The 'old and the new' of decommissioning Dounreay

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Abstract. The Dounreay site is situated on the north coast of Scotland, mainland United Kingdom, and since the 1950s it has been instrumental in fast breeder research and fuel reprocessing plant development. The work programme on the site has changed, and is now one of safe decommissioning and site restoration. Previous papers have discussed and reviewed progress during the very early stages of the decommissioning programme and this paper provides an update on the work programme from a primarily radiation protection perspective. This paper discusses progress in decommissioning the Dounreay site and the adoption of 'tried and tested', as well as innovative techniques to achieve this decommissioning safely. This includes detailed discussion of the radiation protection aspects of decommissioning, and the consideration and implementation of various radiological protection controls within varying decommissioning environments, such as:

- Remote operations.
- Robotics.
- Shielding.
- Remote readout dosimetry (during personnel entry into elevated dose rate areas).

The change from an operational to a decommissioning work programme at Dounreay, created a requirement to modify the type and variety of radiological personal protective equipment (PPE) available. The selection of appropriate PPE, utilised following exhaustion of the hierarchy of controls, to remove the residual radiological risk to personnel is discussed within the paper. The benefit of developing this PPE, as well as other controls, in collaboration with the operatives performing the work, is clearly obvious. The paper concludes with a review of the relative merits and success of the decommissioning techniques that have been adopted, from a radiological protection perspective, together with a summary of lessons learnt.

KEYWORDS: Dounreay; Decommissioning; Site restoration; Lessons learnt.

1. Introduction

The United Kingdom Atomic Energy Authority (UKAEA) was established on 19th July 1954 and constructed the Dounreay site on a former unused Admiralty airfield and adjacent farmland, starting in March 1955. The site is large and houses a number of complex and unique plants, including fast reactors, a materials test reactor, metallurgical laboratories (housing fume cupboards, glove-boxes and shielded cells), novel fuel reprocessing plants and waste storage facilities. There are many publications about Dounreay and more information is available on the Dounreay Site Restoration Limited's web pages www.dounreay.com.

In November 2001 the UK Government announced its intention to radically change the way that the government-funded nuclear clean-up work was managed on the sites operated by UKAEA and British Nuclear Fuels Limited (BNFL). In July 2002 a policy paper entitled *"Managing the Nuclear Legacy"* [1] was put to Parliament setting out how this would operate in practice. The key elements were:

- A declared intention, through competition, to ensure that best practices from the private and public sectors are used to undertake the clean-up work;
- A commitment to ensure that clean-up was carried out safely, securely, cost-effectively, in a way that protects the environment;
- A commitment to transparent management to command public confidence.

Unlike many other sites, Dounreay was reasonably well positioned, as there was already a single mission in place to close the site. The Dounreay Site Restoration Plan, which was produced in response to the Nuclear Installations Inspectorate/Scottish Environment Protection Agency

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(NII/SEPA) Safety Audit of 1998, and provided a good starting point in terms of defining the site's closure strategy. At that time, it was anticipated that decommissioning would be complete by around 2060.

The UK Government passed the Energy Act in 2004 and in March 2005 the Nuclear Decommissioning Agency (NDA) was established as a non-departmental government body to take forward the national nuclear decommissioning programme. Competition was a key element of the NDA's strategy and it soon became evident that Dounreay was targeted as one of the first, of the twenty NDA sites to be competed. UKAEA was given an initial dowry contract to manage Dounreay for the period until the site was competed and given the target of becoming a stand-alone site by March 2008.

It was evident that if UKAEA were to be a credible bidder in the competition to manage the Dounreay site then its performance on delivering decommissioning projects safely, on time and to cost would need to improve. These changes have had a significant impact on the work programme of the site and in the site's business processes, requiring an evolutionary change in the way that radiation protection service support is provided.

Dounreay Site Restoration Limited (DSRL), is the site licence company operating under contract to the Nuclear Decommissioning Authority (NDA), responsible for the closure programme at Dounreay and is a wholly-owned subsidiary of UKAEA Limited. DSRL has held the site licence, waste disposal authorisation and other necessary legal permits for managing the site since 1st April 2008.

