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^{181}TUNGSTEN CONTAMINATION INCIDENT[1]

by

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INTRODUCTION

The Stanford two-mile accelerator has been in operation since May 26, 1966. During this time several unexpected health physics problems have been defined and workable solutions found. The major anticipated problems naturally are related to external radiation produced by the beam directly and the activation of beamline components. One problem, the extent of which was not fully realized before beginning operation, is radioactive contamination. The contamination problem has two origins: (1) machining activated beamline components and (2) cooling water. Of these two, cooling water has proven to be the most troublesome.

The potential problems from irradiated water were examined during the design phase of SLAC by DeStaebler.[2] Based on DeStaebler's results, Coward calculated the saturation activity produced in a large water dump by a one (1) megawatt electron beam (Table 1). Of the four major isotopes produced, ^{7}Be and ^{3}H have the longest half-lives and should be the most troublesome to deal with, but ^{7}Be is very efficiently removed by mixed bed resins and the major problem is handling the contaminated resins with curie quantities of ^{7}Be. The production and removal

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[1]Work supported by the U.S. Atomic Energy Commission.

[2]DeStaebler, H., "Photon Induced Residual Activity," Report No. SLAC-TN-63-92, Stanford Linear Accelerator Center, Stanford University, Stanford, California (1963).

of ^{7}Be has been examined experimentally by Busick.[3] Another source of contamination within the water system is the corrosion of irradiated elements that have become radioactive. Usually the contribution to the total activity is small when compared to the ^{7}Be present. One incident at the positron source demonstrated that corrosion can indeed be a serious problem.

DESCRIPTION OF INCIDENT

Positrons are produced by an electron beam striking a target called the positron source within the accelerator. The positrons are then heavily focused and accelerated through the remainder of the accelerator.

Typically an electron beam with an average power of 100 kW strikes the positron target. This power dissipation presents severe cooling problems. In addition, the solenoids and beam scraper require cooling. Figure 1 shows a schematic of the water flow and equipment layout at the positron source.

The Health Physics Group routinely samples the cooling water and sump water for this area and ^{181}W had been detected in small amounts. These samples contained concentrations of 1×10^{-4} μCi/cc down to 3×10^{-6} μCi/cc. The edge cooled coils inside solenoid A had shorted and were scheduled to be replaced by center cooled coils during a two-week maintenance shut-down period. This meant that the water lines had to be broken and activated parts removed.

Like many unexpected events of this nature, we discovered the problem quite by accident. On October 30, 1967, a fire was reported at the positron source area. This occurred at about 1100 hours. Also that same morning an employee was engaged in cleaning and reworking the positron source sump. Members of the

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[3] Busick, D., "^{7}Be Build-Up in a Large Water Beam Dump System at the Stanford Linear Accelerator Center," Report No. SLAC-PUB-521, Stanford Linear Accelerator Center, Stanford University, Stanford, California (1968).

Health Physics Staff investigated the fire and made the necessary radiation measurements, then proceeded to the sump from which an employee was observed bailing water. We found that his shoes were contaminated as well as the sump lid and aisle.

At this point it became obvious that the source of the contamination was the e^+ source. A maintenance crew had started disassembling the e^+ source that morning. Radiation surveys were made and the Health Physics emphasis had been placed on external radiation monitoring. This was true because analysis of water samples from this water system were low (3×10^{-6} μCi/cc) and the γ radiation levels from the activated e^+ source, a copper target, were ~5R/hr. It was our thought at the time that as long as the tungsten stayed with the water there would be minimal contamination resulting from working on the hardware.

The source of contamination was apparently insoluble deposits found inside of the solenoid, including the coils and associated outlet cooling lines. The deposits appeared as a fine, reddish colored film. The contamination began to appear shortly after a low point in the solenoid was drained or following removal of the cooling lines from the solenoid. The insoluble material inside of the solenoid was dislodged, contaminating the physical structures in the immediate vicinity of the solenoid and the people doing the work. Micro-curie quantities of ^{181}W were found on shoes, clothing and hands.

