

NUCLEAR ENGINEERING

INTERNATIONAL

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Network improvements

Corrina Thompson looks at recent upgrades to radiation monitoring networks in Russia, the UK and Canada.

Environmental radiation monitoring regimes are used to measure the impact of nuclear activity and emergency situations on the environment at different nuclear sites around the world. The information provided by monitoring systems is used in a variety of ways, including testing compliance with emissions limits, searching for specific types of radioactive material and providing a warning system for emergencies.

Systems vary in their specification and purpose, and some are being upgraded to provide more effective monitoring following the Fukushima nuclear accident. This article takes a look at some recent improvements.

Mayak

Rosatom, the Russian State Nuclear Energy Corporation, described the environmental radiation monitoring network at the Mayak site in the Urals and current upgrades to the system to *Nuclear Engineering International*.

Rosatom utilises its automated radiation situation monitoring system (ARSMS) at Mayak, where fuel reprocessing and nuclear work associated with military purposes takes place.

ARSMS continuously monitors the radiation situation of the territory, sanitary protection

zone and selected points in the Mayak controlled area, under normal operations and in an emergency. Remote control centres (RCCs) are connected to the main control centre, and to system subscribers via the internet.

The remote centres carry out data collection and treatment, and they transmit and present information from the attached sensors. There are 12 centres, six in Mayak's enterprise units and sanitary protection zones and six in residential areas (Ozersk, Kyshtym, Kasli, Novogornyy, Metlino and Tatysh).

Sensors measure gamma-radiation exposure dose rate and weather parameters (wind speed and direction, temperature, humidity and pressure). Each centre has a set of sensors that depend on its location and purpose.

Monitoring results are displayed in Ozersk, Kyshtym, Kasli, Novogornyy, Metlino and Tatysh, as well as on the centre displays. These are forwarded to the control centre by radio, telephone or cellular communications depending on operational conditions, location of control centres and information volume. In the event that permitted limits are exceeded, the RCC contacts the control centre and forwards the latest measurement results for all parameters. Cellular communications are

more frequent.

Rosatom told *NEI* that Mayak's monitoring network has been upgraded to include RCCs equipped with a radio channel (frequency 433MHz). In addition a self-contained power supply has been developed and installed, data consolidation and retransmission units have been developed for the system, and the control centre software was updated.

The main ARSMS control centre at Mayak stores all data, contacts the remote centres by telephone (both automatically at specified time intervals and manually), adds new measurable parameters, and adds new RCCs with automatic identification of measurable parameters. It also remotely changes control values of measurable parameters in RCCs.

The centre carries out reviews of archived data during specific periods to analyse the radiation situation. It transmits data to system subscribers, responds to any deterioration and automatically informs Mayak management, the Crisis Management Centre (CMC) and maintenance personnel.

When an RCC finds a limit has been exceeded, the control centre switches to emergency mode and immediately informs management and maintenance personnel. In

Figure 1. Structure of the automated radiation situation monitoring system (ARSMS) used at Mayak in Russia

