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and Mitigation of Beryllium**

by

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# Removable Thin Films Used for the Abatement and Mitigation of Beryllium

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**Abstract.** The use of removable thin films for the abatement of hazardous particulates has many advantages. Removable thin films are designed to trap and fix particulates in the film's matrix by adhesion. Thin films can be applied to an existing contaminated area to fix and capture the particulates for removal. The nature of the removable thin films, after sufficient cure time, is such that it can typically be removed as one continuous entity. The removable thin films can be applied to almost any surface type with a high success rate of removal.

## I. INTRODUCTION

This technique was tested during the Decontamination and Decommissioning (D&D) of the Tokamak Fusion Test Reactor (TFTR) at the Princeton Plasma Physics Laboratory [1]. The removable thin films were applied to areas that were contaminated from the oxidation of lead bricks surfaces, which were utilized for radiation shielding [1].

The use of thin films had a high success rate of removal of lead oxide particulates. Due to this success, this process may be useful in the decontamination of other hazardous particulates. These particulates may include beryllium, coal dust, metal fumes, wood dust, and microbes.

For this experiment, beryllium was chosen to test the effectiveness of the removable thin films. Beryllium is emitted through natural and anthropogenic sources into the atmosphere. Elemental beryllium is the lightest of all chemically stable solids; it is lighter than aluminum and 40% more rigid than steel [2]. Due to these qualities, beryllium is extremely useful and can be found within nuclear facilities and is used for many commercial products [2].

Beryllium fumes and dust are among the most toxic substances known and have been classified by International Agency for Research on Cancer (IARC) as a human carcinogen [2]. Workers exposed to airborne beryllium or beryllium compounds can develop Chronic Beryllium Disease and may also develop lung cancer [2].

Inhalation is considered the primary route of exposure to workers [3]. Inhalational exposure to beryllium and beryllium compounds can result in Chronic Beryllium Disease, which is an inflammatory lung disease. Granulomas, interstitial fibrosis, and a beryllium-specific immune response characterize this disease. Acute Beryllium Disease is another effect of inhalational exposure to high levels of beryllium. This is a beryllium induced pulmonary disease that occurs with less than one year's exposure. This disease results from direct toxicity and is not an immune mechanism like Chronic Beryllium Disease. Since better industrial hygiene methods have decreased the levels of occupational exposure to beryllium, Acute Beryllium Disease is very rare [3].

## II. METHOD AND MATERIALS

Two proof of principle tests were conducted. First, the

removable thin films process was applied to various surfaces that were contaminated with a luminescent dust (Fig. 1). These surfaces include: stainless steel, aluminum, galvanized steel, PVC, and Lexan™. The luminescent dust was used as a substitute for the beryllium. To determine the presence of the luminescent dust an ultraviolet light was used. Two sets of each surface sample were made. For the first set, the samples were initially coated with the removable thin films, and then the luminescent dust was applied. Next, another layer of the removable thin films was applied, sandwiching the dust in between the two layers. The second set of samples were first coated with the luminescent dust; then the removable thin films were applied (Fig. 2). After the thin films cured, they were removed from the surface samples. The removable thin films peel off as one entity (Fig. 3). Once the thin films were removed the ultraviolet light was used to determine if any luminescent dust remained on the samples. It was determined that the samples that sandwiched the dust between two layers of the removable thin films, mitigated the contaminate more efficiently (Fig. 4).



Fig 1. Luminescent dust is applied to the samples



Fig 2. The thin films are applied to the samples.



Fig 3. The thin films are removed after they have cured

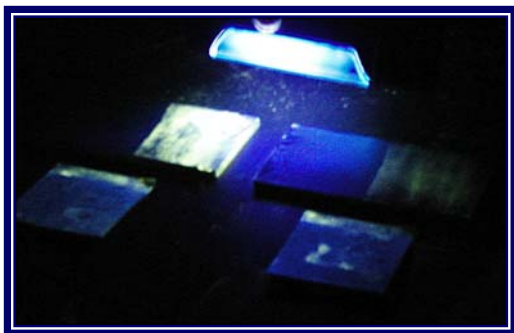


Fig 4. Samples under UV light. The sample on the left, reveals that luminescent dust is still present after the removal of the thin films. The sample on the right shows that very little luminescent dust remains after removal of the thin films.

