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The Atomic Man: Case Study of the Largest Recorded ^{241}Am Deposition in a Human

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Dade Moeller – an NV5 Company

Richland, WA

*“Learning from Plutonium
and Uranium Workers”*



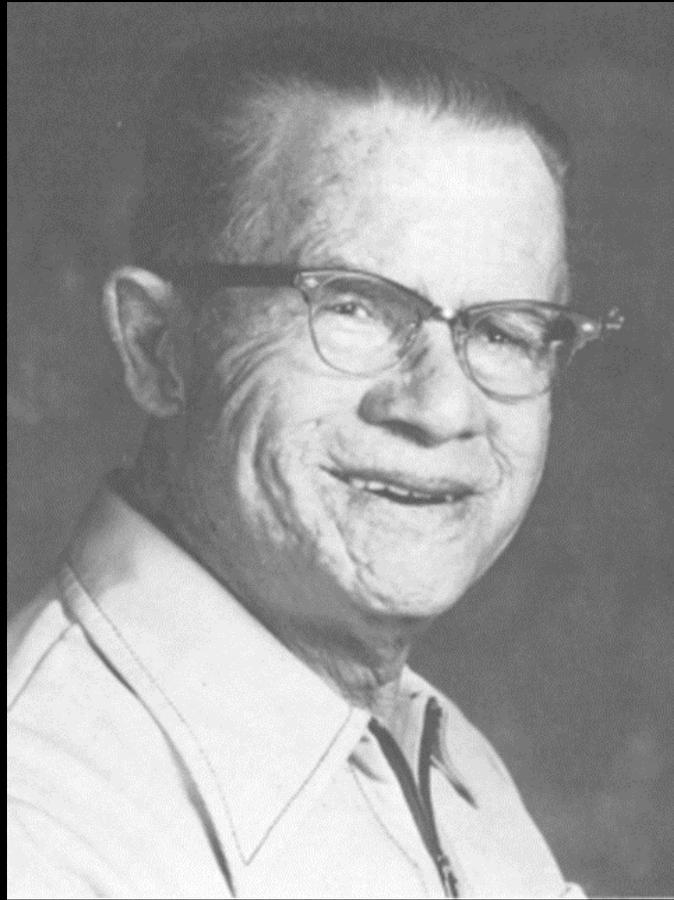
USTUR Case No. 0246

“... a 76-y-old man who died of cardiovascular disease 11 y after massive percutaneous exposure following a chemical explosion in a glove box...”

McInroy et al.

Health Phys. 69(3):318-323; 1995

Harold McCluskey “Mac” aka “The Atomic Man”



The Accident – Aug 30, 1976 - ~3 a.m.



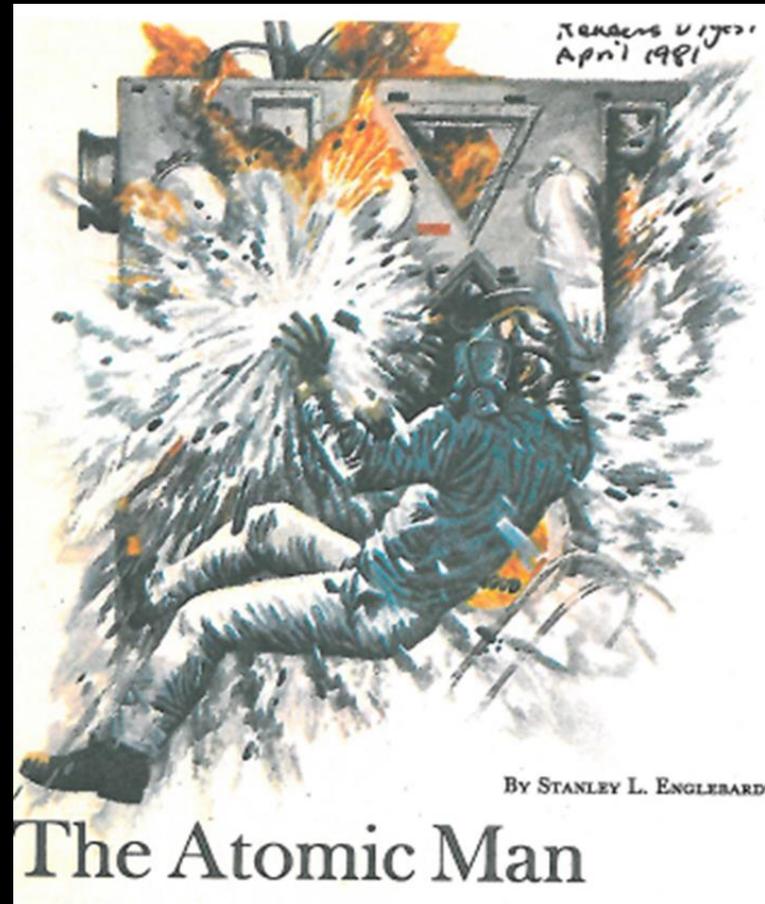
Plutonium Finishing Plant
Am Recovery Facility

