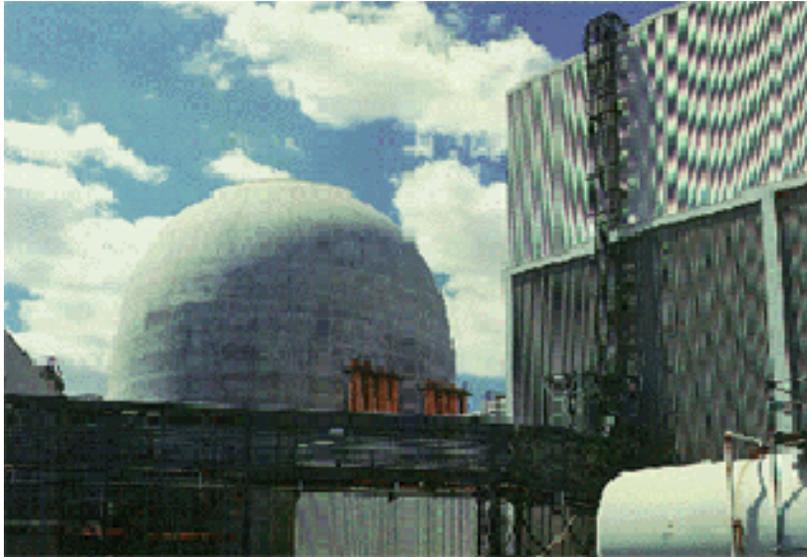


Remote Robotic Probe Control



Remote Robotic Probe inspects pipes and other hard-to-access gear at electric power generating stations. Windows NT was chosen as the operating system software.

In a world where downtime is measured in thousands of dollars per minute, quality and reliability are priceless. That is why system designer Foster Miller of Waltham, Massachusetts chose Opto 22 hardware and software to control their robotic inspection vehicles.

A nuclear reactor works by heating a liquid with the energy produced by a fission reaction. The hot liquid is radio active on the primary side. Steam for the power generating turbines is produced by a heat exchanger, called a steam generator, which produces non radio active steam on the secondary side.

Where No Man Has Gone Before

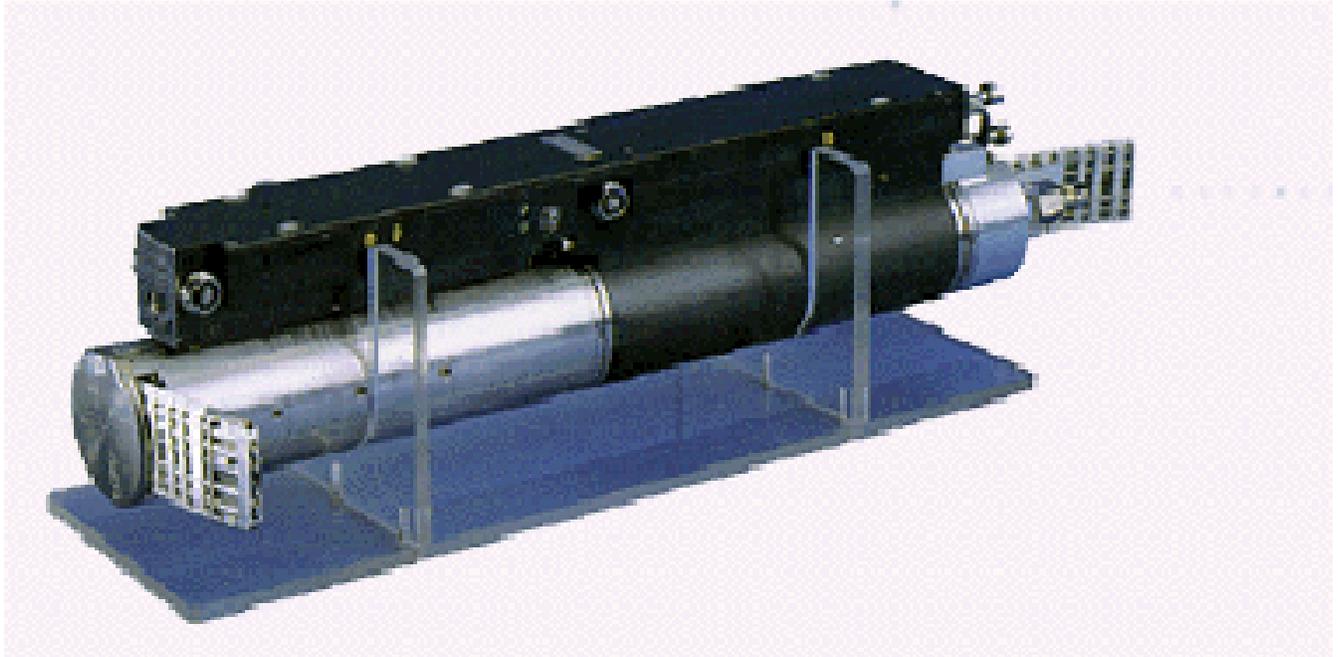
Even with sophisticated water treatment technologies, deposits can form deep within the reactor's heat exchangers. Previously inaccessible to inspections, repairs of plugged or leaking tubes were limited to inserting sleeves or, in the extreme cases, replacing the steam generator. A more cost effective alternative was provided by Foster Miller in the form of an extremely versatile remotely-piloted inspection and maintenance robot. With components hardened against radiation, the robot can go anywhere and do pretty much anything that's required.

Using sophisticated sensors and TV cameras, operators can view and correct most problems from the relative safety of the control room. Unnecessary downtime for the system is greatly reduced by fully diagnosing problems before repair is attempted. Remote inspection allows the repair team to accomplish many cleaning and debris retrieval tasks remotely.

CECIL is Foster Millers steam generator maintenance robot.

The steam generators in pressurized water reactor plants are difficult to maintain and extremely expensive to replace. Sludge formed during plant operation settles on the tubes and tubesheet, promoting corrosion. In addition, foreign objects left in the generator during initial fabrication or maintenance can damage the tubes, causing primary to secondary side leakage. The result is a costly forced outage.

CECIL is a teleoperated robot which provides high quality visual inspection, removes hard and soft sludge from the tubesheet, searches for and retrieves foreign objects, and collects sludge samples. The robot has evolved over several years and has become the industry's state-of-the-art secondary side maintenance system. CECIL has been



deployed successfully in nuclear plants worldwide. Utilities using CECIL report fewer forced outages, reduced maintenance, reduced personnel radiation exposure, and prolonged steam generator life.

How Does It Work?

Cecil travels along a monorail which is temporarily installed in the blowdown lane of the steam generator. The revolutionary feature of the system is the flexible lance, which can access any point within the tube

bundle. The lance is fed through CECIL's body, rotated 90 degrees, and driven down each intertube lane. It is equipped with a color video probe to inspect the tube bundle, monitor work in progress, and document "before" and "after" conditions. CECIL's activities are controlled by an operator stationed in a remote, low-radiation area.

All of the analog and digital control signals for Cecil originate in an Opto 22 control system. Using a revolutionary flowchart-based control language called OptoControl, the 120 optically-isolated signals control all robot and lance functions. The lance also contains a color TV probe to enable operators to review before-and-after conditions, control the robot, and search for foreign objects.

Serial commands to Compumotor motion controllers were easy to format in OptoControl. Operator commands are translated from joystick positions to motor instructions in OptoControl flow charts.

Other OptoControl charts control the water-processing functions. Sludge processing recycles water to reduce waste.

Increased Life

Robot reduces down time and extends steam generator life

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