

The Karen Silkwood Story

Karen Silkwood died on November 13, 1974 in a fatal one-car crash. Since then, her story has achieved worldwide fame as the subject of many books, magazine and newspaper articles, and even a major motion picture. Silkwood was a chemical technician at the Kerr-McGee's plutonium fuels production plant in Crescent, Oklahoma, and a member of the Oil, Chemical, and Atomic Workers' Union. She was also an activist who was critical of plant safety. During the week prior to her death, Silkwood was reportedly gathering evidence for the Union to support her claim that Kerr-McGee was negligent in maintaining plant safety, and at the same time, was involved in a number of unexplained exposures to plutonium. The circumstances of her death have been the subject of great speculation.

After her death, organs from Silkwood's body were analysed as part of the Los Alamos Tissue Analysis Program. Silkwood's case was important to the program because it was one of very few cases involving recent exposure to plutonium. It also served to confirm the contemporary techniques for the measurement of plutonium body burdens and lung burdens.

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In the evening of November 5, plutonium-239 was found on Karen Silkwood's hands. Silkwood had been working in a glovebox in the metallography laboratory where she was grinding and polishing plutonium pellets that would be used in fuel rods. At 6:30 P.M., she decided to monitor herself for alpha activity with the detector that was mounted on the glove box. The right side of her body read 20,000 disintegrations per minute, or about 9 nanocuries,¹ mostly on the right sleeve and shoulder of her coveralls. She was taken to the plant's Health Physics Office where she was given a test called a "nasal swipe." This test measures a person's exposure to airborne plutonium, but might also measure plutonium that got on the person's nose from their hands. The swipe showed an activity of 160 disintegrations per minute, a modest positive result.

The two gloves in the glovebox Silkwood had been using were replaced. Strangely, the gloves were found to have plutonium on the "outside" surfaces that were in contact with Silkwood's hands; no leaks were found in the gloves. No plutonium was found on the surfaces in the room where she had been working and filter papers from the two air monitors in the room showed that there was no significant plutonium in the air. By 9:00 P.M., Silkwood's cleanup had been completed, and as a precautionary measure, Silkwood was put on a program in which her total urine and feces were collected for five days for plutonium measurements. She returned to the laboratory and worked until 1:10 A.M., but did no further work in the glove boxes. As she left the plant, she monitored herself and found nothing.

Silkwood arrived at work at 7:30 A.M. on November 6. She examined metallographic prints and performed paperwork for one hour, then monitored herself as she left the laboratory to attend a meeting. Although she had not worked at the glovebox that morning, the detector registered alpha activity on her hands. Health

¹ 1 nanocurie = 2,220 disintegrations per minute

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physics staff members found further activity on her right forearm and the right side of her neck and face, and proceeded to decontaminate her. At her request, a technician checked her locker and automobile with an alpha detector, but no activity was found.

On November 7, Silkwood reported to the Health Physics Office at about 7:50 in the morning with her bioassay kit containing four urine samples and one fecal sample. A nasal swipe was taken and significant levels of alpha activity were detected (about 45,000 disintegrations per minute (dpm) in each nostril and 40,000 dpm on and around her nose). This was especially surprising because her left nostril had been almost completely blocked since a childhood accident. Other parts of her body also showed significant alpha activity (1,000 to 4,000 dpm on her hands, arm, chest, neck, and right ear). A preliminary examination of her bioassay samples showed *extremely* high levels of activity (30,000 to 40,000 counts per minute in the fecal sample). Her locker and automobile were checked again, and essentially no alpha activity was found.