The Accident

- Chemical explosion in an ion exchange column within a glove box.
- Ion exchange column loaded with 130 g (10^7 MBq, 450 Ci) of ^{241}Am for 5 months.
- Unrecognized buildup of hydrogen gas caused by radiolytic decomposition of the cation resin
- Restarting process by eluting with 7M HNO_3

The Accident

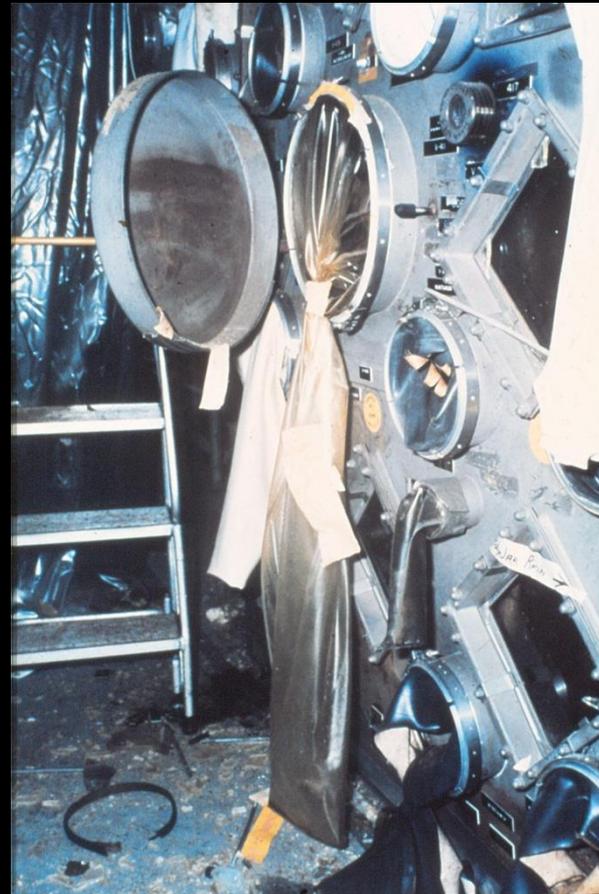
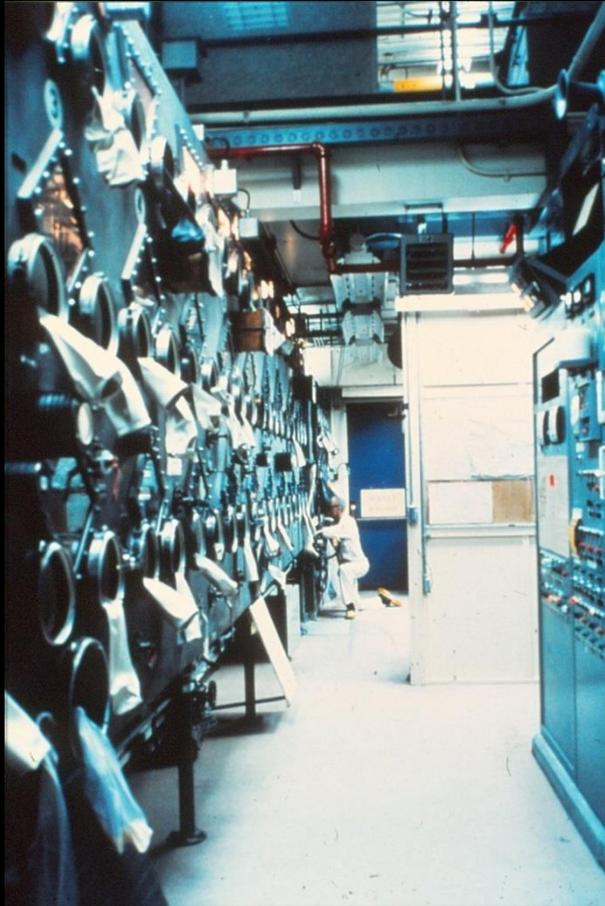
- Operator heard hissing, observed brown fumes venting from column, and noted warm gloves.
- More hissing from bottom of column.
- “It’s going to blow!”