2. What is there to do?

Dounreay occupies a large expanse of land, housing numerous buildings with varying radiological hazard, from none to considerable. Decommissioning Dounreay is clearly a significant task and the following section provides information on how this decommissioning is progressing and the techniques being adopted from a radiological protection perspective. Fig. 1 shows the Dounreay site as it is now and how it will look once it is decommissioned, the current target date is 2024 or earlier.

Figure 1: Present and future of the Dounreay site

A paper published in 2002 [2] provided the status of decommissioning at that stage. Significant decommissioning progress has been made since that date and this paper provides information on a selection of the decommissioning projects.

3. Decommissioning and Site Restoration

To safely remediate the Dounreay Site on behalf of the Nuclear Decommissioning Authority (NDA), DSRL is adopting 'tried and tested' and innovative techniques, implemented through a hybrid approach of remote and hands-on decommissioning at varying stages of each plant's decommissioning programme.

The following text provides an update on progress of a number of the Dounreay plants and how decommissioning is being safely achieved, including the consideration and implementation of various radiological protection controls within varying decommissioning environments, such as:

- Remote operations.
- Robotics.
- Shielding.
- Remote readout dosimetry (during personnel entry into elevated dose rate areas).

3.1 D1200 Laboratories

3.1.1 History

Laboratory 77/78 was used for metallurgical investigative work on irradiated fuel specimens. Shielded glove-boxes were designed and built for tensile measurement work on these specimens.

Laboratory 75 was used for X-ray diffractometry measurement of irradiated fuel specimens, and varying types of high active work, mainly final preparation of samples. Specimens were prepared for density measurement, transmission electron microscopy, electron probe microanalysis and scanning electron microscopy. Materials submitted for this analysis included wrapper material and fuel samples.

The interior of the glove-boxes were contaminated with fission products, actinides and activation products presenting both an internal and external exposure hazard to the decommissioning operators.

The shielded glove-boxes had lead shielding and were mounted on the floor of the laboratory. They were also equipped with ball-and-tong manipulators or Master Slave Manipulators (MSMs) and bagged posting ports, shielded by mobile lead and steel plugs mounted on rails. They were constructed of stainless steel alpha containments surrounded by support frames on which the lead brick and steel plate shielding were mounted. Lead bricks were mounted on the sides of the glove-boxes, while steel plating was mounted on the roof and floor of each glove-box, with additional lead brick shielding provided on the top and bottom of the boxes as necessary. Manipulators were located under/over viewing windows, constructed out of lead glass. Laboratory 75 had steel shielding on the operating face.

3.1.2 Decommissioning

Before the containment was constructed for decommissioning the glove-boxes were cleared of all removable waste and equipment. Following the removal of the waste extensive remote decontamination of the interiors was carried out, this continued until no further improvement could be seen based on direct probe measurement through posting ports and from posted out smear samples. This reduced the glove-boxes dose rates both internally and externally. A comprehensive radiological survey of the glove-box interiors and exteriors was carried out, this included posting out samples for alpha and gamma spectrometric analysis. This information along with the estimated man hours it would take to complete the task was used to estimate a dose budget and an individual dose restraint for effective dose. The dose budget was a collective dose in man-mSv and was used to define the task limit for the Thermo Fisher Scientific EPD system. Dose and dose rate alarms were set, based on the survey data to give the operators warning of unexpected conditions.

A task risk assessment was carried out by the operators, Health Physicist and safety advisers, which identified the controls required to carry out the task ensuring that doses were kept As Low As Reasonably Practicable (ALARP) and within the defined dose budget. These controls were then incorporated into a method statement which detailed how the tasks would be executed.

With the dose rates reduced, the shielding was then removed to expose the glove-box structure (Fig. 2). The criteria for making this decision was simply that further reduction in dose rates could not be achieved without unreasonable effort and cost. All services to the boxes were isolated and stripped back to the external surfaces of the boxes including the ventilation. This left free access all round at floor level and above.