Following her cleanup, the Kerr-McGee health physicists accompanied her to her apartment, which she shared with another laboratory analyst, Sherri Ellis. The apartment was surveyed. Significant levels of activity were found in the bathroom and kitchen, and lower levels of activity were found in other rooms. In the bathroom, 100,000 dpm were found on the toilet seat, 40,000 dpm on the floor mat, and 20,000 dpm on the floor. In the kitchen, they found 400,000 dpm on a package of bologna and cheese in the refrigerator, 20,000 dpm on the cabinet top, 20,000 dpm on the floor, 25,000 dpm on the stove sides, and 6,000 dpm on a package of chicken. In the bedroom, between 500 and 1000 dpm were detected on the pillow cases and between 500 and 2,000 dpm on the bed sheets. However, the AEC estimated that the total amount of plutonium in Silkwood's apartment was no more than 300 micrograms. No plutonium was found outside the apartment. Ellis was found to have two areas of low level activity on her, so Silkwood and Ellis returned to the plant where Ellis was cleaned up.

When asked how the alpha activity got into her apartment, Silkwood said that when she produced a urine sample that morning, she had spilled some of the urine. She wiped off the container and the bathroom floor with tissue and disposed of the tissue in the commode. Furthermore, she had taken a package of bologna from the refrigerator, intending to make a sandwich for her lunch, but then carried the bologna into the bathroom and laid it on the closed toilet seat. She remembered that she had part of her lunch from November 5 in the refrigerator at work and decided not to make the sandwich, so she returned the bologna to the refrigerator. Between October 22 and November 6, high levels of activity had been found in four of the urine samples that Silkwood had collected at home (33,000 to 1,600,000 dpm), whereas those that were collected at the Kerr-McGee plant or Los Alamos contained very small amounts of plutonium if any at all.

The amount of plutonium at Silkwood's apartment raised concern. Therefore, Kerr-McGee arranged for Silkwood, Ellis, and Silkwood's boyfriend, Drew Stephens, who had spent time at their apartment, to go to Los Alamos for testing. On Monday, November 11, the trio met with Dr. George Voelz, the leader of the Laboratory Health Division. He explained that all of their urine and feces would

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be collected and that several whole body and lung counts would be taken. They would also be monitored for external activity.

The next day, Dr. Voelz informed Ellis and Stephens that their tests showed a small but insignificant amount of plutonium in their bodies. Silkwood, on the other hand, had 0.34 nanocuries of americium-241 (a gamma-emitting daughter of plutonium-241) in her lungs. Based on the amount of americium, Dr. Voelz estimated that Silkwood had about 6 or 7 nanocuries of plutonium-239 in her lungs, or less than half the maximum permissible lung burden (16 nanocuries) for workers. Dr. Voelz reassured Silkwood that, based upon his experience with workers that had much larger amounts of plutonium in their bodies, she should not be concerned about developing cancer or dying from radiation poisoning. Silkwood wondered whether the plutonium would affect her ability to have children or cause her children to be deformed. Dr. Voelz reassured her that she could have normal children.

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Silkwood, Ellis, and Stephens returned to the Oklahoma City on November 12. Silkwood and Ellis reported for work the next day, but they were restricted from further radiation work. After work that night, Silkwood went to a union meeting in Crescent, Oklahoma. At the end of the meeting, at about 7 P.M., she left alone in her car. At 8:05, the Oklahoma State Highway Patrol was notified of a single car accident 7 miles south of Crescent. The driver, Karen Silkwood, was dead at the scene from multiple injuries. An Oklahoma State Trooper who investigated the accident reported that Silkwood's death was the result of a classic, one-car, sleeping-driver accident. Later, blood tests performed as part of the autopsy showed that Silkwood had 0.35 milligram of methaqualone (Quaalude) per 100 milliliters of blood at the time of her death. That amount is almost twice the recommended dosage for inducing drowsiness. About 50 milligrams of undissolved methaqualone remained in her stomach.

At the request of the AEC and the Oklahoma State Medical Examiner, Dr. A. Jay Chapman, who was concerned about performing an autopsy on someone reportedly contaminated with plutonium, a team from Los Alamos was sent to make radiation measurements and assist in the autopsy. Dr. Voelz, Dr. Michael Stewart, Alan Valentine, and James Lawrence comprised the team. Because Silkwood's death was an accident, the coroner did not legally need consent from the next of kin to perform the autopsy. However, Silkwood's father was contacted, and he gave permission for the autopsy over the telephone. The autopsy was performed November 14, 1974, at the University Hospital in Oklahoma City, Oklahoma.

