Memorandum / Note

Summary - Workshop on Beryllium Applications and Health & Safety Aspects for ITER

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Summary from the Presentations and Discussion at the Workshop on Beryllium Applications and Health & Safety Aspects for ITER

ITER Organization, 28 – 30 June, 2017

The Workshop on Beryllium Applications and Health & Safety Aspects was held at the ITER Organization (IO) Headquarters on 28-30 June, 2017. The workshop was organized by the ITER Beryllium Management Committee (IBMC) and comprised six sessions covering the following beryllium topics.

- Session 1: introduction to the ITER project
- Session 2: Specifications and Design of Beryllium Facilities
- Session 3: On-Site Operational Aspects
- Session 4: Working with Beryllium (Monitoring, Occupational Hazard and Medical Follow-up, and Health & Safety)
- Session 5: Beryllium Workers and Training
- Session 6: Conclusion summary session

Presentations as well as the Session Chair summaries can be found on the website for those registered for the workshop (http://www.iter.org/beryllium-workshop) and on IDM for internal participants (Workshop on Beryllium Applications and Health & Safety Aspects for ITER or https://user.iter.org/?uid=V7G7LA).

Many of the presentations overlapped in scope and content with other sessions; therefore an overall summary of the key points is made for different important topic areas rather than for sessions. Additional details can be found in the presentations.

Key Points from the Presentations (and Discussion)

1. Beryllium Contamination Monitoring

- Sampling for beryllium surface and airborne levels is performed both within controlled zones and the areas surrounding the controlled zones to confirm control measures are adequate and to identify any possible spread of contamination.
- Frequency of control varies between organisations. AWE Aldermaston (UK) and JET make daily controls (multiple samples during one day); Atmostat (Industry) makes weekly measurements; others, such as Efremov, Bochvar, and Kompozit, make monthly controls.
- Additional controls can always be made for non-standard events or issues.
- Personal Air Samplers (PAS) and portable units are used to monitor the airborne levels for individuals or for processes.
- Records are kept and accessible; some consider PAS results as confidential.
- Currently no real time beryllium monitoring equipment is possible; however, this could change if funding was available.
2. Airborne Limits for No Protection

- Regulations are different from country to country.
- Airborne value of 2 µg/m$^3$ time-weighted-average (TWA) over 8 hours in France and UK.
- Airborne value of 1 µg/m$^3$ in Russia.
- Airborne value of 0.5 µg/m$^3$ in China.
- No requirement for airborne measurements for Juelich in Germany.
- Short term exposure limits (typically 15 minutes) applied in CN but not applied now in all countries, e.g. UK.
- Need to take account of particle size. Occupational Exposure Level (OEL) of 0.2 µg/m$^3$ limit from USA Occupational Safety and Health Administration (OSHA) (averaged over 8 hours; 2 µg/m$^3$ as short term exposure limit (STEL) over a 15 min sampling period). Beryllium Science and Technology Association (BeST) recommends a limit of 0.6 µg/m$^3$, inhalable (8 hours TWA).
- There are differences among:
  - the inhalable particulate fraction which is the fraction of the cloud of particles that can be breathed through the nose or mouth;
  - the thoracic particulate fraction which is the fraction of the cloud of particles that can penetrate the head airways and enter the airways of the lung; and
  - the respirable particulate fraction which is the fraction of inhaled airborne particles that can penetrate beyond the terminal bronchioles onto the gas-exchange region of the lungs.
- Scientific Committee on Occupational Exposure Limits (SCOEL) considers limit based on sensitisation and suggests 0.02 µg/m$^3$.
- No clear correlation between surface contamination and airborne levels.

