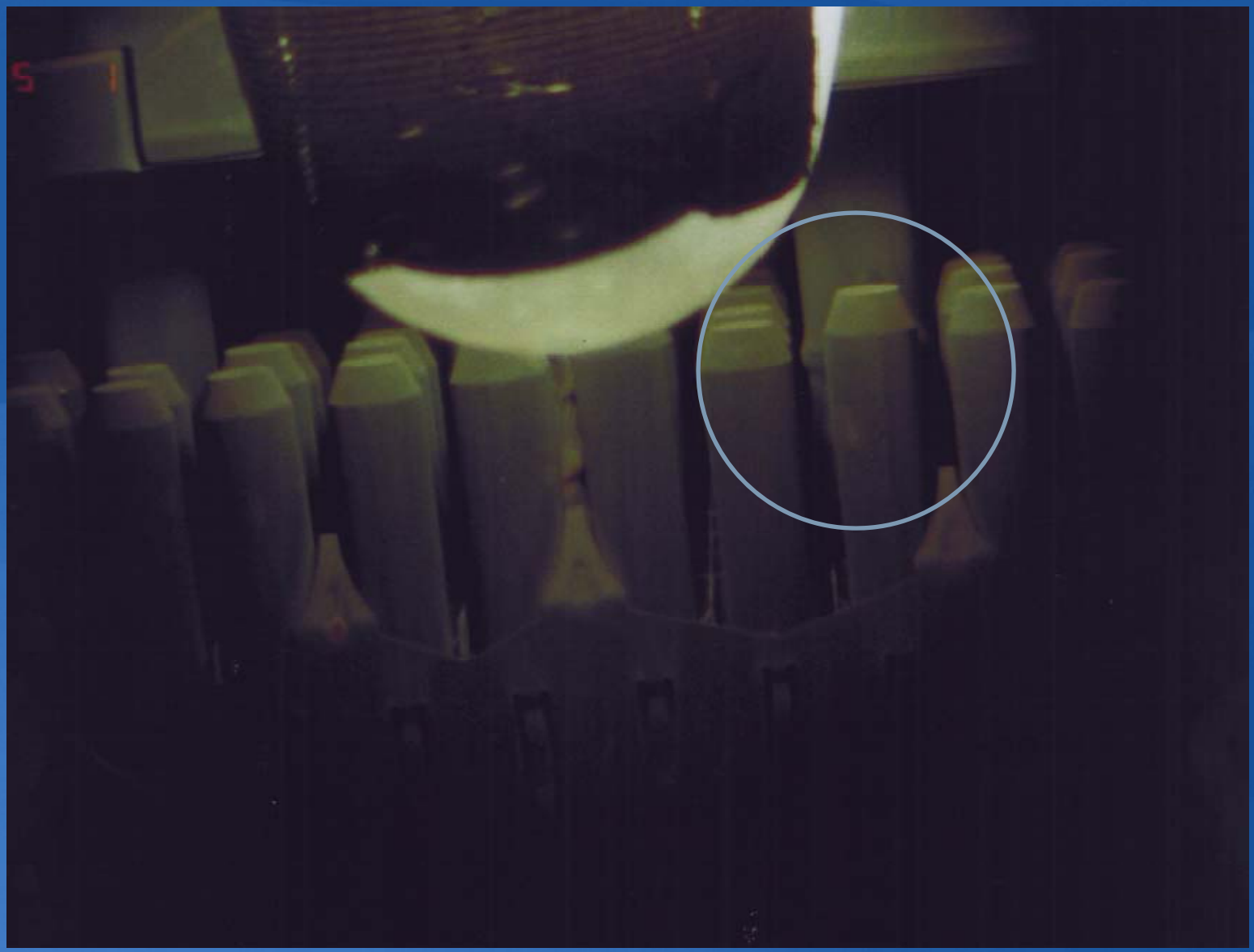
A/E Flow chart

- Is there sufficient axial clearance for sleeves to clear guide tube stubs?
  - Yes
  - No
- Will have to consider thermal expansion between fuel assembly and canister/cask.