The Accident

- Explosion peeled open the column, blew out leaded glass windows and glove ports.
- Struck Harold McCluskey (age 64) in right side of face, peppered with glass shrapnel, concentrated nitric acid, resin beads, and ^{241}Am .
- Chemical burns of face, eyes, neck and right shoulder.
- Lacerations with embedded foreign bodies.

The Accident – Aug 30, 1976



61st HPS Meeting - USTUR: Five Decade
Follow-up of Plutonium and Uranium Workers



The Accident



Initial Response

- Helped from room by co-worker
- Nurse summoned
- Clothing removed and face, eyes, head, shoulders flushed with water
- Skin contamination levels exceeded alpha survey instrument's highest scale
- Transported by ambulance to the Emergency Decontamination Facility (EDF), 25 miles away in Richland

Initial Treatment at EDF

- 1 g Ca-DTPA upon arrival
- Warm shower in EDF staff shower
- Transferred to surgery table/decon tub for debridement
- Bathed with mild liquid detergents
- Vigorous scrubbing not possible because of acid burns
- Direct alpha measurements not useful for monitoring decon progress – used smear/wipe approach and 19 skin check points to evaluate decon progress

Estimated Personal Contamination Levels

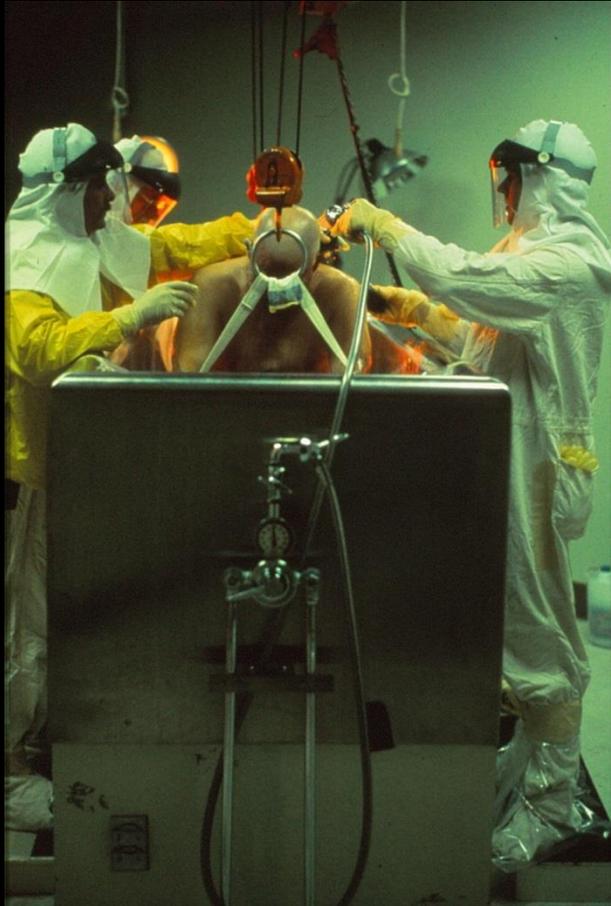
Time	Location	Approximate Level
Initially deposited	Skin and clothing	40 – 190 GBq
Early response	Mostly facial	> 220 MBq
12 hours post accident	Facial	70 MBq
A few days	Facial	7 MBq

Skin Decontamination

Shower – Bathe – Scrub - Debride

- Twice daily baths for first week, then daily for 2 months
 - Ca-DTPA applied, rinsed off
 - Light scrubbing with mild liquid detergents
- Variations in decon reagents and techniques during first 2 weeks did not have significant impact on reduction
- From Day 10 on, reagents of choice were Schubert's solution (tartaric acid, citric acid, DTPA, CaCl) and liquid (mild baby) shampoo
- Daily showers

