

BERYLLIUM-COPPER INVESTMENT CASTING: A CLEAN-UP CASE STUDY

CIHC – DECEMBER 6, 2019

JOEL BERMAN, CIH, CSP CP, CSP ASP, CSP SMS, CAC, CIAQM, CDPH I/A/PM

VICE PRESIDENT, HEALTH SCIENCE ASSOCIATES (FOR A VERY LONG TIME)





MY SIGNATURE BLOCK HAS
BECOME A LOT LIKE
ALPHABET SOUP



WE HAVE NOT GOTTEN TO THE POINT WHERE WE
HAVE BERYLLIUM SPHERES YET. TO INFINITY AND
BEYOND (OOPS WRONG MOVIE QUOTE!).



BERYLLIUM

- STRONGER (THAN STEEL), LIGHT WEIGHT METAL (LIGHTER THAN ALUMINUM).
- HIGH MELTING POINT.
 - 1287 °C, 2349 °F (CONTRAST WITH LEAD 327.46 °C, 621.43 °F)
- BOILING POINT
 - 2500 °C, 4532 °F (CONTRAST WITH LEAD 1740 °C, 3164 °F)



YOU
IDIOT!
THAT ONE
HAD THE
CHIPS
IN IT



LYNCH

BERYLLIUM (CONTINUED)

- EXCELLENT THERMAL STABILITY AND CONDUCTIVITY, REFLECTIVITY, AND TRANSPARENCY TO X-RAYS.
- ESSENTIAL MATERIAL IN THE AEROSPACE, TELECOMMUNICATIONS, INFORMATION TECHNOLOGY, DEFENSE, MEDICAL, AND NUCLEAR INDUSTRIES.
- BERYLLIUM IS CLASSIFIED AS A STRATEGIC AND CRITICAL MATERIAL BY THE U.S. DEPARTMENT OF DEFENSE (DOE).
- IN 2014, THE US PRODUCED 270 METRIC TONS OF BERYLLIUM DOMESTICALLY AND IMPORTED ANOTHER 68 METRIC TONS.

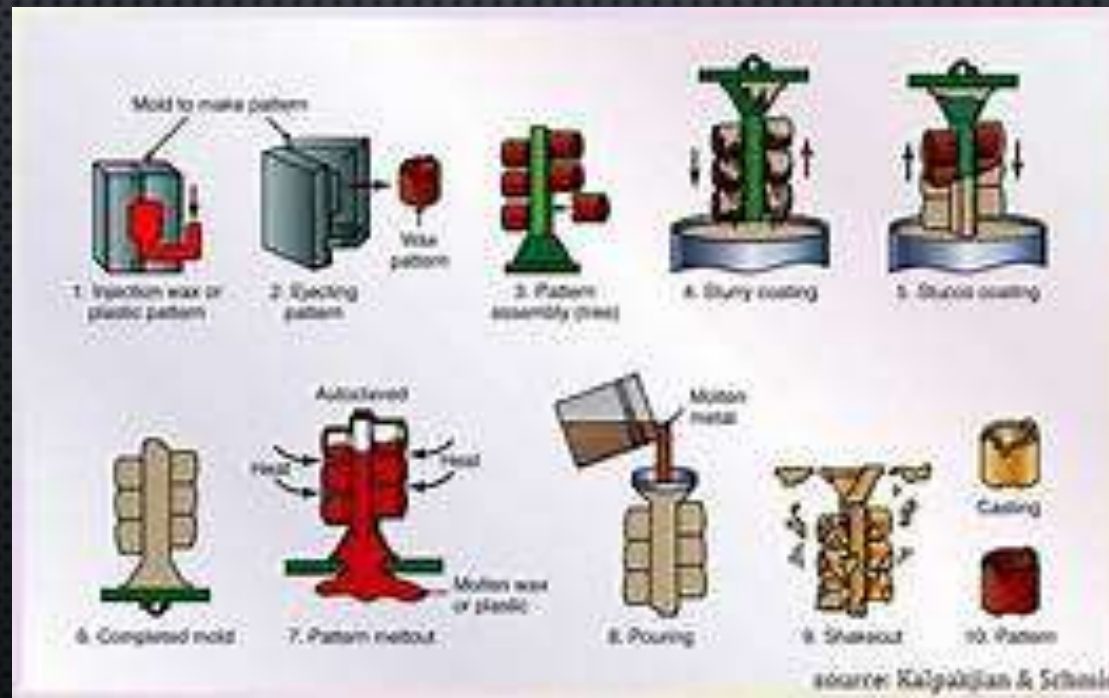
BERYLLIUM (CONTINUED AGAIN)

