

# Industrial Robot

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## Robotic snake arm reaches into radioactive regions

Inspecting equipment in radioactive environments is a very hazardous assignment. Safe operation of nuclear power generation plants requires regular inspection and repair of many radioactive areas. When staff at the Pickering nuclear power plant of the Ontario Power Generation decided they needed a "better way" to inspect and repair upper feeder cabinets (UFC) they turned to OC Robotics. The UFC provide for reactor cooling, handling pressurized heavy water (D<sub>2</sub>O) and

have radiation hazards such as hot spots, contamination and tritium. Dose rates can range from 100 to 400 mRem/h. The UFC also have some crawl only spaces and limited turn around areas making human inspection difficult in the highly radioactive environment.

OC Robotics answered the call with their Snake-arm robot™. The entire inspection and repair system is known as snake-arm feeder inspection robotic equipment (SAFIRE) (Figure 4). The design offers a very flexible reach, much like a snake and not the usual limited number of pivots found in industrial robots. The arm offers 19 degrees of freedom of movement.

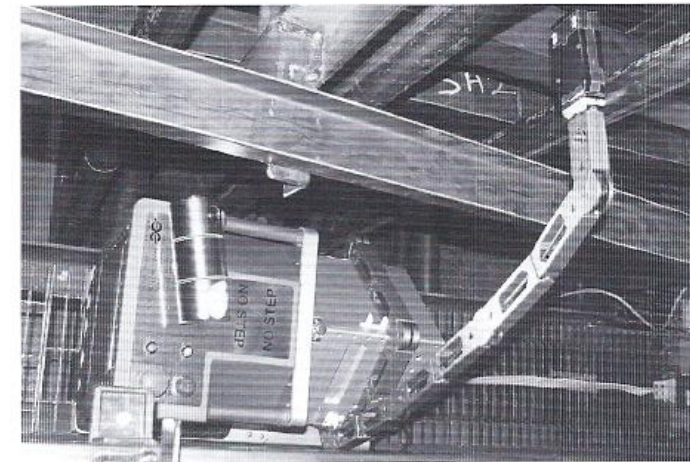
The robot has a reach of 2 m and is designed to carry a payload of 0.5 Kg. The inspection end of arm "tool" includes three cameras, two with fixed focal length and a third mounted to look off to the side of travel at 90°. The two fixed focus cameras are mounted on the front of the arm, one a wide angle for navigation and the other a narrow angle focus for close inspection.

The camera head can pan, tilt and rotate for careful inspection. Illumination is provided by two sets of high-power LED lights that illuminate the camera viewing areas. Additional cameras are mounted on the mobile vehicle and the base station to provide views of the entire operation. A pan-tilt-zoom camera with lights is mounted on vehicle and a second on the base station. The video signals are fed to the control station over 500 m of fiberoptic cable. At the control trailer, the video signals are recorded as a permanent record of the inspection.

The robot arm is mounted on a mobile vehicle, which is remotely directed to "walk" along the catwalks in the radioactive areas. The arm can reach up to inspect areas above or can be directed to "look" below the catwalk (Figure 5). Movement of the arm is controlled and powered via wire ropes, which travel inside the structure. Motors for the motion are located in the mobile vehicle along with the video image-processing equipment.

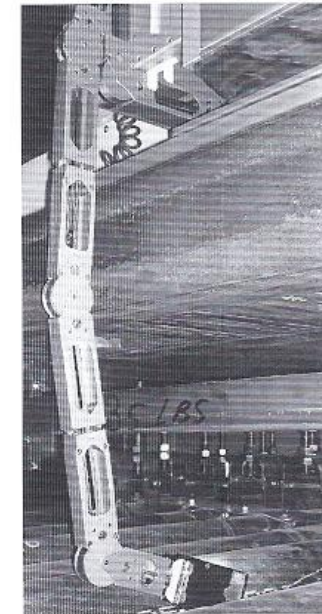
Operation of the robot is directed from an operator station located in a

Figure 4 The SAFIRE snake-like robot reaches up into radioactive equipment to inspect



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Figure 5 Inspecting below the walkway, the SAFIRE robot reaches down to complete and inspection



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trailer parked outside the reactor buildings. While the SAFIRE greatly reduces the exposure to radioactivity, it does not eliminate the exposure, as an operator in protective gear and with an external air supply must setup the equipment and remove when the procedure is completed.

Two operators work together to direct an inspection procedure from the trailer. One operates the robot arm and the other directs the inspection process by controlling the cameras and assessing the video information in real time. Training of the operators is conducted on a virtual test environment using the actual control software but not the actual arm hardware. The proprietary control software was also used during the system design process to help insure that the snake-arm kinematics was compatible with the CAD model of the operating environment.

OC Robotics is a trading style of Oliver Crispin Robotics Ltd. For more info on the SAFIRE system, please visit the OC Robotics web site at: [www.ocrobotics.com](http://www.ocrobotics.com)

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