



Human Performance in the Nuclear Industry

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Abstract: Management of employees human performance in the Nuclear Industry is endemic to their safety when working. In the United Kingdom it has been a key focus since 2003. Employees were made aware through a detailed program of workshops, of the error prevention methods and how to apply them. The use of effective incident barriers became embedded in the safety culture. The methodology implemented was personal ownership, to enable self assessment of behaviors, attitudes and beliefs. When put in place, there are many specific barriers, which can reduce the chances of an error occurring. They come under the headings of organisational, procedural and physical barriers. All of these were used in some way and continue to be reinforced on a daily basis. Specific barriers are applied in specific situations. However, some general ones are also effective. In common use are the Take 2 or Take 5 Minutes, point of work risk assessments. Applying the human performance barrier Independent Verification (I.V.) would result in 'Take 3 and I.V.' This would independently double check the risk assessment. New ways of thinking are required to continuously improve and evolve. Results of the error reduction process included; reduced workload, increased plant reliability, efficiencies and productivity.

Keywords: *Error, Human, Performance, Work, Prevention, Nuclear, Barriers, Safety, Process, Behaviour.*

I. INTRODUCTION

This paper describes the history of human performance error prevention, as used in the nuclear industry. How error prevention tools are used and how we could improve on the ways in which they are employed on a daily basis. In the 13 years of use at nuclear facilities, it is suggested the error prevention tools have the error prevention tools applied to themselves and review their application to promote continuous improvement.

'Complacency' is recognised as one of the error enablers. Being comfortable with the way in which the human performance error prevention methodologies are used, is itself an error precursor. If we think we have got it right

and don't need to change or improve, then we are not applying the tools correctly.

The 'Norms' is another recognised error enabler, "it's always been done like that," is a reply when asked why a particular action lead to an event of some kind. If we fall into the same trap and don't review how we employ the prevention methodologies, we again are not applying the tools correctly.

II. HISTORY OF HUMAN PERFORMANCE IN THE NUCLEAR INDUSTRY

The nuclear event on April 26th 1986 at the Chernobyl-4 plant in the then Soviet Union, led to changes in the approach to process safety in nuclear plants the world over. The World Association of Nuclear

Operators (WANO) was formed on 15th May 1989, under a banner of international cooperation. Through open exchange of operating experience, all members could then work together to achieve the highest possible standards of nuclear safety.

The Institute of Nuclear Power Operations (INPO), founded in December 1979, established a Special Review Committee on Human Performance in late 1993. This committee, along with several working groups, was asked to identify actions to bring about continued improvement in human performance within the commercial nuclear power industry [1]. It was this document, which was adopted and reviewed by WANO to form the basis, in 2002, for improving human performance [2].

III. HUMAN PERFORMANCE IMPROVEMENT

There is now good evidence through human performance improvement to demonstrate the benefits to safety, production and output.

In the UK over a 2-year period, the performance of key performance indicators (KPI's) were ahead of WANO "Best in Class" targets for 2004/05. This was attributed to the business improvements at that time. Implementing and reinforcing the Human Performance error prevention process had a bearing on these results, Non-outage defects backlog reduced by 55%, Accident frequency rate reduced by 40%, Unplanned automatic trip rate reduced by 30%, Work schedule adherence was 28% better [3]

Human error contributes to around 80% of nuclear events in the industry, the remaining 20% attributable to equipment / plant failures. This not only has a bearing on the performance of the facilities themselves, but the overall public perception of the nuclear industry. Of the identified human errors, 30% of the mistakes

were down to the individuals and 70% due to the organisations failing to prevent the errors. This is shown in Fig. 1. [4]



Fig. 1. Contribution of human error to the occurrence of events. [4]

IV. WHY CONCENTRATE ON HUMAN PERFORMANCE?

Human beings are fallible, they make mistakes, and even with the best intentions something can invariably go wrong.

"People know the right thing to do for any situation in three ways." First, instinct triggers automatic responses. This is a fixed reaction 'hard wired' in the human mind that elicits a special response, such as the dilation of the eyes as one walks into bright sunlight. No learning is required. Second, a suitable response is determined by learning either by education, by trial and error, or from others' experiences. Examples include reading a book on finances, learning to ride a bicycle, reading operating experience reports, or learning the expectations of a new employer or work group. Finally, thinking is a process of building idea upon idea to make sense of a situation. Thinking gathers data to generate cues that may help a person recognize a familiar pattern about what to do. Thinking generates new ideas coupled with new knowledge leads to better understanding [5].

The skills, knowledge and attitudes of individuals take time to change. It is for this reason that effective barriers must be put in place. Managers implement and strengthen

defenses, they reinforce error-prevention techniques and maintain the standards and expectations for staff.

