Ergonomics Research Techniques

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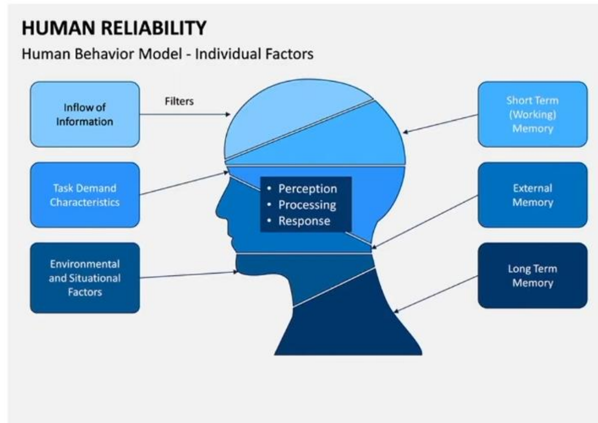
Week 11: Lec 38- Human reliability

Human Error Assessment and Reduction Technique (HEART)

Welcome back. Today we are going to talk about the human reliability. So when we are discussing about the behavioral and cognitive methods in the field of cognitive ergonomics, human reliability is very important component that we should all understand and measure it. So when we are talking about human reliability, it means that when somebody is or the operator is in a particular system and interacting with each component of the system, maybe the other operator or maybe the machine component in the particular environment, it is very important that there is less chance of error of doing any kind of activities or kind of operation. So if we miss to do that, if there is some kind of error happens, there is always a chance that we increase the cost of the whole system, in terms of money or in terms of time or the kind of breakdown process time, everything. So when we are talking about somebody or some worker or operator working in a particular system, in a particular working environment, there the kind of human reliability we need to secure. So that minimum requirement is being taken care and there is less chance of error. Because if there is any error, there is some kind of mistakes, then definitely there is going to happen some kind of accident. And because of accidents, there are lot of loss. So we need to understand any system from the perspective of the human reliability. If we understand that particular aspect, then we will be able to do some kind of precautionary measure to run that particular system smoothly. So here today we are going to understand the human reliability and how do we assess them or how we can take the precautionary measures based on those assessment. So that part we are going to study.

Human reliability

- Successful human performance within specified timeframes and environmental conditions.
  - Achieving the desired performance outcomes.
  - Reducing the human error.



So before we go ahead with the particular tool or techniques which is going to help us to measure or assess the human reliability, first let us understand more about human reliability. So what exactly it is? So successful, any successful human performance within specific time frame, because when we are talking about a person working in a specific area of work, then what happens, we need to understand there is a time limit. If we cross the time limit, that is also a failure of that particular system. So we need to make sure that successfully a person or the human or the operator is performing that particular task within the specified time frame and the environmental condition. Whatever environmental conditions is being decided, we need to make sure the he or she is in a position to complete that in that specific environment. So achieving the desired performance outcome and reducing the human error. If we can do that, then it happens that whole system will run successfully.

Management of human reliability

- There are multiple factors, contribute to the error or 'shape' human performance-

Job related

- Difficulty or complexity of task
- Time availability
- Physical work environment

Individual related

- Physical capability and condition
- Stress
- Motivation

Organization related

- Clarity of roles and responsibilities
- Level of supervision
- Workplace culture

So when we are talking about human reliability, we need to understand the human behavior model and their individual influencing factors. We can understand if there is an environment where somebody is operating and they are interacting with a particular machine or many machines and the peers like you know many other operators, then what will happen? There will be inflow of information to the brain. There will be task demand because if somebody is in a particular working environment, definitely there is a task demand. Also there will be some environmental and situational factors. So when I am working in the morning, when I am working in the evening or in the afternoon, situations are not exactly same. It is not about the time frame. I am talking about, suppose there is I am taking a class in a particular classroom and somebody knocked the door to ask for something. So that is a situation. How do we react on it? The same situation may happen in a shop floor, in an assembly line. So how people think people are reacting to it. So suppose there is an assembly line going on and there is some wrong product came into. So how do you eliminate? How do you take decision and eliminate it? So those are the environmental and situational factors. Also it talks all those things are related with your short term memory, external memory and the long term memory. So all these factors are actually the influencing factor and it creates the human behavioral model. So that is the background of human reliability. Now when we talk about human reliability, we need to understand how do we manage it. So there are multiple factors which contribute to the error or shape of human performance. So they may be categorized as job related, individual related and organizational related. So if we talk about job related, it may be difficult or complex work, time of availability. So if it is within a very short time span you have to do or you have enough time, you are so relaxed, so how you are performing it, physical work environment, these are the major element that we consider in the job related area. In individual physical capability and conditions, stress and motivation and in organizational related clarity of roles and responsibilities. Suppose there is an assembly line going on, if there are two workers working together in the same assembly line, who is doing what? What supposed to be done by whom? All these clarity need to be there. If there is not much clarity, there will be definitely a chance to do some kind of mistake and accidents may happen. Level of supervision and workplace culture. This is very important aspect that is the workplace culture. So how do we interact with our peer, how do we interact with our supervisor or the people who are working under us? So how this structure is going on? What is the kind of level of freedom is there, level of responsibilities are there, so all those things matters when we are talking about human reliability.

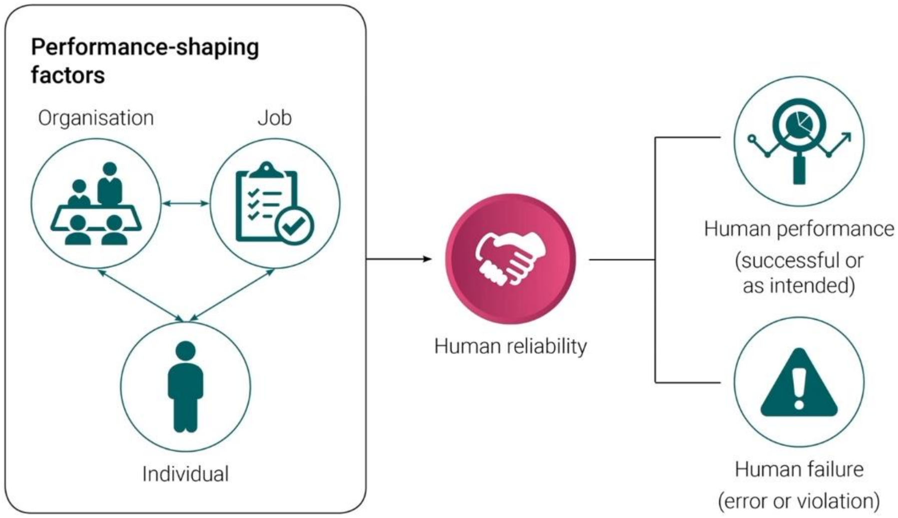
Managing human reliability in the 10 Human and Organizational Factors (Department of Mines, Industry, Regulation and Safety; Government of Western Australia)

Now these are some 10 elements that is going to connect or that is going to help you to understand how do you manage the human reliability. So first is the usable procedure, training and competency. So if you are trained enough, competent enough, definitely the reliability, there is a chance of chance that reliability is in an increased state. Staffing and workload, organizational change, safety, critical communication. So if safety and critical communications are made properly, then what will happen? Basically every information will pass from one operator to other operator very nicely and flawlessly and therefore there will be less chance of mistake, error and all those things. Then designing for the people, so if you are designing things for people, then definitely it is more beneficial and you will be able to handle or manage the human reliability correctly. Then fitness of work, health and safety culture and maintenance inspection and testing the error. So here this is very important is the testing the error. Suppose you have some kind of problem, but how do you test it? How do you make sure that the things are going to be corrected in this way? So how the situation can be tested? So if there is a problem, if you give a proper instruction and those instruction is impacting or not, how do you manage them? All those things if it is being taken care, then definitely managing the human reliability will be far more easier way or it will be more easy method.