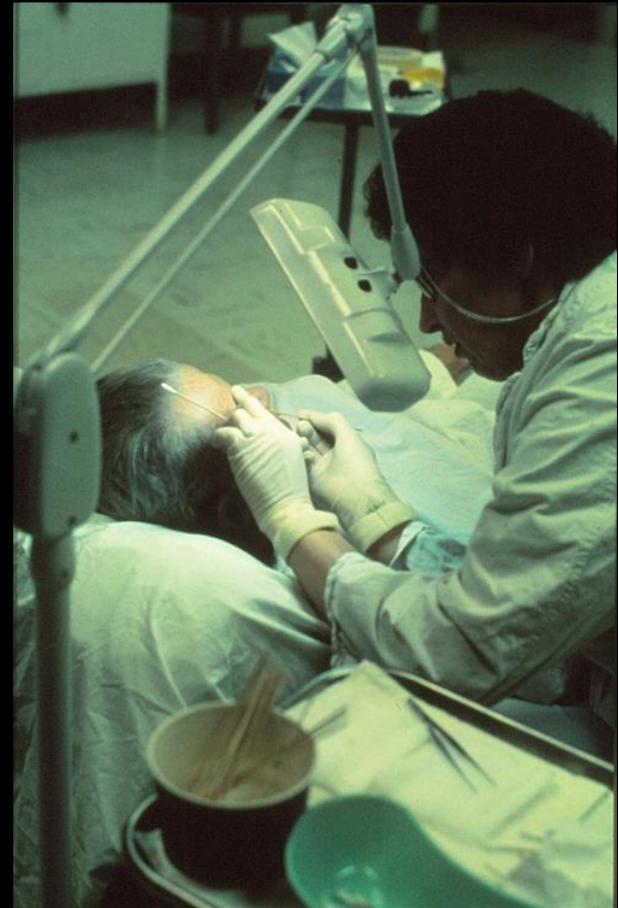
Skin Decontamination



Skin Decontamination

- Daily superficial debridement of face and neck for first 4 months removed scale, crusts, scabs, extruded foreign bodies (metal, plastic, cloth and glass), up to 0.5 cm
- Decontamination was extended, extensive, difficult and never complete.
- None of the attending team incurred recordable radiation dose or intake of radioactivity during the course of patient decontamination, treatment, and care.

