



# Rare but Significant Exposures:

Treating Corroded Cadmium Plating  
in a Museum Setting

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# Overview of Talk

- Hazards and Exposure Risks
- Cadmium at NASM
- Tests conducted
- Biomonitoring
- Results

# Hazards of Cadmium, CAS 7440-43-9

- Toxic
- Carcinogen
- Dangers:
  - Inhalation
  - Ingestion
  - Contamination

LD50 >5000mg/kg as a pigment



# General Sources of Cadmium Exposure

**Smoking:** 1000-3000 ppb in smoke, absorb 1-3 mcg per pack- doubles body burden.

**Food-** Consume 8- 30 mcg US/EU diet or 40 ppb- Retain: 1-3 mcg in the body. (EPA drinking water 5ppb)

**Industry:** Smelting (Zn/Cu), electroplating, plastics, Batteries

**Pigments:** CdSe, CdSe+CdS, CdS, CdS+ZnS (especially with pastels or mixing powder to paint/ glaze).



# Work related exposures

## Major route: Inhalation of Fumes and Dust.

- Incidental ingestion from contaminated hands, food, smoking.
- Heated operations have highest risk (fumes from electroplating, welds, smelting)

### Absorption rates by Route

- Breathing: 5-50%
- Ingestion: 1-10%, more if iron or mineral deficient.
- Skin: negligible

### Elimination by Route

- Stored in Liver and Kidney, leaves slowly through Urine and Feces.

# Cadmium as a coating

- Electroplated to iron, copper, aluminum, or titanium alloys
- Corrodes before base metal
- Pervasive in 20th century technological collections
  - Limited use today



Electroplating baths



Cadmium-plated steel  
Military grade AN5 bolts

# Project Overview: *Flak-Bait*

Martin B-26B-25-MA Marauder

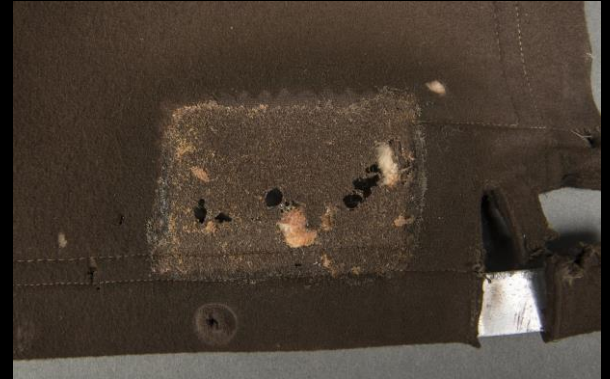


Nose Interior, Before Treatment

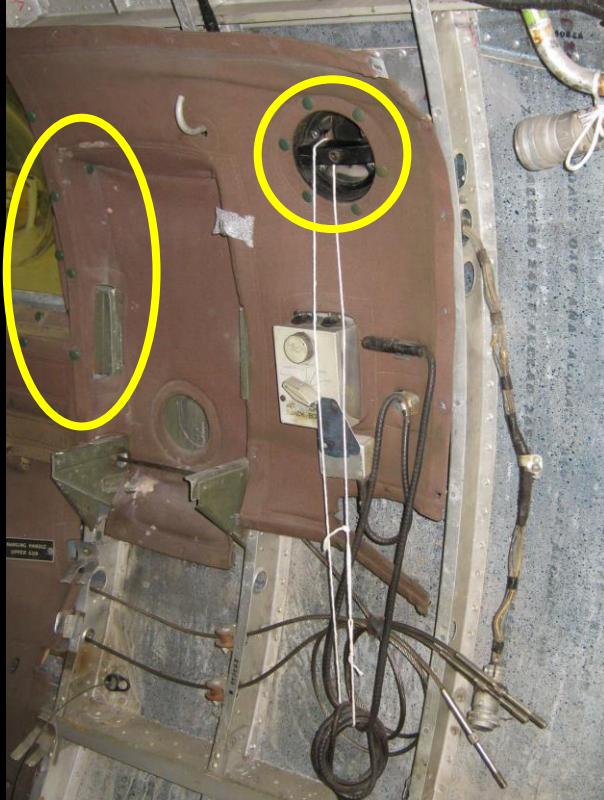


# *Flak-Bait* Nose Insulation Panels

50+ panels needed interventive treatment



# Insulation Panel Hardware



Corroded cadmium-plated steel buttons

Snap into aircraft ribs and around instruments



# Cadmium Standard Operating Procedures

- Reduce corrosion with damp cotton swabs by hand
- Coat metal to prevent future corrosion