Appropriate specimens were collected, preserved, and retained by Dr. Chapman for his pathological and toxicological examination. At the request of the coroner and the AEC, certain organs and bone specimens were removed, packaged, frozen, and brought back to Los Alamos for analysis of their plutonium content. Because Silkwood had been exposed to plutonium and had undergone *in vivo* plutonium measurements, her tissue was also used in the Los Alamos Tissue Analysis Program to determine her actual plutonium body burden, the distribution of the plutonium between different organs of her body, and the distribution within her lung. On November 15, small samples of the liver, lung, stomach, gastrointestinal tract, and bone were selected and analysed. The data, shown in Table 1, indicated clearly that there were 3.2 nanocuries in the liver, 4.5 nanocuries in the lungs, and a little more than 7.7 nanocuries in her whole body. These measurements agreed well with the *in vivo* measurements made before Silkwood's death (6 or 7 nanocuries in the lung and a little more than 7 nanocuries in the whole body).

There was no significant deposition of plutonium in any other tissues, including the skeleton. The highest concentrations measured were in the contents of the gastrointestinal tract (0.05 nanocurie/gram in the duodenum and 0.02 nanocurie/gram in a small fecal sample taken from the large intestine). This demonstrated that she had ingested plutonium prior to her death.

With the exception of the left lung, the remaining unanalyzed tissues were repackaged and kept frozen until it was determined whether or not additional analyses were required. The left lung was thawed, inflated with dry nitrogen until it was approximately the size that it would have been in the chest, and re-frozen in that configuration. It was packed in an insulated shipping container in dry ice and sent to the lung counting facility at the Los Alamos Health Research Laboratory. The data were then compared with the *in vivo* measurements made prior to her death. As expected, without the ribs and associated muscle attenuating the x rays from the americium-241, the results for the left lung measured postmortem were about 50 per cent higher, but not inconsistent with the *in vivo* result.

Some of the most interesting observations made during Silkwood's tissue analysis were: 1) the distribution of plutonium-239 within her lung and 2) the concentration of plutonium in the lung relative to that in the tracheobronchial lymph nodes (TBLN). After the frozen left lung was returned to the Tissue

Analysis Laboratory, the superior lobe was divided horizontally into sections. Those sections were further divided into two parts: the outer layer of the lung (pleura and sub-pleural tissue) and the inner soft tissue of the lung (parenchyma). The plutonium concentrations in the inner and outer parts of Silkwood's lung were about equal, in stark contrast with another case examined under the Tissue Analysis Program in which the concentration in the outer part of the lung was 22.5 times higher than that in the inner part. That difference was an indication that Silkwood had probably been exposed within 30 days prior to her death, whereas the other case had been exposed years prior to death. Furthermore, the concentration of plutonium in Silkwood's lung was about 6 times greater than that in the lymph nodes, whereas in typical cases that ratio would be about 0.1. Both of those results indicated that Silkwood had received very recent exposure and supported the view that the plutonium tends to migrate from the inner part to the outer part of the lung and to the lymph nodes over time.

The saga of Karen Silkwood continued for years after her death. Her estate filed a civil suit against Kerr-McGee for alleged inadequate health and safety program that led to Silkwood's exposure. The first trial ended in 1979, with the jury awarding the estate of Silkwood \$10.5 million for personal injury and punitive damages. This was reversed later by the Federal Court of Appeals, Denver, Colorado, which awarded \$5000 for the personal property she lost during the cleanup of her apartment. In 1986, twelve years after Silkwood's death, the suit was headed for retrial when it was finally settled out of court for \$1.3 million. The Kerr-McGee nuclear fuels plant closed in 1975. ■

Table 1. Amounts of Plutonium-239 in the Organs of Silkwood

Organ	Plutonium-239 (nanocuries)	Concentrations (picocuries/gram)
lung (whole)	4.5	4.6
parenchyma	4.5	4.6
pleura	0.01	0.004
liver	3.2	2.4
lymph nodes (TBLN)	0.02	0.80
bone	~ 0	~ 0