Figure 2: A glove-box with some of its shielding removed

With the shielding removed a modular containment was constructed to fully enclose the glove-boxes (Fig. 3). The containment was fitted with a waste posting port to allow waste packages to be posted out into waste drums. The port was fitted with a posting bag which sat in the drum and allowed the operator to tape off the bag and cut through the taped section which maintained containment (Fig. 4). The containment consisted of three stages, a large well lit work compartment, an undressing compartment and an outer compartment that provided a buffer between the laboratory environment and the undressing area. A physical barrier was positioned between each compartment to demarcate the areas which have an increased level of risk, and provided a seat upon which an operator could sit while removing footwear before proceeding to the next compartment.

The containment interior was painted with strippable coating to aid decontamination and the floor and any exposed surface was covered with non-slip fire retardant PVC (Fig. 5).

Ventilation was provided by a mobile filtration unit (MFU). This maintained an inward air flow velocity across the access boundary of greater than 1 $m.s^{-1}$, thus minimising the risk of back flow caused by eddying in the vicinity of the change barrier which could result in a release of airborne activity. Air monitors were positioned at the entrance and to sample from within the undressing stage to provide operators with a warning of abnormal conditions.

The operators working within the containment wore fully enclosed airline suits with an oversuit to help with contamination control at the undressing stage. The oversuit was removed in the work area before traversing into the undress stage. Cut and puncture resistant gloves were worn to help protect against injury which potentially could result in a contaminated wound, or cut damage to the hands.

Figure 3: Modular Containment around the glove-box

Figure 4: Waste posting port

Figure 5: Glove-box prepared for decommissioning

Size reduction of the glove-boxes involved cold cutting techniques; using reciprocating saws, evolution saws, nibblers, etc. Operational experience had shown that the fines produced from cold cutting equipment were not readily mobile, thus the generation of airborne activity was significantly reduced compared to hot techniques. At all times serious attention was paid to housekeeping within the containment. This was crucial to prevent contamination spreading about the containment floor and walls, and helped to keep contamination on the oversuits to a minimum. This in turn reduced the risk of an intake at the undressing stage.

Despite the fact that initial decontamination and waste removal had been done, there still remained some localised high spots of fixed activity. The operators became more exposed to these spots as size reduction progressed. Wherever possible, temporary shielding was used to reduce operator exposure and alternative cutting points selected so as not to release this activity.

When the size reduction of the glove-boxes was complete the interior of the containment was decontaminated using H Type vacuum cleaners, tacky rags and damp swabs. Following this, the strippable coating and PVC layers were removed, posted out as waste and a thorough radiological survey carried out to demonstrate that the containment was free from detectable radioactive contamination. The containment was then dismantled and the panels stored for further use. The final step was to paint the concrete stands which were to remain in-situ until the building was demolished. The paint keeps the surface sealed, prevents any ingress of unexpected contamination and provides an easy surface to decontaminate.

3.2 The Research Reactor Fuel Reprocessing Plant Medium and High Active Cell Decommissioning

3.2.1 History

The Research Reactor Fuel Reprocessing Plant reprocessed research reactor irradiated fuel to recover unused uranium. The process involved dissolvers in which the fuel was dissolved in acid, then a solvent extraction process recovered the uranium and separated the fission products. This process took place within heavily shielded concrete cells.

Radiation dose rates within the shielded cells during the operational phase were extremely high and are still significantly elevated today, with the gamma dose rate of the order of 100s of $mSv.h^{-1}$.

3.2.2 Decommissioning

Aggressive washouts using hydrofluoric and nitric acid has, to date, reduced the gamma dose rate at the dissolvers to slightly above 100 $mSv.h^{-1}$. This is still very high and it is intended to use remote methods utilising Remote Operated Vehicles (ROVs) to progress the next stage of the work (Fig. 6).