Human error

- A result of an unintentionally inappropriate or undesirable human behavior.
- It is common for unwanted events in industry to be attributed to human error when the desired performance outcome is not achieved.

So when we are talking about human reliability, one important term comes into mind that is the human error. So if there is a failure of human reliability, definitely error comes into picture. So what is the error? A result of an unintentionally, inappropriate or undesirable human behavior, which is unintentional. So I am not doing it intentionally. Inappropriate. Of course I should not do it, but it happened. So inappropriate and undesirable. I never, this is not desired to be done, but it happened. So those are the things we will be calling it as error. So what is the definition? A result of an unintentional inappropriate or undesirable human behavior. It is very common for unwanted events in industry to be attributed to human error when the desired performance outcome is not being achieved. So that will be termed as human error.



Performance-shaping factors and human reliability, failure and performance (Department of Mines, Industry, Regulation and Safety; Government of Western Australia)

Now when we are talking about human failure or human error and the individual working in a particular situation, this is the model where human reliability comes into picture. So you have organization, in that you have a specific job to be performed and you are the individual who is working. So you are working, interacting with the organization, you are interacting with your job, that means you are performing your job and all these are both way interaction which is going to go for an error when there is a lack of human reliability. So that is why human reliability is very, very important. So this, what will happen? Human performance will go down, so successful or maybe intended and then there will be some kind of human error. So for all these cases, if you are successful, then you are, that means human reliability is on the higher side. But if there is an error, that means human reliability is on lower side. So that is where human reliability plays an important role.

- To identify the types of error
- To inform the type of action required to reduce the same error occurring again.

Human error: Types & management

Slips

Lapses

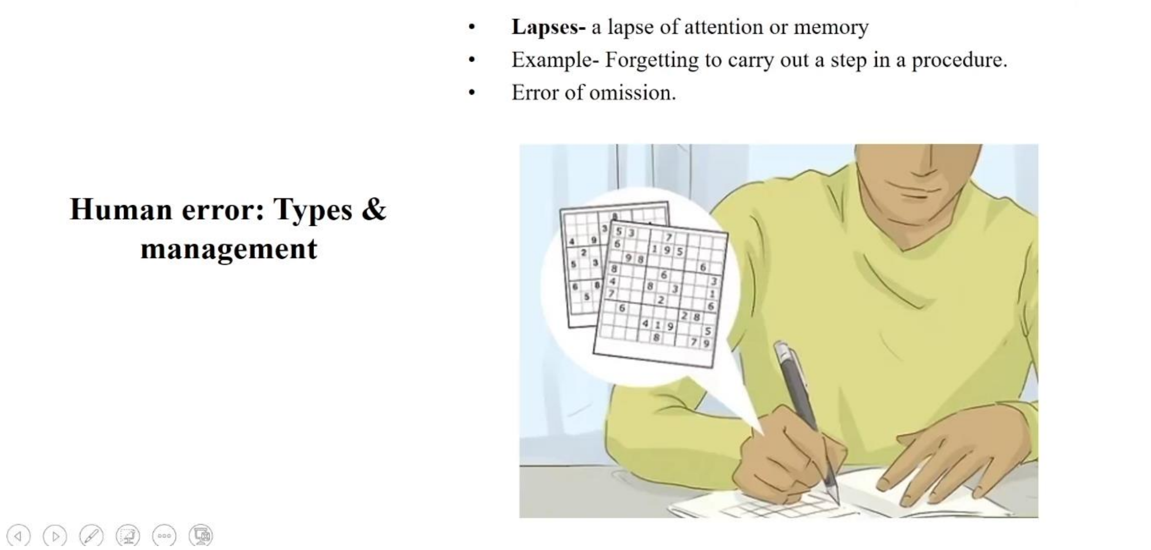
Mistakes

Now when we are talking about error, let us understand what are the types of error. So mainly we find three major types, slips, lapse and mistakes. Let us find out the definition of them.

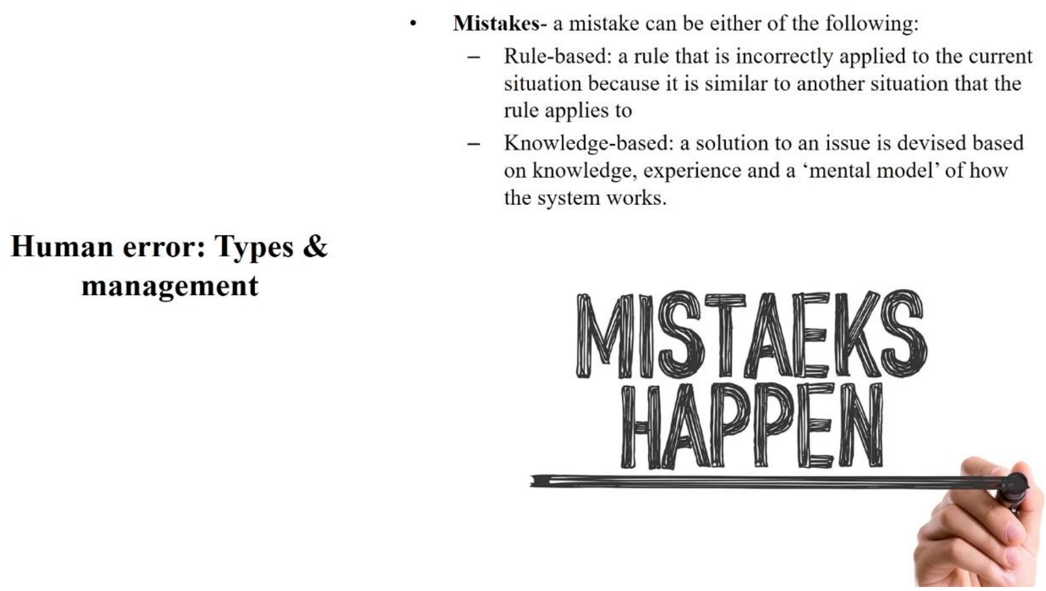
- **Slips**- when a process and its implementation are familiar, but there is a performance failure.
- Example- Pressing the wrong button or reading the wrong gauge
- Error of commission.

