New Plant Cable Issues

SC-2 Knoxville Tennessee

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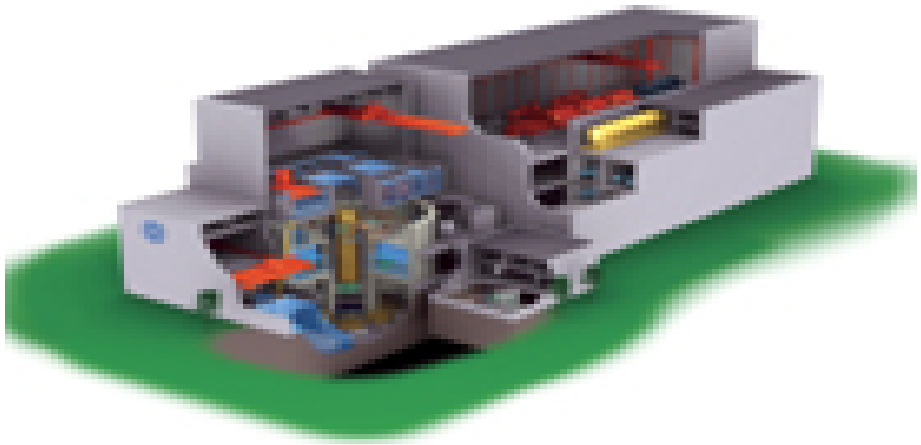
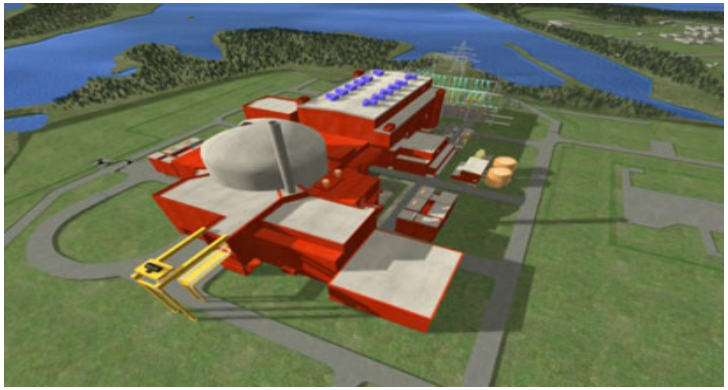
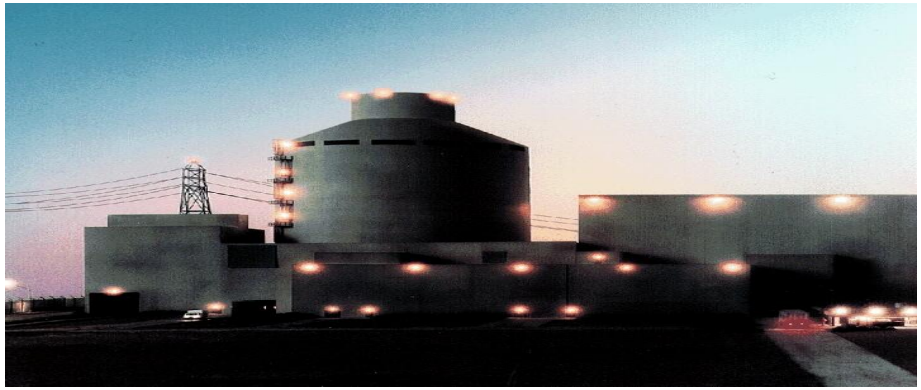
NEW NUCLEAR PLANTS







