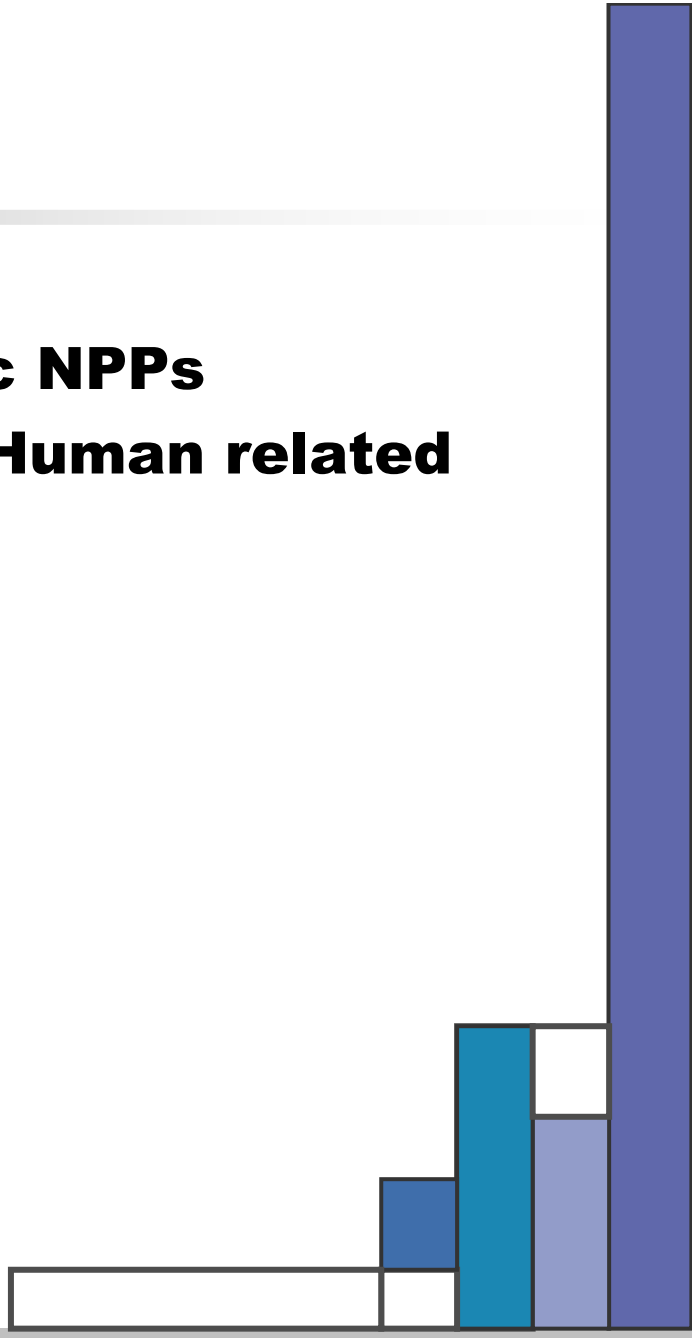
Development of a Root Cause Analysis Method for Human-Related Events

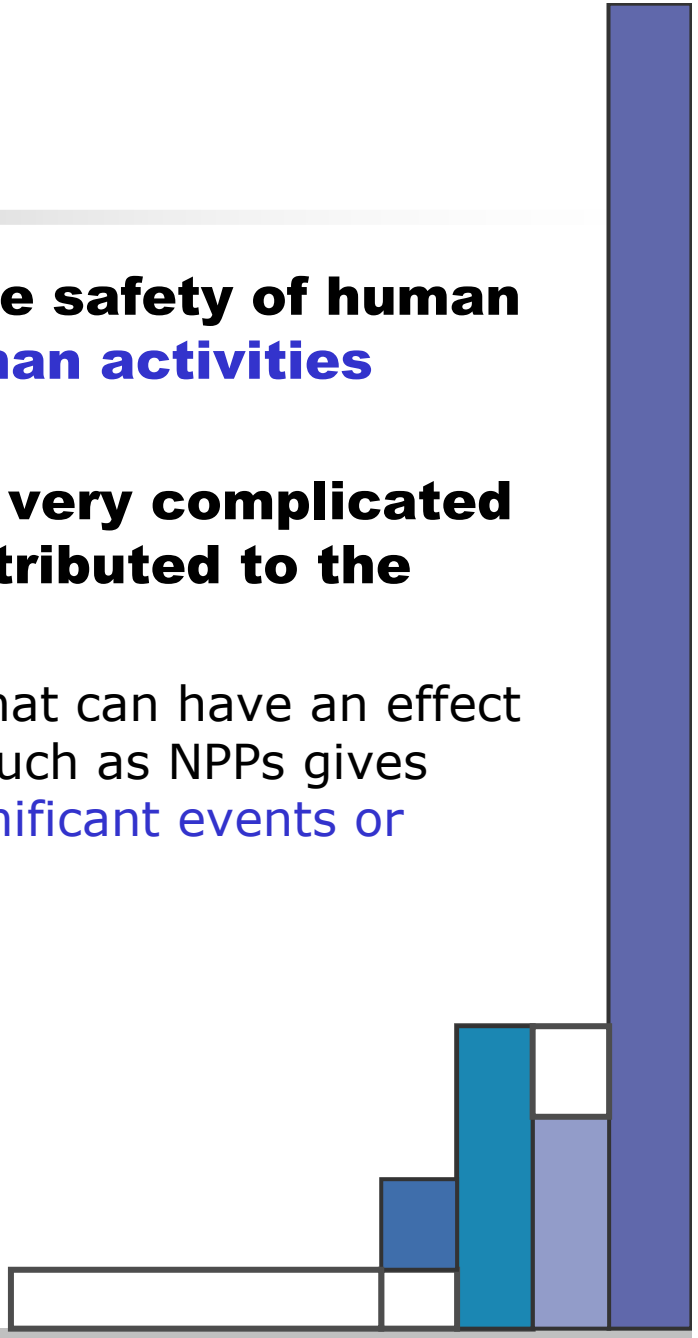
Operational Safety Analysis Department
Korea Institute of Nuclear Safety
Ji Tae, Kim
jtkim@kins.re.kr

