Summary of US liquid breeder strategy

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TX and HX Summary from Yesterday

- Niobium or Tantalum alloy tubes
  - Vacuum permeator appears feasible (~10 mPa range) based on estimates of transfer coefficients – dominated by mass transfer in PbLi itself
  - Nb will eventually getter all available O, N and C given sufficient time based on kinetics resulting in increase in DBTT
    - Niobium limit ~1000 ppm
    - Niobium-Zr ~3000 ppm (requires heat treatment)
  - Corrosion impact of O on PbLi-Nb system? No direct data
  - O partial pressure in vacuum or helium must be ~10^{-10} to ~10^{-11} torr based on a lifetime assumption
  - N or C partial pressure from PbLi side must also be investigated, and synergistic H effects. Is there any materials research needed here?
  - Achieving these partial pressures requires very very good preconditioning of Helium coolant, and very good vacuums – technological system R&D needed, accident scenarios
- Paladium
- Molybdenum – seems to brittle
- SiC
  - Expensive, but feasible? More feasible than Nb or Ta
  - Brittle, loading
  - Is this second option?
- Corrosion barrier coatings
  - ?
- More “stages” of direct contact TX and HX - bubble columns
- Removal of T from helium coolants – still requires high temperature contact

Keep in mind that a full size system is not needed until DEMO timeframe, not needed for ITER
Is there sufficient reason to switch

- Before the DCLL critical issue discussion, consensus was there was not sufficient reason as this time to switch
  - DK never advocates switching to HCLi but thinks we should keep our eye on and support others efforts in this area to the extent we can
  - Steve Z. also doesn’t think there is sufficient technological or cost reason to change course, but that we should keep our eye on large NASA Li project that could become large investor in Li technology rivaling EU investment in PbLi and capitalizing on previous significant US experience in Li
  - Abdou: the path forward, even in the worst case of no successful R&D on the critical high temp issues (FCI, TX, HX) is the HCLL.
  - DCLL enables the US to take full advantage of the EU development while exploring methods for attaining high temp
  - Neil/Siegfried see no real change in the reasons for DCLL selection
- And now, after TX and HX discussion, is there a change?
Clear statement on TBM

- The TBM community sees no reason (either technical or cost related) to change paths away from the DCLL concept at this time. **DCLL enables the US to take full advantage of the EU development while exploring methods for attaining high temp**

- The follow strategy is recommended:
  - Continue to focus on the critical issues for TBM and meeting TBWG milestones.
  - Develop various cost pathways involving staging development over time, low temperature testing programs, collaborating closely with EU HCLL effort and with other interested ITER parties
Various Strategies for DCLL TBM R&D and Deployment

- **Low Cost Scenario (minimal ITER utilization)** - Support EU HCLL effort, no independent DCLL TBM
  - Support EU in areas of unique US expertise (e.g. MHD, Tritium, TBM engineering scaling, safety, etc.)
  - Design small tests for aspects of more attractive options (e.g. small SiC FCI tests, tritium permeator)

- **Moderate Cost Scenario (Good ITER utilization)** – Temporally staged effort starting from small tests with EU, building towards independent TBM
  - Design small tests for aspects of more attractive options or small TBMs using EU loops
  - Develop independent loop systems and TBM over longer time, testing in ITER at a later time (ITER+5 or +10)
  - Still do very simple half port tests for EM loads and Structural Load testing?

- **Full Resource Scenario (Optimum ITER utilization)**: Coordinate world-wide effort for half-port DCLL TBM with EU, China, Japan, etc.
  - Rely on EU R&D for issues on FS fab, tritium extraction, PbLi chemistry control,
  - Coordinate R&D on SiC insert fab and compatibility, MHD effects, ancillary equipment and TBM design and construction, etc. among interested parties
  - Plan on half-port operation from ITER+0 (ancillary equipment is still staged as needed
  - Parallel work on longer term issues beyond ITER
Possible DCLL TBM Testing Strategies that affect cost

- Most conservative: Low temperature operation only
  - PbLi temperature < ~450°C, low corrosion, high FS strength, lower tritium permeation, low temperature ancillary equipment
  - Primary He temperature kept even lower to create temperature differential for testing thermal function of FCI, investigating natural convection effects
  - Substitute FCIs using FS/Alumina and deploy SiC at later stage

- Reasonable: Higher TBM temperature operation after successful low temperature operation
  - PbLi temp up to ~700°C in TBM only, ancillary equipment still low temperature (using bypass flow)
  - Allows testing high temperature behavior of TBM and FCIs including tritium permeation, compatibility

- Most aggressive: All high temperature operation including high temp loop piping and TX and HX testing in ITER