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NRC Regulatory Perspective on NDE of Novel Materials

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Nonmetallic Repairs

- As nonmetallic repairs such as carbon fiber reinforced polymer, fiberglass, and plastic piping are applied in areas subject to N-752 and applications of 10 CFR 50.69 we can expect many more non-code repairs to large runs of service water piping
- Nonmetallic non-code repairs will have much higher uncertainties in material quality, installation, and longevity
- We will need some way to determine which repairs would be more susceptible to failure

What are the Main Issues?

- If a large number of plants use these non-code installations, we can anticipate operational experience at one or more
- The quality of the other installations will be called into question
- How do we verify that the nonmetallic repairs of risk-significant systems were installed correctly?

Main Repair Methods

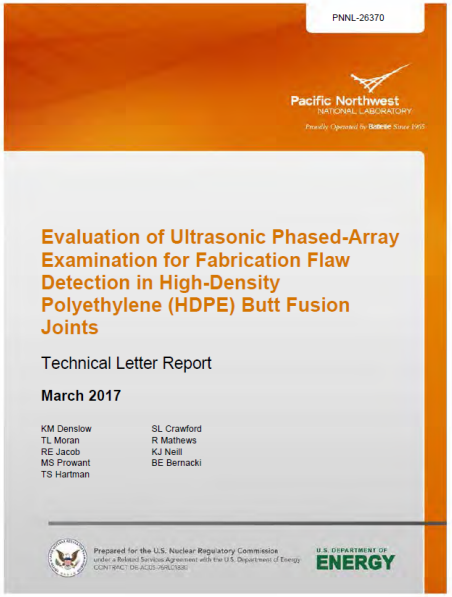
- Carbon Fiber Reinforced Polymer (CFRP) linings and coatings
  - Very strong if installed properly
  - Very sensitive to installation variables
  - Assumed to carry entire load with load transfer occurring at terminal ends
- High Density Polyethylene (HDPE) Pipe replacements
  - Piping is very robust, but joints are the weak points
- Novel Coatings
  - New repair methods may present new challenges

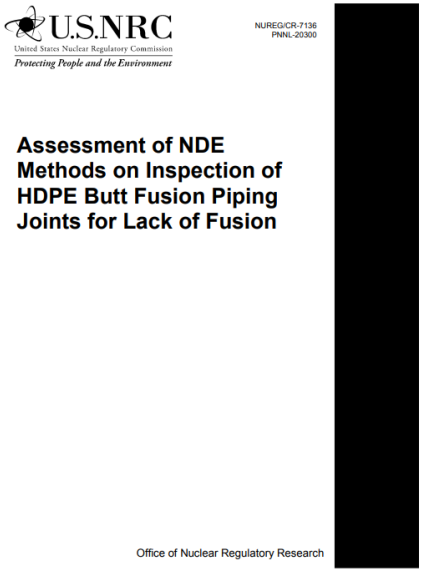
Carbon Fiber Reinforced Polymer

- CFRP provides a variety of challenges for nondestructive examinations (NDE)
  - The composite nature of the CFRP makes it challenging to examine with ultrasound
  - Carbon Fiber is conductive, making electromagnetic methods less effective
  - Tap testing is less effective though multiple layers and extra epoxy
  - No field method to measure Tg (nondestructive or otherwise) is ready for deploy at NPPs
  - No calculated critical flaw size

High Density Polyethylene Pipe

- A lot of research has been done on the NDE of HDPE
- Inspections of welds are still not effective at finding small areas of poor fusion
- Recent fracture mechanics work shown at ASME Code meetings suggests that very small flaws may cause the welds to fail over time





Novel Repair/Replacement Methods

- New nonmetal repair methods are being developed
- We can expect some novel methods to be implemented without the usual ASME Code Case process
- This can result in methods that are not friendly to standard NDE practices or that do not account for NDE as part of their design

Extent of Condition Evaluations

- The big question:

  How does one evaluate repairs years after installation to provide assurance that the repair is sound?

Assessing CFRP Installations

- The entire surface would need to be examined, with an emphasis on the terminal ends
- Acceptance Criteria need to be developed
- Methods?
  - Chips to determine Tg
  - Visual testing?
  - What else?

Assessing Installed HDPE

- Checking HDPE Installations
  - Failure is likely limited to the joins and not the bulk material
  - Ultrasonic testing may be effective if flaws have grown resulting in separation of the joint line (essentially a lack of fusion defect).

Assessing Novel R/R Methods

- This will have to be developed ad-hock as the methods are proposed

Path Forward

- NRC is doing limited, confirmatory research on NDE of CFRP focused on (1) ensuring that it's possible to make qualification mockups and (2) does tap testing detect the critical defects and what additional NDE methods may be used for characterization of flaws
- The NRC would like to be keep in the loop on new repair methods as they are being developed.