Contents



Introduction

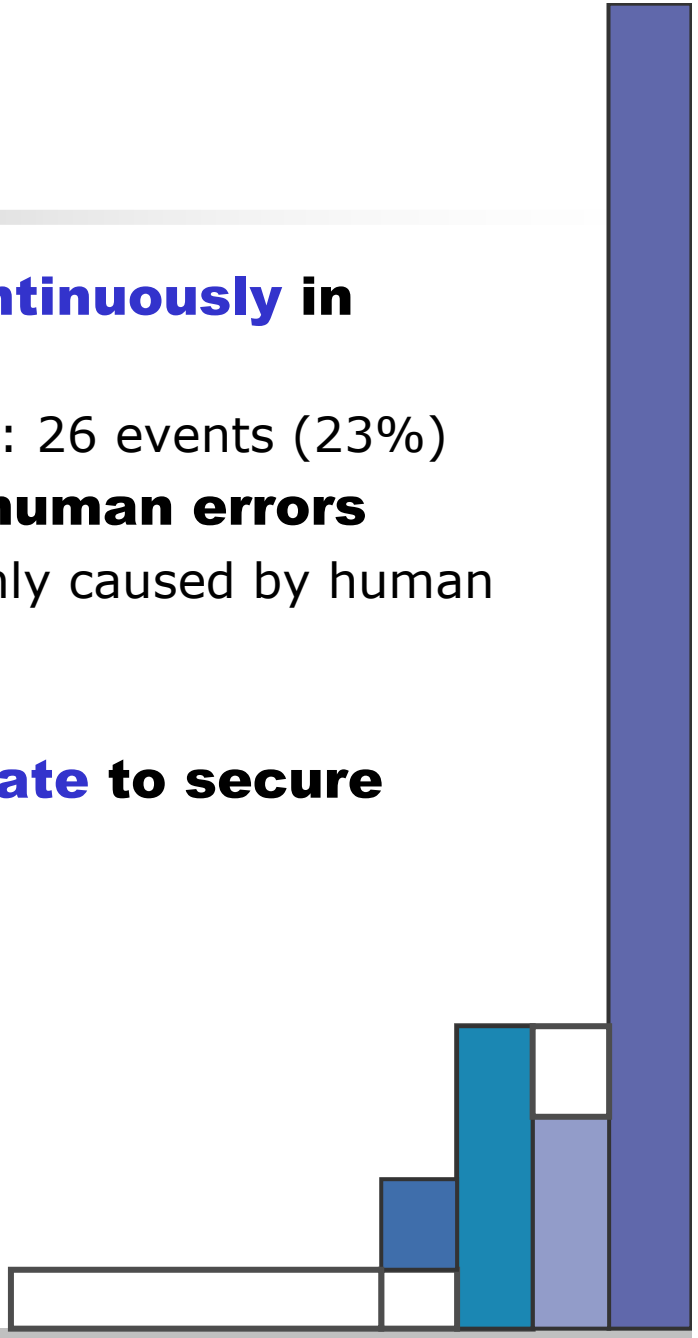
- **One of the most affecting factors to the safety of human involved facilities is inappropriate human activities (human errors).**
- **Human activities in NPP operation are very complicated and more than 30% of incidents are attributed to the human related factors. (WANO)**
  - Analyzing inappropriate human activities that can have an effect directly or indirectly on complex systems such as NPPs gives insights for the prevention of recurring significant events or near-miss.



Introduction

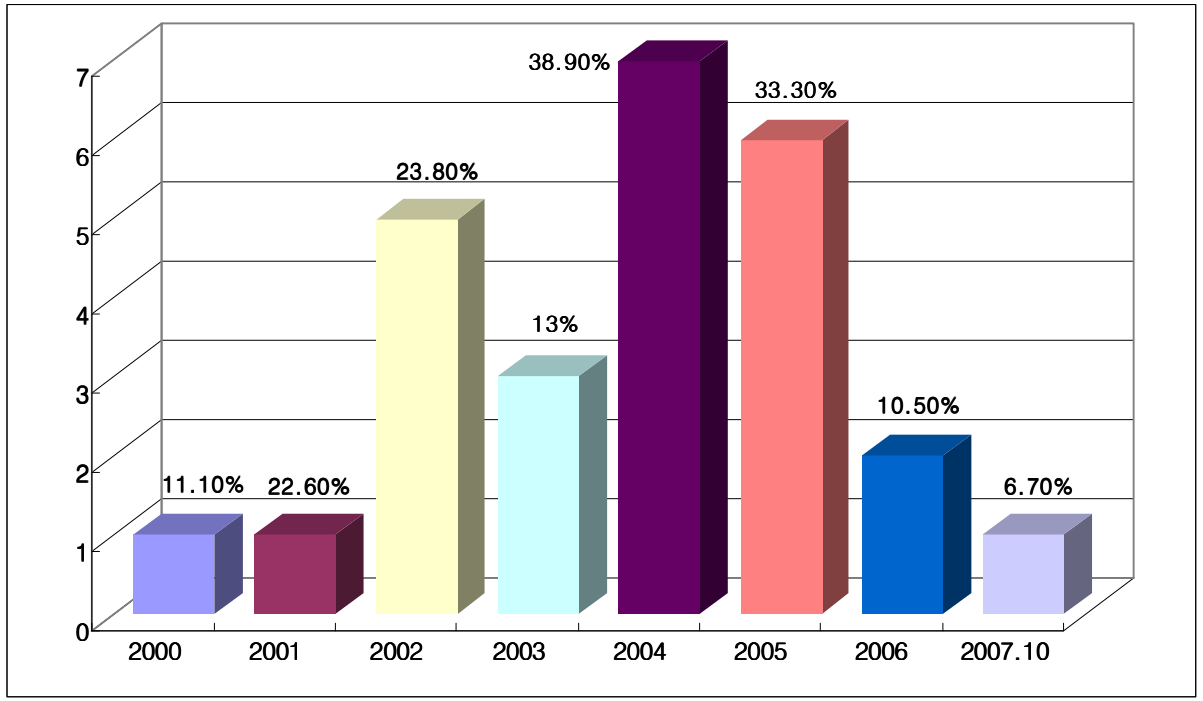
- **Events related human errors occur continuously in domestic nuclear facilities**
  - Reported events (114 events) since 2000 : 26 events (23%)
- **Possibility of significant event due to human errors**
  - TMI, Chernobyl, and JCO accident are mainly caused by human errors.

→ **Necessity of decreasing human error rate to secure safety of NPPs**



Recent Human Errors in domestic NPPs

- **Human errors in domestic NPPs**
  - 2000 ~ 2007.10 : 114 events are reported
    - ✓ **Human related events : 26 events (22.8%)**



Development of RCA method for Human related Events

- **Necessity**

Limitation of time for event investigation	✓ Almost event investigation reports are submitted in a few days. ✓ In the case of U.S NRC : about 45 days for event investigation
Limitation of inspectors for event investigation	✓ 2~3 inspectors of OSAD ✓ 1~2 inspectors (experts) of related Dep't as characteristics of event
Less experiences of RCA about human related events	✓ Priority : Inspectors (experts) who have knowledge about event-related parts ✓ When Inspectors do not have knowledge of human engineering
No practical RCA method for human related events	✓ Lack of objectivity of analysis results for events ✓ Difficulties for establishment of long-term regulation

Development of RCA method that an inspector can use easily

Human related event Root cause Analysis Method

(HuRAM)