Buttons also needed:

- Spray paint removal
- Iron corrosion treatment



# Other Treatment Methods Tested:

- Chemical bath: Metal Rescue
  - Manufacturer: Workshop Hero
  - Promising results
  - But, stripped paint



Example Button  
Before and After Treatment



Metal Rescue Product Line

# Other Treatment Methods Tested:

- Freedom Flex-Shaft rotary tool
  - Mechanized cleaning
  - 220 grit radial bristle disc
- Asked OSHEM to attend tests to conduct air sampling



# Freedom Flex Shaft Tests



Treatment tests conducted by Meghann Girard

Air monitoring and wipe samples collected by Chuck Fry



# Freedom Flex Shaft Tests

## Air Sample Results:

(8-hour time-weighted average)  
settled Cd dust

0.004 mg/m<sup>3</sup>

OSHA PEL:

0.005 mg/m<sup>3</sup>

OSHA Action Level:

0.0025 mg/m<sup>3</sup>

## Key Takeaways:

- OSHA Action Level triggered
- HEPA vacuum reduced dust by ~85%

## Wipe Sample Results:

\* Note: no OSHA guidance on

Location	Concentration (mg/m <sup>3</sup> )
Table, Before HEPA Vacuum	2850 µg/ft <sup>2</sup>
Table, After HEPA Vacuum	445 µg/ft <sup>2</sup>
Meghann's arms, Before Hand Washing	247 µg/ft <sup>2</sup>

# Occupational Exposure Limits

OSHA: 5 mcg/m<sup>3</sup> average  
over 8 hours.

*Under the standard, occupational exposure is defined as an employee's exposure to airborne cadmium in the workplace that is independent of the employee's use of respiratory protective equipment.*

Acute inhalation above 5 mg/m<sup>3</sup> can cause long term lung damage (*pulmonary edema, tracheobronchitis, pneumonitis*).

## Minimal Risk Levels (MRL)

- Inhalation: 0.03 mcg/m<sup>3</sup> acute
- Inhalation >1 year: 0.01 mcg/m<sup>3</sup>
- Oral: 0.5 mcg/kg/day (less than 1 year)
- Oral 0.1mcg/kg/day (>1 year)



# Symptoms of Cadmium Exposure

## Inhalation:

### Short term:

- Low to medium: irritation of nose and throat.
- High: delayed cough, chest pain, sweating, chills, weakness, difficulty breathing (9mg/m<sup>3</sup>/5h), death (40-50mg/m<sup>3</sup>/1h).

Long term: Loss of sense of smell, emphysema, kidney damage, anemia. Possible increase cancer.

## Ingestion:

### Short term:

- Nausea, vomiting, diarrhea, abdominal cramps

Long Term: Kidney damage, anemia, loss of bone density. Itai-Itai disease

# Biomarker Monitoring

Blood: recent exposure

Urine: Total body burden, can be used to estimate dietary or airborne cadmium exposure.

Fecal: daily dietary intake



# Why Medical Surveillance?

Identifies workers who may be at increased risk

Prevent kidney and lung disease

Detect and minimize existing cadmium induced disease



1910.1027(I)

Currently exposed - The employer shall institute a medical surveillance program for all employees who are or may be exposed to cadmium at or above the action level unless the employer demonstrates that the employee is not, and will not be, exposed at or above the action level on 30 or more days per year (twelve consecutive months)...Biological monitoring that includes the following tests: cadmium in urine (CdU), cadmium in blood (CdB), and beta-2 microglobulin in urine (B(2)-M)

