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COMMENTARY

Lecture notes: Lessons in safety from nuclear power

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Abstract

The implementation of a company-wide performance improvement programme by EDF Energy, which invested in both plant and people, is described. The presentation focuses primarily on the implementation of a systematic approach to training and the use of simulation, which has been a key contributor to improvements across industrial safety, environmental safety, and nuclear safety and improved plant operation.

Keywords: *Systematic approach to training; safety; radioactive; shut down; training standards accreditation board; simulator*

Introduction

EDF Energy is a core part of the EDF Group and is one of the largest energy companies in Europe with key business operations in France, the United Kingdom, Germany and Italy. In the United Kingdom, we have approximately 15,000 employees. We are the United Kingdom's leading generator and supplier of low carbon energy. We produce about one-fifth of the nation's electricity from our nuclear, coal and gas power stations, wind farms, and combined heat and power plants. We have a focus on safe, dependable energy generation and an ethos of service excellence.

EDF Energy's Generation business operates eight nuclear power stations in the United Kingdom with a combined capacity of almost 9000 MW providing around a sixth of the United Kingdom's electricity needs – electricity that is vital to the UK economy. Safety is our number one priority, and we pride ourselves in operating our fleet safely and reliably. In a typical year, our power stations avoid the emission of over 30 million tonnes of CO_2. That is the equivalent of removing over half of the passenger cars from the UK's roads.

A strong safety culture

To be a nuclear professional requires a culture within the company where every individual's critical role in the safe generation of nuclear power is clearly understood and visibly regarded as the overriding priority.

The International Atomic Energy Association (IAEA) defines safety culture as: That assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance.[1]

Every day we take every opportunity to reinforce our culture of safety being our overriding priority by starting every meeting or pre-job brief during a working day with a safety message. This message can be one from the theme of the week (such as training), or it can be one specific to the topic about to be covered. It provides an opportunity for each team member to reflect on the meaning behind the message, share operational or personal experience and to reinforce our behaviours and beliefs.

Special characteristics of nuclear power generation

(1) The amount of energy stored in the core. The power locked up in one of our reactors is in theory capable of powering all of the electrical needs of the United Kingdom for 4 weeks. Reactor power is measured in MW thermal; advanced gas reactors (AGRs) are approximately 1500–1600 MW thermal. The generator

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power is approximately 660 MW of power; this is the equivalent of 1,000,000 horse power. The average power of a car is 100 horse power, so we have the power of 10,000 cars at the generator!

(2) By products are radioactive. In an AGR, CO_2 is going around the reactor at 40 bar pressure (580 psi), travelling at 100 mph and reaches a temperature of 640°C. The boilers are running at 160 bar pressure and producing steam at 500°C. It is a hot and violent atmosphere. The contents of a nuclear reactor are highly radioactive and if released in an uncontrolled manner, highly dangerous. It is worth considering what can happen if we get it wrong. Chernobyl, one of the worst nuclear accidents, occurred in 1986. The radiation and contamination from Chernobyl spread across the Ukraine, Scandinavia, into the United Kingdom and beyond. Alarms in our nuclear power plants went off as the radioactive cloud travelled across the world. Only recently (October 2011) have all the farms affected in the United Kingdom been allowed unrestricted selling of sheep.

(3) Produces heat even after the reactor is shut down. Fuel stays in a reactor for years and you cannot just turn it off like a coal-fired plant. It generates heat after shut down for a long period. Twenty-four hours after shutdown, a reactor is producing heat at approximately 1% of its full on load capacity: enough heat to melt the fuel in the core if it is not removed by the post trip cooling systems.

Performance improvement programme

During the 1990s, significant changes took place in the electricity market and in this period, Nuclear Electric, as it was then, was privatized. To enable it to compete in this new world the privatized company had to reduce its cost base to be competitive in the market. Investment in people and recruitment of new staff was reduced in an effort to match the prevailing adverse market conditions and the reducing wholesale price for electricity. This led to near financial collapse in 2003.

At this time, our key company indicators were also adversely trending and we were seeing a significant number of human performance errors leading to plant problems and unavailability.

In response to this, the company took action and instigated a performance improvement programme focused on three areas:

- A significant plant investment programme with an increase of ~£500 million to improve equipment reliability over a 5-year period
- A new nuclear leadership development programme to improve leadership across the company
- Rebuilding of the skills and training programmes to improve the capability of our staff through:
- Engaging the line management. Historically, training was seen as owned by the training department. This part of the programme required a culture change, where the line identified their problems that required training solutions and the training department worked with the line to develop the solutions.
- Implementing the systematic approach to training (SAT). The programme reviewed the approaches to staff capability development around the world and noted that the American nuclear plants had seen significant improvements in their plant performance. Within these plants, a similar improvement programme had taken place which utilized a SAT-based approach. It was decided to adopt this operational model as best practice. SAT itself was not invented by the nuclear industry and is utilized across many other organizations.[2]
- Establishing the infrastructure to manage the training programmes. The SAT model operates around a 3-tier committee structure that determines the training content of each training programme, ensuring that the right training is delivered to the right people at the right time. The Station Director chairs the level 1 committee focused on strategic direction of the training programmes. The training programme owner (maintenance manager, operations manager or engineering manager) chairs the level 2 committee and is focused on ensuring that the elements of their programme meet the requirements of the level 1 committee. The level 3 committee is chaired by a first-line leader and the committee attendees are from the line. This committee identifies performance gaps and ensures staff remain qualified through developing training solutions.
- Enhancing training facilities. Significant investment in new training academies at each site with increased numbers of training instructors and support staff.
- Enhancing simulator performance (mainly fidelity) and developing new simulators.
- Implementing new technical training programmes for all operations, maintenance and engineering staff.
- Implementing an independent training programme evaluation. In order to ensure that each site is meeting the relevant standards and utilizing training to improve performance, an independent training standards