- HEALTH RISKS.
 - SENSITIZATION OF THE RESPIRATORY SYSTEM.
 - CHRONIC BERYLLIUM DISEASE (CBD). THIS IS AN IMMUNE RESPONSE (ALMOST LIKE AN ALLERGY).
 - SKIN SENSITIZATION INCLUDING RASHES.
 - LUNG CANCER

INVESTMENT CASTING PROCESSING

- A WAX IMPRESSION PART WAS CREATED OF THE FINAL PART.
- A SLURRY WAS MADE TO COAT THE WAX PART, CREATING AN INVESTMENT CAST.
- THE INVESTMENT CAST WAS HEATED TO MELT THE WAX WHICH WAS Poured OUT OF THE CAST.
- SMALL AMOUNTS OF BERYLLIUM COPPER WERE MELTED IN THE FURNACE.
- THE MOLTEN METAL WAS Poured INTO THE INVESTMENT CAST AND ALLOWED TO COOL, FORMING THE FINAL PART.
- ALL OF THESE TASKS WERE PERFORMED UNDER THE INFLUENCE OF AN ACTIVE CANOPY HOOD.

THE INVESTMENT CASTING PROCESS



INVESTMENT CAST AREA



BERYLLIUM COPPER INVESTMENT CASTING OPERATION

- SMALL QUANTITY PARTS CREATED IN A SMALL CRUCIBLE.
- LOW CONCENTRATION OF BERYLLIUM
- LOW LEVELS OF OTHER METAL CONTAMINANTS IN THE MIX, EXCEPT FOR COPPER

(Copper Development Association UNS Number)

CONSTITUENTS	CAS Numbers	M25 (C17300)	M65 (C17465)
Copper	7440-50-8	97.1 - 97.8	97.9 - 98.6
Beryllium	7440-41-7	1.8 - 2	0.2 - 0.5
Nickel	7440-02-0	--	1 - 1.4
Lead	7439-92-1	0.2 - 0.6	0.2 - 0.6
Cobalt	7440-48-4	0.2 - 0.35	--

BERYLLIUM AND OTHER METAL AIR EXPOSURE STANDARDS

- CAL/OSHA PELS
 - BERYLLIUM – 0.0002 MILLIGRAMS PER CUBIC METER OF AIR (MG/M³)
 - COBALT – 0.02 MG/M³
 - COPPER – 1 MG/M³
 - LEAD – 0.05 MG/M³
 - NICKEL – 0.5 MG/M³

WORKER BREATHING ZONE AIR SAMPLING RESULTS DURING NORMAL OPERATIONS (TWO DAYS OF SAMPLING)

Time	Air Volume					
Minutes	(liters)	Beryllium	Cobalt	Copper	lead	Nickel
		mg/m ³				
414	828	<0.00018	<0.00054	0.0051	<0.00045	<0.00036
417	834	<0.00018	<0.00054	0.00078	<0.00045	<0.00036
419	838	<0.00018	<0.00054	0.00041	<0.00045	<0.00036
414	828	<0.00018	<0.00054	0.0039	<0.00045	<0.00036
541	1109	0.000027	—	0.0028	—	—
540	837	<0.000018	—	<0.00036	—	—
Standards and Guidelines						
PEL		0.0002	0.02	1	0.05	0.5
AL					0.03	
TLV		0.00005	0.02	1	0.05	1.5

DOE BERYLLIUM SURFACE STANDARDS

- HOUSEKEEPING STANDARD WHERE BERYLLIUM OPERATIONS HAVE CEASED
 - 3 MICROGRAMS PER 100 SQUARE CENTIMETERS (UG/100 CM²)
- RELEASE STANDARD (I.E. TO THE PUBLIC OR FOR A NON-BERYLLIUM USE)
 - 0.2 UG/100 CM²

WIPE SAMPLE RESULTS INVESTMENT CAST AND PROXIMAL AREAS

- TOTAL PRE-CLEANING WIPE SAMPLES COLLECTED WERE 25 SAMPLES.
- RESULTS RANGED BETWEEN NONE DETECTABLE TO 660 UG/100 CM².
- THE MAJORITY OF THE WIPES (21) HAD RESULTS BELOW THE HOUSEKEEPING PROVISIONS IN AREAS WHERE BERYLLIUM OPERATIONS HAVE CEASED (I.E. 3 UG/100 CM²)
- THE OTHERS WERE 8.06, 9.3, 22, 660.