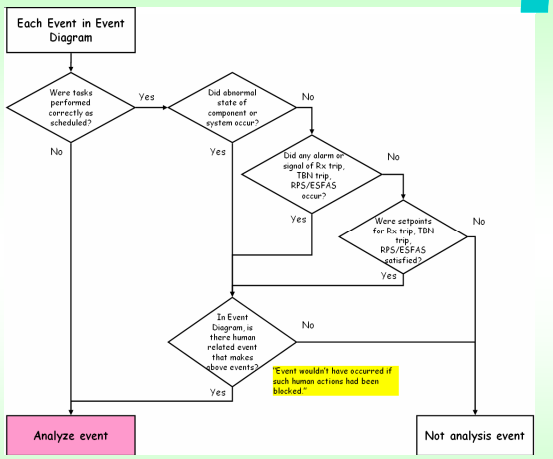
Development of RCA method for Human related Events

Objective

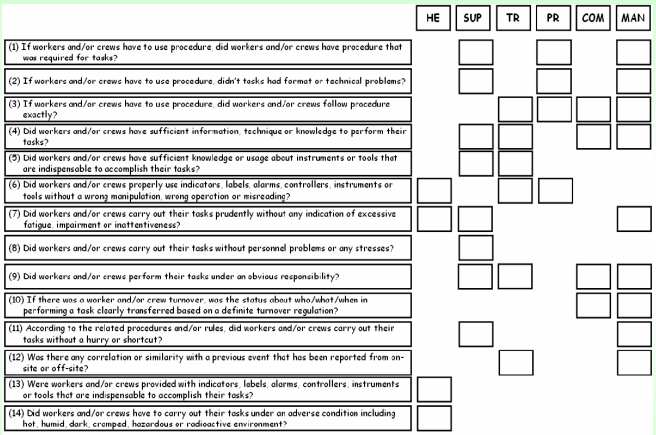
Compact analysis method	✓ In short investigation time
Objective analysis method	✓ No differences of analysis results
Clear analysis method	✓ No dependencies for inspector's knowledge & experience about human engineering

✓ HuRAM

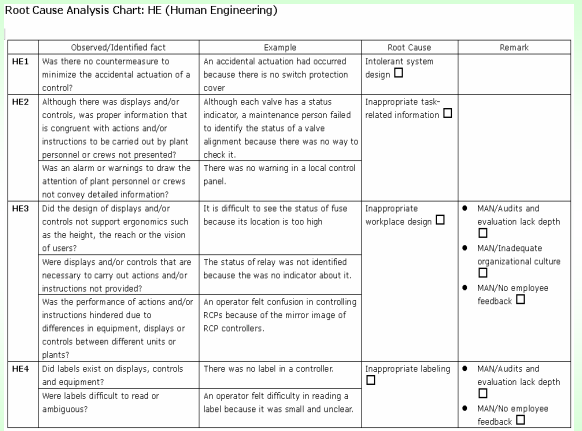
Compact analysis method	✓ Analysis Event Selection Chart
Objective analysis method	✓ General Guidelines & RCA Chart
Clear analysis method	✓ Questionnaires of RCA Chart



✓ Analysis Event Selection Chart



✓ General Guidelines



Root Cause Analysis Chart: HE (Human Engineering)

	Observed/Identified fact	Example	Root Cause	Remark
HE1	Was there no countermeasure to minimize the accidental actuation of a control?	An accidental actuation had occurred because there is no switch protection cover	Intolerant system design ☐	
HE2	Although there was displays and/or controls, was proper information that is congruent with actions and/or instructions to be carried out by plant personnel or crews not presented?	Although each valve has a status indicator, a maintenance person failed to identify the status of a valve alignment because there was no way to check it.	Inappropriate task-related information ☐	
	Was an alarm or warnings to draw the attention of plant personnel or crews not convey detailed information?	There was no warning in a local control panel.		
HE3	Did the design of displays and/or controls not support ergonomics such as the height, the reach or the vision of users?	It is difficult to see the status of fuse because its location is too high	Inappropriate workplace design ☐	• MAN/Audits and evaluation lack depth ☐ • MAN/Inadequate organizational culture ☐ • MAN/No employee feedback ☐
	Were displays and/or controls that are necessary to carry out actions and/or instructions not provided?	The status of relay was not identified because the was no indicator about it.		
	Was the performance of actions and/or instructions hindered due to differences in equipment, displays or controls between different units or plants?	An operator felt confusion in controlling RCPs because of the mirror image of RCP controllers.		
HE4	Did labels exist on displays, controls and equipment?	There was no label in a controller.	Inappropriate labeling ☐	• MAN/Audits and evaluation lack depth ☐ • MAN/No employee feedback ☐
	Were labels difficult to read or ambiguous?	An operator felt difficulty in reading a label because it was small and unclear.		

