

An Introduction of Behavior-Based Safety Program in Nuclear Power Plants

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1. Introduction

There are many methods and approaches for a human error assessment that is valuable for investigating the causes of undesirable events and counter-plans to prevent their recurrence in the nuclear power plants (NPPs). There is behavior-based safety refers to the process of using a proactive approach to safety and health management. It either focuses on risk of behaviors that can lead to an injury, or on safe behaviors that can contribute to injury prevention. Early applications of behavior based safety included the construction and manufacturing industries, but today behavior based safety is applied to a wide variety of industries and service lines. This behavior based safety program can offer a set of significant human error countermeasures to be considered for human error in NPPs as well as other fields of industry.

The current methods for the human error prevention in NPPs are several techniques such as Self-Check, Peer Check, Concurrent Verification, 3-way Communication, etc. However, it is not enough to grasp the whole human error problems in operations because the things are needed in fields are a behavior technique not a simple knowledge. Therefore, we applied a behavior based safety program on the current methods.

2. The Current Human Error Prevention Methods

Human performance and error prevention tools used by personnel to promote safe are Checks, Self-Check (STAR, Stop, Thick, Act, Review), Outside of procedures, Peer Check, First Check, 3-Way Communications, Flagging/Robust Operational Barriers, etc as shown in table 1. The basic purpose of these human performance tools is to help the individual worker maintain positive control of a work situation. A conscientious worker understands the significance of the action and its intended result. Every human performance tools slow things down to ultimately speed things up by avoiding delays that accompany events triggered by active errors. When used thoughtfully and rigorously, human performance tools give the individual more time to think about the task at hand. A primary goal of the worker is to retain positive control at critical steps when error-free performance is essential for safety, not the proper use of a human performance tool. However, these current tools practically are not satisfied in side of technique's utilization and human error prevention effectiveness because these tools focus on knowledge education about the human error prevention skill. Therefore the tools need to improve

though the integration with behavior based safety program for better application.

Table 1 Human error prevention tools

Type	Prevention Tool	Contents
Check technique	SC: Self-Check	STAR(Stop-Think-Act-Review), shall be used for component identification and equipment manipulations
	PC: Peer-Check	A series of actions by two individuals working together at the same time and place, before and during a specific action, to prevent an error by the performer
	CV: Concurrent-Verification.	A series of actions by two individuals working together at the same time and place to separately confirm the condition of a component before, during, and after an action, when the consequences of an incorrect action would lead to immediate and possibly irreversible harm to the plant or personnel
	IV: Independent-Verification.	A series of actions by two individuals working independently to confirm the condition of a component after the original act that placed it in that condition
	FC: First Check	Prior to the performance of the first manipulation of in-field evolutions, as determined by the Pre-Job Brief, excluding Operator rounds, verify the proper step intended to be performed, proper unit, proper train, and component using self-check techniques
Performing Task	PJB: Pre-Job Brief.	A pre-job briefing is a meeting of workers and supervisors conducted before performing a job to discuss the tasks involved, hazards, and related safety precautions
Interception Technique	Oper. Barrier	It is intended to provide an additional barrier so that when an individual is met with a distraction, they return to the right component prior to continuing work
	Tagging	If a component is physically near other similar-looking components and is handled multiple times, flagging helps the user consistently touch the correct component
Basic Principle	Procedures Conformity	All tasks must be performed thoroughly by the document typed procedures
	3Way-Communication	Communication of changes to physical plant equipment during work activities via face-to-face, telephone, or radio requires three verbal exchanges between a sender and a receiver to promote a reliable transfer of information and understanding
	Oops	Rule-based errors can be prevented by properly using written procedures. Oops is a strong method that can be used effectively to prevent knowledge-based errors

3. The Proposed Behavior Based Safety Program

Behavioral safety is the use of behavioral psychology to promote safety, and typically involves creating a systematic, ongoing process that defines critical behaviors reducing the risk of work-related injury. Also, it involves ensuring feedback and reinforcement to encourage and support selected critical safety practices. Traditional safety programs measure incidents, accidents and other lagging indicators to calculate success, but those statistics do not indicate that workers are actually working safely. A behavior based safety program must be integrated appropriately with the existing human error prevention program to develop a successful world-class behavior safety program.