All WANO member nuclear plants must aspire to the following human performance objective;

"The behaviors of all personnel result in safe and reliable station operation. Behaviors that contribute to excellence in human performance are reinforced to continuously strive for event-free station operations" [2].

The criteria contained within this performance objective are assessed during peer reviews and its effectiveness reported. There are two Nuclear Plant Event (NPE) definitions associated with human performance.

- NPE08, "Human error which degraded nuclear safety related systems"
- NPE09, "Human error which could have degraded nuclear safety related systems"

If you look at the timeframe of when human performance error prevention was introduced and concentrate on the years 1992 to 2006, it is interesting to see the reduction in events at U.S. nuclear plants. This is shown in Fig. 2. [6]

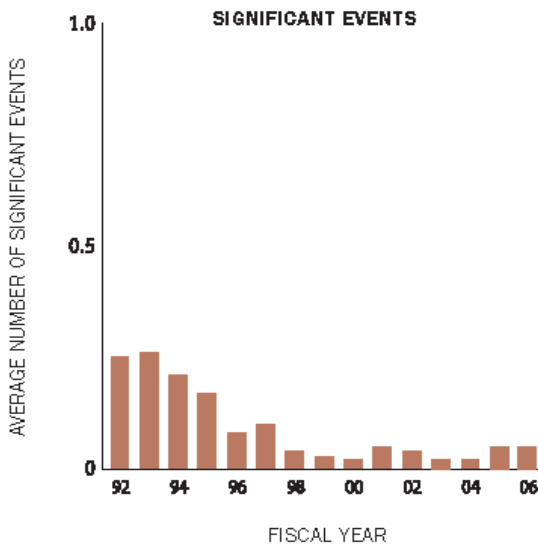


Fig. 2. Significant Events at U.S. Nuclear Plants: Annual Industry Average, Fiscal Year 1992-2006 [6]

Significant Events are events that meet specific NRC criteria, including degradation of safety equipment, a reactor scram with complications, an unexpected response to a transient, or degradation of a fuel or pressure boundary. Significant events are identified by NRC staff through detailed screening and evaluation of operating experience.

V. ERROR PREVENTION TECHNIQUES & BARRIERS

In order to understand which error prevention techniques are most applicable, one must first understand what enablers can contribute to errors.

12 main error enablers were identified and focused on as shown in Table I [7].

Table I. The Error Enablers

Time Pressure	Distractions/Interruptions
Fatigue/High workload	Inexperience/Lack of knowledge
Complacency	Poor communication
Stress	Lack of assertiveness
Resource planning	Lack of Teamwork
Lack of awareness	Norms

Plant trip risk procedures were assessed and each error enabler considered for the current task. Suitable barriers were then applied and reviewed in action.

Barriers

There are many barriers to prevent things from going wrong, they can be Organisational, Procedural and Physical. The most important aspect is all barriers set by management are reinforced at every opportunity. It would be their expectation for staff to adhere to procedural usage, encouraged to have a questioning attitude and to stop when they are unsure.

Organisational

The organisational barriers are the ones embedded within the company's systems. This makes it less likely that a plant modification occurs without drawing changes being in place coupled with operational and maintenance procedures. There are many interconnected systems that will not allow the next step to take place until it is satisfied all the key elements to a successful outcome are met. This cascades down to the competency levels of the person writing the work order instruction.

The organisational barriers can contain latent errors. These are hidden deficiencies in the process or values that provoke an error or cause the defense to break down. The organisation also influences the culture at its locations through the reinforcement of its standards and expectations. People are encouraged to work in a blame free culture but not to the extent where they are unaccountable for their actions. One of the main organisational barriers which sets the benchmark for all expectations is training. Shortfalls in training or a lack of training reduces the effectiveness of the understanding of what is required.

Procedural

There are many procedural barriers in common use across industry. They hold the individual responsible for their use. The following typical work task and barriers used will highlight possible areas for concern.

A work task can be broken down into 3 areas; Pre-work, Work and Post work.

Pre-work – The barrier used at this point is the Pre-Job Briefing. Pre-work discussions are carried out when there is potential to impact on safety. Everyone associated with the work is involved. The roles and responsibilities are defined. The critical tasks and each step identified. The work instructions and procedures are verified and common

understanding checked. This barrier use may be mandatory depending on the task.

Using prior knowledge, operational or maintenance can be utilised at this point. It demonstrates we are prepared to learn from past experience and use it effectively. Prior knowledge can be in database format or personal experience. Whatever method is used, it should capture previous incidents and near misses.

Stop, Think, Act, Review (S.T.A.R.) or Take 2 / 5 minutes to assess the work area are part of the self checking barrier. This can be formalised by filling in a check sheet to demonstrate its use. Confirmed communications is essential use at this point, to ensure the correct plant item is worked on.