Human error: Types & management

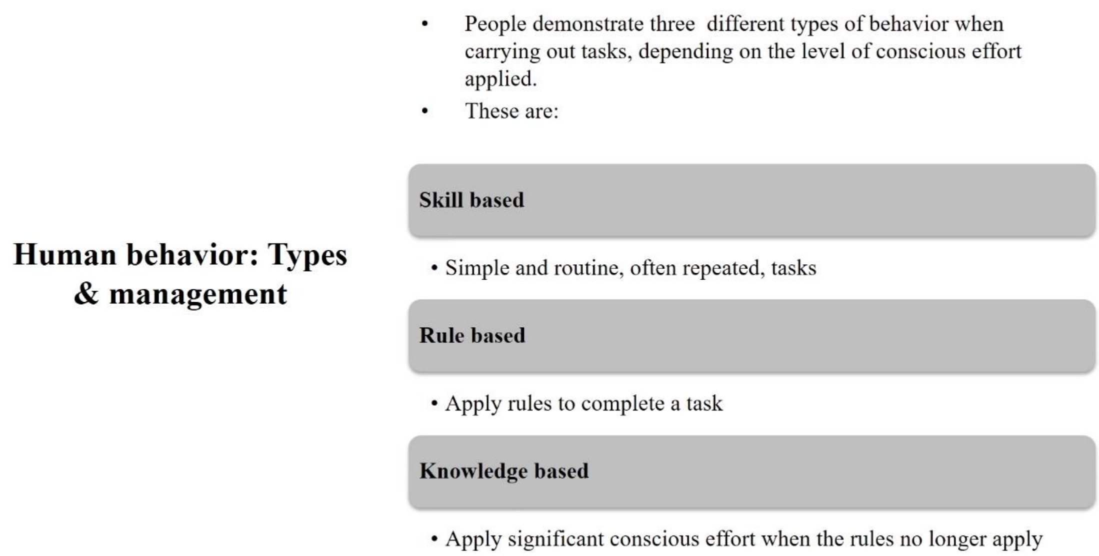
So what is slip? Slip is when a process of its implementations are familiar, but there is a performance failure. So the process we know, but what happens? There is a, while performing it, there is a failure, that is slip. For example, pressing a wrong button or reading the wrong gauge. So if that happens, definitely there is an error in the communication. So this is a type of error which is called as slips.



Next is lapse. What happens in the lapses? Lapses are of the attention or memory. It is there, but we miss to read that memory. Example forgetting to carry out a step in a procedure. So maybe for a particular system you have to do step 1, step 2, step 3, step 4 like that. What you did, maybe after step 1, 2 you missed that step 3 and you performed the step 4. So what happened? The ultimately it is an error. So it is completely memory driven. So that is lapse.



And the third one is mistake. What it is? Mistake can be either of the following. One is rule based mistake, another is knowledge based mistake. What is rule based mistake? A rule that is incorrectly applied to the current situation. So you know the rule, however you applied that rule incorrectly, ok in a situation because it is very similar to another situation and that is why you mapped it wrongly, ok. So that is rule based. What is knowledge based? A solution to an issue is devised based on knowledge, experience and a mental model of how the system works, ok. So what happened? You mentally process it, but you process it because it is based on your own experience, your own understanding, own previous memory, ok. So there maybe you are doing some kind of mistake. So mistakes are two types. One is rule based, another is knowledge based.



Now when we are talking about human behavior and then we are talking about their types and management, we need to understand that people demonstrate different types of behavior when carrying out any particular task and it can be dependent on the level of consciousness effort applies, ok. And these are skill based, rule based and knowledge based. So when we are talking about that you know human behavior in a particular situation and we are talking about how to manage that human behavior, basically the human reliability, it is kind of three types. One is skill based, second is rule based and third is knowledge based. What is skill based? Simple and routine, often repeated task. So every day we are doing it, ok. So if we come we know we need to switch on the particular machine. So you skill to do that, ok. So that is skill based. So rule based is apply rules to complete a particular task and knowledge based as earlier apply significant conscious effort when the rules no longer apply. So what you do? You logically analyze the situation and take the decision. So then it is knowledge based, ok. So there is rule, if this happens you do this, if this happens you do that. So like that you have a flow chart. Now so that is rule based. You have things ready and you are doing it. Now a situation comes where no rule is following. So in a particular situation that this also not there, that also not there, this also not there, nothing is there. It is something else altogether. Then what you have to do? You have to rely on the experience or expertise or the previous memory that you have or maybe you learnt from somewhere else, ok. So based on that knowledge you have to take the decision. Then it is knowledge based and it is very very critical and if we can enhance this particular thing in a particular situation there will be very less chance of error and there will be we will be able to control many incidences and accidents, ok.

- Attention required for the task is minimal
  - The person effectively running on autopilot.
- Although basic progress checks are performed from time to time, these checks are largely subconscious.
- Problems occur when the attention for checking is diverted.

Skill based behavior

Now what is skill based behavior? So when we are talking about skill based behavior, it is basically the attention required for a particular task is required in a minimal amount, ok. So the person effectively running on autopilot, ok. So like it is automatically happening. There is no effort to be played, ok. Although basic progress checks are performed from time to time these checks are largely subconscious, ok. So problems occur when the attentions for checking is diverted. So you know you are with a full attention you are doing this, this, this, this, this. Automatically it is happening. There is no chance of a mistake. But as soon as there is something which is diverting the attention, there will be a chance of doing the mistake. So that is the skill based behavior, ok.

Rule based behavior

- Rules are applied to tasks to either help work through a problem or to identify the correct action to take.
- The rules may be stored in our memory or in the form of written instructions.
- Example
  - If power is reaching the lamp, but there is no light; then the bulb is faulty.
  - If temperature in tank 'A' has reached 75°C, then the switch steam heating to half power.
- Problems occur when part of the rule is neglected, the wrong rule is applied or a step in a written instruction is missed.

What is rule based behavior? So rules are applied to the task to either help the work through a problem or to identify the correct action to take. The rules may be stored in our memory, because normally that is the way we learn. So we memorize every rule. So suppose somebody is coming to the class, from the child rule they know they need to wish to the teacher as soon as the teacher arrives, right. That is the rule. So it is like you know they do it. Now question is if instead of teacher somebody else is coming, do they need to wish or not to wish? So how do they take those decisions, ok? So similar kind of things, ok. So if the power is reaching like it is an example to the lamp, but there is no light, then either bulb is faulty or there may be some other reason. Now question is first rule is everything is correct. Still bulb is not giving light that means bulb is not working properly. So replace the bulb. So it is a rule, right. So this is how the human behave in a particular situation then it is rule based behavior. So if the temperature, it is another example, if the temperature in tank A has reached 75 degree centigrade, then they switch the steam heating to the half power. So if it is reached there then you switch it on to the half, ok. So it is a kind of rule that you set in a particular situation. So problems occur when part of the rule is neglected, the wrong rule is applied or a step in a written instruction is missed. Now take example of the first one, ok. That power is reaching to the lamp, but still the bulb is not getting light. So rule is that bulb is not correct, bulb is damaged or something so you need to replace the rule. Now it happen if a novice person is there what he or she will do? They will read the instruction. Now the last part suppose change the replace the bulb is missing the person is clueless and he or she will not be able to correct the system, maybe one case. Maybe like here you can say wrong rule applied, ok. Now in other situation something is been taken like you know maybe you switch, the switch is not correct or that particular where is you know some kind of tearing is there or some because of some other reason bulb is not you know lighting.

Then if you do not know that then you will rule out everything, you will only stick that the bulb is not actually functioning. You need to replace the bulb. Anyway if you do that suppose there is a problem with this particular where current is reaching to the lamp, but still it will not light if there is a problem in this particular where, right. So that way you need to see that where the problem is lying and how these type of rule based behavior can be taken care and how the system can be improved.

Knowledge based behavior

- Usually applicable in problem solving or troubleshooting tasks.
- Demands significant conscious effort when the rules no longer apply.
- This is when a solution to an issue is devised based on knowledge, experience and a 'mental model' of how the system works.

The last one is the knowledge based behavior. So usually it is applicable in a problem solving or troubleshooting task. So every case you know there is some kind of experience already gathered from your previous handling things, then using that experience you are going to handle the current situation. So it demands the significant conscious effort when the rules no longer apply. This is when a solution to an issue is devised based on the knowledge, experience and a mental model of how the system works, ok. So this is the knowledge based behavior.

