REMOTE RADIOLOGICAL MONITORING WITH THE CARE SYSTEM

by

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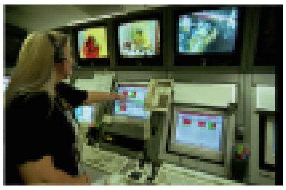

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Abstract

A system was developed which integrates video, voice (cell phone and hardwired sets), teledosimetry, area monitoring and airborne radioactivity monitoring sub-systems into a single package. Software for dose control is the Bartlett Services RMS product. Data from each sub-system is fed to a central control point located outside the radiologically controlled area. Health Physics technicians monitor and control radiological work from that central control station. Installation of CARE hardware in the reactor containment building is accomplished in about 4 hours and the full system is ready for use within one shift. Health Physics personnel dubbed the system CARE to convey to workers our concern for safe and efficient work in radiological areas.

CARE has been used during six outages and has repaid the initial development and installation costs. Benefits from use of CARE include (1) reduced requirement for HP techs, (2) reduced outage costs, (3) reduced radiation exposures, (4) improved job control, (5) improved oversight, (6) continuous job status information to outage managers, (7) real time job turnovers between workers, (8) reactor water level monitoring from the control room without containment access, (9) remote quality assurance inspections, and (10) video taping for use in future training. Tangible benefits of the CARE system are a $1,100,000 saving due to contract HP techs not hired and the avoidance of about 58 person-rem.

System Development

San Onofre Nuclear Generating Station is located on the coast in Southern California and has two operating 1160 MWe Combustion Engineering pressurized water reactors. Unit 2 began commercial operation in August 1983 and Unit 3 followed in April 1984.

Radiation protection at San Onofre is provided by a dedicated staff of professionals and technicians. During plant outages, the health physics staff is supplemented with contract Health Physics technicians (HPTs). San Onofre employs about 50 contract HP technicians for an outage. Outage durations are steadily decreasing and are planned for 35 days each later this year and early in 2001.

Development of the CARE system began at San Onofre in early 1996 after seeing an early version of such a system during an industry bench marking effort. A multi-discipline team was assembled and included health physics, telecommunications, information systems, and nuclear engineering members. The challenge to the team was to create a system which would integrate audio, video, teledosimetry, area radiation, and airborne radioactivity measuring equipment into a single system which would (1) reduce radiation exposure, (2) reduce dependance on contract HP technicians, (3) reduce outage costs, (4) improve worker protection, and (5) improve supervisory oversight.

The system design includes a central control facility located outside and adjacent to the radiologically controlled area (RCA) entry point. This area has three work stations for HP technicians. Bartlett Services RMS software was selected for dose control and is fed with data from up to 50 teledosimeters. A local cellular phone network is used for communications and supports up to 48 phones. These phones can call or be called from any telephone on the site and the phones can be bridged together so that workers and supervisors can all talk together. Up to 30 color video cameras with pan-tilt-zoom features and lighting controls are supported. Data from teledosimeters and phones are transmitted to radio signal receivers throughout the containment building and the information is then carried to the central facility over telephone lines. Video signals are multiplexed and transmitted to the central area over a fiber optic cable. Video camera selection and control is achieved using a computer and software package. Any camera image or combination of images can be directed to any system monitor in the central control point or to any other site location where a monitor is positioned. Initially, a rack of electronic equipment was positioned outside a dedicated containment penetration and a cart of electronic gear was moved into containment as part of system set up. The in-containment equipment is now packaged in large “suitcases” with all electrical connections on the external surface and color coded for quick set up.

The outage control center is provided with a video monitor and the ability to select and view any camera image.

This gives outage managers real time visual information about job status. A monitor is located in the control room envelope to show the reactor system water level monitor and a view under the reactor vessel. This reduces the need for operations personnel to enter containment to verify the reactor water level instrumentation readings and to verity that a leak has not developed while the reactor cavity is flooded. A monitor and phones are set up in a Maintenance facility outside the plant to support turnover between incoming and outgoing workers for critical jobs such as reactor coolant pump and seal work and pressurizer heater work. The workers coming on shift can see the job status and can speak with the on-shift crew about the job. Turnover quality is vastly improved.

System Costs and Benefits

CARE was budgeted at $820,000 and was completed for about $100,000 under budget. The project was formally approved (funded) in May 1996 and CARE was operational in November 1996.