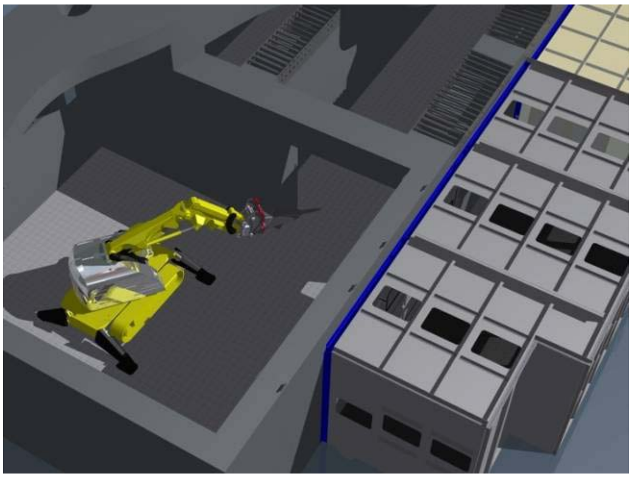
Figure 6: ROV tool commissioning and trials

The ROVs will be deployed from purpose built containment/entry modules constructed against the outer face of the active cell wall and controlled by operators remotely in low dose rate areas. The wall will be core drilled to within approx 80 mm of the inner face and the cores left in place to maintain the shielding capability, as far as possible. When ready the containment will be sealed and the ROVs will break through into the cell from within the containment.

Once in the cell the ROV (Fig. 7), using various tools, will cut/shear the pipework and vessels into suitably sized small pieces to be posted into a waste crate via a waste handling facility which will be installed on the south side of the cell structure. From here the waste will be assayed and dispatched to the on site Low Level Waste (LLW) facility.

Once the medium active cell has been cleared the ROVs will access the high active cells via existing openings between cells. This will give access to the dissolvers and associated transfer vessels. The Intermediate Level Waste (ILW) will be posted out via a roof posting port using a shielded flask and dispatched to the ILW facility.

Figure 7: Diagrammatic depiction of ROV in Medium Active Cell



At this stage, with the majority of the pipework, vessels and dissolvers removed the radiological condition will be reassessed to confirm that conditions are suitable for man entry, to facilitate the final decommissioning work in the cell structure. The ultimate step will be to scabble the concrete surfaces to remove the last of the fixed contamination, this will allow the structure to be left until the building is demolished.

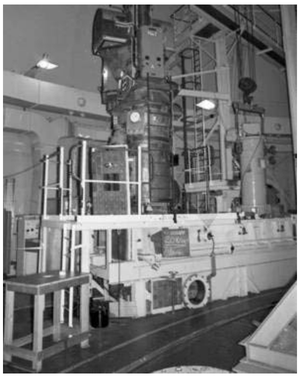
3.3 Decommissioning of the DFR Charge Machines and Canning Station

3.3.1 History

The iconic Dounreay Fast Reactor (DFR) was shut down in 1977. The majority of the reactor fuel was removed for reprocessing until only ‘problem’ breeder elements remained. During normal operations, two charge/discharge machines were used to replace irradiated fuel and breeder elements from the reactor core with unirradiated elements. The charge machines (Fig. 8) were transferred to/from the canning station for exchange of elements. The charge machines had been located on the canning station since 1977, heavily lead shielded and with PVC wrapped round their bases.

As the charge machines could not remove the “problem” breeder elements, enhanced tooling was required and this was covered by the resultant Breeder Fuel Project, which is now at an advanced stage. The canning station footprint space was required for part of the Breeder Fuel Project, so a further project was initiated to decommission and remove the charge machines and canning station from the DFR sphere. This also met a regulatory requirement for early Post Operative Clean Out (POCO) and decommissioning of DFR. This major decommissioning project required careful planning (Hazard and Operability (HAZOP) Studies and risk assessment) with significant radiation protection input at all stages.

Figure 8: Canning Station with Charge Machine when operational



3.3.2 *Decommissioning*

DFR was a liquid metal Sodium-Potassium (NaK) cooled fast breeder reactor with vented metallic fuel. This resulted in the primary NaK becoming contaminated with fission products, dominated by Caesium-137. A major concern was that the charge machines and canning station were likely to be heavily contaminated internally with primary NaK and fission products, with a further likelihood of fuel fragments being present. There was a lack of historic radiological data on the equipment, but several hotspots were identified on the machine surfaces, which were heavily shielded.