WIPE SAMPLE RESULTS PUNCH PRESS PROXIMAL AREAS

- 20 WIPE SAMPLES WERE COLLECTED FOR BOTH BERYLLIUM AND COPPER.
- BERYLLIUM RESULTS RANGED BETWEEN 0.024 TO 2.32 UG/100 CM²
- COPPER RESULTS RANGED BETWEEN 8.5 TO 3200 UG/100 CM²
- OF THE BERYLLIUM RESULTS, 8 HAD RESULTS BELOW THE 0.2 UG/100 CM² RELEASE STANDARD

THE WORST OFFENDERS

	MG/100 CM ²
• INVESTMENT CAST AREA, FLOOR UNDER SANDBLAST	9.30
• INVESTMENT CAST AREA, FLOOR UNDER DRILL PRESS	8.06
• ROOF OF THE BUILDING ABOVE THE EXHAUST HOOD FOR THE INVESTMENT CAST AREA, NORTHEAST CORNER OF CURB THE FAN UNIT ON THE ROOF	22.00
• INVESTMENT CAST AREA, VENTILATION HOOD	660.00

IT WAS DETERMINED A CLEAN-UP OF THE INVESTMENT CAST AREA WAS NECESSARY



REMEDIATION GUIDELINE – KEY POINTS

- GENERAL BACKGROUND OF THE PROJECT
- HEALTH EFFECTS
- EXPERIENCE
- DEFINITIONS
- SUBMITTALS
- AIR MONITORING
- SECURITY
- EMERGENCIES
- MEETINGS
- MATERIALS
- TOOLS
- SCHEDULE

GUIDELINE (CONTINUED)

- CONTAINMENT OF WORK AREA
- CLEAN-UP
- LOAD-OUT OF WASTE
- MAINTENANCE
- CLEAN-UP PROCEDURES
- WORKERS MONITORING
- CLEARANCE CRITERIA

ADVERTENCIA:

Esta Zona Contiene Substancias
Químicas Que El Estado De
California Tiene Conocimiento
Que Causan Cáncer, Defectos
Congénitos O Presentan Otros
Riesgos Para La Reproducción.

(Esta advertencia es exigida por el artículo 25249.6 del Código
de Seguridad y Protección de la Salud de California)

CPC AccuPost

Compliance Poster Company™

TO ORDER CALL: 1-800-877-7828
WWW.COMPLIANCEPOSTER.COM

WARNING:

This Area Contains Chemicals
Known To The State Of
California To Cause Cancer, and
Birth Defects Or Other
Reproductive Harm.

(This warning required by Section 25249.6 of the California
Health and Safety Code)

CPC AccuPost

Compliance Poster Company™

TO ORDER CALL: 1-800-877-7828
WWW.COMPLIANCEPOSTER.COM

12/26/2014 15:00



ADVERTENCIA
Este producto contiene un líquido que puede ser peligroso si se inhala o se absorbe a través de la piel. Evite el contacto con los ojos y la piel. Mantenga este producto fuera del alcance de los niños y los animales. Consulte las instrucciones de uso y las precauciones de seguridad.

WARNING!
This product contains a liquid that may be hazardous if inhaled or absorbed through the skin. Avoid contact with eyes and skin. Keep this product out of the reach of children and animals. Read the instructions for use and the safety precautions.