The logical source of the ^{181}W and ^{185}W is believed to be the tungsten collimator just down beam of the e^+ target. A gamma scan of resin samples from the water system revealed the presence of ^{181}W, ^{7}Be, ^{57}Co, and ^{58}Co. The cobalt isotopes are thought to be from the protective nickel plating of the collimator in the system. The nickel plating is apparently decrepitating, allowing oxidized tungsten to be released to the water cooling system.

SURVEY TECHNIQUES

From a health physics viewpoint, this incident points out the inherent risk associated with dependence on water sampling data and the difficulty in using portable survey instruments to assess contamination potential in this situation. The principal isotopes involved were ^{181}W, ^{185}W, and ^{7}Be. The detection of ^{7}Be and ^{181}W is difficult at the arbitrarily set but acceptable contamination level of 1×10^{-4} $\mu Ci/cm^2$. Table 2 illustrates the response of three survey meters to distributed solution sources of ^{181}W and ^{7}Be. ^{185}W can easily be detected with the GM portable survey meter since it emits a beta particle. ^{181}W emits a 60 keV x-ray while ^{7}Be emits a 477 keV gamma ray 12% of the time.

The SLAC Health Physics Group has a variety of laboratory instruments including capability for pulse height analysis. This instrumentation is necessary for our operational and research functions. By using this laboratory equipment we were able to assess the extent of the contamination problem quickly.

The people involved in this incident were contaminated externally but were not exposed to detectable internal contamination. The maximum permissible body burden for the individual isotopes involved are higher than the amounts detected on their body surfaces and clothing. Personnel air samplers did not reveal the presence of airborn radioactivity attributable to this incident.

CONCLUDING REMARKS

The fact that a radioactive contamination problem occurred at an AEC installation is probably not surprising. However, high energy accelerators do not represent typical AEC installations; SLAC does not possess large inventories of fission products or activated materials.

Due to the operating characteristics of this machine, such as low activation cross sections (microbarns), and limited types of solid target material, one would not expect residual radioactivity in the form of removable contamination to be a major problem. In fact, it resolves usually into more of a nuisance problem in controlling the many relatively low-level sources of radioactive materials (tools, wiring, plumbing, etc.).

What makes this particular problem both interesting and difficult to assess are the kinds of radioactivity produced. Normal operational health physics methods are not adequate at the usual levels of detection. Some of the radioelements produced by high energy accelerators are essentially pure gamma emitters and will not be detected at the arbitrarily set but acceptable levels of radiocontamination prevalent in this country. In the absence of corpuscular emission, ion chambers and Geiger counters are not sufficiently sensitive to detect existing contamination limits. Portable scintillation counters are not always effective because of their high sensitivity to existing low energy background radiation.

To the aforementioned problem we must add the high gamma radiation fields, from induced radioactivity in the targets and associated accelerator hardware, which ranges from a few mR/hr to R/hr levels at reasonable working distances.

The difficulties mentioned above leave us with a choice of laboratory-type instrumentation for detecting radiocontamination. Ideally this instrumentation would be a multi-channel analyzer and NaI crystal for rapid identification and quantity determination.

It is doubtful if we would have fully realized the magnitude of this incident in time to minimize the spread of radioactivity without the laboratory equipment mentioned. This is true in part because radiocontamination was not thought to be a problem at SLAC.

Ten men were directly involved in this incident. One man was heavily contaminated (~50 μCi). The remainder had < 5 μCi of γ-activity on their clothing and hands which could have been easily overlooked with conventional health physics measurements. The men were successfully decontaminated and some clothing was confiscated.

All personnel involved in this incident were subsequently counted in a mobile whole-body counter and found to be free of those radionuclides attributable to SLAC operations.

