HDPE and Nuclear Power Piping Systems

Review of the Barakah Nuclear Power Plant's use of HDPE pipe in an ASME Section III, Class 3 Installation

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DISCUSSION TOPICS

- Barakah Nuclear Power Plant
- ESW Piping System & Design
- American Society of Mechanical Engineers (ASME)
- Materials
- Project Challenges
- Installation and Testing

BARAKAH NUCLEAR POWER PLANT

- Emirates Nuclear Energy Corporation
- Located 300km West of Abu Dhabi, UAE
- Consists of four – KEPCO APR1400 units
- Construction on Unit 1 began in 2012
- $24.4B (USD)
- Currently at 90+% completion

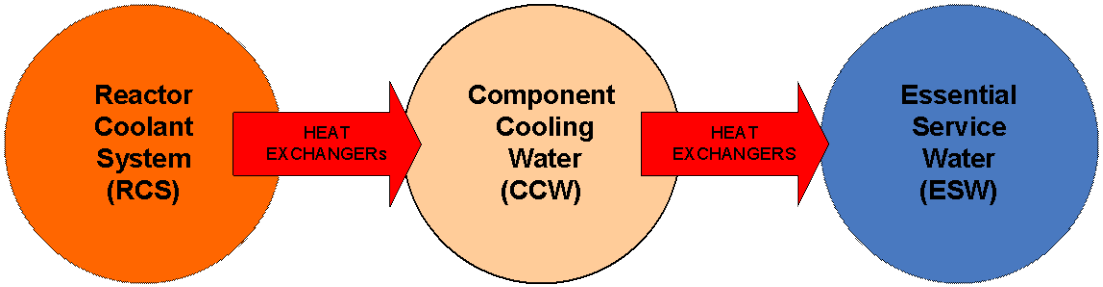
BARAKAH NUCLEAR POWER PLANT

Photo Courtesy of ENEC

BARAKAH NUCLEAR POWER PLANT

BARAKAH ESSENTIAL SERVICE WATER DISCHARGE SYSTEM

Barakah Essential Service Water System



The **Essential Service Water System** (ESW) is designed to provide a source of cooling water to multiple heat exchangers required for the safe shutdown of the reactor following an event.

Safety Related Systems are relied upon to remain functional during and following design basis events.

Barakah Essential Service Water System

- ESW supplies water for cooling of Component Cooling Water heat exchangers
- 8 trains = 21,000 feet (6,480 meters) of pipe for discharge
- Procured and constructed in accordance to ASME BPVC Section III, Subsection ND, Safety Class 3

Barakah Essential Service Water System

- Desired Design/Service Life = 60 years
- Burial Depth = 33 feet (10 meters)
- Maximum Ground Temp = 95°F (35°C)
- Aggressive native soils
- Design Fluid Temperatures = 52.5°F (11.4°C) through 140°F (60°C)
- Design Pressure = 30 psig (207kPa)
- System design conducted by ASME N-type Certificate holder
- Piping materials considered: Coated PCCP and HDPE

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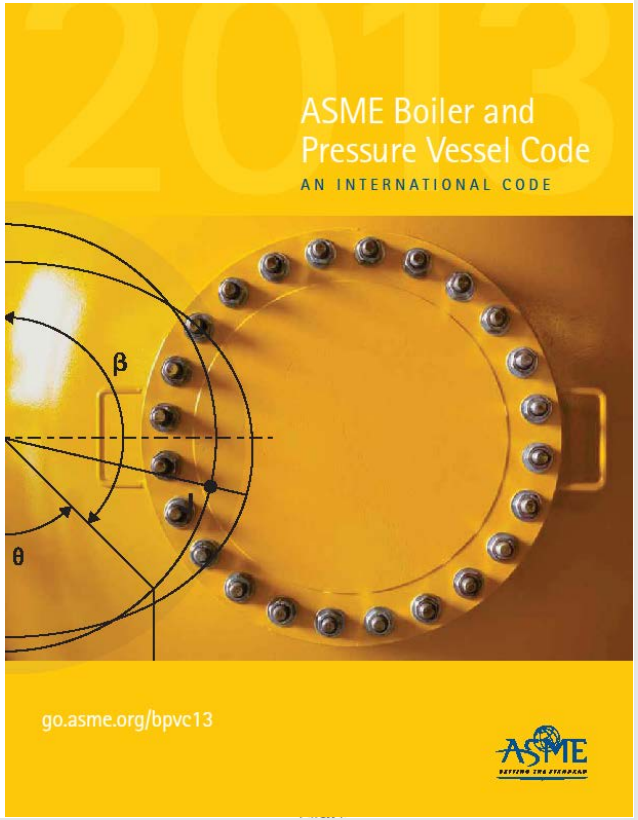
Material Selection: PCCP vs HDPE

- Service life expectations
- Hydraulic efficiency
- Joint reliability
- Seismic design
- Installation concerns
- HDPE chosen for ESW Discharge System

American Society of Mechanical Engineers (ASME)

- Boiler & Pressure Vessel Code: Section III – Rules for Construction of Nuclear Facility Components
- Subsection ND, Class 3 Piping Systems
- Code Case N-755
- N-type Certificates



