Overview of radioactivity vs. chemical toxicity issues for potential target materials

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Hg and Pb are potential high-Z materials for hohlraum fabrication

- Indirect-drive targets for future IFE power plants will require high-Z materials for production of x-rays
- Selection of materials must include many different factors such as target performance, cost, extraction, compatibility, and S&E issues
- Several reasons support the use of Hg and Pb for target fabrication:
  - previous safety work showed that both met radiological criteria
  - economical advantage in using any of these materials instead of the traditional gold-gadolinium cocktail
  - both materials seem to be appropriate for feasible target production
  - recent work on flibe coolant clean-up system presented respective cost-efficient solutions for Hg and Pb
- However, other important aspects that must be addressed before final selection of one particular candidate

Compatibility with the stainless steel structures needs to be addressed

Use of low carbon SS-304 (SS-304L) has been proposed to prevent corrosion of chamber and piping (creep fatigue tests are needed)

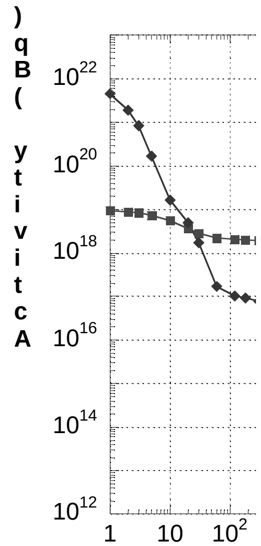
Highly strained components might be designed to have a shorter lifetime or to support a lower stress

When comparing corrosion issues there does not seem to be a big advantage of one material over the other

However, maintenance of structures seems to be more difficult in the case of Pb (expected to precipitate and build up inside pipes)

Previous work has focused in the radiological safety area

- Previous analysis showed that Hg and Pb meet the criteria for contact dose rate, waste disposal rating and accident dose



- We have re-evaluated the accident dose considering conservative weather conditions

- In order to achieve the 1-rem goal, the release of Hg must be limited to **4.2 kg**
  - from the target fabrication facility perspective, this is ≈ 100% release of a 1-hr supply
  - regarding accidents in the coolant circuit (Hg inventory is 0.17 kg), any release result insignificant doses to the public

- In the case of Pb, a **20 kg** release would result in 1-rem
  - considering the Pb inventory at the target fabrication facility, this is equivalent to 10 release of a 4.5-hr supply
  - from the primary coolant loop perspective this is ≈ 1% of the total Pb inventory (1740

Chemical toxicity issues from the use of Hg and/or Pb have yet to be addressed

- Whereas past work has only looked at radiological consequences of a accident, potential chemical exposure could be a critical issue
- This work is a preliminary assessment trying to compare radiologic versus toxicological consequences of Hg and Pb accidental releases
- We have adopted the **TEEL-2** as the criteria at which protective actio will be taken and calculated air concentrations (4.5 m/s windspeed, stability class at 100 m distance as recommended by DOE Standard 1027

Substance	TEEL-0	TEEL-1	TEEL-2	TEEL-3	NIOSH IDLH
Elemental Hg and inorg. compounds	0.025	0.025	**0.1**	10	2
Mercurous oxide	0.025	0.025	**0.1**	10	2
Mercuric oxide	0.025	0.025	**0.1**	10	2
Elemental Pb and inorg. compounds	0.05	0.15	**0.25**	100	100
Lead dioxide	0.05	0.15	**0.25**	100	100
Lead oxide	0.05	0.05	**0.05**	100	100

Units are mg/m^3

We have performed air dispersion calculations to assess chemical exposures

- We have used the standard dispersion equation backward from the lin concentration at the point of interest to estimate the amount of mater released: $\boldsymbol{C = Q / \pi * \sigma y * \sigma z * u}$

- In the case of Hg, a release of **56 mg/s** would reach the value specified l TEEL-2

- For Pb, the smaller value of TEEL-2 would limit the allowed release ra to **28 mg/s**

- We have combined these results with the evaporation model from t ALOHA (Areal Locations of Hazardous Atmospheres) code to determi the radius of the evaporating pool that would match those rates

- We have obtained that the maximum allowed release rates would reached through evaporation at normal temperature from a **13 m** radius H pool and **440 <u>km</u>** radius Pb pool, respectively

HOTSPOT was used to analyze the releases from the radiological assessment

The HOTSPOT code for atmospheric dispersion simulations was run t simulate an instantaneous release of **4.2 kg** of Hg gas and **20 kg** of Pb gas

Assumptions include 4.5 m/s windspeed, D stability class, 100 meter distance from the release point, as recommended by DOE Standard 1027

We have estimated values at the receptor point of interest calculating th peak 15-minute time-weighted average concentration (TEEL-2 limits ar intended for a 15-minute exposure)

Results show a concentration of **6.33 mg/m^3** in the case of Hg and **3 mg/m^3** for the Pb release

This values exceed the TEEL-2 limits by more than an order of magnitude however, we are conservatively assuming that all the mass is directl released as a gas

Conclusions (I)

- From the S&E perspective, one must consider two different kinds of toxicological hazards when deciding on appropriate target materials: **radioactivity** of activated materials and **chemical toxicity**

- Activation results show that both Hg and Pb classify as adequate when analyzing the contact dose rates and waste disposal rating

- Regarding radioactivity releases from accidents at the target fabrication facility, Hg is the most hazardous; however, segregation of the inventory in the plant would make the 1-rem limit goal achievable

- In case of accidents involving the power plant primary coolant loop, Pb seems to pose a greater radiological hazard due to its higher inventory suspended in the coolant flow

Conclusions (II)

- The chemical assessment shows that due to the similar values of the TEELs, neither material is an obvious candidate
- Release rates of several mg/s would reach the TEEL-2 limit at 100 m for both Hg and Pb assuming that they were released in gaseous form
- The high volatility of Hg presents it as a more hazardous option given its high saturation concentration in air at normal temperatures
- If either material is released at a rate deemed to be acceptable from a radiological point of view, the time-integrated concentrations would exceed the TEEL-2 limits by more than one order of magnitude

For lead and mercury the chemical toxicity seems to be the key issue from the S&E point of view. Further investigation is needed.