SMOG-HOG

12/26/2014 15:00

CAUTION

BERYLLIUM AREA

BERYLLIUM DUST

**INHALATION OF DUST MAY CAUSE
SERIOUS CHRONIC LUNG DISEASE**

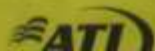
POTENTIAL CANCER HAZARD

P.P.E. REQUIRED FOR ENTRY

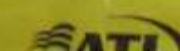
12/26/2014 15:01



CAUTION



CAUTION



CAUTION




12/26/2014 08:59



12/26/2014 13:51



12/26/2014 13:51



12/26/2014 13:51

ROOF EXHAUST HOOD WITH STAINING







22 ug/ 100 cm²



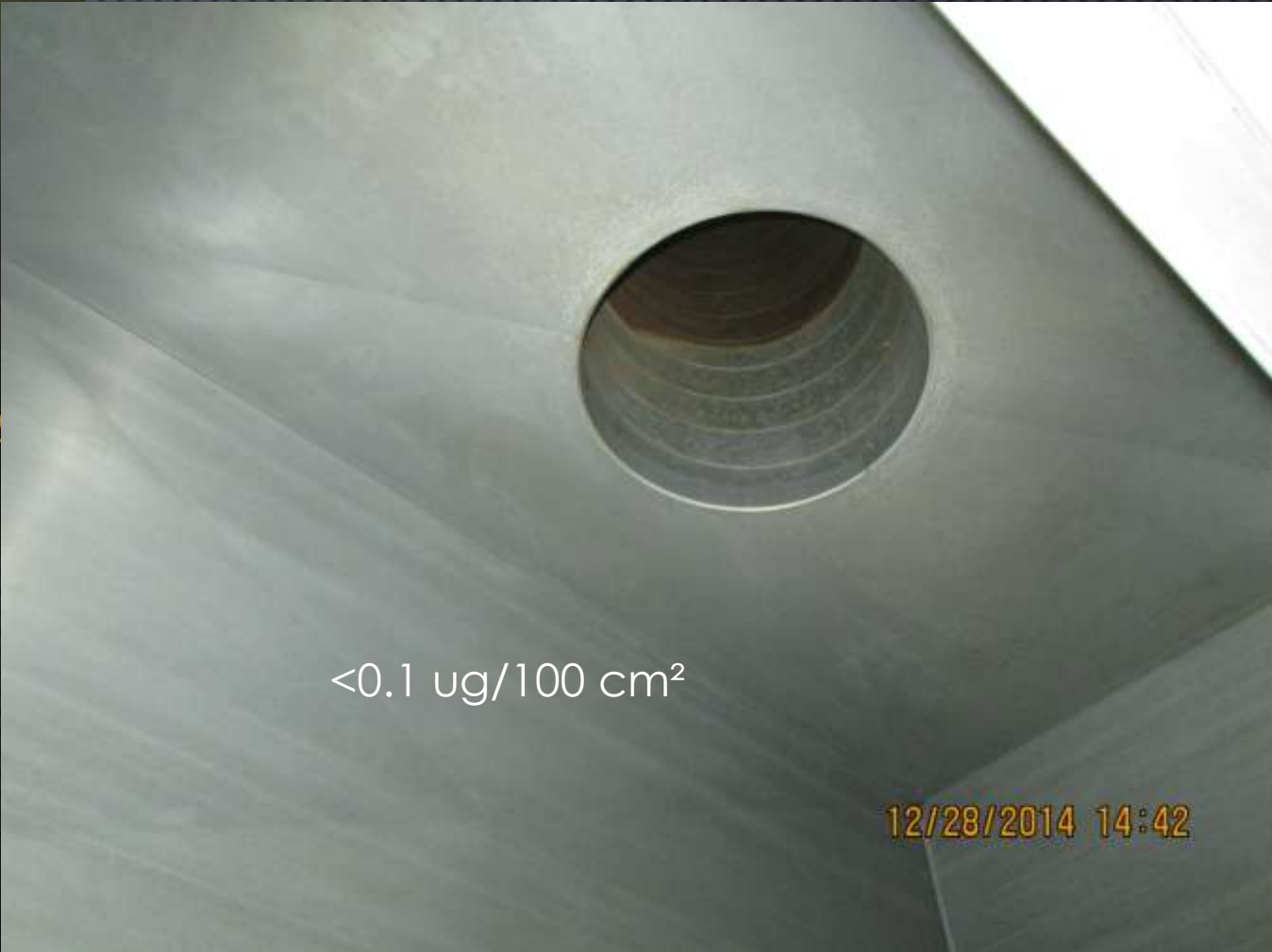
<math>< 0.1 \text{ ug}/100 \text{ cm}^2</math>

12/27/2014 10:13



660 $\mu\text{g}/100\text{ cm}^2$

12/28/2014 14:42



<0.1 $\mu\text{g}/100\text{ cm}^2$

12/28/2014 14:42

AIR SAMPLING DURING CLEAN-UP

- THE PROJECT WAS PERFORMED OVER THREE WORK SHIFTS.
- 9 AIR SAMPLES WERE COLLECTED INSIDE OF THE CLEAN ROOM OF THE CONTAINMENT OR OUTSIDE OF THE CONTAINMENT.
- ALL RESULTS WERE NON-DETECT FOR BOTH BERYLLIUM AND COPPER.
- RESULTS WERE ALSO BELOW PEL AND TLV LEVELS.

