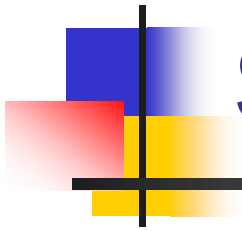

UNO Cavity Liner System: Status Report and R&D Proposal

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Update: Progress since August Phone Meeting

- R&D proposal section written
  - CSU (Warner), CSM (Kuchta) collaboration
  - ~170k* total budget including:
    - Mechanical properties of cavity liner systems & components
    - Accelerated aging studies of cavity reinforcement system (DI water exposure)
    - *In situ* accelerated testing of liner systems
- Contact made with David Sinclair from SNO
- Continuing to evaluate possible materials for testing as part of the R&D program

* Working number– still being finalized

Cavity Liner Requirements

- Provide support for cavity walls
  - Limit and contain fracturing of cavity wall rock
  - Limit damage to equipment/personnel from surface failures
  - Exact bond strength and tensile properties need to be determined in conjunction with cavity design
- Contain a DI water volume of 500kT
  - Seal out external contamination (including Radon)
  - Avoid contaminating the water beyond the capabilities of “reasonable” water filtration equipment
  - Allow repeated fill/empty cycles
  - Provide a reliable seal for 30+ years
  - Avoid breaking the bank!

Preliminary questions:

- Mine engineering issues
  - Mechanical requirements (Petersen, Kuchta)
    - What bond strength is required?
    - What tensile strength is required?
  - Application issues (Kuchta)
    - What surface treatment of rock is required before application?
    - What are the environmental concerns?
  - Retention of bond to cavern surface
    - What will be the impact of water seepage behind barrier?
    - What is the impact of multiple fill-empty cycles ?
- Detector engineering issues
  - How will we interface with PMT mounting scheme? (Wilkes)

More Questions:

- Detector Engineering Issues (Cont.):
  - Extractables from barrier–
    - What will migrate into the water?
    - How much?
    - Ease of filtration?
  - Migration of contaminants through barrier-
    - What will penetrate, and how fast?
    - Particular concern– Radon?
  - Stability/chemical resistance
    - How will the TSM polymer respond to aggressive DI water?
    - How will water vapor permeating the TSM affect the bond to the rock/shotcrete surface?

Investigations of UNO Cavity Liner Design

- Literature search of available materials *UNDERWAY*
- Evaluation of experience at other labs *UNDERWAY*
- Define “straw-man” cavity liner design and minimum requirements for TSM materials

  UNDERWAY
- Mechanical testing & accelerated aging *R&D PROPOSAL*

Preliminary results on literature search

- Much of the available information is empirical, even anecdotal, but improved modeling may begin to change this situation.
- Many options exist:
  - Wide range of permeability to water vapor, Radon, etc.
  - Wide range of bond strengths, tensile strength
  - Custom membrane materials may be possible
  - Many application techniques
- Specific information about water-filled cavities limited– most material I have found is from HEP experience! Not much published literature, some internal notes.

Many commercial TSM products are available...

Product	Manufacturer	Mix Base	Material Type	Fast/ Slow
?	3M	Polyurethane	Liquid/Liquid	Fast
Ardumin TM020	Ardex	Hydraulic Cement	Liquid/Powder	Fast
Castonite M1	Rohm & Haas Composit.	Thermo plastic acrylic polymer	Liquid/Liquid	Fast
Evermine	Mead Mining	Cement/Acrylic	Liquid/Powder	Slow
GSM CS1251	MBT	Polyurethane-Polyurea /Acrylic	Liquid/Liquid	Fast
Lanko 228	CHRYSO	Cement/Acrylic	Liquid/Powder	Slow
Masterseal 840 R	MBT	Methacrylate	Liquid/Liquid	Fast
Masterseal 850 C	MBT	Methacrylate	Liquid/Liquid	Fast
Mineguard	Mineguard Canada	Polyurethane	Liquid/Liquid	Fast
Rocguard	MCC	Cementitious Polymer	Liquid/Powder	Slow
Rock Hold	Mondi / ICTUS	Methacrylate	Liquid/Powder	Slow
Rock Web	Spray On Plastic	Polyurea	Liquid/Liquid	Fast
Rockguard	Engineered Coatings	Polyurea/Polyurethane	Liquid/Liquid	Fast
SPI Polyurea	Speciality Products Int.	Polyurea	Liquid/Liquid	Fast
Tekflex	Fosroc Inc.	Cement Latex	Liquid/Powder	Slow
Tunnelguard	SA Mining & Eng.	Cement Latex	Liquid/Powder	Slow