It is evident the individual plays a major part in effectively utilising the barriers. If they have not taken personal ownership of the process and endeavor to use it, there is scope for errors occurring. When people work around these barriers there is scope for error.

Work – The barriers used at this point can contain mandatory actions, depending on the work instruction. Mandatory actions typically occur during the verification practices such as Peer Checking, Independent Verification or Concurrent / Simultaneous Verification. Confirmed communications is also crucial during the work to exchange the right information at the right time. Place keeping is another specific barrier employed during critical tasks to ensure the correct action is made at the right step. Task Observations are carried when work is taking place. This is an opportunity to carry out a formal or informal review of the complete scope of works. It is a business improvement tool, used to capture the safety culture surrounding the task. A formal study of the work process also checks the standards & expectations are being met.

Post work – This is an area where a Post-Job Review takes place to determine if there are any areas for improvement or worthy of note for the next time. Using this barrier enhances the operating / maintenance experience data gathering and can lead to further training, where appropriate. It is also a documented opportunity to facilitate continuous improvement processes.

Physical

Physical barriers are the ones which prevent entry to areas that require specific access permissions. The permit for work system is the procedural aspect that controls this type of barrier. Boundary enclosures and containment buildings fall into this category also.

All of the barriers discussed were utilised in specific ways in the British Energy, Human Performance Awareness Workshops. Similar barriers are used in WANO member nuclear power facilities, they are shown in Table II. [7].

Table II. Error Prevention Tools

Pre-Job Briefing	Use of Operating Experience
Procedural Use and Adherence	Self checking (S.T.A.R.)
Questioning Attitude (Stop When Unsure)	Peer-Checking
Independent Verification	Clear Communication Techniques
Post-Job Brief	Task Observation

VI. ERROR PREVENTION THE NEXT STEP

It is well recognised that human performance error prevention hinges on the behaviour of individuals. It is this behaviour which drives them to implement the error prevention tools or choose not to utilise them. Self ownership of the processes and

methodologies employed to prevent error are essential. Observing these behaviors can take place at the point of work or checked remotely through documented evidence of the barrier being used.

If we look at the point of work risk assessment Take 2, which encourages the person to take two minutes and review the potentials for error, the documented evidence can take the form of a tick sheet. This barrier is open to any one of the error precursors stopping it from taking place, such as time pressure, complacency or high workload. If no one double checks it took place, it could lead to an event. Adding in an error prevention tool such as Independent Verification (I.V.), would make this process more robust. It would only lengthen the risk assessment time slightly and possibly take three minutes with independent verification taking place or Take 3 and I.V. Although this could depend upon the working party numbers, it could be planned into the work pack. This is an example of behaviour being observed and an additional barrier put in place.

Since people choose their behaviour at any given time, it is perhaps worth using the questioning attitude barrier but applying it to oneself prior to engagement with the task. A prompt to make the person think how their behaviour will affect the task. A very simple example is will I rush this job if I start it 30 minutes from meal time or end of shift? If a behaviour check is covered before a critical task, it may lead to the understanding that they could be distracted due to a personal issue playing on their mind. Carrying out a formal self behaviour check is another way to enhance the error prevention process.

In the age of personal data devices and WiFi interconnectivity, there is now scope for central databases with operating experience and error prevention tools to be available at the point of work, hazardous areas obviously excluded.

VII. CONCLUSION

Management commitment to focus on human performance, in particular error prevention and effective incident barriers, were the catalysts to improvements in this area. Through external peer reviews and benchmarking current best practices, the UK nuclear industry took a collaborative approach to bring their power stations up to the expected standards. They continue to maintain those standards and strive to exceed expectations.

There are select businesses which invest directly in their staff by focusing on their innate human ability to make mistakes and how to take steps to prevent them from occurring.

Within a rational, unified, goal-seeking organisation, business improvement must have an understanding of human performance. It is this understanding that can lead to improved business operations. Trending of human performance errors should form part of the key performance indicators (KPI's). This data can be derived from a robust root cause analysis process, which is performed by suitable qualified experienced persons.

Refreshing and repackaging the use of the error prevention tools, is essential for the success of the process and also facilitates continuous improvement. Readdressing how the barriers are used in particular situations can contribute to the As Low As Reasonably Practicable (ALARP), process.

A formal behaviour self check, will make people think of additional barriers to use dependent upon how they may feel on the day. Only they truly know what is going on in their own mind.

To avoid complacency with the known error prevention tools in use, revisiting all methodologies used and looking for ways to improve are advised. Reviewing when things go

right as well as wrong should also be trended to capture good practices for replication.

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