✓ RCA Charts

Development of RCA method for Human related Events

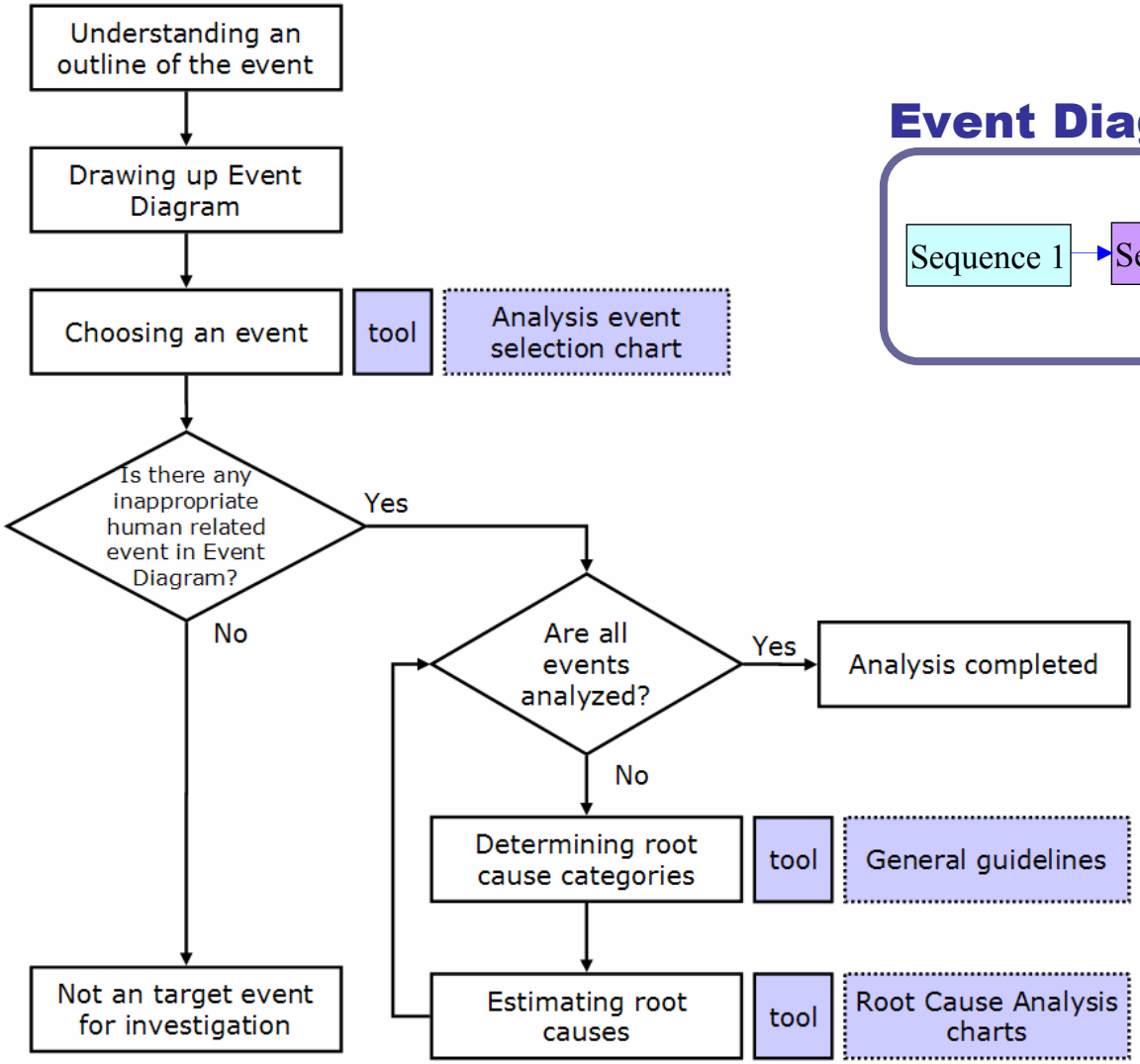
- **HuRAM (Category & Root Cause)**

Root Cause Category	Near Root Cause	Root Cause
Human Engineering (HE)	2	6
Supervision (SUP)	4	9
Training (TR)	4	8
Procedure (PR)	4	24
Communications (COM)	3	10
Management System (MAN)	6	20

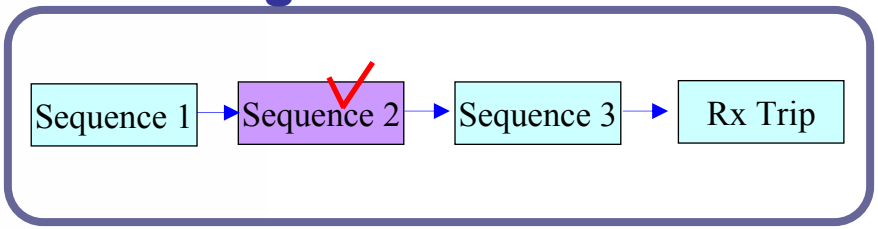
HE Category

Root Cause Category	Near Root Cause	Root Cause
Human Engineering (HE)	Deficient human machine interface (HMI) design	Inappropriate workplace design
		Inappropriate labeling
		Inappropriate task related information
		Intolerant system design
	Stressful task environment	Inappropriate work environment
		Inappropriate workload