The initial, extensive, external radiological survey was followed by removal of external equipment and an internal inspection using an endoscope complete with camera and recording equipment. This inspection revealed a large quantity of NaK oxide covering the majority of the charge machine internals. At this stage, several holes were also cored from the lead shielding to enable radiation measurements at the charge machine surfaces. The information obtained was used to refine the programme of work.

Each charge machine weighed over 25 tons with the majority of the weight associated with the external lead shielding plates. This weight had to be reduced, through removal of lead shielding and peripheral equipment, to enable crane lifts. Health Physics monitoring was carried out throughout this process, as new surfaces were exposed and shielding was removed.

Both charge machines (Fig. 9) were removed to interim storage safely, on time and to cost in July 2005.

Figure 9: Charge Machines on Canning Station ready for removal

The initial scope for the canning station removal project involved removal of a lead shielded top slab (10 tons) and internal components, including a redundant fuel can, the transit flask and trolley (8 tons for both). This was expanded to include removal of the shell itself (4m long by 1.2m wide by 3.6m deep weighing 4 tons) which needed to be cut up for removal through the sphere airlock.

Health Physics monitoring and endoscope surveys revealed higher than expected dose rates, due to the presence of significant levels of NaK oxide and other ‘hot’ items. Undocumented, additional steel-supported lead shielding had also been added to the inside of the canning station and this had to be removed to enable the planned operations to commence.

Dose rates at the trolley top were 200 $mSv.h^{-1}$ for beta and gamma, with 50 $mSv.h^{-1}$ for gamma alone, and similar high dose rate locations at the bottom of the shell. Consequently, strict radiological controls were required to optimise doses and contain loose (and potentially airborne) radioactivity throughout the various project phases. These included:

- Regular review meetings and “toolbox talks” to keep everyone up to date and aware of progress/issues.
- Strategic use of temporary shielding.
- Use of long-reach (remote) tools.
- Reduction of the radiation source at the earliest opportunity. To support this an interceptor unit was developed specifically to remove the NaK oxide. This aluminium/lead shielded interceptor was fitted with a High Efficiency Particulate Air (HEPA) filter to capture the NaK oxide, with a HEPA filtered vacuum cleaner providing the extract and back-up capture of any dust.
- All operations on the canning station were carried out within a filtered ventilation containment to enable normal operations to continue within the DFR sphere.
- Cutting operations were carried out using plasma arc cutting techniques to ensure it was completed as quickly as possible. The procedure was trialled and demonstrated inactively and a second, local extract was provided during the cutting operations to remove any fumes.

The physical dimensions and weight of the various components created unique radiological challenges in conjunction with the manual handling requirements, such as crane lifts and support slinging (Fig. 10).

Figure 10: Canning Station Shell during Crane Lift

Despite a number of challenges encountered during the project, the removal of the canning station was completed in March 2006 safely, on time, to cost and within the predicted dose objectives.

3.4 Dounreay Cementation Plant

3.4.1 History

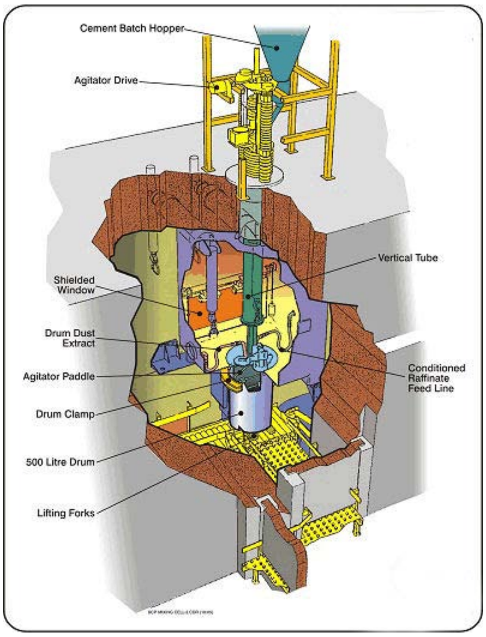
As part of the programme of hazard reduction at Dounreay, the Dounreay Cementation Plant (DCP), which is a modern facility, is responsible for reducing one of the main radiological hazards at the site. It takes liquid waste (raffinate) produced during fuel reprocessing from nearby storage tanks and mixes it with cement inside 500-litre drums to produce a stable block of ILW for long-term storage or disposal. Once the storage tanks are empty, the tanks can be dismantled and their decommissioning completed.