Table 1. Medical Removal Actions Triggered by Initial Medical Surveillance (1910.1027(I))<sup>1</sup>

Biological Measurement	Normal Levels	Elevated Levels, Non-Mandatory Removal	Highly Elevated Levels, Non-Mandatory Removal	Highly Elevated Levels, Mandatory Removal
Cadmium in urine (CdU) <sup>2</sup>	≤ 3	> 3 and ≤ 7	> 7	> 7
Cadmium in blood (CdB) <sup>3</sup>	≤ 5	> 5 and ≤ 10	> 10	> 10
Beta-2 (β <sub>2</sub> MU) <sup>4</sup>	≤ 300	> 300 and ≤ 750	> 750	> 750
Trigger level	All three measurements at normal levels.	Any one measurement at an elevated level.	Any one measurement at a highly elevated level.	After confirmed follow-up testing within 90 days, either CdU or CdB remain at a highly elevated level, or β <sub>2</sub> MU remains at a highly elevated level and either CdU or CdB is at an elevated level.
Risk at this level	Negligible or relatively low risk of renal tubular proteinuria (i.e., consistent with the background rate among the general population).	Elevated risk of renal tubular proteinuria (i.e., above the background level experienced by the general population).	Elevated, and perhaps highly elevated, risk of renal tubular proteinuria (i.e., above the background level experienced by the general population).  Risk may not be abnormal if β <sub>2</sub> MU is highly elevated and CdU and CdB are at normal levels. <sup>5</sup>	Highly elevated risk of renal tubular proteinuria.
Actions	Provide annual biological monitoring and biennial medical examinations.	Provide semi-annual biological monitoring and annual medical examinations until all measurements return to normal levels.	If medically removed from job: Provide quarterly biological monitoring and semiannual medical examinations until physician decides to return employee to job or permanently remove the employee from job.  If not medically removed from job: Provide quarterly biological monitoring and semiannual medical examinations until all measurements return to normal levels.	Mandatory medical removal required. Provide quarterly biological monitoring and semiannual medical examinations until physician decides to return employee to job or permanently remove the employee from job.

<sup>1</sup>This table addresses only medical removal actions specified by the Cadmium standard; other requirements may apply based on the results of the other medical examinations.

<sup>2</sup>CdU = CdU µg per grCr

<sup>3</sup>β<sub>2</sub>MU = β<sub>2</sub>MU µg per grCrU

<sup>4</sup>CdB = CdB µg per lwb

<sup>5</sup>In cases in which the β<sub>2</sub>MU is highly elevated and CdU and CdB are at normal levels, the physician should check to determine that the β<sub>2</sub>MU levels accurately reflect the true β<sub>2</sub>MU levels. If they do, then the physician must determine the cause of the highly elevated levels of proteins in urine (e.g., presence of end-stage renal disease or immune-deficiency diseases).

# OSHA Requirements for Periodic Medical Exam

- Detailed work and medical history
- Complete physical- BP, RESP, Urinary system focus
- Chest Xray (initial)
- Pulmonary Function Testing
- CdU, CdB, B2M, BUN, CBC, SCrea, UA, Prostate test.

1910.1027(I)(9): The employer shall provide the following information:

- A copy of OSHA Cd standard and appendices;
- A description of the affected employee's former, current, and anticipated duties and occupational exposure to cadmium;
- A description of any personal protective equipment, including respirators, used or to be used by the employee, including when and for how long the employee has used that equipment; and
- Relevant results of previous biological monitoring and medical examinations.
- The employer shall instruct the physician *not to reveal orally or in the written medical opinion given to the employer specific findings or diagnoses unrelated to occupational exposure to cadmium.*

# What does the Doctor need?

**PART TWO**

**FAMILY HISTORY:** Has any family member had any of the following? Please check (x) each that apply:

Yes  No Any blood relatives who have had a heart attack before age 55?  
 Yes  No Disabling back pain  
 Yes  No Disability from work for other reasons  
 Yes  No Arthritis  
 Yes  No Muscle or nerve disease. If so, what \_\_\_\_\_  
 Yes  No Any other disease which might affect your treatment?  
Please list: \_\_\_\_\_