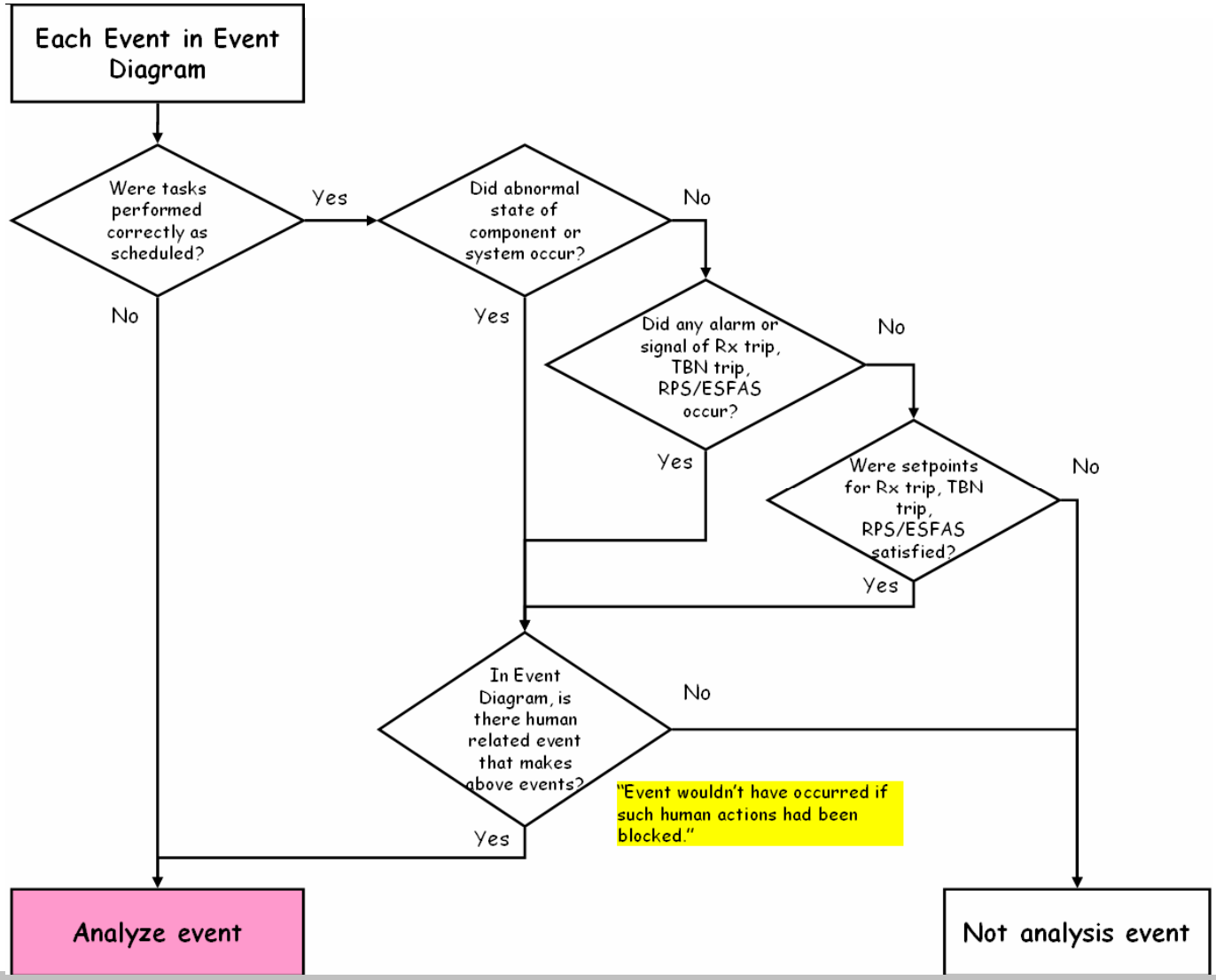
Process of HuRAM



Event Diagram



HuRAM – Analysis Event Selection Chart



HuRAM – General Guidelines

General Guidelines

	Category					
	HE	SUP	TR	PR	COM	MAN
(1) If workers and/or crews have to use procedure, did workers and/or crews have procedure that was required for tasks?		☐		☐		☐
(2) If workers and/or crews have to use procedure, didn't tasks had format or technical problems?		☐		☐		☐
(3) If workers and/or crews have to use procedure, did workers and/or crews follow procedure exactly?			☐	☐	☐	☐
(4) Did workers and/or crews have sufficient information, technique or knowledge to perform their tasks?		☐	☐		☐	☐
(5) Did workers and/or crews have sufficient knowledge or usage about instruments or tools that are indispensable to accomplish their tasks?		☐	☐			
(6) Did workers and/or crews properly use indicators, labels, alarms, controllers, instruments or tools without a wrong manipulation, wrong operation or misreading?	☐		☐	☐		
(7) Did workers and/or crews carry out their tasks prudently without any indication of excessive fatigue, impairment or inattentiveness?	☐	☐				☐
(8) Did workers and/or crews carry out their tasks without personnel problems or any stresses?		☐				
(9) Did workers and/or crews perform their tasks under an obvious responsibility?		☐	☐		☐	☐
(10) If there was a worker and/or crew turnover, was the status about who/what/when in performing a task clearly transferred based on a definite turnover regulation?					☐	☐
(11) According to the related procedures and/or rules, did workers and/or crews carry out their tasks without a hurry or shortcut?		☐				☐
(12) Was there any correlation or similarity with a previous event that has been reported from on-site or off-site?			☐			☐
(13) Were workers and/or crews provided with indicators, labels, alarms, controllers, instruments or tools that are indispensable to accomplish their tasks?	☐					
(14) Did workers and/or crews have to carry out their tasks under an adverse condition including hot, humid, dark, cramped, hazardous or radioactive environment?	☐					

HuRAM – Root Cause Analysis Chart

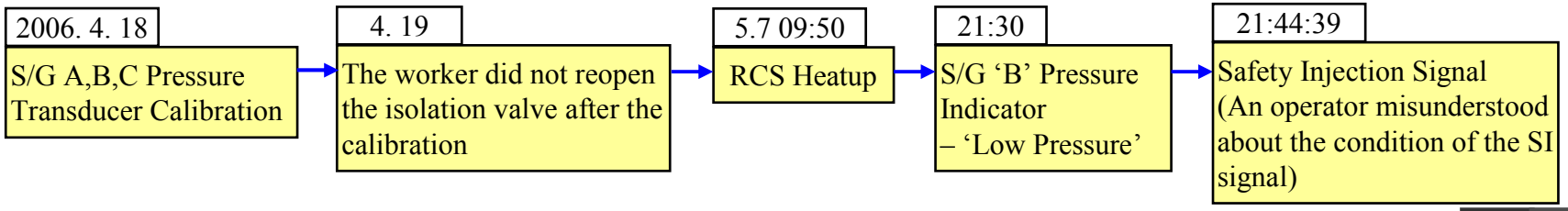
Root Cause Analysis Chart: HE (Human Engineering)

	Observed/Identified fact	Example	Root Cause	Remark
HE1	Was there no countermeasure to minimize the accidental actuation of a control?	An accidental actuation had occurred because there is no switch protection cover	Intolerant system design ☐	
HE2	Although there was displays and/or controls, was proper information that is congruent with actions and/or instructions to be carried out by plant personnel or crews not presented?	Although each valve has a status indicator, a maintenance person failed to identify the status of a valve alignment because there was no way to check it.	Inappropriate task-related information ☐	
	Was an alarm or warnings to draw the attention of plant personnel or crews not convey detailed information?	There was no warning in a local control panel.		
HE3	Did the design of displays and/or controls not support ergonomics such as the height, the reach or the vision of users?	It is difficult to see the status of fuse because its location is too high	Inappropriate workplace design ☐	• MAN/Audits and evaluation lack depth ☐ • MAN/Inadequate organizational culture ☐ • MAN/No employee feedback ☐
	Were displays and/or controls that are necessary to carry out actions and/or instructions not provided?	The status of relay was not identified because the was no indicator about it.		
	Was the performance of actions and/or instructions hindered due to differences in equipment, displays or controls between different units or plants?	An operator felt confusion in controlling RCPs because of the mirror image of RCP controllers.		
HE4	Did labels exist on displays, controls and equipment?	There was no label in a controller.	Inappropriate labeling ☐	• MAN/Audits and evaluation lack depth ☐ • MAN/No employee feedback ☐
	Were labels difficult to read or ambiguous?	An operator felt difficulty in reading a label because it was small and unclear.		

HuRAM – Analysis Example

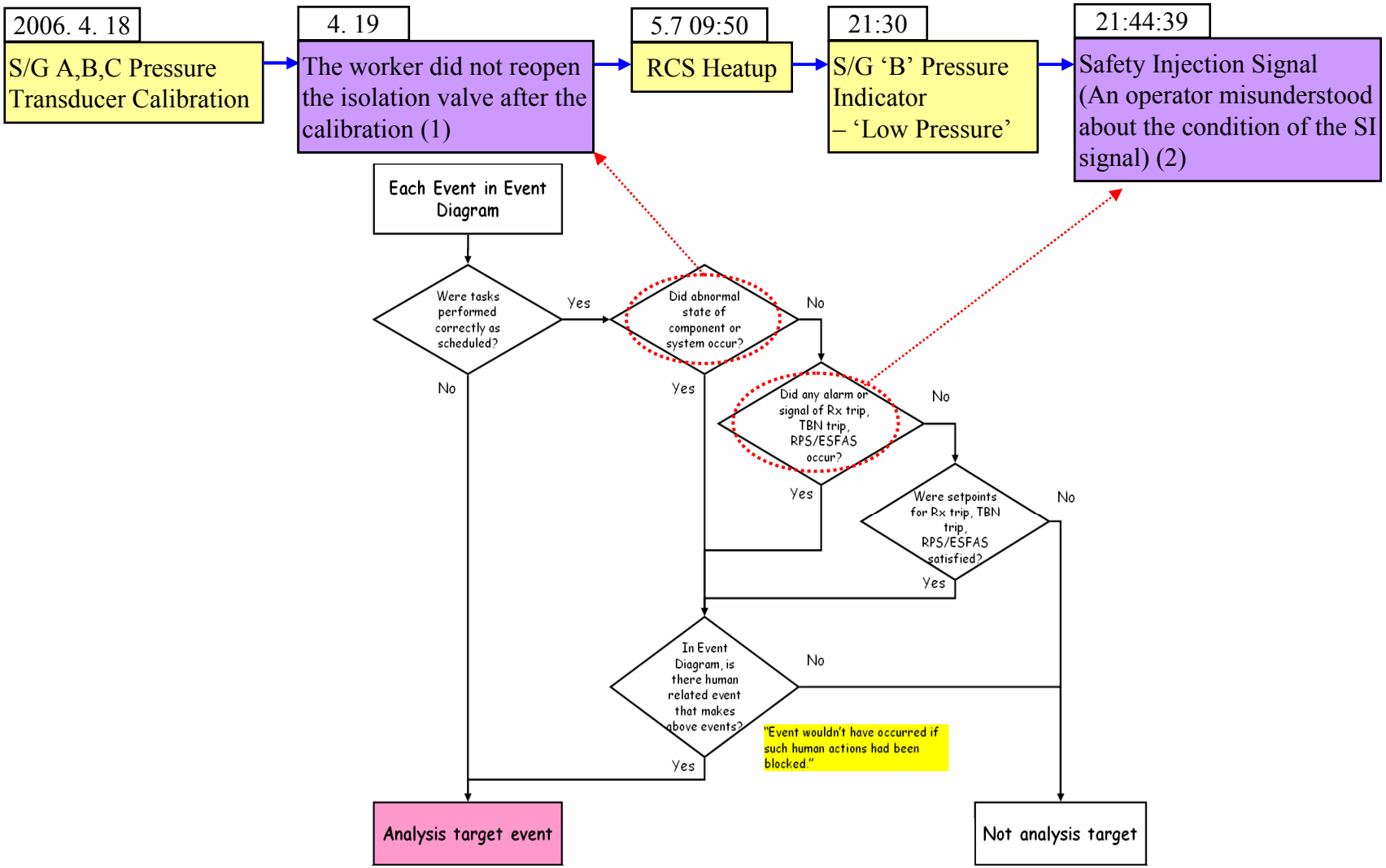
- **Event : Spurious Safety Injection during RCS Heatup**
  - ✓ Date of Event : 2006. 5. 7
    Plant Name : Ulchin-1
    Reactor Type : PWR
    Reactor Supplier : Framatome