Human factors in incident investigation

- An incident investigation gathers and organizes information.
- These information can be used to identify the human and organizational factors that contributed to the incident, and therefore inform recommendations for improvement.
- The key to effective investigation is to ensure that the approach used discovers the underlying reasons why an incident occurred, not just the error made by the last person involved.

Now human factors in the incident investigation. So first we should understand what is incident and what is accident. So when there is some kind of mistakes happen or there is some kind of failure of human reliability then what happen the system fails. Now due to the system fails there is some kind of loss then it is basically the accidents. Whereas if only there is a mistake but it just you know you have taken care of the situation, there is not much of you know property loss, then maybe you can term it as incident. Depending on the situation to situation, this incidents and accidents these terms keep on interchanging with each other. So what we are going to understand in this particular slide is that when we are talking about investigating the incident, what is the role of human factors. So an incident investigation gathers and organize the information and these information can be used to identify the human and organizational factors that contributed to the incident and therefore inform recommendation for improvement. So we understand what are the sequences happen and where there is a failure and how do we improve that situation. So that recommendation we give. So the key to effective investigation is to ensure that the approach used discovers the underlying reasons why an incident occurred, not just the error made by the last persons involved. It may not happen the last person who was doing that particular job is only responsible. It may happen that something went wrong earlier in the whole system and therefore the last person did some kind of error. So when we are talking about investigating the incidents what you have to do, you have to study the study in full length. So that is the procedure or steps we should follow when we are investigating any kind of incident.

Human errors in incident

- The cause of an accident; due to lack of training.
- The analysis should find out why the person involved lacked training, what lead to an untrained person being involved in the task and what system within the organization failed.

So again in that particular case the causes of an accident may be due to the lack of training. The analysis should find out why the person involved lacked that particular training, why was there is kind of unavailability of training or the way the training has been given was not enough or the content of the training was not enough for this particular case, what. So maybe we need to evaluate those as well. So what lead to an untrained person being involved in the task and what system within the organization failed. So when we are talking about investigating the incidents, all these should come into picture.

Human errors in incident

- Factors that promote effective incident investigation include:

A system allowing any worker to formally report an incident

Clear guidance on how initial reports are to be made and the information required in those reports

The option to report anonymously

Rules for determining whether or not to investigate a reported incident and the required speed of response

Resource to conduct an investigation, with external support available as needed

Now when I am talking about the same thing that is the human errors in any incidents factors that promote the effective incident investigation, it is mainly nine components. So a small system allowing any worker to formally report an incident. So if the person who made this or who met with that particular incident, if formally is not being reported, that will not be able to analyze or will not be able to understand or investigate that incidents. So that first is the reporting. Having clear guidance on how initial reports are to be made. So every industry, every situation should have their own guideline that how to report that particular incident and the information required in those reports. So because every situations are different, so in every context these guidelines should be there beforehand. So the option to report anonymously. So otherwise what will happen? If somebody met with some kind of incident he or she may be biased enough to report it and then what will happen? There will be less chance of investigating the things properly. So anonymous reporting should be available. This facility should be available in every organization. So rules for determining whether or not to investigate a reported incident and the required speed of response. These things can be made into a policy and that should follow over and over the years and maybe if it is required they can do the amendment of those policies. And the resources to conduct an investigation with external supports available as needed. If they are unable to do it in house, they may take help from the outside.

HEART

Human Error Assessment and Reduction Technique

So now when we understood all these aspects of human reliability, now let us understand one small technique or one very small tool which is going to be used to assess the human reliability. Name of this technique is HEART that is Human Error Assessment and Reduction technique. So what we are going to do? We are going to assess the human error and we are going to try to reduce this particular human error which is being found in a particular system. So this technique is called HEART.

Introduction

- Designed to be a quick and simple technique for quantifying the risk of human error.
- A general method, applied to any situation or industry where human reliability is important.
- A quantitative human error probability assessment technique.
- Can be used in combination with qualitative human task analysis techniques that identify operator tasks to be assessed.

Now first let us have some introduction of it. So it is designed to be a quick and simple technique for quantifying the risk of human error. A general method which is applied to any situation or industry where human reliability is important like automobile industry, maybe railway, maybe in aviation, nuclear power plant, everywhere wherever the human reliability is a major concern, we can use this particular technique. A quantitative human error probability assessment technique, so it is quantitative. It is not qualitative. It can be used in combination with qualitative human task analysis. So that also we can do that identify the operator task to be assessed.

Introduction

- Relatively simple to use when compared with other human reliability quantification methods.
- It is easily understood by practitioners from both engineering and social science background.
- 9 generic task types (GTTs) are described in HEART.
  - Each with an associated nominal human error potential (HEP)
- 38 Error Producing Conditions (EPC) that may affect task reliability
  - Each with a maximum amount by which the nominal HEP can be multiplied.

So relatively this particular technique is simple to use when compared with other human reliability quantification method. It is easily understood by practitioners from both engineering and social science background because both these type of people actually use this particular tool and it is very easy. When we will explain it, we will understand that how quickly someone can learn this particular technique. So what it has, it has 9 generic task step. We call it GTT, 9 generic task types and described in HEART each with an associated nominal human error potential. Each task we will be having nominal human error potential. So there is whenever we are having a task, there is always a chance there will be some kind of nominal error. So that is being taken care in this particular technique. So we call it HEP that is the nominal human error potential. 38 error producing conditions already predefined. So in a particular situation there may be any one of them or four of them, five of them may present. So they quoted almost 38 error producing condition or EPC that may affect the task reliability. This EPC each with a maximum amount by which the nominal human error potential can be multiplied. So we will, what we are going to do HEP multiplied by EPC.

Introduction

- HEART is recognized as a successful and cost-effective tool for predicting human reliability and identifying ways of reducing human error.
- It can be also applied to any industrial operation due to its methodology being centred upon the human operator rather than the technical process.
- Types of process- Observation by expert

So HEART is recognized as a successful and cost effective tool for predicting the human reliability and identifying the ways of reducing the human error. So first we are going to identify the human reliability where the problem is there and how do you reduce it. It can also be applied to an industrial operation due to its methodology being centered upon the human operator rather than the technical process. So as this is specifically for human not for the technical like machines. So that is why this is very much acceptable tool in the industry and types of processes only by the observation and of course we need a skill to observe it. So somebody who is very much expert in the operation of that particular situation he or she only will be able to do it. If you are a novice person who is observing that particular operation first time will not be able to do it. You need a time to understand the whole process and then only you will be able to use this particular tool.

Introduction

- HEART is based on the following premises:
  - Basic human reliability- dependent upon the generic nature of the task to be performed.
  - Given perfect conditions- this level of reliability will tend to be achieved consistently with a given nominal likelihood within probabilistic limits.
  - Given this perfect conditions do not exist in all circumstances- the human reliability predicted may be expected to degrade as a function of the extent to which identified.

