Radiation hardness testing of an organic liquid scintillation detector for use in high dose rate accident response scenarios

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National Maritime Research Institute
Introduction

- Fuel location and identification for decommissioning efforts of Fukushima Daiichi NPS.
- Uncertain fuel debris state.
Difficulties

- High dose rates.
  - Requirements for the investigation of inside primary containment vessel (PCV) – 100 Gy/hr dose rate with 1000 Gy total dose tolerance.

- Air dose rate inside the PCV.
  - Unit 1 - 4.1-9.7 Sv/hr.
  - Unit 2 - 73 Sv/hr.
  - Unit 3 – 1 Sv/hr.

- Submerged situation – Reactors flooded with sea water.
  - Unit 1 – 3 m water.
  - Unit 2 – 30 cm water.
  - Unit 3 – 6 m water.

- Unknown geometry.
  - Potential for blockages and obstacles inside the reactor.
AVEXIS MiniROV

- AVEXIS MiniROV – 145mm ø x 250mm.
  - Developed for the inspection of legacy storage ponds.

AVEXIS MicroROV

- MicroROV – 110mm ø x 450mm
  - Smaller diameter to fit through 115mm access ports.
  - Radiation tests of each component is underway.
Detector Payload

• Payload requires both neutron and gamma ray detection capabilities.

• Detector/s must fit inside the ROV central body design envelope.
  – 110 mm ø x 300 mm.

• Detector/s must tolerate dose rates of 100 Gy/hr, 10 hour exposure time.
  – Total absorbed dose of 1 kGy.
Organic liquid scintillation detectors

• EJ-301 liquid scintillator detector.

• Detector small size.
  – 35 mm Ø x 80 mm.

• Mixed field capabilities.

• Radiation hardness & tolerance unknown.
Radiation Hardness Testing

• Dalton Cumbria Facility.
  – $^{60}$Co irradiator

• Consists of 2 $^{60}$Co rods.
  – Can be used in conjunction or isolation.

• Capable of supplying absorbed dose rates between 240 – 27,000 Gy/hr.
Testing

• First experiments set to 942 Gy/hr ± 2%.
  – Detector observed no damage after 800 Gy.

• Second experiments dose rates reduced.
  – Minimum dose rate, 10 Gy/hr, the detector is fully saturated after a few seconds.
Conclusions

- Organic liquid scintillator detector ideal for localisation of dose rates 10 Gy/hr.
  - Small size ideal for a backup detector.
  - Survives through high dose rates.

scCVD Diamond Detector by Cividec Instrumentation

CeBr$_3$ inorganic scintillator by Scionix, Netherlands
CeBr$_3$ inorganic scintillator

ROV control board

Water pumps

HD camera and LEDs

scCVD diamond detector

Thank you for listening