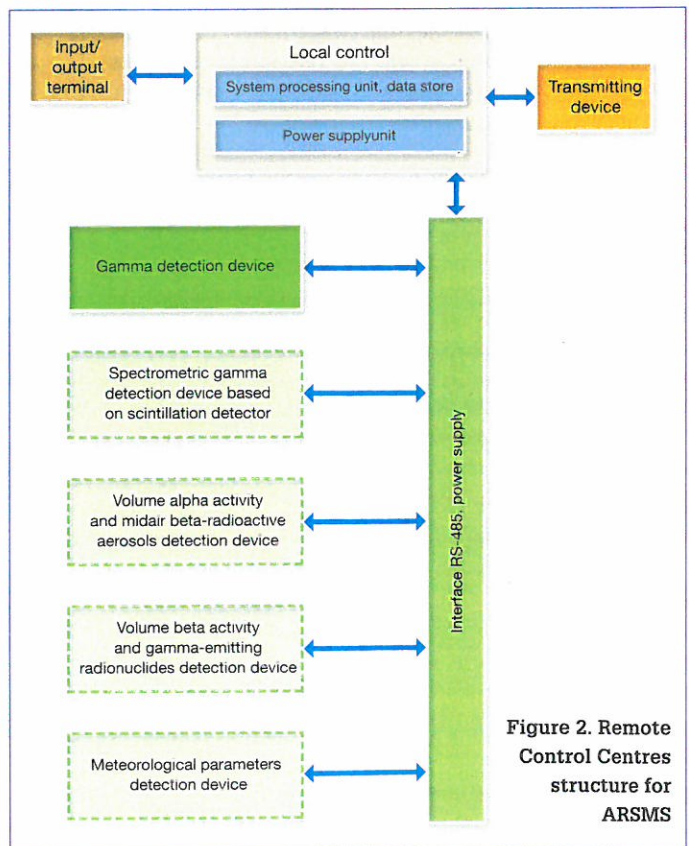
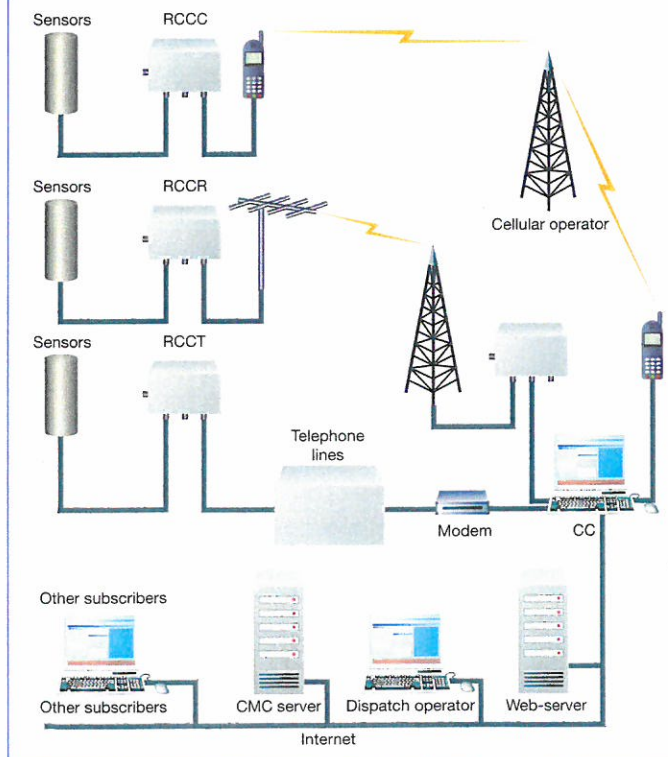


Figure 2. Remote Control Centres structure for ARSMS



The Metrac vehicle and Groundhog system in use at Strathy beach near Dounreay, UK (Credit: DSRL, NDA and Nuvia)

this mode it contacts RCCs at intervals and it returns to normal operating mode when it receives normal values.

The Mayak management, Crisis Management Centre and Kyshtym authorities receive data on the radiation situation automatically, immediately after the RCC transmits it to the control centre. Rosatom said any internet user may also enter the Crisis Management Centre website and learn about the current radiation situation.

Rosatom is encouraging development of the ARSMS system by increasing the number of RCCs.

Meanwhile, the Unified State Automated Radiation Situation Monitoring System (USARSMS) monitors radiation in Russia as a whole. It is a countrywide network of monitoring stations. The Russian Federal Service for Hydrometeorology and Environment Monitoring (Roshydromet) is the central co-ordinator and regional, aerial and industry monitoring systems are being incorporated in the system.

Rosatom's ARSMS is a major part of USARSMS and covers nuclear power stations and nuclear industry enterprises. Sensors operate automatically, take measurements every minute and transmit the average value to the ARSMS centre on an hourly basis. All the data is forwarded to the Rosatom Crisis Management Centre, as well as to local government authorities, ministries and agencies concerned. The information can be freely accessed on the internet. It is the automatic data transmission that underlines its accuracy for the end user, and stakeholders cannot make any changes, according to Rosatom.