The first installation (U2C9 RFO) of the original system required about three full days work for five people and cost about 0.86 person-rem (0.0086 person Sievert) for installation and start up . These RFOs also included chemical cleaning of the secondary side of the steam generators. Most CARE hardware was installed in a cart, was moved into containment, and was located adjacent to a dedicated penetration. About 5000 feet of cable was strung inside the containment building to support Proxim modems for teledosimetry, micro cells for the cell phone system, and power, control and signal cables for each video camera. Cabling from the containment penetration to the central control point was done ahead of the outage. The second use (U3C9 RFO) of the system required about 12 man-days and 0.46 person-rem (0.0046 person Sievert) for installation. The reduction in time and dose expended was due to experience gained during the first outage. The number required and positions for Proxim modems and micro cells in Unit 2 containment was especially helpful information for the Unit 3 outage set up.

CARE was used in support of two mid-cycle outages which were required for follow up examinations of steam generator secondary side degradation discovered during the cycle 9 refueling outages. Only the amount of CARE equipment necessary to support eddy current testing was installed for these mid-cycle outages.

The cycle 10 RFOs had extensive RCS nozzle work and pressurizer heater work in addition to the normal refueling and routine maintenance efforts. CARE accounted for an estimated 12.5 p-rem savings for each outage and enabled us to avoid hiring about 10 contract HP techs for each outage. Shorter outages (52 and 45 days) reduced the avoided contract HP tech costs to about
$150,000 per outage.

Cumulative benefits derived from use of CARE include (1) a cumulative cost saving of $780,000 due to HP technicians not hired, (2) a 32.5 person-rem savings over doing the same work without CARE, (3) improved supervisory oversight of work, (4) availability to outage management of real time, visual, job status, (5) “remote” quality assurance inspections, (6) video taped outage work for use during future training, and (7) favorable Station recognition by outside entities (NRC, INPO).

Lessons Learned

Early experience indicated that we need additional “indoctrination” of our HP technicians, more worker training on the use of cellular phones, a more robust cell phone to headset connector, a simpler method of assigning and attaching electronic dosimetry to a worker, more micro cells for complete phone coverage of containment, a dedicated power supply for the CARE equipment cart in containment, a cable management system, and quicker, easier CARE hardware installation in containment.

System Improvements

Each of the lessons learned has been addressed during an “evolutionary” development of the CARE system. All of our staff HP technicians are now fully supportive of CARE. This is largely a result of opportunities to use the system and to see the ease and thoroughness with which work can be remotely monitored and controlled.
The addition of some micro cells and of an industrial strength connector have made the cell phones durable and reliable throughout the containment building. Provision of our own dedicated electrical panel eliminated problems such as interference from portable electrical equipment operating on the same circuit and disconnection of CARE equipment.

Development of a cap and a vest has greatly simplified placement of electronic dosimetry on a worker. The cap and vest are designed to position and hold a TLD and an electronic dosimeter detector in the desired location (e.g. top of head, elbow). The vest has a pocket on the front and back to hold the dosimeter transmitter and is "infinitely" adjustable for worker size. Vests are staged on coat hangers with the electronic dosimetry installed. A worker dons the vest and assignment of the electronic dosimetry is by a single bar code which can be manually entered into a computer system or may be entered using a laser gun.

Ease of installation and cable management was solved by reconfiguring the hardware and eliminating the rack and cart of CARE electronics. Equipment to support six video cameras, two micro cells and two Proxim modems is now built into a rugged, easily moved box. This CARE-Pack requires a single cable to each video camera, micro cell and Proxim modem. Electronic dosimeters, area monitors and airborne monitors all communicate by radio signal with the Proxim modems. Cell phones communicate via the micro cells. All video, voice and radiological information is carried from a CARE-Pack to a Penetration Box on a single multi-strand cable. One Penetration Box supports up to four CARE-Packs. All information from and control of the entire CARE system is now carried between the Penetration Box inside containment and the central control point (dubbed CNN) on one multi-strand cable and one coax cable. CARE-Packs are color coded, all cable connections are external to the CARE-Pack, and cable connectors are selected to prevent incorrect hook ups.

A patent application is on file and covers the modular CARE system and the specialized caps and vests used to position dosimetry on workers.