The conversion of the liquid waste to a solid takes place inside each drum on a conveyor belt within a sealed cell of the DCP. An empty drum is moved into position, raised, clamped and its lid removed. The liquid waste is transferred into the drum and a quantity of cement is stirred in. The mix is allowed to cure before a grout cap is added and the drum is ready to be moved into the adjoining storage area. All this takes place remotely, behind shielded cell walls to protect operators from radiation.

3.4.2 Incident

An incident occurred when a drum was not raised and secured into its proper position against the face of the Mixing Cell (shown in Fig. 11), nor was its lid removed. Unfortunately, subsequent operations proceeded on the basis that the drum had been correctly prepared for filling. As a result, 266 litres of conditioned radioactive Material Test Reactor (MTR) raffinate was transferred into the process cell and sumps instead of the drum and 300 kg of dry cement powder was then deposited on top of the drum, with some over-spilling into adjacent areas [2].

Figure 11: Diagram of the DCP Mixing Cell



The cell was designed to safely contain a spillage of radioactivity and consequently none of the radioactivity escaped from the cell and no workers were exposed to radioactive materials.

3.4.3 Shielding and Remote Operations

To enable the remediation of contaminated equipment after the raffinate spill, a shielded containment (Fig. 12) constructed of 100 mm thickness steel was used.

Figure 12: Steel shielded containment used during recovery operations

The mobile shield plug and associated equipment were withdrawn in to the shielded containment. The shielding reduced dose rates in the external area immediately surrounding the containment to 2 to 5 μSv.h^{-1}. The equipment was dismantled and decontaminated using grinders and pneumatic shears that were operated remotely using MSMs. Each grinder was supported using a block and tackle arrangement (Fig. 13 and Fig. 14).

Figure 13: Grinder supported by block and tackle.

Figure 14: Remote grinding operations in shielded containment

Once a section of equipment was dismantled (Fig. 15) it was then lifted using slings in to a drum prior to waste sentencing (Fig.16).

Figure 15: Remote dismantling of contaminated equipment

Figure 16: Slinging of dismantled equipment

In addition to the shielded containment, a temporary steel shield wall (Fig. 17) was used to block the plug aperture. This helped to reduce dose rates that operators were exposed to from the cell during man entry to the shielded containment during the final phase of decontamination.

Figure 17: Operative in shielded containment during recovery operations

During this work remote readout electronic dosimetry, as discussed later in this paper, was utilised and proved highly effective. For example, when an Operator and Health Physics Surveyor worked behind the steel shielding and wore remote readout electronic dosimetry on their chest and on their favoured arm it supported personal dose optimisation as discussed below.

Using the engineered control meant that the Hp(10) dose rates to the body were kept to an average of 70 $\mu Sv.h^{-1}$ compared with the maximum dose rate seen by the fully exposed extremities of 1300 $\mu Sv.h^{-1}$ (1.3 $mSv.h^{-1}$). As doses and dose rates were monitored by a third party, they were able to advise the operator on the optimal body position relative to any shine paths. This was done via a wireless communications system.

Exposure time to the extremities was also kept to a minimum, by the use of mock ups to practise the removal of equipment and the use of remote tooling. In addition, protective gloves were changed regularly to minimise dose to the hands due to loose beta contamination. The Hp(0.07) dose rates to the extremities averaged at 1700 $\mu Sv.h^{-1}$ (1.7 $mSv.h^{-1}$) with a maximum dose rate of 56000 $\mu Sv.h^{-1}$ (56 $mSv.h^{-1}$). Having said this, however, it should not be used in isolation for dose control, but in conjunction with engineered and other managerial controls.