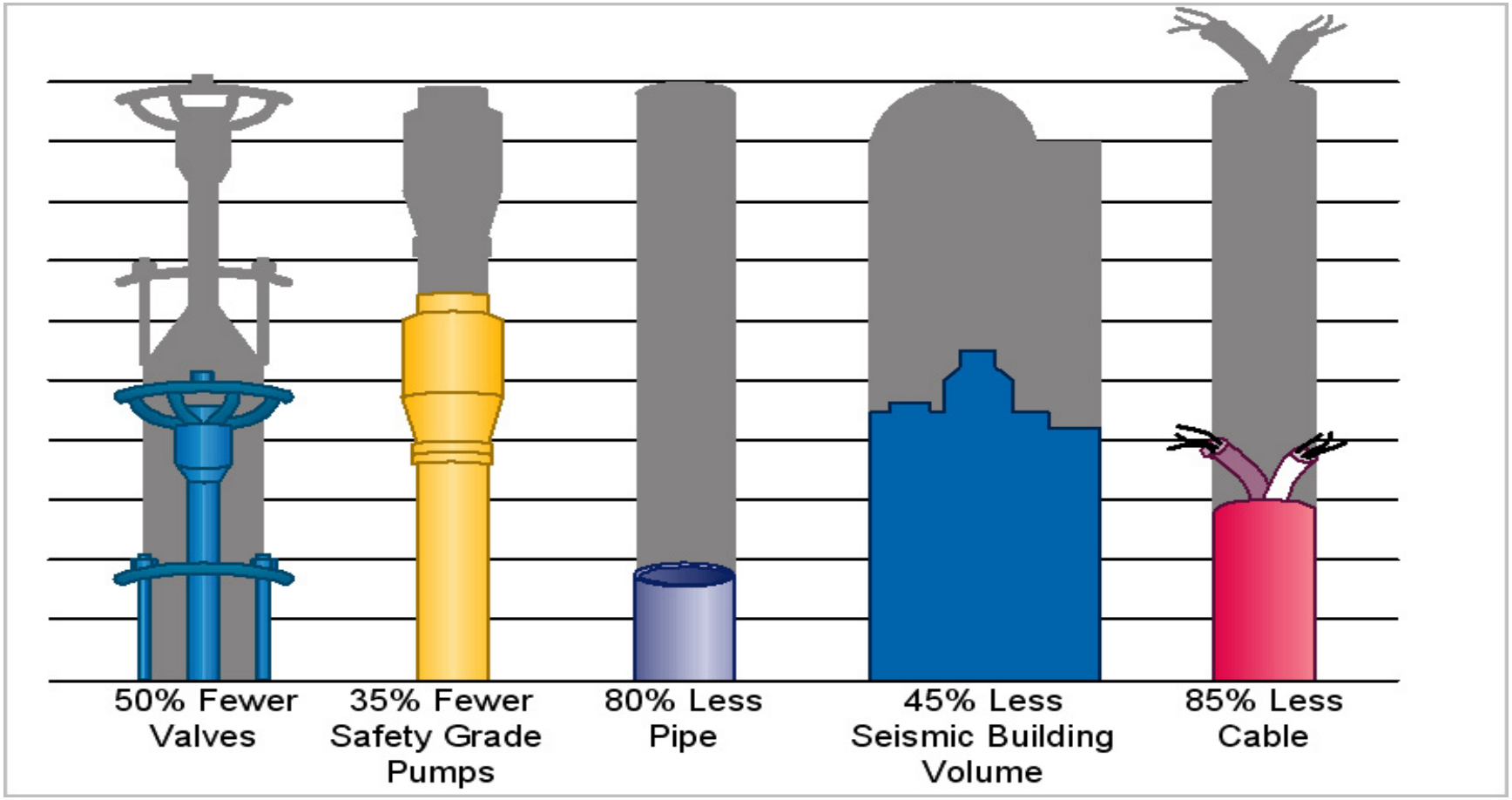
Agenda

- Introduction
- Cable Designs
- Issues
- EQ Requirements
- Standards

Introduction

- A typical boiling-water reactor (BWR) requires approximately 60 miles of power cable, 50 miles of control cable and 250 miles of instrument cable
- A pressurized-water reactor (PWR) may require far more, as illustrated by the containment building of Waterford Steam Electric Generating Station, Unit 3 which required nearly 1,000 miles of cable (NUREG/CR-6384)

AP 1000


50% Fewer Valves
35% Fewer Safety Grade Pumps
80% Less Pipe
45% Less Seismic Building Volume
85% Less Cable

Cable Requirements

- 85% Of Cable Equals 50-150 Miles
- Sounds Like a Lot
- Depends on Mix

Cable Designs

- MV – Typically 5 to 15 KV Shielded
  - In Past 5 KV NS used, Easier to Terminate
    - Future Only Shielded?
  - Thermoset LSZH Jackets vs CSPE
  - LCS shield vs Helically Applied
  - Moisture Impervious Options
    - Conductor Strand Fill
    - Water Blocking Tapes/Yarns/Powders
    - Bondable Tapes, CWC Cu, etc

LV Power and Control Cables

- Power
  - Jacketed Singles or Unjacketed Singles
    - If Jacketed Thermoset LSZH (or CSPE)
- Control
  - Not Shielded in the Past
    - LCS or Cu/Polyester For Testing Purposes/EMI
    - Twisted Pairs vs 1/C/Parallel, or Cabled: EMI
    - Thermoset LSZH Jacketed vs CSPE?

Instrumentation

- Al/Polyester Shielded for Analog Systems
  - Copper/Polyester, Tinned Cu Braid
- Insulating Jackets – 75C/90CRated?
  - Thermoset LSZH or XL Polyolefin
  - If Overall Shield Need Insulating Jacket and Protection Jacket (FR)?