Skin Decontamination



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Contamination Measurements



Contamination Measurements

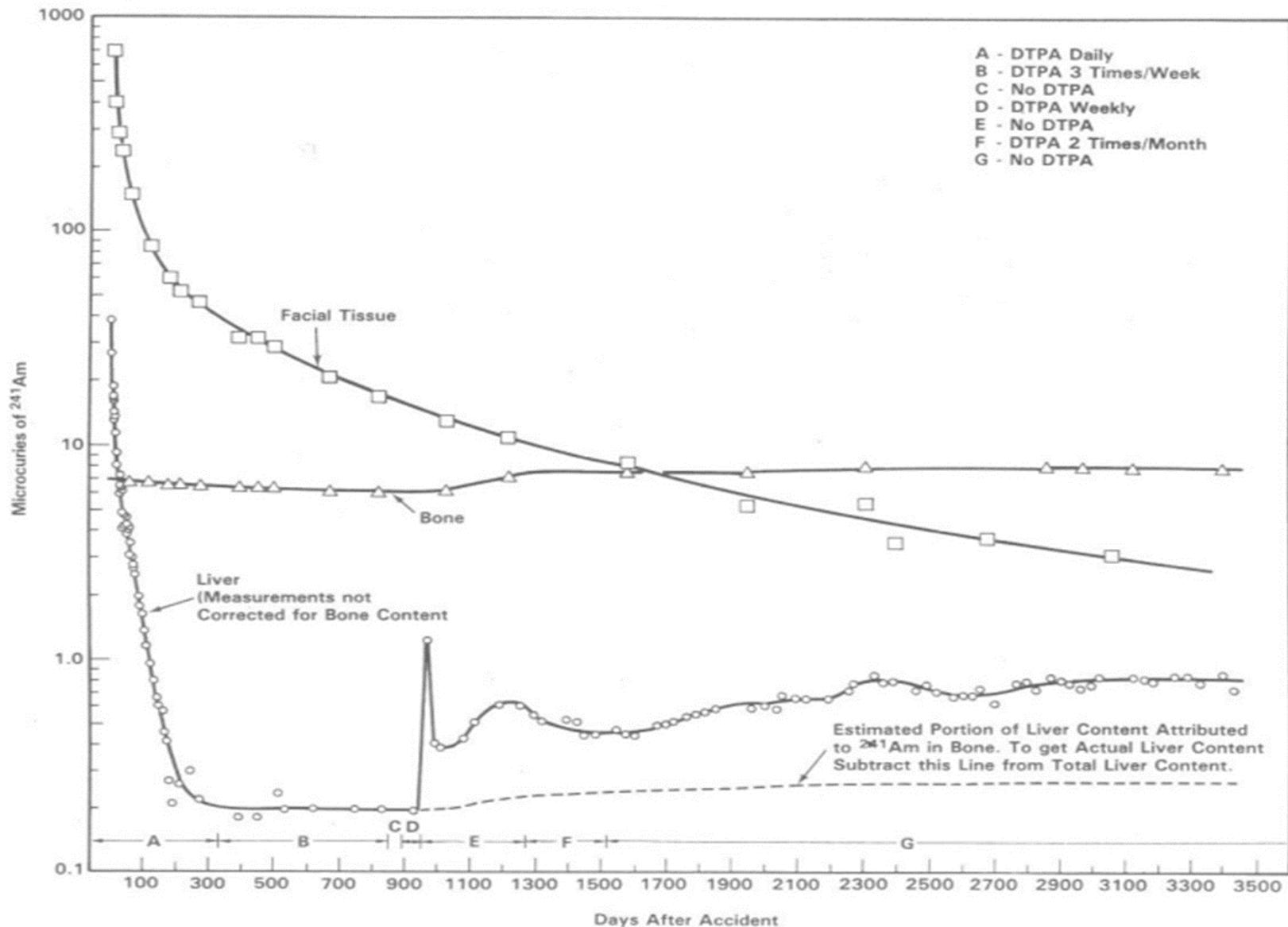


Treatment – DTPA Therapy



- Ca-DTPA with Zn supplement for first 5 days
- Zn-DTPA beginning day 5 following expedited FDA approval as IND
- 583 g DTPA by slow push iv over 4 years with no side effects
- Considered life-saving
- Approach to DTPA therapy today is basically the same

Measurement of Liver, Bone, and Facial Tissue on ^{241}Am Accident Subject Over 9.4 Year Period



Therapy

- Therapy limited systemic deposition to 13 μCi (500 KBq) instead of 500 μCi (19 MBq)
 - Factor of 40 reduction
 - MPBB in 1976 was 0.05 μCi (1.85 KBq)

- Bone marrow aspiration on Day 16 was interpreted to be within normal limits.

Transition to Home

- Day 45 – recognized primary obstacle to release to home was concern for contamination spread from facial desquamation.
- Travel trailer to determine contamination problems associated with release to home. (Day 79 moved in)
- By late November was able to go into community and have Thanksgiving dinner with his family (Day 103)
- Nov/Dec – home during day. Return to trailer at night.
- January (5 months post accident) – released to home

Psychological Support

- Clinical psychologist
- Emotional issues
- Personal and family concerns
- Dealing with response from others
- Community acceptance

Long-term Follow-up

- Monthly medical checks by Hanford occupational medicine staff
- Bioassay measurements (urine, feces, liver, skeleton, facial contamination)
- Mental attitude was excellent
- Reasonably healthy for 10 years, then multiple hospitalizations

Post Mortem Follow-up

- Aug. 17, 1987 - Death from congestive heart failure due to coronary heart disease that pre-existed the accident).
- Autopsy
 - No evidence of malignancy.
 - 22 soft tissues and 5 bones obtained at autopsy were volunteered to USTUR for analysis and dosimetry

USTUR Analyses – Health Phys. 69(3)

Toohey & Kathren, 1995 and McInroy, et al., 1995.

Organ/Tissue	Post Mortem Content (kBq)	11-y Cumulative Absorbed Dose (Gy)
Total Body (ICRP2 MBPP = 1.85 kBq)	540 4.6 µg	Not reported
Soft Tissue (inc. liver)	55	Not reported
Mean Skeleton (7 kg)	490 (410 – 550 by 6 methods)	18
Bone Surface (120 g,)	490	510
Bone Marrow	20	2.6
Liver	28	8
Lung	2.0	1.6
Muscle	13.5	4.4