- **Event Diagram**



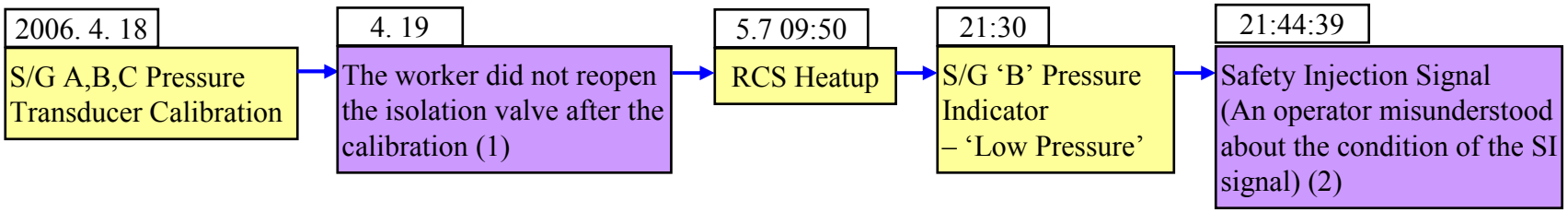
HuRAM – Analysis Example

- **Event Diagram**



HuRAM – Analysis Example

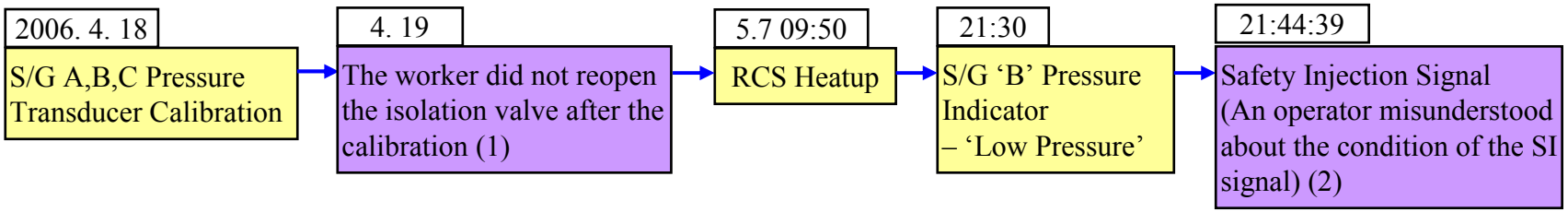
- **Event Diagram**



	HE	SUP	TR	PR	COM	MAN
(1) If workers and/or crews have to use procedure, did workers and/or crews have procedure that was required for tasks?		√		√		√
(2) If workers and/or crews have to use procedure, didn't tasks had format or technical problems?						
(3) If workers and/or crews have to use procedure, did workers and/or crews follow procedure exactly?						
(4) Did workers and/or crews have sufficient information, technique or knowledge to perform their tasks?						
(5) Did workers and/or crews have sufficient knowledge or usage about instruments or tools that are indispensable to accomplish their tasks?						
(6) Did workers and/or crews properly use indicators, labels, alarms, controllers, instruments or tools without a wrong manipulation, wrong operation or misreading?	√		√	√		
(7) Did workers and/or crews carry out their tasks prudently without any indication of excessive fatigue, impairment or inattentiveness?						
(8) Did workers and/or crews carry out their tasks without personnel problems or any stresses?						
(9) Did workers and/or crews perform their tasks under an obvious responsibility?						
(10) If there was a worker and/or crew turnover, was the status about who/what/when in performing a task clearly transferred based on a definite turnover regulation?						
(11) According to the related procedures and/or rules, did workers and/or crews carry out their tasks without a hurry or shortcut?						
(12) Was there any correlation or similarity with a previous event that has been reported from on-site or off-site?						
(13) Were workers and/or crews provided with indicators, labels, alarms, controllers, instruments or tools that are indispensable to accomplish their tasks?						
(14) Did workers and/or crews have to carry out their tasks under an adverse condition including hot, humid, dark, cramped, hazardous or radioactive environment?						