Based on the evaluation of the existing method, learning objectives are necessary to bring the program to successfully incorporate elements of the suggesting program with behavior based safety. The learning objectives build upon the existing strong safety culture and management support, and seek to better integrate employee participation into the program. The preceding

methods are composed of 15 techniques as shown in table 2. We considered 6 techniques among these techniques because the rest of techniques are a kind of attitude rather than a technique. The risk prediction training, point & confirmation technique are the excellent method to enhance worker's risk prediction ability. In case of point & confirmation technique, a probability of human error decreases by 70% if point & confirmation technique is used according to a Japan research result.

Table 2 An investigation of behavior based safety program improvement

type	Prevention tool	Review	Improvements
Basic Human Error Prevention Tools	Circumstance Perception	A Principle than a preventive technique	
	First Task Review		
	First Check		Consideration of Behavior based Safety
	Attitude having doubt	A Principle than a preventive technique	
	Oops		
	Self-Check		Consideration of Behavior based Safety
Conditional Human Error Prevention Tools	3Way-Communication		Consideration of Behavior based Safety
	Phonetic Alphabet		Promotion to practical use
	Pre-Job Brief.	A Principle than a preventive technique	
	Concurrent-Verification		Consideration of Behavior based Safety
Peer-Check			Consideration of Behavior based Safety
	Tagging Oper. Barrier	A Principle than a preventive technique	

4. A Case Study

Figure 1 and table 3 show examples of a behavior based safety program and a case of a behavior based safety application in a work of boric acid injection. Those examples presented in figure 1 and table 3 link well with the human behavior aspects of other traditional risk reduction efforts. The suggesting program will help to raise the effectiveness of human error reduction technique and reduce overall personnel- and process- related error risks.

(R1) What kinds of risk are latent there? a situation Putting in NFB by using a page-phone(or speaker)
(R2) Risk point <input type="checkbox"/> Workers have to confirm the NFB number again because there are 3 sorts of NFB with same number. <input type="checkbox"/> An electric shock possibility on a terminal plate.
(R3) What do you do? [point & confirmation] 1-1. Confirming the objects through the speaking over the phone with MCR crews (phonetic alphabets). 1-2. asking to co-workers 2-1. Isolation the terminal plate 2-2. using of a tool by tree, not by hands 3-1. Using always insulating gloves
(R4) A behavior objective of a team: Let's do it! [Touch & Call] - (Touch & Call) Let's Confirm the objects through the speaking over the phone with MCR crews, and use insulating gloves, Very Good! One Point : - (Touch & Call) Speaking with MCR crews, Insulating gloves, Very Good! (3times)

Fig. 1 An example of a behavior based safety application

Table 3 A case of a behavior based safety application in a work of boric acid injection

time	Designer	Manager	Worker	outsider	others	An example of using Human error prevention tools
0:05			Boss, I will inject the boric acid 10 times 150 liters each till boric acid density 1615ppm			
0:18		Yes, inject the boric acid keeping the control rod position and axial power deviation in band.				
0:24			Yes, I will inject the boric acid keeping the control rod position and axial power deviation in band.			Keep the control rod position, Keep axial power deviation, Boric acid injection, very good!
0:30			Safety manager! Please Peer Check!			
0:33				Yes, sir.		

5. Conclusion

This paper suggests a behavior based safety program integrated with current human error prevention tools in NPPs. We selected 6 techniques (self-Check, Peer Check, 3-Way Communication, First Check, Concurrent Verification, and Independent Verification) as objects of the research in side of a behavior science after inspection of the process of human error prevention techniques. Training system should be considered with behavior science experts or ergonomics experts and progressed centering on practical exercises with risk prediction and touch & call technique The behavior based safety techniques are very effective methods, but the techniques have to be adjusted with the proposed method to apply in fields of nuclear industry and need to sustain a continuous feedback and analyze the effectiveness in use of the proposed method.

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