Zelenogorsk

The Zelenogorsk uranium enrichment plant in Russia recently won the TVEL Best Fuel Company Enterprise for Civil Protection at a nuclear fuel facility, a key factor in the win being its Automated Measuring System for Industrial and Ecological Monitoring (AMSIEM) and its automated mobile

emergency response system (ASEMKAR).

Radiation monitoring is only one aspect of measuring impacts on the environment at nuclear sites with systems often including chemical sensors and weather stations. At Zelenogorsk, AMSIEM monitors HF, NH₃, NO₂, and SO₂ as well as gamma dose rates and meteorological conditions. The AMSIEM system continuously monitors industrial areas, workplaces, storage facilities, and the city of Zelenogorsk.

Saphymo's SkyLINK radio system for wide area monitoring is the foundation of AMSIEM and can transmit data over a distance of up to 100km. It has ultra-low power requirements and a battery life of up to ten years. Saphymo stated that even under harsh conditions, the system has proven reliable since 2010. The system consists of 13 GammaTRACER dose rate probes, 40 chemical sensors in the industrial zone, seven chemical sensors for the plant perimeter and city, and a single weather station.

In the event of levels being exceeded, an alarm is triggered and all data are fed into an emergency planning forecast model for decision-makers in the regional and national administration. These include Zelenogorsk municipality, Krasnoyarsk region and Rosatom headquarters in Moscow.

The monitoring system was extended in 2013 to include mobile emergency response, which includes different probes and hand-held MiniTRACE gamma dose rate meters, which use GPS and a ShortLINK radio receiver, used within 5km of a mobile operations centre truck.

From 2016 the mobile emergency response system is expected to include the self-erecting GammaTRACER Spider, which can be deployed from a drone or helicopter to provide measurements in areas where first responders may be at risk.

Dounreay

The Dounreay site in Scotland, which was used for fast breeder experiments and reprocessing, is now being decommissioned.

As a result of poor waste management practices when the reprocessing plants were operating, small fragments of nuclear fuel were released into the environment, mainly from an effluent outlet. These fragments are concentrated in an area of seabed and wash up on local beaches near the nuclear site. A detector system called Groundhog was developed to find these particles. Recently a more suitable vehicle with better detectors has been used.

This system is used by Dounreay Site Restoration Ltd (DSRL) under requirements set by the Scottish Environment Protection Agency to detect and remove particles, as stated in the site's legal radioactive discharge authorisations. The work is carried out by

Nuvia Ltd using the Groundhog Evolution 3 detector system.

DSRL and Nuvia explained that most of the particles are characterised by Cs-137 activity and can be found at depth in sand by looking for gamma emissions. The detector system used in the Groundhog system comprises an array of five NaI(Tl) detectors, each 76mm in diameter and 400mm long, arranged so they provide a contiguous 2m-wide detection system. The output of the detectors is digitised allowing oversampling, a method to make multiple measurements of an area each second, which enhances the sensitivity of the system.

The output from each detector is continuously displayed, on a computer that also monitors the magnitude of the signal and sounds alarms for various scenarios. These include a caesium alarm if a gamma signal is detected within the expected energy range for Cs-137 gamma emissions, and a background change alarm. Both of these compare the most recent measurement to the mean of the last ten background measurements. There is also an alarm if the gamma signal associated with Co-60 is detected, as particles containing this isotope have been found, very rarely. The height of the detectors above ground and the velocity of the vehicle are also monitored in order to keep these within acceptable parameters.

The detector system is mounted on the front of an all-terrain vehicle, the selection of which was influenced by the conditions and terrain – essentially a marine environment with a mixture of wet and dry sand.