The second proof of principle test was conducted at a Los Alamos National Laboratory Beryllium Facility. This facility is in the process of being decontaminated and then reclassified as a non-beryllium area. The same application method that was used for the luminescent dust was applied to various surfaces. Different surfaces were chosen, such as, floors, walls, ventilation ductwork, light fixtures, and milling machines to test. For each location two areas were blocked out. The first block was tested to determine the amount of beryllium that was present. The thin films were applied to the second block and left to cure. After twenty-four hours the thin films were removed and this area was tested to determine what beryllium concentration was still present. This test resulted in a two order of magnitude reduction of beryllium contamination, after one application. The use of thin films for the removal of beryllium contamination provided a highly efficient and cost effective mitigation and abatement technique.

TABLE I

Sample #	Location	Before <sup>a</sup> (ug/cm <sup>2</sup> )	After <sup>b</sup> (ug/cm <sup>2</sup> )
R1	Floor below Baghouse	0.026	0.00074
R2	Top of vacuum pump	0.25	0.00356
R3	Way cover to Bridgeport mill	0.968	0.507
R4	Floor NW of Bridgeport	0.0015	0.00004
R5	Top, ductwork	0.064	0.00033
R6	Top, Light fixture	0.0578	0.00084
R7	Wall by grinder	0.00265	0.00046
R8	Grinder table top	0.0026	0.0032
R9	Floor NW corner of room	0.0124	0.00227
R10	Blank	0.03	0.03

BERYLLIUM DECONTAMINATION VIA REMOVABLE THIN FILMS

<sup>a</sup> Contamination levels before thin films were applied

<sup>b</sup> Contamination levels after thin films were applied

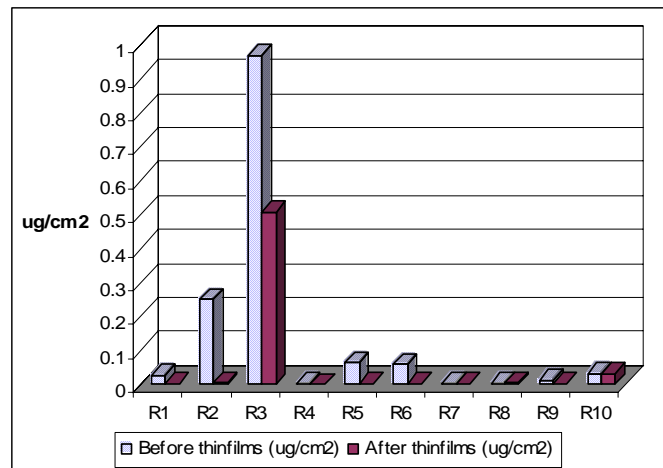


Fig 5. Comparing the beryllium concentrations before and after the thin films were used for mitigation.

### III. CONCLUSIONS

It was determined that the application of the removable thin films provided the most effective means of removing lead oxide surface dust and beryllium dust. The removable thin films were both highly effective in reducing the hazardous particulate concentration and cost effective, due to the single application process. After an extensive literature search, it was concluded that this was the first time removable thin films were applied as a mitigation technique for the safe removal of hazardous particulates.

More research and testing is needed for this mitigation technique. Tests need to be conducted to determine if the removable thin films can be used as a preventive control for beryllium particulates and other hazardous particulates. There is a need to improve the efficiency of the film's adhesion process to increase the amount of hazardous particulates that

are fixed to the product. Currently the removal of the thin films, after they have cured, is labor intensive. A better removal method, which is less time consuming and labor intensive, needs to be developed. To achieve better statistical data, more field testing of the removable thin film technique should be conducted.

#### IV. ACKNOWLEDGMENT

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