TABLE 1

EXPECTED SATURATION ACTIVITIES FORMED BY STOPPING

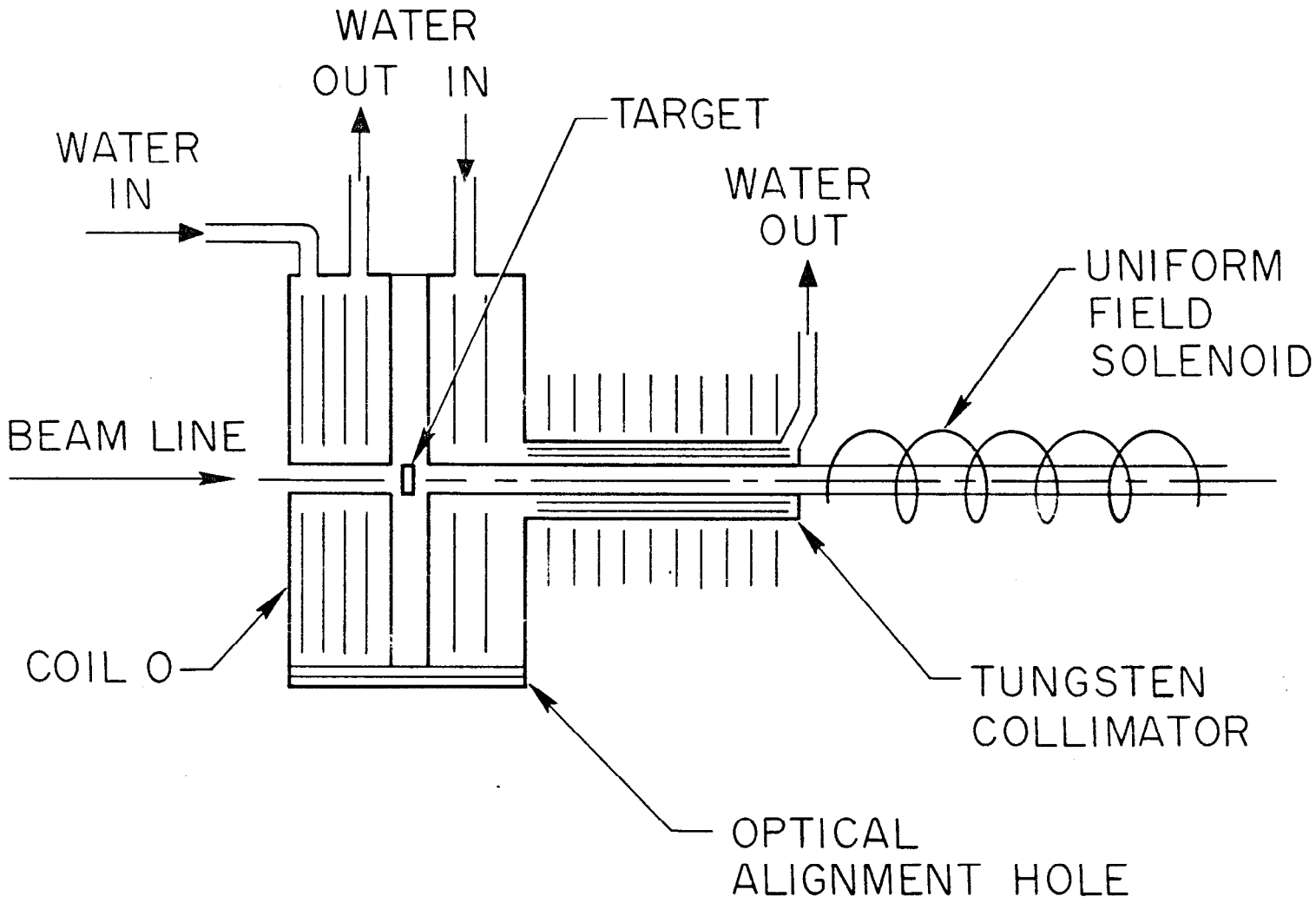
A 1 MEGAWATT ELECTRON BEAM IN WATER

Daughter Nuclide	Half-Life	Saturation Activity (curies/MW)
O^{15}	2.1 min.	35,000
N^{13}	10.0 min.	1,390
C^{11}	20.5 min.	1,390
Be^{7}	53.0 days	280
H^{3}	12.3 years	400

TABLE 2

Relative Response Above Background of Selected Radiation Monitors to 60 keV and 477 keV Gamma Energies

Survey Meter		^{181}W	^{7}Be
G.M.	mR/hr - μCi	0.2	0.02
Ion Chamber	mR/hr - μCi	0.03	0.01
CRM - G.M.	c/m - μCi	3×10^3	8×10^2



POSITRON SOURCE

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