To optimise area coverage rates (the maximum area covered in a single month is approximately 700,000 square metres) and



Saphymo supplied its SpectroTRACER monitors for use at the Bruce Power nuclear site in Canada

detection probabilities, there is a requirement for the average velocity to be 1m per second. DSRL and Nuvia said this is an "extremely challenging requirement" for any normal gearbox driven vehicle and was a key factor in the selection of a vehicle powered by hydraulics. The current base vehicle is the Metrak H5.

The system also includes a high-resolution global positioning system allowing the geo-referencing of all measurements made and all particles detected. The system underwent independent trials in 2007, during which it demonstrated its ability to detect a 1×10^5 Bq particle at a depth of 200mm with 89% probability and a 1×10^4 Bq particle at 50mm with 84% probability. "In practice during routine monitoring we have detected and recovered a 1.2×10^5 Bq particle at 350mm and a 4.5×10^3 Bq particle at 100mm. The Groundhog has proven itself to be reliable and as a system, operated by trained and experienced personnel, capable of outperforming its theoretical capabilities in the detection of particles," DSRL and Nuvia stated.

Nuvia also uses the Groundhog to carry out beach monitoring near the Sellafield site.

Bruce Power

The Bruce Power nuclear site in Ontario, Canada, recently assessed the operational performance of its new gamma monitoring system, which was installed following the Fukushima accident.

The gamma monitoring system is part of a major upgrade which aims to improve emergency response communications and radiological-monitoring systems. Bruce Power wanted to examine its stations' abilities to withstand a beyond-design-basis event (any extreme threat that may exceed what its stations were designed to handle).

Bruce Power contracted management consultants ScottMadden and technical services giant RTI International (a nonprofit institute) to help produce and execute a new monitoring strategy.

A key lesson from Fukushima is that after the accident it was difficult for officials to gain a coherent, credible understanding of the facts, which led to a lack of direction. In addition, the magnitude of the accident meant the restricted zone was extended to 80km, which greatly exceeded the scope of the pre-planned emergency response (typically 10km). This meant that many surveyors were taking radiological measurements without knowing if they were entering hot zones, risking exposure. Also, with only limited data from the field, official recommendations for actions to protect the public were invalidated by field data, putting the community at greater risk.

This analysis informed the creation of the new system at Bruce Power. ScottMadden

and RTI worked with Bruce Power to conduct a gap assessment, design and install a state-of-the-art remote radiological-monitoring system, and customise a centralised, analytical software tool that enables all responders to access a single version of what is happening in an emergency. The new tools and associated processes significantly reduce the risk of radiation exposure for first responders in the field, and diminish the potential for erroneous or conflicting data that could hamper response efforts in a rapidly evolving situation.

RTI, working in conjunction with these companies developed a custom database and software application called Nu-PathNET, which provides insights into the effects of a radiological release. The secure data centre hosting the system is located off-site, so the system will be unaffected by events at the stations. The database consolidates critical data from radiological monitors, meteorological and environmental sources, and dose models. Then, because the software is integrated with geographic information systems, it displays how the plume will affect every road, stream, or home in the affected area.

The new system uses fixed and portable tools to monitor conditions, including gamma and air-monitoring devices. The gamma monitors collect radionuclide and air particulate data from across the monitoring zone in real time, to limit the dose exposure for first responders.

A network of deployable monitors can be used in the event of a plume reaching beyond 10km. They are dropped in front of the plume, so surveyors need not take blind measurements, minimising exposure. The data are transmitted in real time over cellular and satellite communications.

Saphymo has provided 59 self-contained spectroscopic gamma monitors, all of which were delivered in autumn 2014. Of these, 44 monitors have been installed, five are in reserve and 10 are mobile units. They must measure and operate reliably while receiving a gamma dose rate of up to 1Sv per hour.

Harsh Canadian weather conditions dictated the need for a robust system and another important factor was safe operation and data transmission during emergency conditions. Seismic requirements were part of the brief, as well as permanent autonomous operation and a reliable redundant communications interface.

