

liner in a nuclear reactor and measuring the radioactivity of debris in the lubricating oil and that emitted by the exhaust of the engine.

Tracers have been used in quality-control procedures by a manufacturer of printed circuit boards. Tracers were incorporated into masking agents and etch solutions to detect any minute quantities of these compounds after the boards were cleaned. The presence of these impurities was correlated with defects in solder joints after accelerated aging tests. The advantages of tracers are that they are nondestructive and yield results in a shorter time than the aging tests.

Radioisotope tracers are particularly useful in detection of problems. One aircraft manufacturer has eliminated the problem of "bucking bars" being left in the aircraft by placing microcurie quantities of cesium-137 in the bars. A radiation detector can then reveal the presence of any of the bucking bars. Otherwise these heavy metal pads, which are placed behind rivets as they are driven into place, might be left in the aircraft and become a potential hazard in flight if they remained undetected.

Tracers are valuable as detectors of obstructions in underground pipe lines. In one case a pipe line extending 25 miles from a compressor station to a polymer processing plant had been installed 30 years ago and had not been used for about the last 25 years. A new use for the line was proposed, and a cleaning tool was propelled down it by air pressure to remove debris. A sealed source containing 300 millicuries of radioactive gold was attached to the tool. As expected, the tool stuck at an obstruction somewhere in the middle of the line. A crew was sent out with a Geiger counter to find the plugged section. The obstruction was located within 25 feet and removed. Without this technique the line would have been abandoned, according to plant engineers, and a new pipe would have been installed at considerable cost.

Tracer studies also have important applications in the pharmaceutical industry. They can detect and measure radioactive atoms from the original tagged sample regardless of the nature of the chemical structure in which they are incorporated. Thus drug researchers can detect, isolate, and measure not only the original labeled compound but also its many derivatives.

Most of the tracer work in drug research uses carbon-14 or tritium because the drugs are complex organic molecules. To a smaller extent