Courtesy of CSM

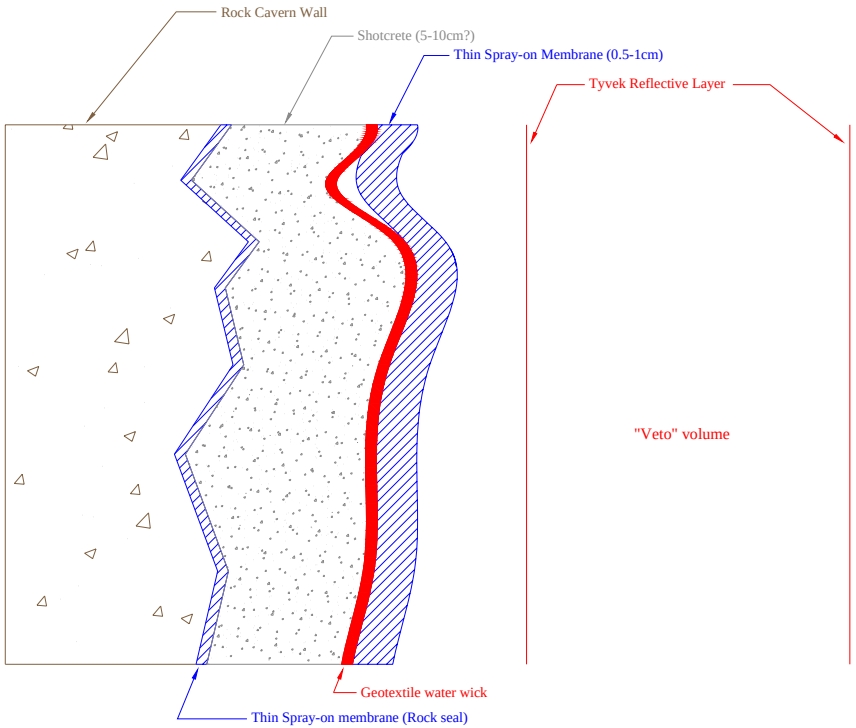
...And custom products are possible

Existing HEP Experience

- David Sinclair from SNO Lab has been very helpful
  - Not much published data regarding cavity design– Sinclair is looking into securing internal reports/documents for us.
  - SNO cavity design virtually identical to UNO straw-man design
  - SNO used Urylon for TSM– now “out of favor” due to difficulties with application
  - Multi-layer TSM application (alternating colors!) necessary to discover pin-prick leaks (initial cistern test leaked badly)
  - Smoothing and preparation of shotcrete surface critical
  - SNO cavity leaks slowly– Believed to be due to penetrations in cavity liner. PMTs should be suspended from top deck
- No contact with yet with KamLAND– beginning to look for a contact there.

Cavern Wall Water Containment: Revised straw-man design

- Cavern wall excavated, rock wall stabilized, surface scaled
- Preliminary layer of geomembrane applied
- Rock bolts/cables, steel mesh installed
- Shotcrete applied, large overhangs filled, surface smoothed
- “Geotextile” layer applied (water wick to sump at detector base)
- Surface prepared, Spray-on membrane applied (several layers, alternating colors?)
- Water volume makes contact with secondary spray-on membrane
- Detector veto volume isolated from membrane by film layer



R&D Proposal

- The main goals of research are:
  - To provide feedback for cavity design
  - To determine if TSM lined cavity for water containment is feasible (and cost effective)
- Outline of R&D plan:
  - Mechanical tests of candidate TSM materials
  - Application of candidate liner materials at CSM Experimental Mine and studies of system mechanical properties.
  - Tests of mechanical properties before after immersion in DI water and accelerated aging
  - Tests of candidate materials in DI water cistern at CSM experimental mine

Mechanical Testing

- We have access to the materials lab at CSU, which allows us to characterize candidate TSM materials.
  - Bond strength
  - Modulus of elasticity
  - Ultimate strength
  - Elongation at yield
- Provides critical input into cavity design.

In situ Mechanical Testing

- CSM has a teaching mine available to test proposed liner designs.
- Equipment exists for applying sample TSM/Shotcrete liners and testing them.
  - Bond strength and ground support can be measured.
- Surface preparation of rock before application can also be studied.

Accelerated Membrane Aging

- We will construct a temperature-controlled DI water immersion tank at CSU to allow for accelerated (high temperature) aging of TSM samples.
- DI water will be tested before and after sample immersion to look for extractables (commercial testing lab).
- Mechanical properties of TSM materials will be re-tested following immersion aging.

Accelerated Aging in CSM test Mine

- A test cistern (~10,000 L, 10m2 X 1 m deep) can be produced in CSM experimental mine and candidate liner system applied.
- DI water system from CSU will be used to maintain high-purity, high temperature DI water in cistern
- Tests will be done on cistern leak rate and DI water immersion impact on membrane bond strength to Shotcrete and mine wall
- Repeated water fill/empty cycles can also be tested

Current Funding & R&D Proposal

- SUNY Stony Brook has provided $10K for initial research at CSU.
- CSU/CSM have submitted a request for $170K to be included in the UNO R&D proposal.

Conclusions

- Cavern-wall based water containment seems feasible.
- Previous examples exist– SNO, KamLAND, but questions remain.
- CSU and CSM are submitting a request for R&D funds to study new TSM/Shotcrete ground support designs and long-term aging effects of DI water on TSMs and adhesion.
- These studies provide important feedback into cavity design and detector costing.