3. Surface Contamination Limits

- Wide range of acceptable surface and ground (not components) contamination limits depending on the country (before action is necessary) → 20 to 5000 µg/m$^2$.
- In France the indicative current limit from INERIS is 300 µg/m$^2$.
- For example, Atmostat sets a maximum limit of 300 µg/m$^2$ in the workshop (where beryllium is machined), with decontamination triggered when the measured contamination reaches 200 µg/m$^2$.
- Ulba (Kazakhstan) which produces beryllium and has to deal with ~100 tons of beryllium per year sets up 3 beryllium zones depending on the activities and beryllium concentrations; the maximum limit of surface contamination is 2000 µg/m$^2$ for smooth surfaces and 5000 µg/m$^2$ for porous surfaces. In some instances, workers have to go through a sauna or steam bath for sweating and skin cleaning following their work in the beryllium area.
- Surface levels are sometime used as a starting point to set initial Respiratory Protection Equipment (RPE).
4. Surface Sampling Method

- Although this technique has many critics, surface contamination measurements are used by all the organizations to assess the beryllium contamination levels.
- Accuracy of the technique was discussed and participants considered an accuracy of between ± 10 - 50% taking into account operator variability and analysis.
- Both wet and dry techniques have been used for surface contamination measurements.

5. Beryllium Facilities

- Should be typical of a cleanroom, operating theatre environment (from class 100 to 10 000).
- Air changes per hour: between 3 -12 times per hour depending on the organisation.
- Depressurization of beryllium facilities rooms: 5 Pa to 80 Pa; depressurization ensures contamination stays in the room.
- Flow shall always be clean to dirty.
- Cleaning – daily or weekly (depending on the contamination levels and type of activities being performed) using wet methods and High Efficiency Particulate Air (HEPA) vacuuming (no blowing or conventional vacuum cleaning).
- Housekeeping is the key to contamination control.
- Yearly maintenance – systems monitored and logbook to maintain records of activities.
- Consider how you will tour/demonstrate or monitor work in the facility with visitors to minimize disruption. That might mean a viewing window or video capability.
- Specify shipping container, configuration, and cleanliness condition to minimize the space needed to repackage in the facility design.
- Consider the potential need for long term storage of the tiles/panels, and if an inert cover gas system might be necessary. Beryllium does oxidize over time, and at least one vendor ships with a N₂ cover gas.
- Consider what roof/pipe/tank leaks can cost you by spreading beryllium where you don’t want it in your design. This issue has caused significant work stoppage and expensive cleanup in an old US facility.
- Plan for structure and inventory that can be easily decontaminated.
- Plan for one way access and exit of beryllium areas.
- There was no clear position about the types of fire extinguishing system that are used in the beryllium facilities.
- Facility access by badge reader with link to worker being up-to-date on training and medical surveillance.
- Equipment, isolation points, and controls need to be outside the beryllium area as much as possible to allow for preventive maintenance and repairs without exposure.
- Minimize or eliminate the use of “one-of-a-kind” software, equipment, or systems as well as equipment/software that is proprietary.
- Use Nuclear Grade Filtration Systems that are designed to be safely maintained and tested; use multiple filtration steps with HEPA filtration for final stage.
- Use high quality components from reputable manufacturers.
• Use components that last (e.g. LED lighting instead of fluorescent).
• Staff with experience in control of beryllium operations is a must for the design and initial implementation phases.
• Viewing windows or video feeds could be a way to minimize entries to the beryllium facility.

6. Beryllium Analysis

• In-house capability provides short turnaround of results, e.g. AWE Aldermaston, JET, Atmostat...
• Recommendation that the analysis laboratory is close to operations for efficiency but not part of the facility in case there is need to recover from a breakdown where analysis will be used to confirm the status of beryllium contamination.

7. Medical

• Pre-exposure medical examination is performed in all cases:
  - Typically includes lung function test, medical questionnaire, and consultation with doctor. In some cases periodic chest x-ray, Beryllium Lymphocyte Proliferation Test (BLPT), urine, nasal swabs, electrocardiogram...
  - Bi-annual or annual medical follow up for Beryllium workers
• Skin injuries are to be taken seriously; there is the possibility for the wound not to heal and this can require local surgery.
• Worker history kept for 30 years (Atmostat).
• Biological monitoring is considered but no clear evidence that the approach is fully reliable. Biological monitoring is an emergent need supported by SCOEL.
• BLPT is available for some organizations but usually on a voluntary basis.
• Some cases of medical exclusion were identified.
• Atmostat considers beryllium as an allergen material.
• BLPT performed at the Hôpital Henri Mondor (Creteil, France).
• Sensitisation can occur from exposure to beryllium. Studies suggest that about 1% of the general public can become sensitized to beryllium (even without a beryllium occupation and based on what they eat in some cases) and 8% of sensitised persons could develop Chronic Beryllium Disease (CBD).
• NGK look for allergic tendency in their workers; they do “type I” allergy test against plant and skin sensitivity.