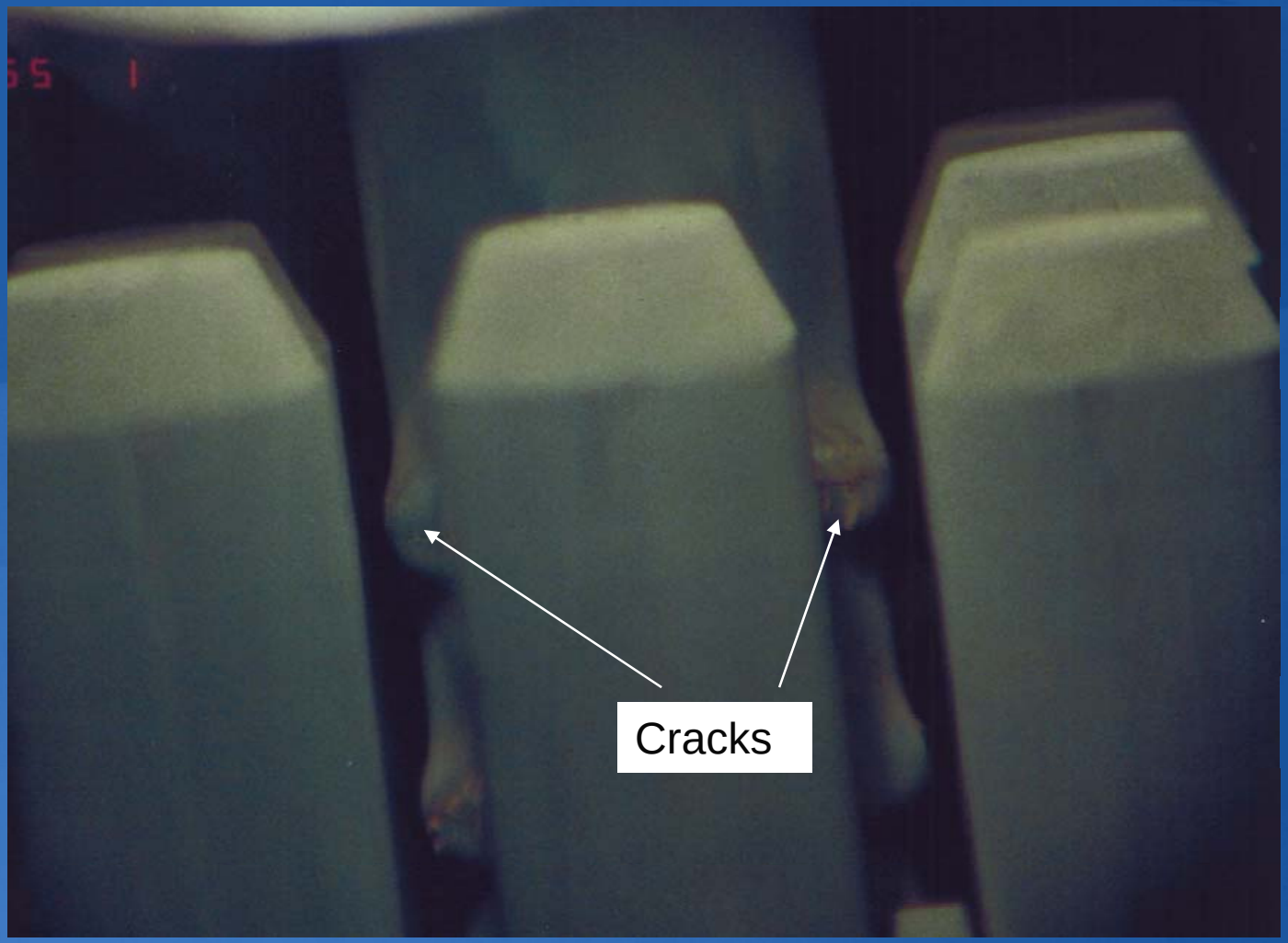
Axial Clearance



Fuel Rods and Bulge Joints



Cracked Bulge Joints



Insufficient Axial clearance

Top nozzle will remain engaged to guide tube.

- **Confinement**
  - No breach of confinement boundary
- **Configuration**
  - No changes in configuration of fuel rods
  - Guide tube remains within sleeve, thus no impact on structural analyses
- **Retrievability**
  - No change in alignment
- **No gross cladding rupture**
  - Confirmed by A/E

