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Ref: 1<sup>st</sup> Stakeholder Consultation- Questionnaire for beryllium and its compounds

Please find below my comments regarding your questions:

Questions:

1. General Questions

- a. Our interests would include the use of high purity Beryllium foil, as used in X-Ray tubes and X-ray detectors, and to a lesser extent the use of Beryllium as an alloying agent in Beryllium Copper electrical contacts. We do not use or have any experience with Beryllium compounds as noted in your document.
- b. Beryllium is the best possible choice for X-Ray tube windows, as its physical properties allow for maximum X-Ray transmission, excellent vacuum and thermal performance, and mechanical toughness even when rolled out to less than 12 microns thick. Some of our X-ray detector systems use similarly constructed Beryllium foils, although the industry trend is towards materials that may sacrifice mechanical toughness for improved X-Ray transmission. As an example, detector windows made of thin Silicon Nitride ( $\text{Si}_3\text{N}_4$ ) have been successfully used in Instruments that do not require mechanical toughness; the benefits in Low Energy X-Ray transmission are significant compared to Beryllium.

2. Applications in which Beryllium Metal and Beryllium Oxide are in use.

- a. Our use of Beryllium is confined to metallic thin foils, and in some electrical contacts as Be-Cu. We do not use Beryllium Oxide or other Be- Compounds.
  - i. The beryllium content of X-Ray tubes and Detectors is of such a low weight percent that it is generally considered to be below regulatory concern for disposal purposes. (typically, 12 mm dia x 12.5 microns thick).
  - ii In some X-Ray detector applications, Beryllium has been replaced by  $\text{Si}_4\text{N}_3$  which has improved X-ray transmission properties. There may be other materials used by other companies.

- b. We are not aware of any reintroduction of Beryllium into the material cycle.
- 3. Quantities and ranges in which beryllium and its compounds are in use:
  - a. Our usage per year is under 300 grams total.
  - b. Cannot determine.
  - c. Beryllium in X-Ray tube windows is unlikely to be replaced anytime soon.
- 4. Potential emission into the waste stream.
  - a. An X-Ray tube that weighs 15 kg has about 2 grams of Beryllium. We generally do not try to reclaim this material.
  - b. The beryllium in our waste stream has been coated with a polymer to prohibit oxidation to BeO. It remains as a solid, very thin foil as waste.
  - c. No known risks.
- 5. Substitution
  - a.
    - i. X-Ray tubes require Beryllium foil for windows. It withstands the radiation, is mechanically tough, is relatively transparent to Low energy X-rays, and can be made vacuum tight despite being very thin. X-Ray detectors can use Silicon Nitride windows as a substitute for Beryllium in **some** applications, however Silicon Nitride is incredibly delicate and will fracture easily when even a small particle strikes the surface.
    - ii. see above.
    - iii. Silicon nitride, as used for X-Ray Detector windows is very expensive, difficult to handle, and difficult to manufacture. Beryllium has been used in many applications for decades.
- 6. Socio Economic Impact of a possible restriction.

Beryllium, as used in X-Ray tubes, cannot be replaced. Period. In some X-ray detectors, it might be possible to use other materials, but at a significant cost penalty and likely a durability cost as well. Considering the tiny amount of Beryllium used, this application should be considered 'Below Regulatory Concern.'

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