accreditation board (TSAB) and evaluation process was put in place. The TSAB seeks to establish three things: that the training programmes are soundly based; confidence that people coming out of training are well trained and qualified to do their jobs; evidence that the site is continuously seeking to add value through training.

Use of simulators in the UK nuclear industry

It has long been recognized that a blended approach to training delivery (classroom, workshop and simulation) improves staff skills and knowledge retention and in addition simulation allows the development and assessment of desired behaviours in a safe environment.

Within the nuclear industry, training on simulators is not new. The Central Electricity Generating Board commissioned its first simulator at Berkeley Power Station in 1959 and it is now a legal requirement in the nuclear power industry.

The last nuclear power plant to be constructed in the United Kingdom was Sizewell B. A condition of consent to build Sizewell B was that 'The licensee shall make available a suitable simulator for the purposes of training control room operators and that this shall be in use for such training not less than 12 months before nuclear fuel is loaded into the reactor.' For Sizewell B, the Full Scope Replica Simulator in the control room had to be in use by November 1992.

Simulation is also used routinely, in addition to operator training, in a variety of ways as follows:

- To validate procedures. The Full Scope Replica Simulator can be used to validate the initial Station Operating Instructions in terms of content, structure and effectiveness.
- To validate modifications. Prior to implementation, plant changes can be tested on the simulator.
- To develop soft skills. Replica simulators allow soft or non-technical skill development such as training that allows shift teams to practise different team-working styles.
- To put potential job candidates in a simulated environment allowing observation of their approach to real-life situations.
- To test the assertiveness of junior team members or command and control skills in emergency exercises.

Simulators come in many different forms from simple to highly complex. Each has its specific use to enhance the skills and technical competence of the individual. All are used to develop and assess behavioural competence.

Basic principles simulators

In initial training, there is a limit to the information that can be presented and easily digested by new or inexperience staff. Complex full scope simulators offer a wealth of information but this can overwhelm students who are at the fundamental stage of their development. There is therefore a requirement for some form of intermediate simulator that:

- Is capable of presenting a working power plant with dynamic responses to transients.
- Provides students with an understanding of how the plant interacts.
- Allows students to visualize the big picture.

At the early stages of development, students need to concentrate on important aspects of the learning with the ability to convert theory in the classroom to practice on the simulator without distractions provided by the volume of equipment modelled on a full scope simulator. This requirement is fulfilled by the basic principles simulators which provide:

- Sufficient simulation to cover coherent operations in real time.
- A simple environment with reduced quantity of alarms and controls, which can detract from the objective.
- Information on specially designed tutor formats to support learning.
- An interface that requires minimum of instruction before training can begin.
- Engagement that optimizes the learning experience

Full scope station simulators

Modern nuclear power plant full scope simulators provide an environment as near identical to a real control room as possible. All aspects of the control room are replicated. This allows the reactor desk operator and supervisor to become fully immersed in training exercises and consequently allows quality assessments of their technical and behavioural competences to be achieved.

Simulators such as this provide an environment to train reactor operators in real time with the highest degree of realism. The panels, displays, etc. are made exactly as the real control room. However, all the instruments and dials are driven by computer models.

Simulators play a crucial role for operations engineers to establish correct people behaviours at the outset, providing an opportunity to practise, using the operating procedures, normal, fault, and emergency conditions.

Using simulators, it takes typically 2 years to train someone with appropriate technical qualifications to control and supervise operations on modern nuclear power stations.

All operations engineers receive the following initial training on a full scope simulator replicating the operation of their plant:

- Perform shutdown and restart of reactor and turbines (repeated with different extent of human performance tool usage).
- Demonstrate multiple aspects of classroom teaching on plant systems.
- Perform routine plant changeovers.
- Assessments done individually on the simulator, which would be frozen mid-way through a fault, and student asked to deduce situation from indications.
- Simulator abnormal operations. All minor faults in the Fault schedule are addressed.
- Simulator and classroom analysis of major accidents.

Emergency exercises

Simulators are used during emergency exercises to allow control room operators to demonstrate competency in dealing with mock site incidents and nuclear emergencies. Simulated environments allow plant technicians and maintenance staff to practise personnel rescue and repairs to the actual plant. Fire remains the most likely cause of an incident on one of our nuclear sites. So for training purposes, the site fire monitoring system is simulated allowing practice in dealing with alarms.

Conclusion

The use of simulation in all stages of the initial development of suitably qualified staff to embed theory and develop practical hands-on experience is a significant contributor to the improvements demonstrated in all areas of operations, maintenance and engineering. The positive trend shown in our key performance indicators for safety (industrial, environmental and nuclear) and operations demonstrates the success of the improvement programme.

Conflict of interest

No conflict of interest has been declared.

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