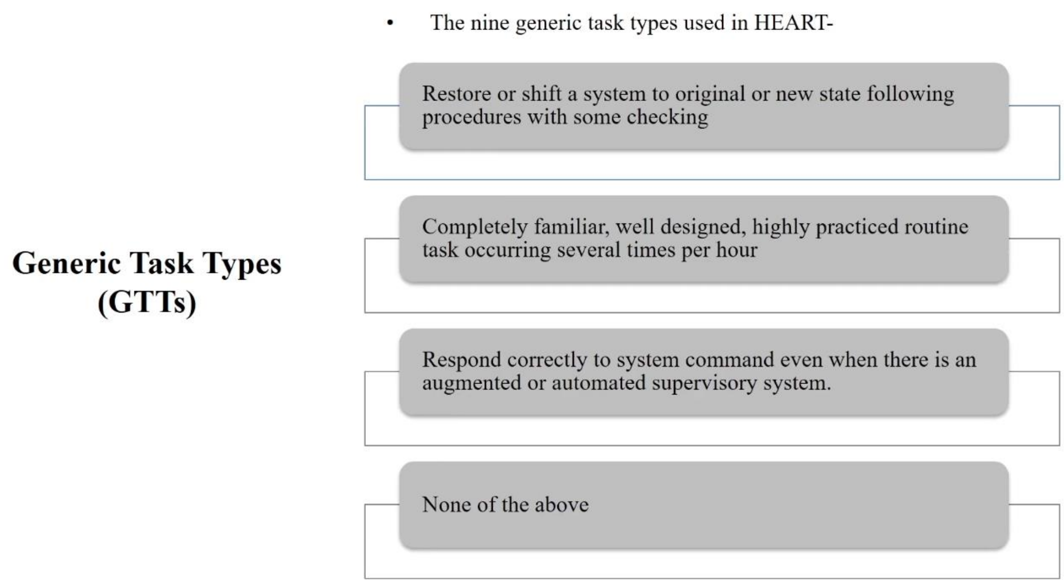
So HEART is based on the following premises. First one that the basic human reliability which is dependent upon the generic nature of the task to be performed. Given perfect condition this level of reliability will tend to be achieved consistently with a given nominal likelihood within probabilistic limit and given this perfect condition do not exist in all circumstances. It may not possible that this perfect situation is always exist. So the human reliability predicted may be expected to degrade as a function of the extent to which it is identified. So these are the kind of area or premises this HEART can be used.

Generic Task Types (GTTs)

- The nine generic task types used in HEART-

- Totally familiar, performed at speed with no idea of likely consequences
- Shift or restore to new or origin on a single attempt
- Complex task requiring high levels of comprehension and skill
- Fairly routine task performed rapidly or given scant attention
- Routine highly-practiced, rapid task involving relatively low level of skill

Now first let us understand these nine generic task type. So these are very generic. You can categorize the task of the industry in any one of them. So first one is very much familiar. So we are calling it totally familiar, performed at a speed with no idea of likely consequences. So that is first. Second is shift or restore to new or origin on a single attempt. Third, complex task requiring high levels of comprehension and still. Fourth, fairly routine task performed rapidly. So initial one it is completely you know, the fourth one fairly routine task. But it is done very rapidly or given a scant attention. Then routine task and highly practiced rapid task involving relatively low level of skill.



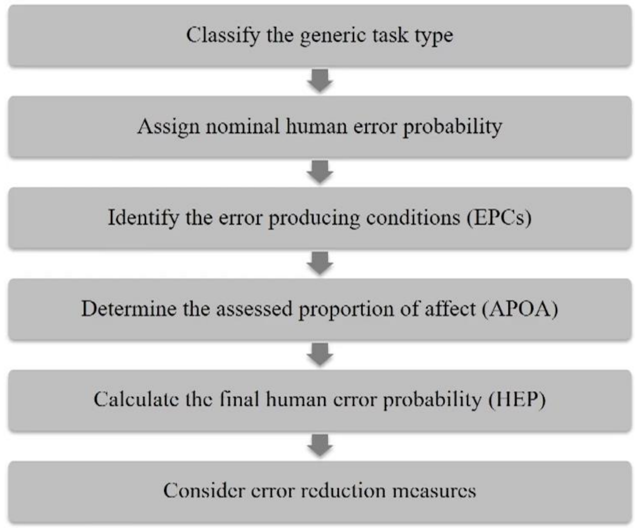
Sixth is restore or shift a system to original or new state following procedures with some checking. Then completely familiar, well designed, highly practiced routine task occurring several times per hour. So eighth is respond correctly to system command even when there is an augmented or automated supervisory system. And the last one none of the above. So these are the nine generic task type identified for HERT.

Key elements

- The key elements of HEART
  - Classify the task for analysis into one of the 9 Generic Task Types (GTTs).
  - Assign the nominal HEP to the task.
  - Decide which EPCs may affect task reliability.
  - Consider the assessed proportion of affect (APOA) for each EPC.
  - Calculate the task HEP.

Now let us understand the key element. So classify the task when you are talking about using or implementing HEART. It is the classifying the task for analysis into any one of these nine generic task. So among all these nine, you may have only one identified for your chosen analysis. So assign the nominal HEP to that task. How do you do that? We will show in the next table. Decide which EPC may affect the task reliability that we are going to see in the next slide. And then consider the assessed proportion of affect, APOA for each. So what is that? Assessed proportion of affect, we call it APOA. Assessed proportion of affect for each EPC and calculate the HEP. So like that we are going to understand that how, what is the kind of level of human reliability you have in that particular task.

Steps of HEART



So now let us understand the steps. What you are going to do? I think partially I already explained. Still I am going to repeat it that classify the generic task type. So from that table, you are going to understand among all these nine, which one you are, which one is your case. Then assign the nominal HEP that is the human error probability. Identify the error producing condition. Assess the assessed proportion of affect that APOA. Calculate the final human error probability and consider the error reduction measures.

Steps of HEART

- **Step 1**
  - Task: Generic task unreliability
    - Classify the task in terms of its generic human unreliability into one of the 9 generic HEART task types. (Table 1)
  - Output
    - Nominal human unreliability probability.
- **Step 2**
  - Task: Error producing condition & Multiplier
    - Identify the relevant error producing conditions (EPCs) to the scenario/ task under analysis which may negatively influence performance and obtain the corresponding multiplier. (Table 2)
  - Output
    - Maximum predicted nominal amount by which unreliability may increase (Multiplier)

Generic task		*Proposed nominal human unreliability (5th–95th percentile boundaries)*
A	Totally unfamiliar, performed at speed with no real idea of likely consequences	0.55 (0.35–0.97)
B	Shift or restore system to a new or original state on a single attempt without supervision or procedures	0.26 (0.14–0.42)
C	Complex task requiring high level of comprehension and skill	0.16 (0.12–0.28)
D	Fairly simple task performed rapidly or given scant attention	0.09 (0.06–0.13)
E	Routine, highly practised, rapid task involving relatively low level of skill	0.02 (0.007–0.045)
F	Restore or shift a system to original or new state following procedures, with some checking	0.003 (0.0008–0.007)
G	Completely familiar, well-designed, highly practised, routine task occurring several times per hour, performed to highest possible standards by highly motivated, highly trained and experienced person, totally aware of implications of failure, with time to correct potential error, but without the benefit of significant job aids	0.0004 (0.00008–0.009)
H	Respond correctly to system command even when there is an augmented or automated supervisory system providing accurate interpretation of system stage	0.00002 (0.000006–0.00009)
M	Miscellaneous task for which no description can be found. (Nominal 5th to 95th percentile data spreads were chosen on the basis of experience suggesting log-normality)	0.03 (0.008–0.11)

Table 1: Generic task unreliability

Now step by step in detail. When I am talking about this table 1, I am going to refer this particular table. So here you can see A, B, C, D, E, F, G, H, M. So all these things are being mentioned here and according to the GTT, you can see the proposed nominal human unreliability value. So this is fifth percentile, this is 95th percentile data. So what you have to do? Identify the task in terms of its human unreliability into any one of these nine tasks. That is the first step. Then what is the second step? Second step is the error producing condition and then multiply. So you have to find out error producing conditions and then you need to multiply. So for that what you are going to do? So identify the relevant error producing conditions to the scenario or task under analysis which may negatively influence the performance and obtain the corresponding multiplier.