HuRAM – Analysis Example

Event Diagram



Root Cause Analysis Chart: SUP (Supervision)

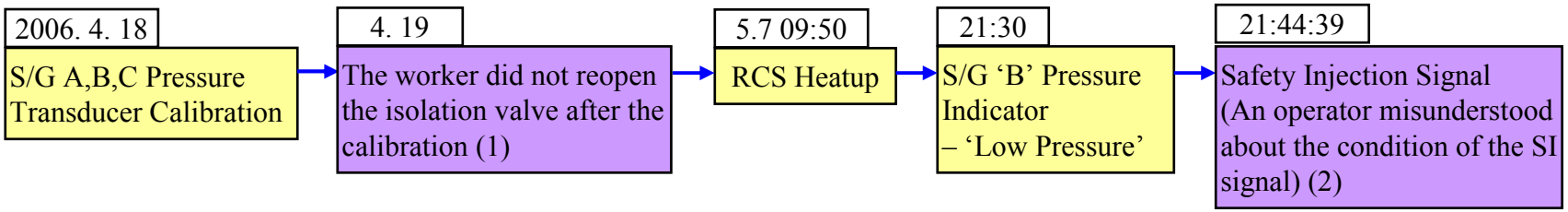
	Observed/Identified fact	Example	Root Cause	Remark
SUP1	Did plant personnel or crews not have crucial resources (information including the effect of failures in actions and/or instructions, related procedures, etc.) that are critical to perform the task?	Maintenance person did not know the importance of an assigned task because there is no indication about the result of failures in carrying out the task.	No preparation ☐	• MAN/Inadequate communication of SPAC ☐ • MAN/Inadequate organizational culture ☐
SUP2	Was supervisor not present during the performance of actions and/or instructions?	An operator carried out an critical action.	No supervision ☐	MAN/Inadequate organizational culture ☐
SUP3	Did supervisor promptly order additional actions and/or instructions when plant personnel or crews were carrying out their actions or instructions?	A supervisor instantly asked a maintenance person who are carrying out his task to perform additional work.	Inappropriate job plan ☑	• MAN/Inadequate communication of SPAC ☐ • MAN/Inadequate organizational culture ☐

✓ ***(1) Root Cause Category :*** **SUP**

Root Cause : **Inappropriate job plan**

HuRAM – Analysis Example

Event Diagram



Root Cause Analysis Chart: TR (Training)

	Observed/Identified fact	Example	Root Cause	Remark
TR1	Although plant personnel or crews mastered the required KSA (knowledge, skill, ability), did they forget how to apply KSA in performing actual actions and/or instruction?	Although an operating crew was regularly trained how to control the level of SGs during startup, SG level control failed in actual case.	Failure to apply relevant knowledge ☑	
TR2	Were any actions and/or instructions which cause irrelevant human behaviors not included in a training program?	An operating crew did not have sufficient experience about turbine operations under a normal startup condition because of a training program that deals with a limited power condition.	Not training program ☐	

- ✓ ***(1) Root Cause Category :*** **SUP**

  Root Cause : **Inappropriate job plan**
- ✓ ***(2) Root Cause Category :*** **Training**

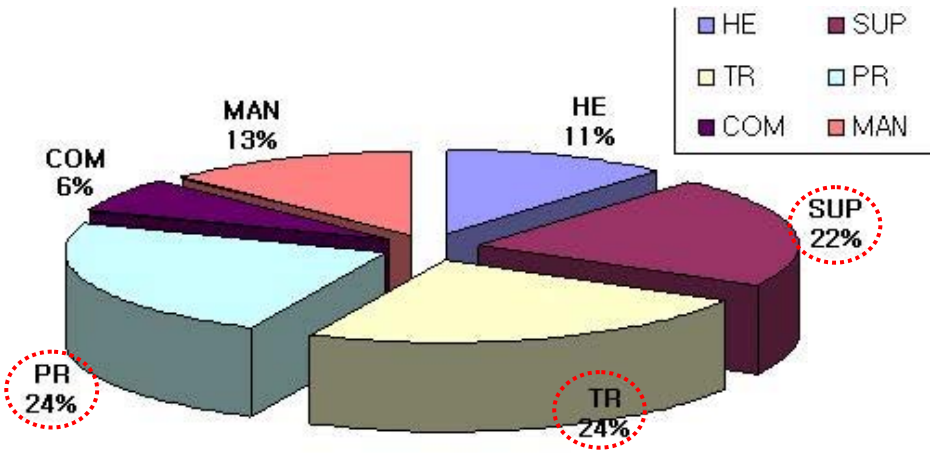
  Root Cause : **Failure to apply relevant knowledge**

Analysis Results using HuRAM

- ✓ **Analyzed Events : 116 in 137 human related events (1986~2006)**

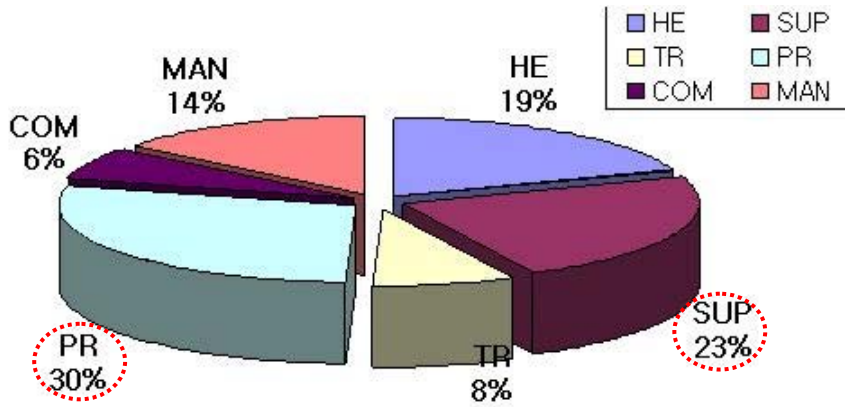
  Events occurred in Primary System : 37 events

  Events occurred in Secondary System : 79 events



Analysis Results using HuRAM

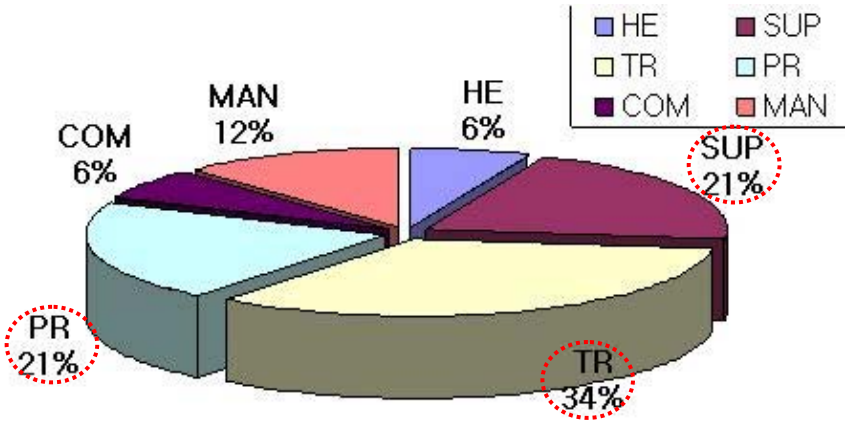
Primary system



Root Cause Category	Primary
Procedure	22 (30%)
Supervision	18 (23%)
Human Engineering	15 (19%)
Management	11 (14%)
Training	6 (8%)
Communication	5 (6%)
Total	77