**SOCIAL HISTORY:** Please check (x) each that apply:

Marital status:  Single  Married  Divorced  Widowed  Separated  
Who do you live with?  Alone  Children (ages \_\_\_\_\_)  Spouse  
 Parents  Significant Other  Friends or Relatives  Other \_\_\_\_\_

How much alcohol do you usually drink?  None  1-5 drinks per week  
(1 drink = 1 can of beer, 1 glass of wine or 1 shot of liquor)  6-12 drinks per week  More than 12 drinks per week  
 Yes  No Have you ever used illegal street drugs? When? \_\_\_\_\_  
 Yes  No Have you been a cigarette smoker in the last 5 years?  
 Yes  No Currently, do you smoke? If yes, how much per day? \_\_\_\_\_  
 Yes  No Has a physician prescribed medical marijuana to you? If yes, date last used \_\_\_\_\_

Number of years of schooling completed (i.e., 11th grade, 4 years of college, etc.): \_\_\_\_\_  
Please check (x) if you have:  GED  Technical School Degree/Certificate  
Aside from your current problem, what are the most stressful things in your life? \_\_\_\_\_

**WORK STATUS:**

Yes  No Do you believe this problem is caused by your work?  
 Yes  No Are you out of work because of this problem? If yes, since what date?  
 Yes  No If working, are you on physician ordered restrictions because of this problem?  
If yes, please list restrictions: \_\_\_\_\_  
Please list physician ordering restrictions: \_\_\_\_\_  
Expiration date of restrictions: \_\_\_\_\_  
 Yes  No Have you ever lost work because of any injuries in the past?

Check (x) all that apply:

Job being held  Retired  Fired  Student  
 Working-Full Time  Medical leave  Self employed  Other: \_\_\_\_\_  
 Working-Full time  Homemaker  Not working - why? \_\_\_\_\_

Job title (current): \_\_\_\_\_  
Employer / Company Name: \_\_\_\_\_ Address: \_\_\_\_\_  
Supervisor's name: \_\_\_\_\_ Supervisor's phone: \_\_\_\_\_  
Length of employment: Years: \_\_\_\_\_ Months: \_\_\_\_\_  
Do you (if you) enjoy your work (check on scale where appropriate)?

0 NOT AT ALL  1  2  3  4  5 VERY MUCH  6  
In general, before your pain began, did your employer treat you fairly?

0 NOT AT ALL  1  2  3  4  5 VERY FAIRLY  6  
After your pain began, was your employer helpful and understanding of your pain problem?

0 NOT AT ALL  1  2  3  4  5 VERY HELPFUL  6 UNDERSTANDING

Please select the category that best describes your work situation prior to your pain problem:

Sedentary: Occasional 10 lb. lift, 10 lb. maximum  
 Light: Frequent 10 lb. lift, 20 lb. maximum  
 Medium: Less than 50 lb. frequently; 50 lb. maximum  
 Heavy: Frequent 50 lb. lift; 100 lb. maximum  
 Very Heavy: Frequent 50 lb. lift; greater than 100 lb. maximum

Key:  Frequently = <10% of the time  
 Occasionally = 11-25% of the time  
 Frequently = 34-67% of the time  
 Continuously = 68-100% of the time

PAGE 2 of 5

1910.1027(l)(10) The employer shall promptly obtain a written, medical opinion from the examining physician for each medical examination performed on each employee.

- The **diagnosis** (related to Cd exposure)
- The physician's **opinion** as to whether the employee has any detected medical condition(s) that would place the employee at **increased risk** of material impairment to health from further exposure to cadmium, including any indications of potential cadmium toxicity;
- The **results of testing** that directly assess the employee's absorption of cadmium;
- **Recommendations to remove or limit** employee's activities, duties, or PPE use.
- A statement that the physician has clearly and carefully **explained to the employee** the results of the medical examination, including all biological monitoring results and any medical conditions related to cadmium exposure that require further evaluation or treatment, and any limitation on the employee's diet or use of medications.