Modeling & Dosimetry Implications

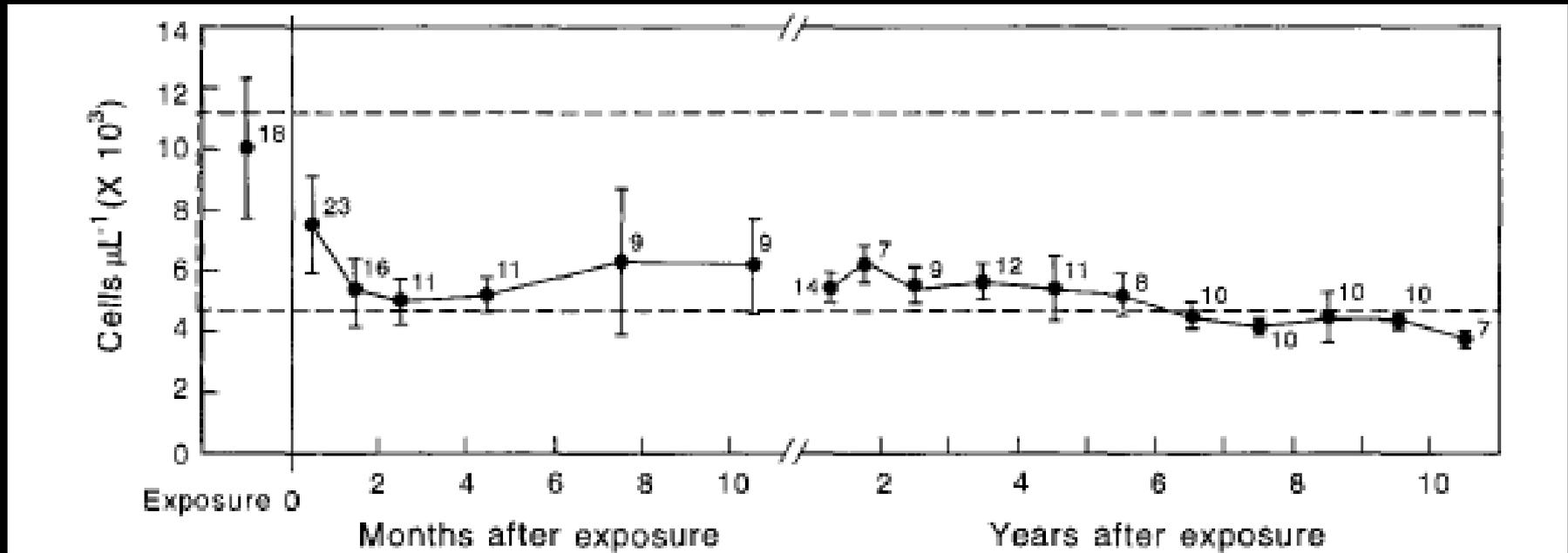
- General agreement with Am biokinetic model
- Distribution consistent with previous USTUR case.
- Greater initial uptake by skeleton and soft tissue, less by liver, compared to then contemporary ICRP-30 and ICRP-48 models
- Translocation had not occurred as expected.
 - Age-related? Radiation-related?
- Shorter liver half-time (7-y) compared to ICRP-30 (40-y) and ICRP-48 (20-y).
- Good agreement with subsequent ICRP 67 (1993) model

Radiation Effects

- Presence of ^{241}Am in face likely slowed healing of acid burns.
- Significant depression of lymphocytes and platelets, but no clinical symptoms manifested.
- Lymphocyte count returned to normal following unrelated treatment with heparin for thrombophlebitis.

Radiation Effects

Leukocyte concentrations in circulating blood (Filipy et al. 1995)



Neutrophils & lymphocytes showed similar trending

Radiation Effects

- Significant elevation of chromosome aberrations in lymphocytes in first year after accident and fluctuating thereafter. No direct relationship between aberration frequency and dosimetric parameters.
- Histopathology findings
 - Decreased cellularity of marrow
 - Extensive peritrabecular fibrosis
 - Lack of bone remodeling – possibly age-related
- Radiological effects relatively limited, but might have been more pronounced had exposure time been longer.