Error-producing condition	Maximum predicted nominal amount by which unreliability might change going from 'good' conditions to 'bad'
1. Unfamiliarity with a situation which is potentially important but which only occurs infrequently or which is novel	×17
2. A shortage of time available for error detection and correction	×11
3. A low signal-to-noise ratio	×10
4. A means of suppressing or overriding information or features which is too easily accessible	×9
5. No means of conveying spatial and functional information to operators in a form which they can readily assimilate	×8
6. A mismatch between an operator's model of the world and that imagined by the designer	×8
7. No obvious means of reversing an unintended action	×8
8. A channel capacity overload, particularly one caused by simultaneous presentation of non-redundant information	×6
9. A need to unlearn a technique and apply one which requires the application of an opposing philosophy	×6
10. The need to transfer specific knowledge from task to task without loss	×5.5
11. Ambiguity in the required performance standards	×5
12. A mismatch between perceived and real risk	×4
13. Poor, ambiguous or ill-matched system feedback	×4
14. No clear direct and timely confirmation of an intended action from the portion of the system over which control is to be exerted	×3
15. Operator inexperienced (e.g. a newly qualified tradesman, but not an 'expert')	×3
16. An impoverished quality of information conveyed by procedures and person–person interaction	×3
17. Little or no independent checking or testing of output	×3
18. A conflict between immediate and long-term objectives.	×2.5
19. No diversity of information input for veracity checks	×2.5
20. A mismatch between the educational achievement level of an individual and the requirements of the task	×2
21. An incentive to use other more dangerous procedures	×2
22. Little opportunity to exercise mind and body outside the immediate confines of the job	×1.8
23. Unreliable instrumentation (enough that it is noticed)	×1.6
24. A need for absolute judgements which are beyond the capabilities or experience of an operator	×1.6
25. Unclear allocation of function and responsibility	×1.6
26. No obvious way to keep track of progress during an activity	×1.4
27. A danger that finite physical capabilities will be exceeded	×1.4
28. Little or no intrinsic meaning in a task	×1.4
29. High-level emotional stress	×1.3
30. Evidence of ill-health amongst operatives, especially fever	×1.2
31. Low workforce morale	×1.2
32. Inconsistency of meaning of displays and procedures	×1.2
33. A poor or hostile environment (below 75% of health or life-threatening severity)	×1.15
34. Prolonged inactivity or highly repetitious cycling of low mental workload tasks	×1.1 for first half-hour ×1.05 for each hour thereafter
35. Disruption of normal work-sleep cycles	×1.1
36. Task pacing caused by the intervention of others	×1.06
37. Additional team members over and above those necessary to perform task normally and satisfactorily	×1.03 per additional man
38. Age of personnel performing perceptual tasks	×1.02

Table 2: Error-producing conditions (EPCs)

So as this is a precomputed chart, here also it is a precomputed chart for error producing conditions. Now then what you are going to do? The maximum like after step 2, what you are going to get? Maximum predicted nominal amount by which unreliability may increase. So you are getting the multiplier. So these are the values, these are the multipliers.

Steps of HEART

- **Step 3**
  - Task: Assessed proportion of effect
    - Estimate the impact of each EPC on the task based on judgement.
  - Output
    - Proportion of effect; value between 0 to 1.
- **Step 4**
  - Task: Assessed effect (APOP)
    - Calculate the assessed impact for each EPC according to the formula:

    [(Multiplier – 1) Assessed proportion of effect] + 1
  - Output
    - Assessed impact value

In step 3, what you are going to do? Assess the proportion of affect. So estimate the impact of EPC on the task based on your judgment. In next part, what you are going to do is the assess the affect that is the APOA. So calculate the assessed impact for each EPC according to the formula. So multiplier minus 1 multiplied by this APOA plus 1. So then you will get the assessed impact value. Now we will give the example and you will understand that.

Steps of HEART

- **Step 5**
  - Task: Human error probability
    - Calculate overall probability of failure of task based on the formula:

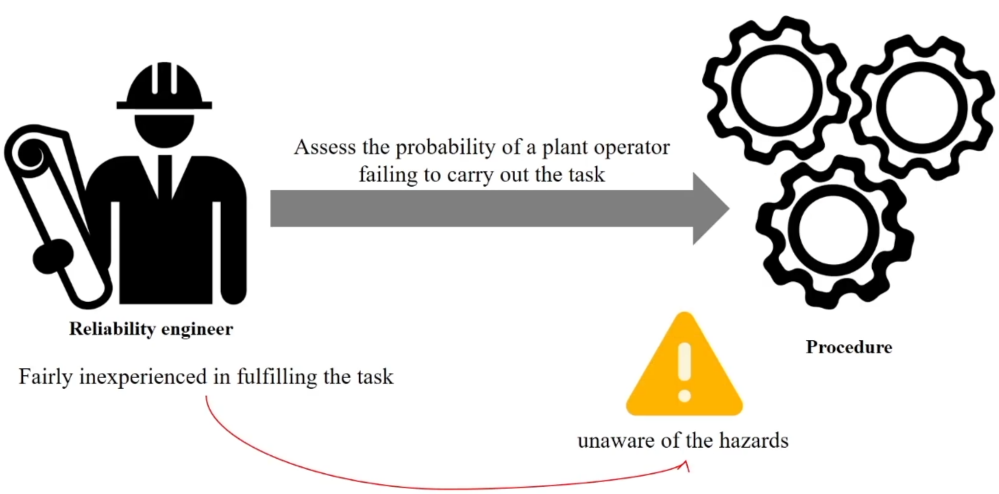
      Nominal human unreliability × Assessed impact 1 × Assessed impact 2….etc.
  - Output
    - Overall probability of failure
- **Step 6**
  - Task: Error reduction measures

Once we complete that step, what you are going to do? That human error probability. So calculate the overall probability of failure of task based on this formula and then you get the probability of overall probability of the failure and then what you need to do? Task reduction measures you have to take in care. Now we will go ahead with the example so that you can understand it. The context first I describe and then I will take you to the data.

Working HEART

- **Context**
  - A reliability engineer has the task to assess the probability of a plant operator failing to carry out the task of isolating a plant bypass route as required by procedure.
  - The operator is fairly inexperienced in fulfilling the task.
  - It does not follow the correct procedure.
  - The individual is therefore unaware of the hazards created when the task is carried out.

So a reliability engineer in a particular situation has the task to assess the probability of a plant operator failing to carry out the task of isolating plant by pass route as required by the procedure. So that the person has to do. So the operator is fairly inexperienced in fulfilling the task. It does not follow the correct procedure. The individual is therefore unaware about because the person is not experienced. The person was not aware about the situation. So the person, the individual is therefore unaware of the hazards created when the task is carried out. So this is the kind of context you have and now there is an incident and you are going to understand the human reliability, human error and you are going to give the measure. So how you are going to do it?



So what this is the human like pictorially, this is the reliability engineer, this is the procedure to be followed and problem is the situation was not person who is operating, the person is not aware about the situation. So some assumptions to be taken before we go ahead or start the analysis.