# What should the Doctor provide you?



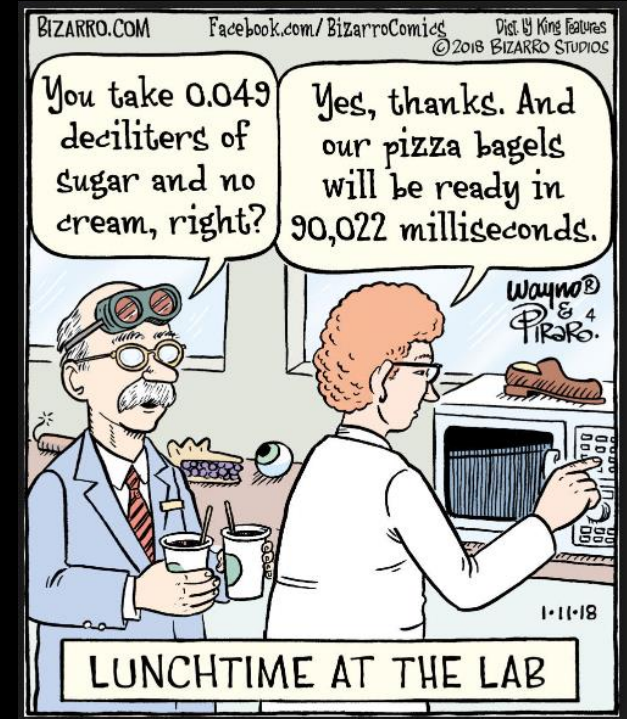
# What were the considerations for medical monitoring in this case?

Monitoring was for a single exposure “new” procedure.

Performed in July, Results in September, Medical surv.

Initiated >3 months later.

Concerns about “unmonitored” unknown





# Medical Monitoring Plan:

- 1) Medical monitoring, physician written opinion, bio-monitoring, risk communication.
- 2) Repeat personal monitoring
- 3) Offer repeat testing, and annual testing.
- 4) Enrolled in Respiratory protection program.



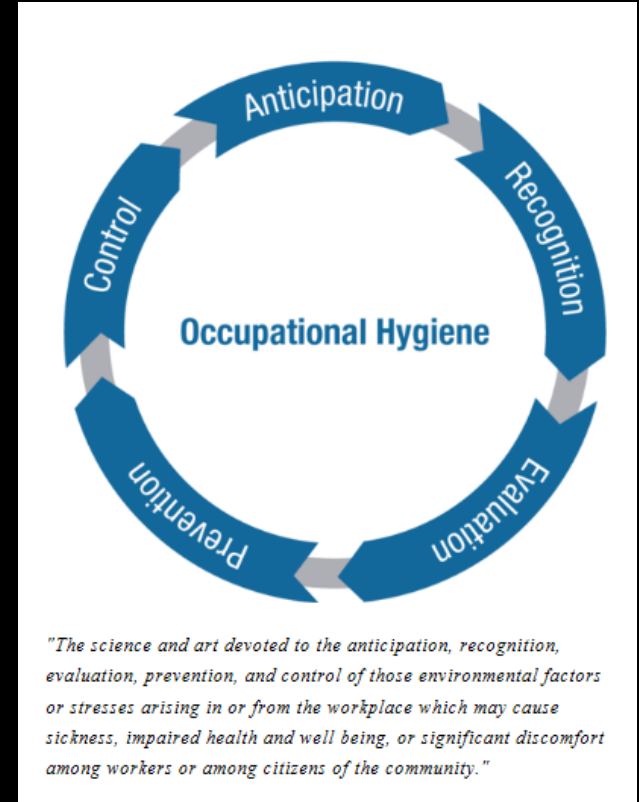
# Medical Monitoring for Intermittent exposures in Conservation

Wide variety of hazards, many unknown/untested

Wide variety of procedures

Short or intermittent exposures

Donor fund limitations



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# Button Treatment Conclusions

Conducted treatment by hand

With assistance!



Example buttons before and after treatment



Buttons,  
Panel #6,  
before and  
after  
treatment



# Questions?

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