8. Training

• A specific beryllium training is provided by all organizations; the fundamentals are covered in the training program and the content is similar; in some cases additional details are provided related to related processes, e.g. waste management, smearing, incidents, ...
  - Procedures for working with beryllium.
Designation of controlled areas and local rules.
- Classification of workers (training and medical).
- Exposure limits.
- Personal and area monitoring.
- Exposure controls (PPE, engineering controls, ventilation).
- Working practices (cleaning, contamination control).
- Transport and movement between areas (packaging and labelling).
- Clearance.
- Waste management.
- Medical and Mask Fit test.
- Incident response.

9. Clearance Levels - Removal of Beryllium Contaminated Items from Controlled Areas
- Varies depending on the organization and country regulations (if any).
- JET, AWE, PISCES consider values below 10 µg/m² for clearance.
- Efremov considers 30 µg/m².

10. Transfers and Tracking
- It’s not clear if tracking beryllium inventory is a requirement for storing beryllium; however, good practice would suggest that a tracking system be in place to understand onsite quantities and its whereabouts.
- JET operates an electronic receipt and transfer system (area to area), transfers only between designated areas, with external surface contamination of packaging < 10 µg/m².
- Some organizations check beryllium inventory each year.
- Others track weight of raw material before and after machining to assess beryllium in the filtration /collection system.

11. Receipt of Beryllium
- Organizations propose that surface contamination measurements are made upon receipt of beryllium components.
- Measurements are taken from the component in a beryllium controlled area with operators using PPE/RPE.
- Juelich cleans the samples in an ultrasonic bath as part of the receipt process.

12. Local Instructions (Code of Practice)
- Vary with organization and country.
• A set of local procedures for working with beryllium following local limits and procedures seems to be available for those organizations that joined the workshop.
• JET has produced an extensive code of practices to cover its onsite rules and practices relating to working with beryllium. The code provides a guideline and detailed practices of the activity are controlled by procedure and work risk assessments in all cases.

13. Cleaning of Beryllium Components
• Ultrasonic bath techniques appear to be the standard process used by the organization.
• 10 µg/m² has been possible on the surface of ITER Blanket First Wall (FW) panels.
• Several 10s of µg/m² remain in the slots of FW panels.
• Some suppliers have regulations only requiring surfaces to be clean to 30 µg/m² and others use facility levels 300 µg/m².
• US have developed proprietary dry wipes specifically for beryllium clean-up that have been licensed to an outside vendor. Lint free wipes, cheesecloth, fluffy wipes, glove wipes, and floor buffer pads, for example, have been treated for different tasks.
• High Heat Flux tested components show increased surface contamination at 5.9MW/m².
• Overall, cleaning of FW panels seems unlikely to achieve < 10 µg/m².
• SWIP (China) indicates that, from their experience, cleaning of flat surfaces to < 10 µg/m² and of slots to < 50 µg/m² seems feasible and cost effective.
• It has also been stated that cleaning of rough surfaces would be more difficult than smooth surfaces; so the roughness resulting from the final machining operation (such as etching) on the beryllium tiles of a FW panel would impact the final surface concentration level following cleaning.

14. Machining of Beryllium
• Several of the organizations specialise in machining of beryllium.
• Juelich prepares beryllium samples for analysis using a fume hood in wet conditions.
• JET set up a beryllium workshop for modification of tiles for the ITER like wall.
• Wet techniques, local extract, confinement barriers are used.

15. Incident Management
• 2 unconfirmed cases of beryllium disease reported in the past by AWE Aldermaston.
• The UK Company Exotec mentioned 1 case of an operator sustaining a beryllium related skin injury (a small granuloma on the thumb which had to be removed surgically).
16. Storage of Beryllium

- Practices are in place to reduce the build-up of beryllium oxide on the surface of components during storage. Beryllium does oxidize over time.
- Current information suggests that controlled conditions such as vacuum and inert gas storage will reduce the formation and/or increase of surface contamination levels.
- Tests are ongoing at JET.
- Double bagging with desiccants between bags is also utilised.
- Controlled areas are used for storage.