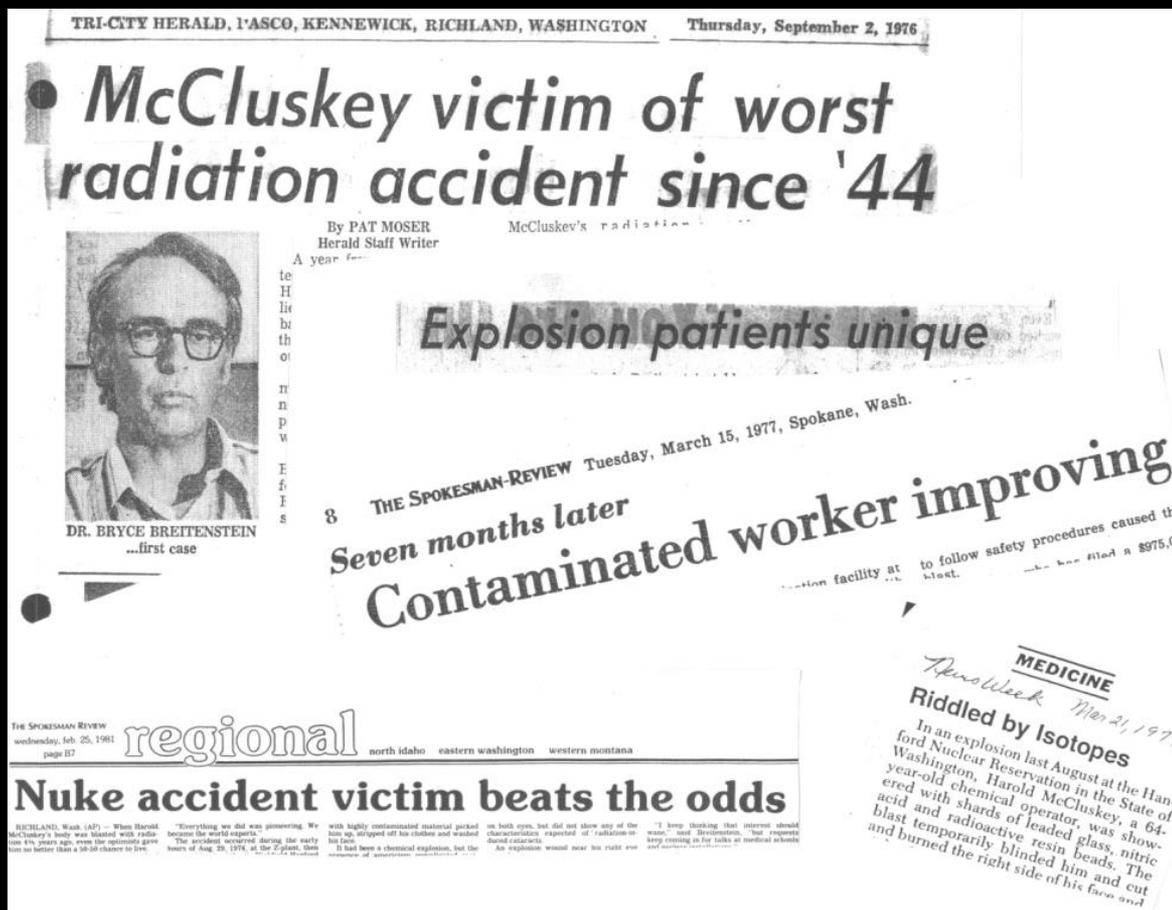
Other Effects

- Vision problems from nitric acid were most significant
 - Cataracts removed from left and right eyes (547-d and 1030-d post accident) were acid-induced rather than radiation.
 - Vision compromised by acid scarring of cornea (cornea transplant).
 - Mildly progressive photophobia
- Acid scarring
- No indications of malignancy (12% chance of no malignancy)
- Gross and histopathology tissue examinations revealed no abnormalities other than those associated with existing pre-accident cardiovascular disease.

Emergency Decontamination Facility - Then

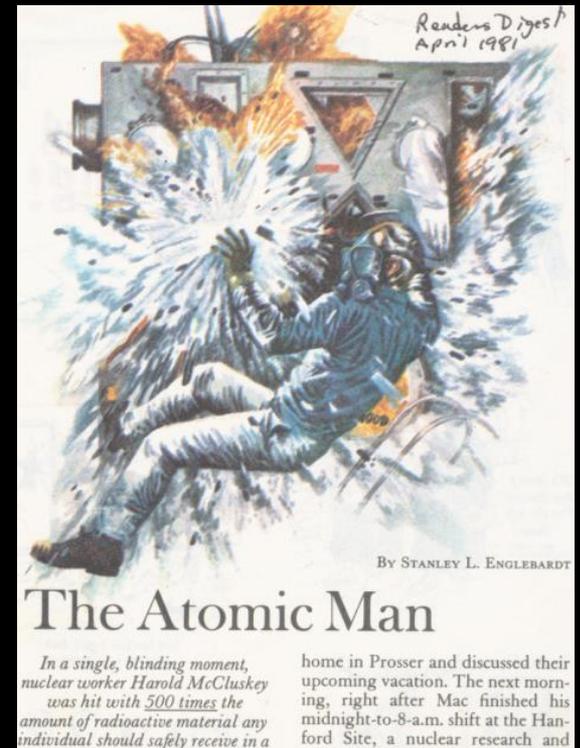
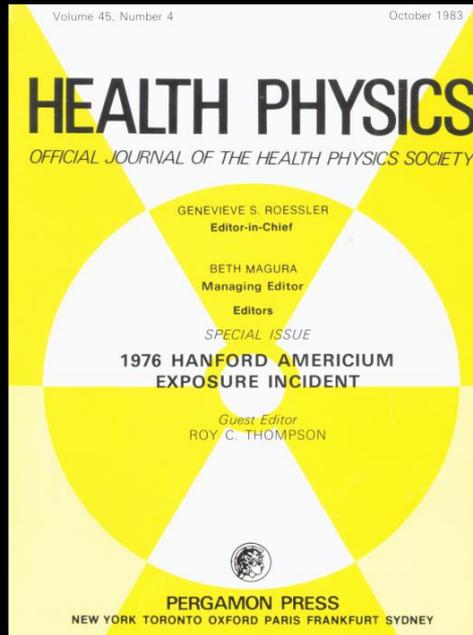


- Communications- major effort
 - Wide public interest
 - Protect patient privacy
 - Provide accurate info
 - Tag-Team meetings



Health Physics
Oct. 1983 (dedicated)

Sept. 1995 (5 post mortem articles)



Guideposts
Oct. 1981

EXPLOSION IN THE NUCLEAR PLANT

by Harold McCluskey
Prosser, Washington



I licked my lips nervously, wondering what to do. Through the porthole of leaded Lucite, I could see the eight-foot-high welded steel tank, waiting. Don't worry! I hid myself. You've handled hundreds and hundreds of these things.