Communication Cables

- Telephone and REA Type Cables in Past
- Category Cables (5, 5e, 6, 7, etc)
  - Shielded – Cyber Security
  - Stranded in Plants
  - Ruggedized-Armor
  - Thermoset LSZH jacket – Insulating Jacket
- Field Bus, Profibus, etc

Coaxial Cables

- More Triaxial, or Quadaxial (CWC Cu)
- LOCA Test Electrical Monitoring
- Insulating Jackets
  - Protective Jacket (FR) Over this?
- TIC – Special Designs

Fiber – P1682 Being Written

- Issues With LOCA Testing - Fiber Does Not React Like Copper Cables
  - Time Dependency Radiation, Dose Rate, etc
  - Photo Bleaching
    - Higher Temperature Excursion May be Lower Loss
    - Have to Look at Margin Differently
  - Systems: Craftsmanship, Representative Sample
  - Installation: Bend Radius Effects Loss

Fiber

- LSZH Jackets – Thermoset?
- How Radiation Resistant –May be Standard Material, Depends on:
  - Length
  - Connections
  - Loss Budget

Assemblies

- Lot of Talk Of Connectors
- Not a Lot of Qualified Connectors
  - Generally 50F to 65F Rated
- Flexibility
- Sealing Requirements
- Connect Disconnect Cycles
- New IEEE 572 Standard

Others

- SIS/Thin Wall Cable for Panels
  - Colors
  - Flexible Strand
- High Temperature Cables
  - Pressurize Heater Cables
  - Silicone Cables
- Appendix R Cables
- Flex Cables – Cranes, etc

Issues Summary

- Jackets
  - Thermoset LSZH or CSPE
  - Insulating Jackets – 75C or 90C
  - Jacketed 1/C
  - Mechanical/FR Jacket over Insulating Jacket (Coax, M/C)
- EMI Shielding
  - Copper Shields Instead of AL – Maybe Braid
  - LCS Shield instead of Helical Tape
  - Shield Most Cables? Testing, Security
  - Condition Monitoring
  - Fault Detection

Issues Summary (Cont)

- Beta Shielding – Additional Jacket?
  - What if Beta is So High Jacket Falls Off?
- Connectors – What Will Be Needed?
- Digital – What Cable Designs Needed?
- Submergence
  - MV Moisture Impervious Designs
  - LV Designs Flooding of Containment
  - Current NRC Activity:Flooded Manholes
- Special Designs Always Come Up

New Plant Profiles

- Still Not Definitive Information on Profiles
- MSLB
- LOCA Test Duration
- Gamma Radiation Levels
- Beta Radiation Levels
- Submergence

RG 1.131 – Discussion To Be RG 1.211 Discussion

- The specialty cable with connectors should be included in future qualification programs.
- The NRC research suggests the potential for cracking of age-embrittled cable materials during subsequent installation of field splices.” Field splices of age-embrittled cables should be avoided.

RG 1.131 – Discussion To Be RG 1.211 Discussion

- Power cables that are routed underground should be capable of performing their function when subjected to anticipated environmental conditions such as moisture or flooding.
- Also, based on recent underground power cable failures, the staff has concluded that the field splices for medium-voltage cables in inaccessible locations should be avoided.
- In addition, power and instrumentation and control cables for which failures could disable risk-significant equipment should have condition monitoring programs to ensure that the cables can perform their safety function when needed.

RG 1.131 – Regulatory Position To Be RG 1.211 Discussion

- “The qualification type tests for coaxial, triaxial and twinaxial cables should include sufficient testing of cable’s critical electrical performance characteristics to permit an adequate analysis of the compatibility of the coaxial, triaxial and twinaxial cables for the specific application, as appropriate.”

RG 1.131 – Regulatory Position To Be RG 1.211 Discussion

- Programs for monitoring of environmental conditions (such as temperature, radiation levels), and condition monitoring should be implemented for power, instrumentation, and control cables whose failures could disable risk-significant equipment.
- Condition monitoring programs may include any appropriate technique, supplemented with walkdowns to look for visible signs of anomalies attributable to aging with particular emphasis on the identification of localized adverse environments or “hot spots.”
- For safety-related power cables, which are inaccessible or installed underground, appropriate inspection, testing and monitoring programs should be implemented to detect degradation.

IEEE

- IEEE 323 Is Reaffirmed
  - 27 Comments – Also Looking at IEC
    - Waiting for IEC to Start Harmonization
- IEEE 383 Is Reaffirmed – Cable Potential Issues
  - Long term water
  - Testing of cables with connectors (coaxial, and data cables) – and what parameters are tested
  - Data cables not really addressed
  - Fiber Hybrid (Fiber plus copper cables)
  - High Beta
  - Submergence after LOCA on passive systems
  - Shield integrity testing
  - Sample selection issues, information on Arrhenius, aged flame test, etc.

QUESTIONS ????