Working HEART

- **Assumptions**
  - The operator is working a shift in which he is in his 7th hour.
  - There is talk circulating the plant that is due to close down.
  - It is impossible for the operator's work to be checked at any time.
  - Local management aim to keep the plant open despite a desperate need for re-vamping and maintenance work.
  - If the plant is closed down for a short period, if the problems are unattended, there is a risk that it may remain closed permanently.

What are those assumptions here? The operator is working a shift in which in his seventh hour. So that means first hour, second, so he is kind of exhausted. He did lot of work. He is about to take the shift off. So that is the situation one. Second, there is a talk circulating the plant that is due to close down. So there is some kind of psychological things like change in the environment of this place. So it means that company is going to shut down. So there is always an annoying and anxious situation. It is impossible for the operator's work to be checked at any time. So they know that whatever they do, there is less chance somebody will come and supervise it. So that is the condition. So local management aim to keep the plant open despite a desperate need for revamping and maintenance work. So already management is in a situation where they are running it just like that. If the plant is closed down for a short period, if the problems are unattended, there is a risk that it may remain closed permanently. So these are the kind of assumption. Now these assumptions always comes from your field visit. So this information is very important because when we are talking about human reliability, all these varieties, it actually changes from context to context. If we do not gather all this information, it may happen that we will not be able to analyze the situation properly. So these types of information is very important when we are starting any kind of incident analysis. So this is the assumption for this particular case.

Working HEART

- **Methods**
  - From the relevant tables, it can be established that
  - The type of task in this situation is of the 'F' type-
    - Restore or shift a system to original or new state following procedures, with some checking.
  - This task type has the proposed nominal human unreliability value- 0.003
  - Other factors to be included in the calculation are provided in the table:

Now method. From the relevant table like the first table and second table, it can be established that type of task what the person was doing in this situation is of F type. So let us go back and see what is F type.

Generic task		*Proposed nominal human unreliability (5th–95th percentile boundaries)*
A	Totally unfamiliar, performed at speed with no real idea of likely consequences	0.55 (0.35–0.97)
B	Shift or restore system to a new or original state on a single attempt without supervision or procedures	0.26 (0.14–0.42)
C	Complex task requiring high level of comprehension and skill	0.16 (0.12–0.28)
D	Fairly simple task performed rapidly or given scant attention	0.09 (0.06–0.13)
E	Routine, highly practised, rapid task involving relatively low level of skill	0.02 (0.007–0.045)
F	Restore or shift a system to original or new state following procedures, with some checking	0.003 (0.0008–0.007)
G	Completely familiar, well-designed, highly practised, routine task occurring several times per hour, performed to highest possible standards by highly motivated, highly trained and experienced person, totally aware of implications of failure, with time to correct potential error, but without the benefit of significant job aids	0.0004 (0.00008–0.009)
H	Respond correctly to system command even when there is an augmented or automated supervisory system providing accurate interpretation of system stage	0.00002 (0.000006–0.00009)
M	Miscellaneous task for which no description can be found. (Nominal 5th to 95th percentile data spreads were chosen on the basis of experience suggesting log-normality)	0.03 (0.008–0.11)

Table 1: Generic task unreliability

So here, restore or shift a system to original or new state following. So that is the F type situation. So here I mentioned it. In this particular I highlighted it. So what it says, the restore or shift, so that I mentioned and this task type has the proposed nominal human unreliability, which is 0.

003. So you can see it is mentioned here 0.003, nominal unreliability score. Other factors to be included in the calculation are provided in the next table. So you can see from here.

	Error-producing condition	Maximum predicted nominal amount by which unreliability might change going from 'good' conditions to 'bad'
1.	Unfamiliarity with a situation which is potentially important but which only occurs infrequently or which is novel	×17
2.	A shortage of time available for error detection and correction	×11
3.	A low signal-to-noise ratio	×10
4.	A means of suppressing or overriding information or features which is too easily accessible	×9
5.	No means of conveying spatial and functional information to operators in a form which they can readily assimilate	×8
6.	A mismatch between an operator's model of the world and that imagined by the designer	×8
7.	No obvious means of reversing an unintended action	×8
8.	A channel capacity overload, particularly one caused by simultaneous presentation of non-redundant information	×6
9.	A need to unlearn a technique and apply one which requires the application of an opposing philosophy	×6
10.	The need to transfer specific knowledge from task to task without loss	×5.5
11.	Ambiguity in the required performance standards	×5
12.	A mismatch between perceived and real risk	×4
13.	Poor, ambiguous or ill-matched system feedback	×4
14.	No clear direct and timely confirmation of an intended action from the portion of the system over which control is to be exerted	×3
15.	Operator inexperienced (e.g. a newly qualified tradesman, but not an 'expert')	×3
16.	An impoverished quality of information conveyed by procedures and person–person interaction	×3
17.	Little or no independent checking or testing of output	×3
18.	A conflict between immediate and long-term objectives.	×2.5
19.	No diversity of information input for veracity checks	×2.5
20.	A mismatch between the educational achievement level of an individual and the requirements of the task	×2
21.	An incentive to use other more dangerous procedures	×2
22.	Little opportunity to exercise mind and body outside the immediate confines of the job	×1.8
23.	Unreliable instrumentation (enough that it is noticed)	×1.6
24.	A need for absolute judgements which are beyond the capabilities or experience of an operator	×1.6
25.	Unclear allocation of function and responsibility	×1.6
26.	No obvious way to keep track of progress during an activity	×1.4
27.	A danger that finite physical capabilities will be exceeded	×1.4
28.	Little or no intrinsic meaning in a task	×1.4
29.	High-level emotional stress	×1.3
30.	Evidence of ill-health amongst operatives, especially fever	×1.2
31.	Low workforce morale	×1.2
32.	Inconsistency of meaning of displays and procedures	×1.2
33.	A poor or hostile environment (below 75% of health or life-threatening severity)	×1.15
34.	Prolonged inactivity or highly repetitious cycling of low mental workload tasks	×1.1 for first half-hour ×1.05 for each hour thereafter
35.	Disruption of normal work-sleep cycles	×1.1
36.	Task pacing caused by the intervention of others	×1.06
37.	Additional team members over and above those necessary to perform task normally and satisfactorily	×1.03 per additional man
38.	Age of personnel performing perceptual tasks	×1.02

Table 2: Error-producing conditions (EPCs)

Now what is that? Error producing condition. What are the error producing condition? Number 9, 12, 15, 18 and 31. So based on those assumptions and context identified during the observation and during the field visit, we realize these are the error producing conditions and these are the multipliers for them. These are the multipliers for them.

Working HEART

Factor	Total HEART effect	Assessed proportion of effect	Assessed effect
Inexperience	×3	0.4	(3.0 – 1) × 0.4 + 1 = 1.8
Opposite technique	×6	1.0	(6.0 – 1) × 1.0 + 1 = 6.0
Risk misperception	×4	0.8	(4.0 – 1) × 0.8 + 1 = 3.4
Conflict of objectives	×2.5	0.8	(2.5 – 1) × 0.8 + 1 = 2.2
Low morale	×1.2	0.6	(1.2 – 1) × 0.6 + 1 = 1.12

- **Result**
  - The final calculation for the normal likelihood of failure can therefore be formulated as:

$$0.003 \times 1.8 \times 6.0 \times 3.4 \times 2.2 \times 1.12 = 0.27$$

So what we are going to do, so you can see we outline these multipliers and then this affect error and the assessed effect. So we multiplied as per the formula given in our earlier slides. So if we do this, this is the final result. So the final calculation for the normal likelihood of failure can therefore be 0.27. So that is the working hard. Now why we call it as working hard? It may happen that during further analysis, something can be changed, some situation can alter. That is why always we call it as working hard, not the hard calculation. We call it working hard.