4. Innovation and developing Good Practice

4.1 External dose assessment and control

All personnel working in radiological designated areas at Dounreay wear a passive dosemeter that is used to measure personal dose for an individual’s legal dose record. These dosemeters, however, only provide a retrospective measure of dose received by an individual and give no indication of the instantaneous dose or dose rates that an individual has/is being exposed to. Therefore, personnel entering areas with elevated dose rates wear, in addition to their legal dosimetry, a dosemeter capable of measuring instantaneous dose and dose rates in order to optimise the dose received. Certain electronic dosemeters can measure instantaneous Hp(10) and Hp(0.07) dose and dose rates. When coupled with a transmitter it is possible to remotely monitor an individual’s instantaneous dose and the dose rate that they are being exposed to via a receiver and then a laptop computer, with appropriate software.

Electronic dosemeter and transmitter units tend to be relatively small, light and thus will not adversely affect the operator’s dexterity, except in the most restrictive of environments. The electronic dosemeters can usually also be attached to wrists and ankles, as well as to the chest. This is useful in situations where the extremities could be exposed to elevated local beta dose rates.

The unit used at Dounreay is the Thermo Fisher Scientific Mark 2 Electronic Personal Dosemeter (EPD) (Fig. 18), that can be coupled to a transmitter (Fig. 19) that sends a signal via a receiver to a laptop computer running the Thermo Fisher Scientific ViewPoint software (Fig. 20). The system has been used to great effect in a number of situations, for example, clean up and recovery of a cell and equipment following a raffinate spill within an engineered containment.

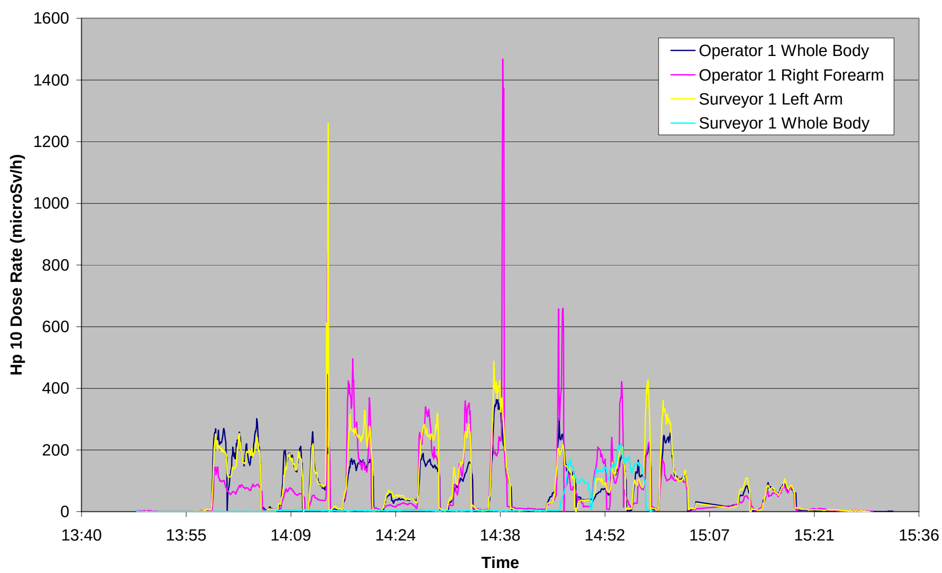
The data generated by the software can be exported in to a spreadsheet package for further manipulation. Fig. 21 shows an example plot of dose rate against time for personnel.

Figure 18: The EPD

Figure 19: EPD and Teleadapter personal transmitter

Figure 20: Teletrak laptop & antenna

Figure 21: Graph of Hp(10) Dose Rate against time for personnel



The benefits of using remote readout dosimetry include:

- Quick and simple to set up and deploy.
- Health Physics Surveyors do not have to physically access an area and therefore restricts dose to the operator.
- As the dosemeter is small and lightweight, it can be easily manoeuvred into areas of interest.
- Real time results relayed to the laptop are easy to read and interpret, rather than trying to remotely read and manipulate a relatively heavy radiation monitor whilst wearing respiratory protection.
- Graphical representation of data points which is easy to interpret and quickly assess gamma and beta dose rates in these areas.
- Elevated dose rate areas, that is ‘spikes’ are highlighted, where efforts could be concentrated prior to man access to reduce the dose rate in these area.
- Dose and dose rate alarms can be set for whole body, skin dose & dose rates providing more effective control of dose constraints and task management.
- Multiple users/operators can be tracked using the system.
- Multiple dosemeters can be worn on different areas of the body i.e. ankles, arms, back ,etc.
- The system can be used within shielded enclosures providing there are sufficient repeaters.