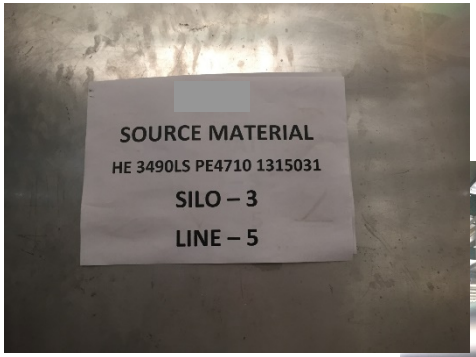
ASME Nuclear HDPE Materials

- Resin to meet ASME Code Case N-755-1
  - Plastic Pipe Institute TR-4 Permanent Listing
  - PE4710
  - 2000 hour PENT
- UAE based resin producer selected
  - ISO 4427 to ASME/PE4710
  - Gap analysis audit per ASME
  - Bimodal pre-compounded resin
  - Superior sagging performance
  - Surveillance from production to packaging

Photo Courtesy of UPI

ASME Nuclear HDPE Pipe

- 36-Inch DR 17 HDPE pipe per design conditions
- UAE based pipe extruder selected
- Testing – lot specific
- Surveillance



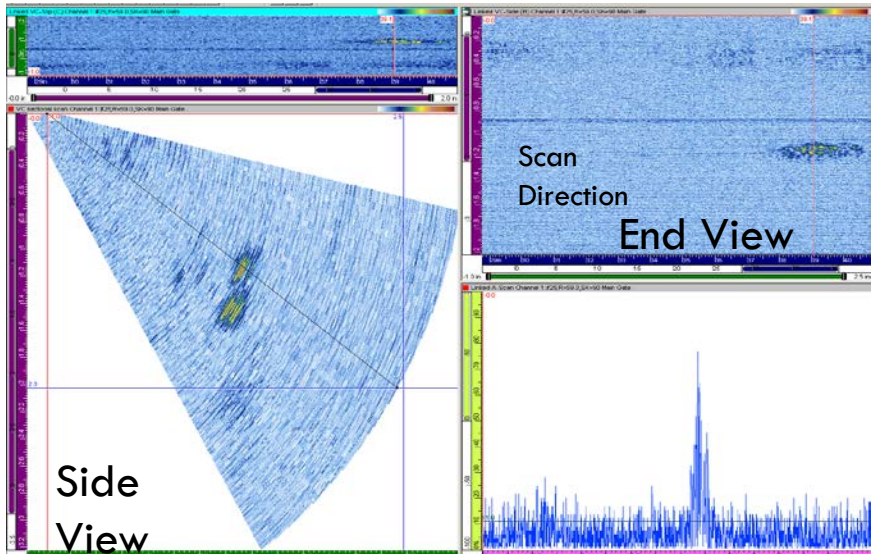
Photos Courtesy of UPI

ASME Nuclear HDPE Elbows

- 36-Inch DR 13.5 feedstock for fabricated elbows (1.22X)
- Feedstock extruded in UAE – shipped to USA
- Elbows produced under ASME NPT
- Welders qualified per N-755-1 Mandatory App. I
- Fitting ends counter-bored
- Volumetric examination (PAUT)

Volumetric Examination

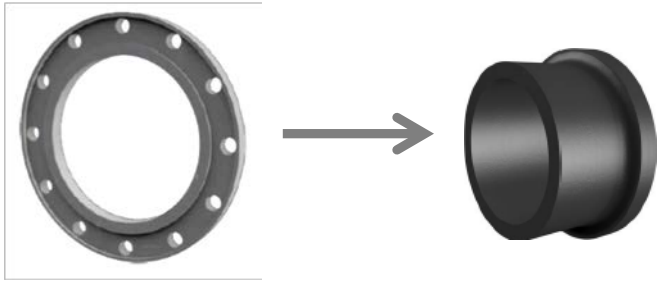
- NDE
  - Phased Array Ultrasonic Testing
  - No industry developed acceptance criteria
  - Field exams performed at night



Photos Courtesy of Structural Integrity Associates

ASME Nuclear HDPE Flanges

- Connections at Hx buildings
- Manufactured in the USA
- Void free
- Backing rings made from ASME SA516 Grade 70 steel plate used



Photos courtesy of GFCP

Project Challenges

- First of Kind Project
- Geography
- HDPE Code implementation
- Supply Chain
- Climate/Field Conditions

Photo Courtesy of ENEC

Barakah ESW Discharge System Installation

- Installed by ASME NA Certificate holder
- Challenges:
  - ASME site survey
  - 115°F (46°C)
  - Sand
  - Non-destructive examination (NDE)
- N-755-1 only allows for butt fusion welds

Photo Courtesy of ISCO

Barakah ESW Discharge System Installation

- Fusion procedure qualification:
  - 20 samples
  - High Speed Tensile Impact Testing
  - Elevated-Temperature Sustained-Pressure Testing
- Operator qualification
  - 2 weld samples each
  - Free bend test
- Joint data recorder

Photos Courtesy of McElroy Mfg.

Barakah ESW Discharge System Installation

- Hydrostatic Pressure Testing per N-755-1
  - Joints exposed
  - 4-hour initial pressurization
  - 1-hour test
  - Pass if within 5% of test pressure & no visible leaks
  - Performed at night

Photo Courtesy of ENEC

Barakah ESW Discharge System

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Conclusion

- First ever greenfield nuclear HDPE project
  - Implemented ASME Code Case N-755 Rev1
  - Used Class 3 HDPE materials
  - Utilized ASME HDPE N-type stamps for design, supply and installation
- Project's success provides confidence for other global nuclear owners to consider HDPE
- Assisted in evolution of Code Case N-755
- Appendix XXVI of ASME BPVC Section III
- Appendix XI of ASME BPVC Section XI

Thank You