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Argonne National Laboratory

A "MOCK-UP" METHOD FOR STUDYING THE POSSIBLE MODES OF RADIOACTIVE CONTAMINATION

R. F. Plott

August 15, 1949

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Radiation Effects on Reactor Materials

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OF RADIOACTIVE CONTAMINATION

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Radiation Effects on Reactor Materials

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A "Mock-Up" Method for Studying the Possible Modes
of Radioactive Contamination

R. F. Plott

Introduction

The writer, while at the Hanford Works, had occasion to serve as a consultant for Mr. John G. Myers of the Health Physics Division there. At the time (1948), Mr. Myers was seeking a means of training Operations crews to do "hot" work without initially exposing them to irradiation. In some manner it was hoped to detect nominally invisible errors connected with the performance of a certain operation or sequence of operations upon a non-radioactive assembly which duplicated a radioactive assembly that would be tackled after a suitable initial training period. I believe it was Mr. Myers who first suggested the use of fluorescent materials.

Materials

The aforementioned suggestion at once appeared to the author as being especially pertinent to the problem at hand. Immediate investigation proved this contention to be correct.

Two materials on hand in the laboratory were found to be especially adaptable. One was a small sample bottle of Zyglo penetrant oil, a water soluble oil, manufactured by the Zyglo Division of the Magnaflux Corporation, North Chicago, Illinois. The other was a liberal supply of Welch Duo-Seal Vacuum Pump Oil sold by the Welch Scientific Company, Chicago Illinois.

The Zyglo penetrant oil fluoresced a brilliant yellow in ultra-violet light and the Duo-Seal oil fluoresced a brilliant blue. Thus it was possible to consider a system in which there were two kinds of contamination, namely "yellow" and "blue". The "yellow" contamination could readily be washed away by a water spray (except the penetrant in cracks and other surface defects). The "blue" contamination required the application of an organic solvent to remove it completely. (Here again the oil in cracks and other surface defects was not as readily removed as the less tenaciously held oil)

Species of radioactive contamination can occur individually as a solid, liquid, or gas, or as any combinations of these three forms of matter. The liquid contamination could be represented directly by each of the oils.

Solid contamination could be "tagged" by each of the oils. It was found that moist, finely-divided sand could be coated with "yellow" contamination and that dry (baked-out), finely-divided sand could be coated with "blue" contamination.

The investigation of the gas phase was not made, but it appears quite possible the condensed vapors off the "yellow" and "blue" contamination could be used to indicate the vapor-borne contamination.

The high sensitivity limit of visual detection of fluorescence may, under suitable conditions, be a fraction of a part per million of the fluorescent substance. In the presence of appreciable quantities, visual detection of the fluorescent material may be made in a well-lighted room by the use of a fairly intense ultra-violet light source. The usage of the fluorescent method for tracing contamination readily can be made semiquantitative. By the application of quantitative measuring equipment, an accurate representation of the proportion of contamination could be made.

Method of Application

Parts of equipment in the "mock-up" known to be "hot" can be covered with an unnoticeable layer of either the "blue" or "yellow" fluorescent oil. Should some part of the operation be suspected of allowing water-borne contamination, then the water-soluble "yellow" Zyglo penetrant may be used. (Globules of Duo-Seal Oil in water are also detectable.) Should some part of the operation possibly lead to spread of contamination by the application of organic solvents, then the "blue" Duo-Seal oil may be most applicable.

It is usually advisable to have the "mock-up" equipment clean and free from oil and water, when the fluorescent materials are applied, in order to achieve the maximum utility of the method.

The tools, likewise, must be clean, as must the workmen and their work clothing.

After careful instruction concerning the desired operation, the performance is carried out according to plan. The application of ultra-violet light to the equipment then will allow a vivid "post-mortem" discussion. The heretofore invisible contamination is now clearly exhibited. The points of contact of tools used in the operation exhibit a characteristic fluorescence, spilled water upon the floor indicates "contamination fluorescence", etc. Last of all, the clothing, gloves, hands, face, etc. may be carefully examined. CAUTION: Never expose parts of the body to the ultra-violet lamp closer than two feet and then for only a few seconds. Do not look INTO the lamp!

Often after a workman carefully handles "contaminated" tools with gloves, which thus become "contaminated", he removes the gloves in the usual manner, "contaminating" the bare hands. Usually it is not long before the face, hair, pencils or bill-fold become "contaminated".

It must be pointed out that this training technique must be carefully used or it may develop phobias in those being trained, which would cause them to become useless in the performance of even a simple operation of little or no hazard level.

Conclusion

The employment of certain fluorescent materials to indicate the modes of solid and liquid and perhaps gaseous contamination that may occur in working with "mock-up" radioactive materials or equipment is especially useful for the proper training of people. The fluorescent material, like the radioactivity to be later encountered is not visually detectable without some aid. Thus, by the use of the fluorescent method, errors and other bad practices can be minimized in the "mock-up" work. In fact, a semi-quantitative or even a quantitative evaluation may be made of many of the radioactive hazards without the workmen ever having been exposed to radioactivity.

Recommendations

I strongly recommend that the herein described technique be used in all non-routine work for which radioactive hazard experience is not available. The method is not a "cure-all", but it definitely will point the way to sound procedures for handling radioactive contamination.

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