Nuclear: The Big Clean-up

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SUMMARY

This paper presents a series of observations of the hazards and challenges faced as part of the clean-up of the UK's Nuclear Licensed Sites after decades of electricity production. In some hazardous environments, the dynamic decision making of humans is often preferable to the use of robots, however this does not come without risk. Protective equipment, whilst absolutely necessary to reduce the risks to the operator, can impact their performance when undertaking decommissioning operations. Human Factors and Ergonomics play a critical role in ensuring these tasks are undertaken safely, reliably and efficiently.

KEYWORDS

Nuclear, Decommissioning, Human Performance

Introduction

From 1956 onwards the UK's first nuclear power stations began generating electricity. Now, almost seventy years on, there are seventeen Nuclear Sites in the UK undergoing clean-up to be ready for their next use. Many facilities are now redundant, empty of their previous hustle and bustle to produce electricity for homes and businesses up and down the country, laying dormant in a state of care and maintenance. Current plans indicate it will take more than 150 years to complete the nuclear clean-up and decommissioning of these sites.

Decommissioning in the Nuclear Sector uses an interesting mix of humans and robots to solve difficult problems in degrading environments. As technology progresses with increasing momentum, more solutions to remove the human are proposed. However, it is undeniable that operators with decades of experience are often best placed to work flexibly within these challenging environments, affording the dynamic decision-making that is critical in hazardous areas. By placing human beings in these areas, Human Factors and Ergonomics play a critical role in ensuring these people can work safely and reliably to clean up these facilities and keep the public safe too. This paper presents a series of observations of the hazards faced by people undertaking decommissioning activities on nuclear sites.

The Risks

The main radiological risks of decommissioning nuclear facilities broadly fall into two categories: inhalation and absorption of radiological material. The activities required to clean up a facility, such as size reduction, waste collection and residue recovery, naturally cause material to become airborne, increasing the risk of inhalation. This risk is relevant not only to the operators in the area but also to personnel outside the area and even, in worst cases, to the public should the airborne activity migrate to outside of the facility. Contamination can also be absorbed by the human, through cuts to the skin causing the material to find its way into the bloodstream.

Some buildings were constructed upwards of 50 years ago, so are either coming to the end of, or have already exceeded, their design lifespan. This has a significant impact on the known and

unknown risks of decommissioning, introducing new conventional hazards in addition to the radiological nature of the contents.

The Clean up

Depending on what each facility was originally tasked with producing, the now redundant areas could contain all manner of hazardous items that will require clean-up. For example, gloveboxes were used for a range of operations including the sampling of liquors and the handling of hazardous substances behind lead shielded glass. Now out of service, they contain redundant equipment such as pipework, filters, tooling, and sampling equipment. Over time, the material passing through the gloveboxes has meant that residues have built up in the forms of dusts or small pieces of material, all of which require recovery. This material can be collected using items as familiar and standard as a dust pan and brush, or hand held domestic hoovers (modified for use in nuclear conditions). The contents is then tipped into containers designed specifically to protect against the risks of a criticality for onward long term storage.

Larger items such as filters and pipework require removal to enable decommissioning to progress. Filters that have captured the hazardous particulate from within the area (meaning the air coming out the other side is clean) must be taken out and disposed of as waste. Pipework that was used to transfer liquors from one facility to another may have collected debris in the lines; it is often difficult to know for sure what is inside before being broken open, ready to be cut up and disposed of as waste. Cold cutting techniques are often employed to minimise the generation of heat and sparks which could lead to a potential nuclear fire. Platforms and scaffolding are erected to enable access to higher areas, however when these are used in highly contaminated areas this runs the risk of creating more waste if this equipment cannot be decontaminated to a suitable level for disposal.

Before areas are entered, as much understanding of the risk is developed as possible; specialists perform surveys of the area and any available records of inventory or material are reviewed to build up a picture of the hazards involved. Records could indicate the type of material within the area whilst surveys can inform the levels of radiological dose being encountered in different places.

The Operator

Upon gaining entry to these areas for manual clean-up, operators will perform as much decontamination as possible to reduce the risks identified above. This includes wiping down areas with Rad Wipes, disposal or grouping of larger items of waste and the collection of residues such as dusts and smaller items. Collection of residues can be via means as simple as a dustpan and brush, or specially modified hand-held hoovers. These tasks are often repeatable and quickly become familiar for teams of operators; whilst this is beneficial in terms of skill, it also runs the risk of developing complacency. This places additional emphasis on the importance of training to ensure operators remain cognisant of the hazards they could encounter during decommissioning. Human Factors perform reviews of the training process and material on each task to ensure it accurately reflects the requirements being placed on the operator.

Larger items will require, where possible, size reduction to maximise efficient waste storage for the future. This means cutting sections of pipework from the ceiling or cutting into the frames of gloveboxes and furnaces to fit them into waste drums. The use of tools that produce sparks is often prohibited, to minimise ignition sources and damage to Personal Protective Equipment (PPE) and therefore size reduction is often undertaken manually, leading to physically demanding work. Human Factors provides support to these tasks by undertaking manual handling assessments, reviews of workspace layouts and the application of anthropometric data. This is particularly important for overhead work to minimise the risk of operator injury and strain, and also to ensure there is sufficient space for the operators to work from height.

To protect operators against the hazard of inhalation, either respirators or air fed suits are usually worn depending on the level of contamination in the area. Whilst affording very robust levels of protection, this PPE has a significant impact on the operators. It takes one operator approximately thirty minutes to be dressed in an air fed suit by a qualified dresser. The process involves wearing a protective clothing layer underneath the suit which is fed with air via a long airline and sealed with duct tape, to keep the air in and the contamination out. To minimise the spread of contamination, operators often wear at least three layers of marigold gloves. To reduce the risk of damage to the suit, a lead apron is often worn over the top and to reduce the risk of wounds, cut resistant gauntlets are the final gloves put on. All of this equipment is heavy, adding approximately three stone on to the operator. The air blown into the suit is warm, often upwards of 20°C. Operators then perform the manual tasks described, which can understandably leave them vulnerable to performance shaping factors such as fatigue and heat stress. Human Factors analysis of these tasks is essential, to combine the task, equipment and environment factors to produce an accurate understanding of the risks presented. To support this, Task Analysis techniques are applied to enable consideration of the types of tasks being undertaken, the time taken to complete these and the persons involved. This enables Human Factors assessment and recommendations to be made to provide the operators with the best working environment and job design.

Human Factors environmental assessments can be undertaken to provide due consideration of factors such as lighting, noise and temperature all of which have the potential to significantly impact operator reliability during task completion. Where necessary, Human Factors recommendations are raised on projects such as the introduction of task lighting to improve visibility, or the management of task duration to minimise the risk of heat stress and fatigue to operators. Consideration of noise levels is also important where communication during tasks is required; the use of noisy cutting tools or the requirement to wear PPE such as ear defenders can impede communication between operators. In these scenarios, recommendations can be raised to introduce the use of radio equipment or development of hand signals which operators are trained in.

Conclusion

Nuclear decommissioning is a hazardous, but necessary undertaking. Facilities must be emptied and cleaned to sufficient levels in a timely manner given the rapidly degrading buildings which are coming to the end of their designed lifespan. The use of humans in these areas is beneficial for efficient clean-up, but the risks are significant. The balance of protection and efficiency is critical, requiring consideration of human performance factors that can be both positively and negatively impacted. Human Factors plays an essential role in the clean-up of our Nuclear Sites in the UK, to protect both the operators in the environments and the public outside.