The use of a remote readout dosimetry system sends a positive message to personnel that doses are being continuously reviewed, to support improving our working practices to restrict doses to ALARP.

4.2 Pressurised Suits

Irrespective of the engineered controls and safeguards put in place, there is still the potential to require the use of Personal Protective Equipment (PPE) to ensure that the residual radiological risk is tolerable. In the context of decommissioning significant radiological hazard plants with loose radioactive material, this could well mean the use of Air Fed Suits that supply air remotely through a hose to a person contained within a hermetically sealed body suit.

At Dounreay, this was traditionally supported by a two-piece suit that was sealed at the waist, as shown during decommissioning work in Fig. 22.

Figure 22: A two-piece Air Fed Suit being worn during decommissioning activities

In common with other nuclear sites, it was acknowledged that an operative in an Air Fed Suit was most at risk during the suit removal process and specifically when all forms of Respiratory Protective Equipment (RPE) are absent. The suit also posed the following challenges:

- The tape applied to provide a seal between the top and bottom halves of the suit is not appropriate in a plutonium environment.
- The tape applied around gloves is not appropriate in a plutonium environment, and also inhibits air circulation to hands and leads to profuse sweating.
- The top half of the suit is awkward to remove in tight spaces and caused large disturbance of air in undressing area, that could potentially cause migration of contamination if there had been a break down in control.

To reduce this risk, so far as reasonably practicable, an evolution was proposed that entailed a one piece suit with an internal, initially air fed and subsequently filtered, respirator (Fig. 23). The new Air Fed Suit offers the following advantages:

- 'In built' full face respirator to provide protection on removal of suit.
- Simple one piece design, restricting folds and creases that can trap contamination.
- Semi rigid cuffs allow air circulation to hands.
- Easier to remove, with a large zip across the shoulder area.
- Easier to remove in tight spaces and less disturbance of air on removal.
- This new Air Fed Suit, excluding the internal full face respirator, is of a use once design so that:
    - The risk of error when monitoring the Air Fed Suit for plutonium contamination and the dose consequences for failing to detect the contamination (with potentially significant internal doses) is no longer an issue.
    - The large resource required to monitor, wash and maintain reusable Air Fed Suits is removed.
    - Reduced handling of potentially contaminated items, with the risk of spreading contamination and the associated intakes during the suit monitoring, washing etc. are removed.
- Has user confidence and 'buy in', as they were involved with its development from conception.

Figure 23: The Dounreay single use one piece Air Fed Suit

The single use one piece Air Fed Suit has been very successful in use and Dounreay is currently arranging for a similar suit, incorporating lessons learnt, to become the site's Air Fed Suit for the future. This new suit will be:

- Thinner, but robust, to optimise the waste disposal aspects.
- Be constructed by different manufacturers, to reduce risks with supply.
- Offer the benefits of the current single use one-piece suit.

- Developed with significant user input.

5. Other significant decommissioning and risk reduction

Reference [2] discussed the decommissioning of a former criticality test facility. This plant is now approaching the final stages of decommissioning. Fig. 24 shows the first entry to the cell without respiratory protective equipment for forty years and Fig. 25 shows the final declassification survey that is still ongoing.

Figure 24: Entry to criticality Cell

Figure 25: Final declassification survey

The Material Test Reactor fuel fabrication plant (Fig. 26) had been operational since the mid 1950s, and its decommissioning, and demolition (Fig. 27) was completed recently.

Figure 26: Operations in fuel fabrication plant

Figure 27: Demolition of fuel fabrication plant

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