True enough. I had been working at the Hanford Nuclear Plant near Richland, Washington, for over 25 years; I was the chief operator in extracting ("stripping") the rare metal, americium, from these vessels containing high-level radioactive waste.

But this particular vessel was different. Aged chemicals are highly unstable. Because of a strike at the plant, this container had been sitting for 135 days—a full 45 days past the safety limit. If I put off this job just one more night, I thought I could persuade my superiors to rescind the order the next day. The waste could be run through the system again and then recaptured in the tank without any hazard. But the order had come down: Strip it. And they meant it.

I had been called in to fill in for a vacationing co-worker. I was grateful for the extra pay, and I didn't mind filling in for one of my buddies, though this was a tough job.

The guys I worked with were a great bunch, but they regarded me with especially my old friend Dave.

Dave and I had been fishing buddies for years. It bothered me that Dave preferred to be out on the golf course Sunday mornings rather than in church, but I felt it wouldn't be right to preach to him about it.

Dave used to enjoy arguing with me about my faith—you know the kind of thing: If Adam and Eve had two sons, then where did Cain get his wife? And, why don't you Baptists dance, smoke or drink?

I was no Bible scholar; I couldn't seem to get through to Dave or to any of the other men at the plant about my faith. They knew all about nuclear energy; it was an awesome force they dealt with every day; it was something that could be contained and measured. They were sure about nuclear power; God's power they weren't so sure about.

At the moment, as I studied the tank, I could have used some reassurance myself. Inside, the deadly radioactive waste simmered, waiting for me to release the nitric acid that would cause the americium to separate out and settle to a resin bed at the bottom of the vessel.

Between me and the tank stood a stainless steel wall dotted with portholes, leaded to keep the radiation out

Reader's Digest
April 1981

The McCluskey Room

- Sealed off for over 35 years
- Very rare entry
- D&D commenced in the 2015
- Glove boxes now removed
- Building to be razed to grade level (2017)

Conclusions

- Not much is different today regarding decontamination methods, DTPA therapy, and radiological measurements.
- The medical treatment administered allowed him to live a reasonably normal life.
- USTUR analyses provided valuable scientific data for confirming and improving biokinetic models.

Conclusions

➤ The accident was tragic.

The response heroic.

The outcome ... probably the best
that could be expected on all fronts.

Acknowledgements

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Theresa Aldridge

Gunars Rieksts

Karen Phillips, MD

And a host of others

(* deceased)

Dedication to the Ideal Patient Harold R. McCluskey (1912 – 1987) “The Atomic Man”



Bibliography

- *Health Physics*, October 1983 (dedicated issue)
- Breitenstein & Palmer. *Rad. Prot. Dosim.* 26:317-322; 1989. (lifetime follow-up)
- *Health Physics*, September 1995 (5 post mortem analysis articles)
- Carbaugh. Chapter 23 of *The Medical Basis for Radiation-Accident Preparedness: Medical Management*. ORAU 2011. (then and now)

ABSTRACT

The Atomic Man: Case Study of the Largest Recorded ^{241}Am Deposition in a Human

Eugene H. Carbaugh

The 1976 explosion of an ion exchange column at the Hanford Site resulted in the largest human uptake of ^{241}Am ever recorded. The worker underwent wound debridement, extensive personal skin decontamination and long-term DTPA chelation therapy for decorporation of ^{241}Am . Because of the contamination levels and prolonged decontamination efforts, care was provided for the first three months at a unique emergency decontamination facility with gradual transition to the patient's home occurring over another two months. Follow-up monitoring and medical care was provided for the rest of his life. Upon his death 11 years later, from causes unrelated to the accident, the USTUR received tissue donations allowing detailed biokinetic and dose evaluation. Dubbed "the Atomic Man" by the press, USTUR Case 0246 has been the subject of numerous reports and journal articles describing the accident, case management, dosimetry, and post-mortem findings. His systemic total body ^{241}Am content was estimated to be 545 kBq at the time of death, distributed approximately 86% in the bone (primarily bone surfaces), 5% in the liver, 5% in other soft tissues, and 4% in the bone marrow. The distribution reflected the high degree of effectiveness of DTPA therapy in removing ^{241}Am from soft tissue, and its relative ineffectiveness in removing it from bone.