Analysis Results using HuRAM

Secondary System



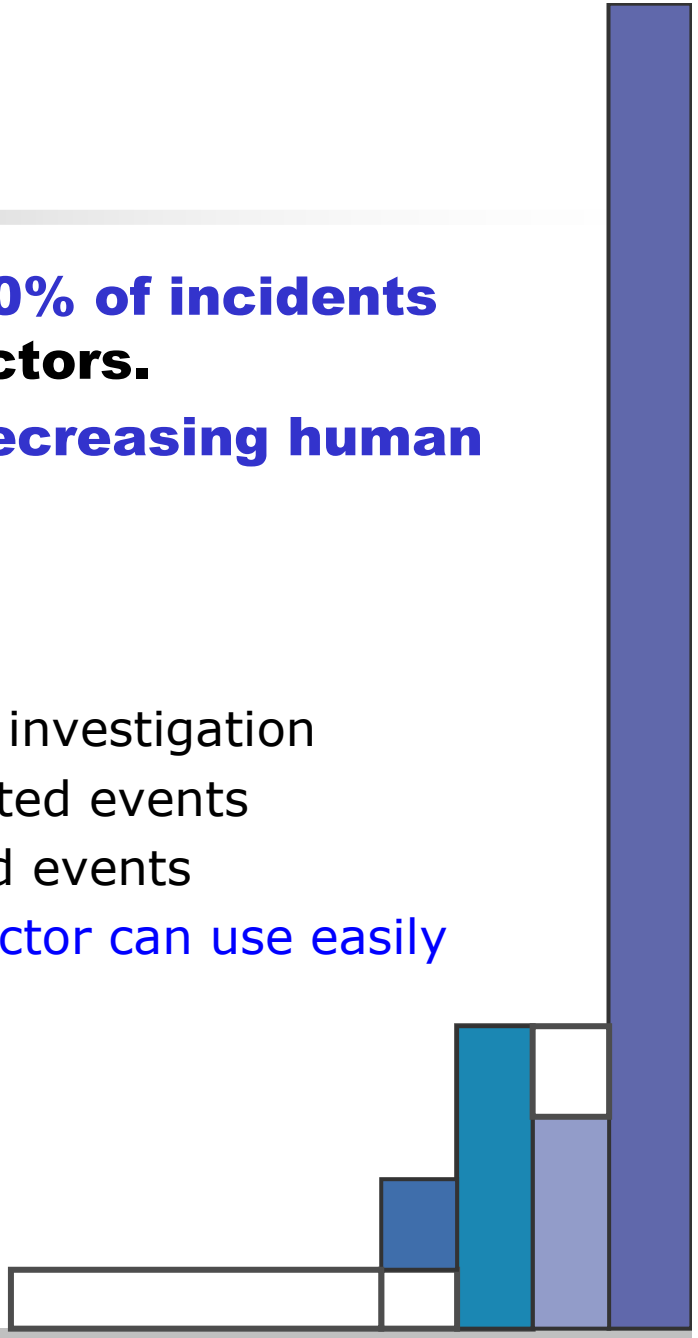
Root Cause Category	Secondary
Training	42 (34%)
Supervision	26 (21%)
Procedure	26 (21%)
Management	15 (12%)
Communication	8 (6%)
Human Engineering	8 (6%)
Total	125

Conclusion

- **Recent reports show that more than 30% of incidents are attributed to the human related factors.**
- **It is necessary to have a method for decreasing human error rate to secure safety of NPPs**

- **Necessity & Objective of HuRAM**
  - Limitation of time and inspectors for event investigation
  - Less experiences of RCA about human related events
  - No practical RCA method for human related events

  → Development of RCA method that an inspector can use easily

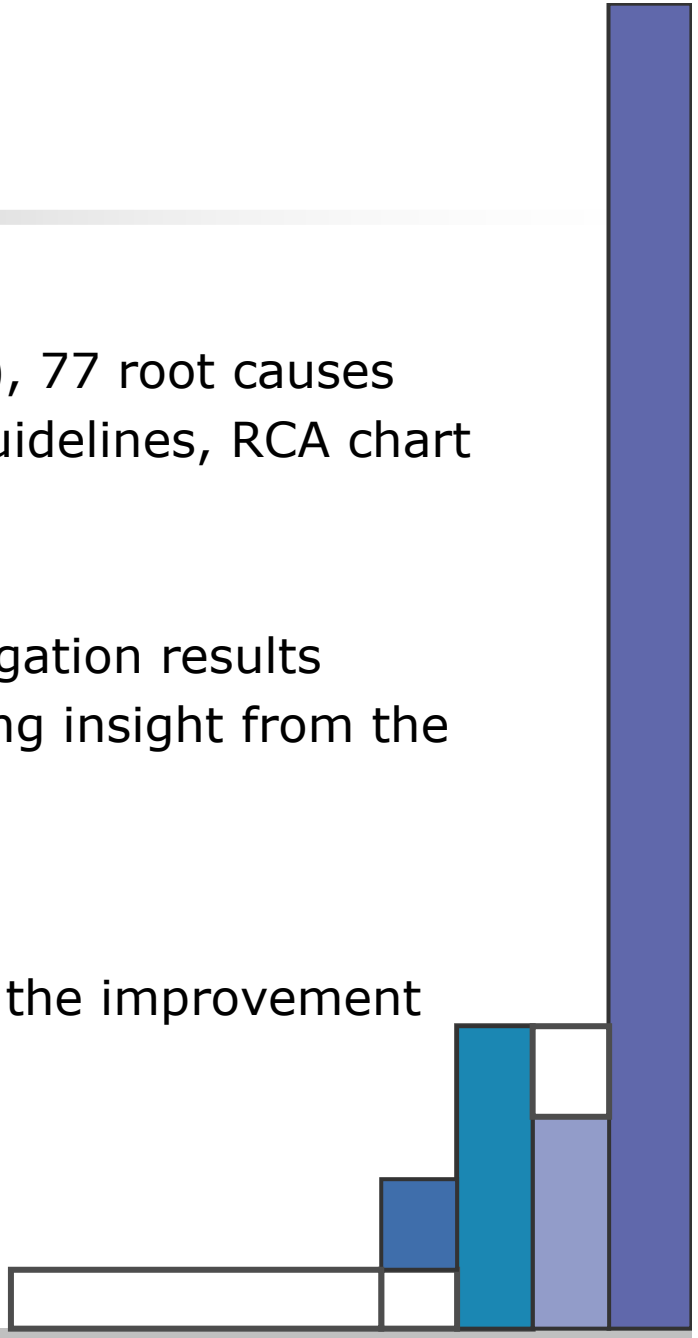


Conclusion

- **HuRAM has**
  - 6 Categories (HE, SUP, TR, PR, COM, MAN), 77 root causes
  - Analysis Target Selection chart, General Guidelines, RCA chart

- **With HuRAM,**
  - Assurance of confidence for current investigation results
  - Reflection of regulatory policy and/or getting insight from the analyzed results

- **Further works**
  - ✓ Assuring objectivity of the HuRAM through the improvement and refinement
  - ✓ Database development for RCA results



Thank you for your attention.