General assumption

Securing drums during truck loading at dock

- **Event 1: Insecure Load**
  - Once the operator on the truck lowers a drum into position, the drum is secured in place with lashing belts to prevent the drum from rolling or sliding off the truck during transport.
  - Based on the failure of some or all of the tasks
  - The overall probability of failure to detect for an insecure drum load during truck loading is **3.17E-2**

Now what are the general assumptions we did? Now this is one more thing that is the securing the drums during the truck loading at a particular dock. So what is the event 1? Event 1 is the insecure load. First one is first event that is being identified for this particular case, the general assumption, under general assumption it is the insecure load. So once the operator on the truck lowers a drum into a particular position, the drum is secured in place with lashing bells to prevent the drums from rolling or sliding off the truck. So one upon it is there, if this lash is not there, it will fall. So that is the situation. Based on the failure of some or all of the task, any one if it miss, so everything will fall. The overall probability of failure to detect for an insecure drum load during truck loading will be then this. This is the value. Now if this is the event that the insecure load, if we go ahead or further we break it down, we will get the like failure to detect insecure clamping. So what are the things? Maybe because of lashing is not being done properly or some other things. Drums are not placed properly. So maybe we can take one step ahead to understand exactly what.

Securing drums during truck loading at dock

General assumption

- **Event 1.1: Failure to detect insecure clamping by ground operator self check and independent check**
  - The overall probability of failure to detect an insecure load by the operator on the ground and independent check by the operator on the truck is **3.13E-2**
  - **Event 1.1.1: Failure to detect insecure clamping by ground operator self-check**
    - The generic HEART task type taken to represent this task of clamping and ensuring it is secure is "*Fairly simple task performed rapidly or given scant attention*".
    - The generic task- type D
    - The nominal unreliability- 0.09
    - The next table shows the EPCs and their impacts

So failure to detect the insecure clamping by ground operator. So it is not while driving. So while actually ground operator were clamping them, so there may be a mistake or failure. Or operator self-check an independent check. So the overall probability of failure to detect an insecure load by the operator on the ground, an independent check by the operator on the truck, it will be like this. If we go further, maybe breaking down it further, failure to detect the insecure clamping by ground operator self-check. So first they did it, then they did a checking. And in that self-check, it is not being detected. Then what happens? The generic hard task type taken to represent this task of clamping and ensuring it is secure is fairly simple task. It is just clamping. So they realized it, it is fairly secure, a simple task performed rapidly and given scant attention. It is given scant attention. So it is one of the condition of your GTT. So maybe that is why it is a type D. A, B, C, D, E, F, G, H, so in the type D. So the nominal unreliability, therefore from the table it is 0.09 and the next table it shows that EPC and their impact. So you can see their impact and then slowly what you can do, you can use this particular formula and can find out this type of situation. So this way you can use the HEART or H E A R T tool to identify the human reliability and where the problem is, where you can reduce or where you can recommend the problem resolving area. So, there was an accident and major problem was actually here, self-check. So if that was being done properly, definitely the situation would not have arisen.

Advantages

- A very low demand on assessor resources and allows flexible assessments.
- Identifies the major influences on human performance in a systematic, repeatable fashion.
- Develop primarily for use in design assessments and appears to be most powerful and useful in this context.
- Can be incorporated by an Functional Task Analysis (FTA).
- Limited training is required.
- Capable of sensitivity analysis
- Versatile- HEART has a track record in various industries.

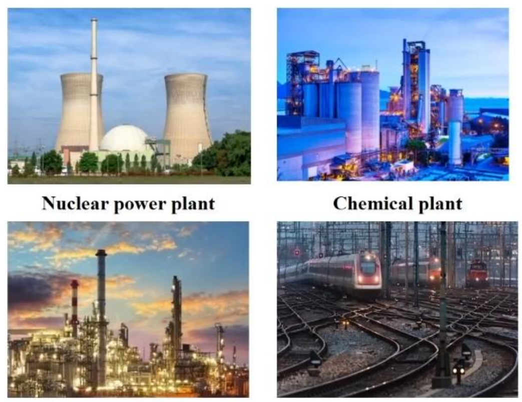
So what are the advantages of this particular technique? So a very low demand on accessors resources and allows flexible assessment, identifies the major influences on human performance in a systematic and repeatable fashion, developed primarily for use in design assessment and appears to be the most powerful and useful in this particular type of context and can be incorporated by an functional task analysis. So if you can do FTA along with this, it will be more effective, more strong tool. And it is very capable of sensitivity analysis as well. And it is very versatile, so HEART has a track record in various industry. It is not that it is only applicable for this or that or like that. So it is applicable for many industries. So that is why this is very useful tool.

Disadvantages

- The EPC data has never been fully released, it is therefore not possible to fully review the validity EPC database.
- Theoretical validation is required.
- HEART relies to a high extent on expert opinion. First in the point probabilities of human error, and also in the assessed proportion of EPC effect.
- The final HEPs are therefore sensitive to both optimistic and pessimistic assessor.
- The interdependence of EPCs is not modelled in this methodology, with the HEPs being multiplied directly.
- This assumption of independence does not necessarily hold in a real situation.

However it has some kind of disadvantages as well. What are those? The EPC data has never been fully released. So we can see this particular chart. This is the different types of condition. This is only 38 numbers. However it is assumed that actually it is more, but it is never being published properly. So it has limitation. Theoretical validation we need to do. HEART relies to a high extent on experts' opinion because if you are not expert in this example, you will not be able to get the analysis done properly. So you really need that first in the point of probabilities of human error and also in the assessed proportion of the EPC effect. Because if you cannot do that, then it is very difficult. You should be extremely expert person, very much expert person in that particular job. Then only you can have these proportion classification. Otherwise it is very difficult. The interdependency of EPC is not modeled in this particular methodology and these assumptions of the independence does not necessarily hold in a real situation. So these are the disadvantages of this particular tool.

Application area



Nuclear power plant | Chemical plant | Petrochemical plant | Railway system

Tools needed

- Pen & paper
- Spreadsheet

Now let us understand what are the major applicable area. So nuclear power plant, chemical plant, petrochemical, railway, aviation, many such industry where human reliability is real, real important factors to be considered to when we are talking about the safety of the whole system and complete functioning of the whole system. So we should be able to use this particular tool to assess, analyze and reduce the human error. And what do you need? We need only pen and paper and for data entry. We should have the spreadsheet with us. So this is all about heart and the next class we are going to study one more such tool which is known as CREAM that is the cognitive reliability and error analysis method.

Summary

- HEART is a qualitative human error probability assessment technique.
- It matches the task being assessed to one of the eight generic task descriptions from a given databases and then to modify the human error probabilities (HEPs) according to the presence and strength of the identified error producing conditions (EPCs).

So to summarize we can say that heart is a qualitative human error probability assessment technique. It matches the task being assessed to one of the nine generic task description from a given database and then to modify the human error probabilities that is the HEP according to the presence and the strength of the identified error producing conditions. So we should use or we should try to use this particular tool if you have access to such kind of data. Or what you can do, hypothetically you can use some data and try to implement and try to get the recommendation done from by using this particular tool. That is all for today's session. We will meet in the next session. Thank you.