Performance was tested over winter 2014/15 when there was heavy snowfall and temperatures dropping to -30°C , as well as a spell of ten days with very low solar insolation. Saphymo's SpectroTRACER has a battery for autonomous operation for up to 10 days and a solar panel with charger designed for continuous operation in worst-case scenarios. The overall system performance was found to be continuously effective. ■

Monitoring after Fukushima

Fuji Electric Co., Ltd. undertook a major upgrade to the environmental monitoring system around Fukushima after the accident in 2011. It installed radiation detectors at over 2500 monitoring posts at schools, kindergartens and public parks in the area.

The enhanced system comprises solid-state radiation detectors, a robust, encrypted communications system with multiple channels and connectivity with other devices in the system, and web-based GUI software to interpret data in real time.

The devices provide continuous operation over 120 hours after a primary power loss in the system, and are capable of withstanding credible external hazards including seismic events, hurricanes, snow, ice, high winds, salt air, varying temperature and relative humidity levels, and heavy rain fall.

Fuji Electric's monitoring network provides continuous operation in various scenarios, including a beyond-design-basis event involving a station blackout, and loss of regional power and communications infrastructure. In remote areas, the system works without AC power.

The enhanced system aims to protect the public and reduce fear, as well as providing reliable information for decision-makers in order to reduce exposure during and after an accident. Information in the new system is consolidated for emergency management purposes, so data can be reviewed quickly and information from the field, labs, weather stations and dose models easily understood. The database and software are housed off-site in a secure centre.

Detector probes can be deployed based on wind direction and speed by dropping them from field team vehicles.



Although evacuees are returning to some remediated areas, cleanup of the highest contamination near Fukushima Daiichi will take a long time and may require new technology. Effective technical communication must be maintained over a long period of time and the tacit knowledge of the multidisciplinary teams involved captured, so modern web-based knowledge management tools are employed. A version of the communication platform (Cleanup Navi) is available in English and information has been summarised in JAEA technical reports and two international workshops (<http://fukushima.jaea.go.jp/initiatives/cat01/index00.html>).

Lessons learned

An important lesson is that basing all planning on past experience is dangerous where large populations and sensitive infrastructure is located in zones at risk from natural catastrophes. Low frequency events should be better covered in disaster response plans.

For regional radioactive contamination, planning can greatly minimise consequences and aid recovery. It should include training response teams, establishing communication channels and material, and setting up

regulatory infrastructure.

A system of civil defence or disaster response already exists in most developed countries and they may only need to develop a wider range of scenarios. Learning from Fukushima, it is important that too much focus is not placed on the cause of the accident, rather effort should be placed on response to the unimaginable occurrence. A good example of this approach is the response to the accident by the Swiss nuclear regulator ENSI.

Communication was one of key issues to be improved in the response to the Fukushima Daiichi meltdowns. Problems were experienced at every level – local, regional, national and international. To be fair, no past accident of this type has been well communicated or has received such extensive media coverage, which continues to the present day. It has to be recognised that, in many cases, fear of radiation causes larger health impacts than radiation itself and so reduction of such fear is an important component of any disaster response plan. Active response is also needed to combat deliberate “fear mongering” by groups with other political agendas.

Although the Japanese government reacted quickly to pass acts for

decontamination, implementation was challenging for cleanup activities and, in particular, the movement, storage and disposal of resultant wastes. For the last, an act passed on November 2014 specified that the disposal site shall be located outside of the Fukushima prefecture. Such an arbitrary decision is clearly driven by social pressure: if the regulatory framework is put in place in advance of an accident, it would not only have facilitated decontamination, but would also have been made on a more logical technical basis.

The Fukushima work demonstrates that large-scale decontamination can be carried out cost-effectively if the value of the land is sufficiently high, although Japanese boundary conditions in terms of the nature of contamination and the technology applied may not be transferable to other sites.

Fukushima work has built an extensive database on the environmental behaviour of caesium, as this is a common contaminant. Although caesium has been extensively studied in the past, the integrated regional assessment, which follows transport from forested mountains to a coastal marine environment is unique and may be useful for other countries with similar geographic and climatic conditions. ■



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