17. Personal Protective Equipment (PPE)

- In general the PPE used by most providers is similar: coats, gloves, hats, overshoes, glasses, and boots – depending on the working environment.
- Some use disposable clothes, others consider reusable and washable clothing.

18. Respiratory Protective Equipment (RPE)

- Used depending on the level of risk and regulations; typically a filtering face piece FFP3 type mask is used.
- Selection of mask/protection level is risk and activity dependent (i.e. for machining or for inspection).
- When airborne levels are unknown (new process), surface levels of contamination and an assessment of the activity are used to set the mask type. Once airborne levels are established the RPE can be revised.
- Using surface contamination levels to set RPE can result in higher levels of respiratory protection. In some cases, surface contamination over a few 10s of µg/m² can lead to the need for full face masks or suited work. These bring added worker protection but can increase the time and cost of the activity.

19. Waste and Waste Management

- Beryllium waste at ITER will be generated from arrival of first components.
- Limited economical interest in recycling, only for massive beryllium.
- Waste to be sealed in 200 litre drums with impermeable plastic liner bags and drop resistant. Principle is track, take samples for analysis, reuse and decontaminate where possible to reduce waste volume.
- IO currently plans to use external waste management service.
- For FW manufacturers, the operation generating the largest quantity of waste is ultrasonic testing due to the amount of contaminated water used.
- Beryllium use in fusion-relevant facilities - exposure under such conditions is deemed to contaminate most in-vessel components.
20. Future Approach Described by Some Organizations

- Some of the organizations working with beryllium expressed the need for continuous improvements, including:
  - Monitoring practices and techniques.
  - Proactive culture of the organization.
  - Risk reduction through engineering solutions.
  - Behavioural reinforcement on health benefits.
  - Plan improvements.
  - Learning from experience.
  - Monitoring performance during transition period if a change is made to regulations.

21. General Comments

- As part of “As Low As Reasonably Achievable” (ALARA) principle and to minimize the expense of medically following workers for 25 years, minimize the number of beryllium workers.
- Engaged workforce promote good practices.
- Limit the number of people exposure to reduce risks.
- Train people on how to deal with situation when people are sensitized (human problem on how to address individual with positive results, make counsellor available).
- Need to generate flow diagrams in case of accidental release.
- The Vacuum Vessel will effectively be a beryllium facility during assembly/installation. Best practices should be established.
- Contamination levels in the soil could cause erroneous results when measuring very low levels of beryllium concentration, as was found by the PISCES group at the University of California, San Diego. Suggestion to benchmark the soil contamination at ITER also to avoid this in the future.
Conclusions

The Workshop on Beryllium Applications and Health & Safety Aspects for ITER was well received by those attending with positive feedback on all aspects of the organization, agenda, presentations and hospitality. The Workshop provided an excellent opportunity for stakeholders of the ITER project to meet with beryllium specialists from international organizations and industries including beryllium suppliers, manufacturers, users from China, the EU, Japan, Kazakhstan, the RF and the US. As part of the Workshop Sessions, several ITER presentations were made, including an overview by Dr. Bernard Bigot, the Director-General, through which the ITER Organization shared information on the Project and on the planned beryllium management. The international colleagues also had the opportunity to visit directly the worksite and witness the progress of this unique international collaboration. Very informative presentations were made with some lively and productive discussions as the external participants shared with the IO their valuable experience and lessons learnt to help the IO establish a robust and effective Beryllium Management Worker Protection Program.

The Workshop objectives were fully met, namely to:

- Clearly identify the IO internationally as a major user of beryllium products and a major beryllium actor in the coming decades.

- Share the IO plan on dealing with beryllium issues to different international beryllium actors and obtain valuable feedback.

- Learn from the plan, activities and experience of these other beryllium actors through specific invited presentations and discussion in sessions on dedicated beryllium topics (lessons learnt/return of experience).

- Provide transparency as to the ITER approach on beryllium safety – sharing the knowledge internally and externally.

It now remains for ITER responsible officers, safety representatives, and the responsible group for beryllium building to follow up on the salient points from the workshop as summarized above, and introduce the findings into the working plans and practices for their components and/or facilities. The IBMC will continue its role to promote the ‘safe working with beryllium’ process and culture, and to provide a forum for presentation and coordination of beryllium topics at ITER.