POST REMEDIATION SAMPLING RESULTS

- COLLECTED 11 POST REMEDIATION WIPE SAMPLES.
- CLEARANCE CRITERIA WAS 3.0 UG/100 CM²
- ALL SAMPLE RESULTS WERE BELOW THIS LEVEL.
- EIGHT SAMPLES HAD NON-DETECTABLE RESULTS
- THREE HAD DETECTABLE RESULTS THAT RANGED BETWEEN 0.14 TO 2.2 UG/100 CM²

GIMBAL RING AND OTHER BERYLLIUM COATED PROJECTS



GIMBAL RING

- A CONTRIVANCE, CONSISTING OF A **RING** OR BASE ON AN AXIS, THAT PERMITS AN OBJECT, AS A SHIP'S COMPASS, MOUNTED IN OR ON IT TO TILT FREELY IN ANY DIRECTION, IN EFFECT SUSPENDING THE OBJECT SO THAT IT WILL REMAIN HORIZONTAL EVEN WHEN ITS SUPPORT IS TIPPED.
- [HTTPS://WWW.DICTIONARY.COM/BROWSE/GIMBAL-RING](https://www.dictionary.com/browse/gimbal-ring)

BERYLLIUM COATED GIMBAL RING

- BERYLLIUM WAS ADDED TO THE PART DURING A BRAZING PROCESS THAT RELEASED SOME FREE BERYLLIUM ONTO THE SURFACE OF THE PART. SOME OF THE BERYLLIUM SURFACES AS COATED, OTHER SURFACES WERE NOT COATED.
- THE COMPONENT WAS THEN TRANSFERRED TO HSA'S CLIENT AND WAS LOCATED IN THEIR CLASS 10K CLEAN ROOM.
- WORKERS WERE CONCERNED RELATED TO THEIR POTENTIAL EXPOSURE TO BERYLLIUM ON THE SURFACE OF THE PART AND OTHER SURFACES OF THE CLEAN ROOM.
- THE CLIENT WAS CONCERNED REGARDING BERYLLIUM CONTAMINATION TO THE CLEAN ROOM.

WIPE SAMPLE RESULTS UNCOATED SURFACES

Sample #	Description/Location	Beryllium (μg)
1	Ghost wipe of inside of slots starting on the underside of the unit, 1 st three slots	940
3	On the top of the unit, in the circular holes, 1 and 2	45

Abbreviations: μg = micrograms per sample; < = less than

BERYLLIUM WIPE SAMPLE RESULTS COATED SURFACES

- 22 WIPES SAMPLES OF THE COATED AREA WERE SAMPLES, INCLUDING AREAS WHERE A BRAZING LINE WAS VISIBLE.
- ALL SAMPLE RESULTS WERE NON-DETECTED FOR BERYLLIUM.
- RESULTS RANGED BETWEEN <1.4 TO 11.7 UG/100 CM².
- COATED SURFACES WERE DETERMINED TO NOT PROVIDE A POTENTIAL FOR EXPOSURE.

BERYLLIUM WIPE SAMPLE RESULTS – GENERAL AREAS IN THE CLEAN ROOM

- 27 WIPE SAMPLES COLLECTED.
 - 12 HAD NO DETECTABLE LEVELS OF BERYLLIUM PRESENT.
 - 11 HAD GREATER THAN 125 MICROGRAMS DETECTED.
 - THE REMAINING HAS DETECTION LEVELS RANGING BETWEEN 1.3 TO 110 MICROGRAMS DETECTED.
 - GENERALLY SMALL SURFACES WERE SAMPLED, WHICH MADE DOCUMENTING THE SIZE ALMOST IMPOSSIBLE.

BERYLLIUM WIPE RESULTS AFTER CLEANING

- 27 SAMPLES COLLECTED.
 - 14 HAD NO DETECTABLE LEVELS OF BERYLLIUM PRESENT.
 - THE RANGE OF ALL OTHER SAMPLE RESULTS WAS BETWEEN 16 TO 68 MICROGRAMS DETECTED.
- WORKER BZ AIR SAMPLES WERE COLLECTED, BUT DUE TO A LABORATORY ERROR, THE SAMPLES WERE DETERMINED TO BE INVALID AND WERE NOT ANALYZED.

CONCLUSIONS

- BERYLLIUM CLEAN-UP CAN BE ACHIEVED
- PRECAUTIONS NEED TO BE TAKEN TO PROTECT WORKERS FROM BOTH AIR AND SURFACE EXPOSURE
- WASTE ANALYSIS NEEDS TO BE PERFORMED
- IMPLEMENT PROGRAMS TO CONTROL RELEASES
- HOUSEKEEPING AND REGULAR CLEANING NEED TO BE PERFORMED AND OF COURSE THOSE WORKERS ALSO NEED TRAINING AND PPE.







JOEL BERMAN

JBERMAN@HEALTHSCIENCE.COM