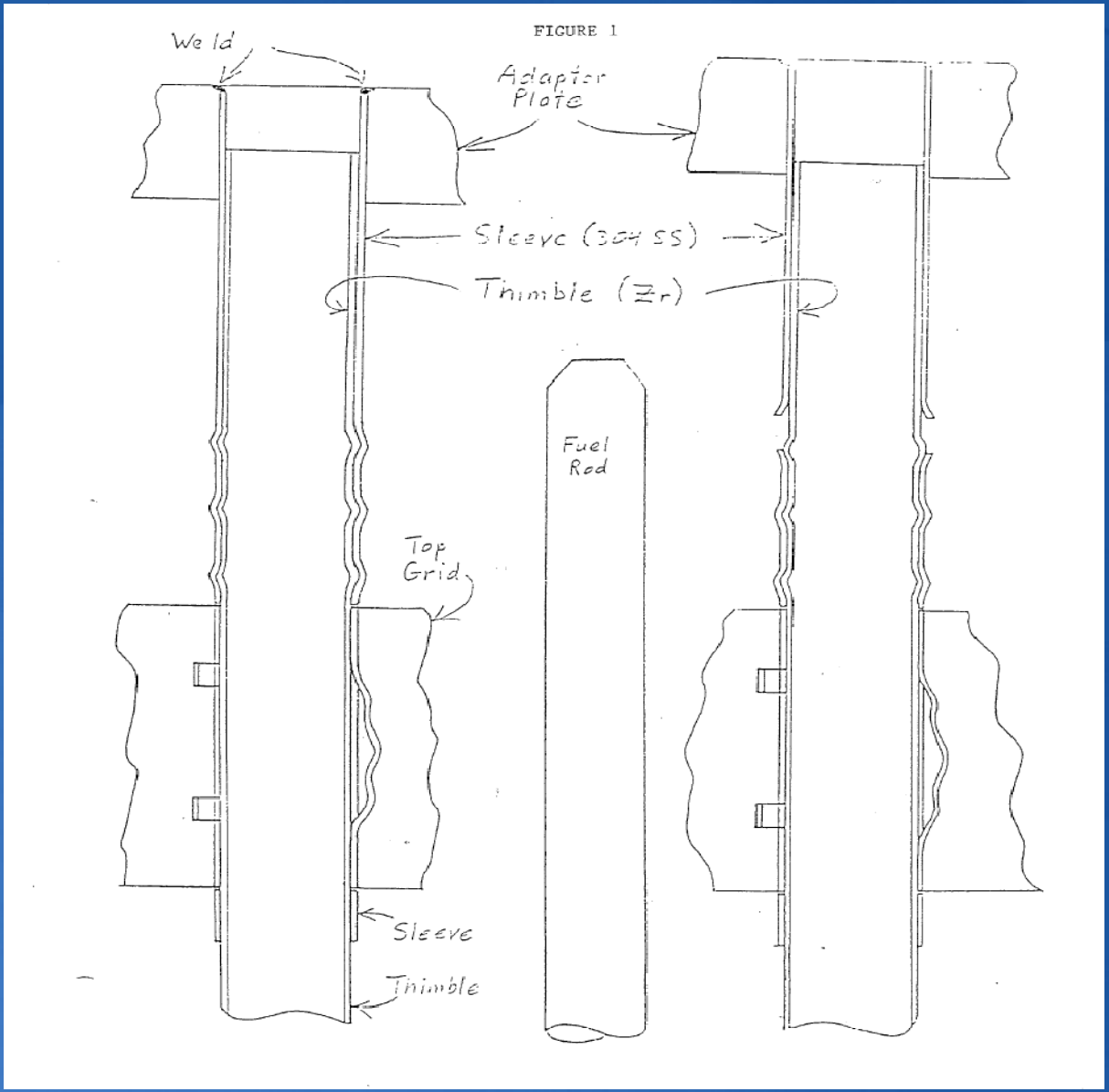
A/E Flow chart

- Is there sufficient axial clearance for sleeves to clear guide tube stubs?
  - Yes
  - No

A/E Flow chart

- For assemblies where axial clearance is sufficient
- Is there sufficient lateral clearance for sleeves to clear guide tube stubs?
  - Yes
  - No

Lateral Clearance



Insufficient Lateral Clearance

Top Nozzle will stay above guide tubes.

- **Confinement**
  - No breach of confinement boundary
- **Retrievability**
  - Top nozzle may be realigned with guide tubes or, if not, removed.
  - Assembly moved via thimble grip handling tool.

Insufficient Lateral Clearance

- Configuration
  - Requires analysis and/or evaluation. For example:
    - Potential geometry changes
    - Potential orientation changes
    - Potential basket deformation
- No gross cladding rupture
  - Confirmed by A/E

A/E Flow Chart

- For assemblies where axial clearance is sufficient
- Is there sufficient lateral clearance for sleeves to clear guide tube stubs?
  - Yes
  - No

Sufficient Lateral Clearance

- Sufficient axial clearance for top nozzle sleeves stubs to become separated from guide tubes AND sufficient lateral clearance for sleeve stubs to clear the guide tubes.
- Sleeve stubs will/could rest on top of the fuel pins.

Sufficient Lateral Clearance

- **Confinement**
  - Will require evaluations and/or analyses to show sleeve stubs will not breach the confinement boundary
- **Retrievability**
  - Top nozzle likely not aligned with guide tubes; removed.
  - Assembly removed via thimble grip handling tool.

Sufficient Lateral Clearance

- Configuration
  - Will require evaluations and/or analyses. For example:
    - Potential geometry changes
    - Potential orientation changes
    - Potential basket deformation
- No gross cladding rupture
  - Confirmed by A/E

Summary

- Flow paths used to ensure that all issues associated with SCC of top nozzle sleeves are addressed for storage and transport.
- Expect that process will show that all (F)SAR analyses and evaluations will allow fuel assemblies susceptible to top nozzle sleeve SCC to be considered undamaged.
- Expect that no license/CoC amendments will be required.