

Handbook on Training Observation for Qualitative Analysis of The Human Reliability Analysis with Emphasis on Narratives

Kenichi Hayase¹, Daisuke Takeda²

¹ Central Research Institute of Electric Power Industry: 2-6-1 Nagasaka, Yokosuka-shi, Kanagawa 240-0196 JAPAN, hayase@criepei.denken.or.jp

² Central Research Institute of Electric Power Industry: 2-6-1 Nagasaka, Yokosuka-shi, Kanagawa 240-0196 JAPAN, d-takeda@criepei.denken.or.jp

ABSTRACT

As a part of the technological improvement of probabilistic risk assessment (PRA) methods, it is necessary to improve human reliability analysis (HRA) that quantitatively assesses the probability of human errors. As a HRA methodology reflecting reality more appropriately, the Nuclear Risk Research Center (NRRC) published “Guide for Qualitative Analysis in The Human Reliability Analysis (HRA) with Emphasis on Narratives” in FY2018 and revised it in FY2020 and FY2023. Of the techniques for collecting information described in the Guide, observations of training and interviews with personnel relevant to tasks to be analyzed are both ways of collecting information from people, which require tips and know-how to efficiently obtain quality sources of information that are necessary for appropriately reflecting realities when performing HRA.

This Handbook covering observation of training systematically compiles tips and know-how for obtaining correct information relevant to the actual situation in a plant, which HRA practitioners can refer to when observing training of the tasks. The tips and know-how are incorporated from knowledge on observing methods obtained from HRA-related literature such as the reports of the Halden Reactor Project and from literature on observing methods in fields such as ergonomics, as well as from hearing survey for experts in observing operator’s behavior in simulator experimental studies.

Keywords: Human Reliability Analysis, Narrative, Training, Observation

I. INTRODUCTION

Probabilistic risk assessments (PRAs) need to take into account not only facility and equipment failures but also human failure events (HFEs) which are events happening in situations where operators/other personnel are executing certain tasks and unable to achieve the task objective or fail to accomplish the task, thereby significantly impacting an accident. The probability of failing at such tasks is known as a human error probability (HEP), the assessment of which is required to be made through a human reliability analysis (HRA).

Various HRA techniques have been proposed thus far, but whichever the employed technique may be, the key to HRA that appropriately reflects realities is having a good understanding of actual field conditions for task execution. To this end, it is important to perform a qualitative analysis to develop “Narratives,” with regard to plant-specific and accident scenario-specific conditions that affect human performance. As such, the Nuclear Risk Research Center (NRRC) of the Central Research Institute of Electric Power Industry (CRIEPI) developed a guide on HRA qualitative analyses (HRA Guide) [1].

The HRA Guide defines the following three elements comprising narratives for tasks required to respond to the PRA accident scenario:

- (1) Task structure information: information regarding plant conditions concerning task structure such as subtasks (“cognitive task” and “execution task”) that comprise a task and their relationships to each other, and error recoveries of each subtask.

- (2) Time progression information: information regarding plant conditions concerning time such as the time limit for task completion and the time required to perform each of the above subtask.
- (3) Performance shaping factors (PSFs) information: information regarding factors that affect personnel in performing each of the above subtask.

The HRA Guide also presents the following three techniques for collecting information to develop narratives:

- (a) Review of plant information and scenario consideration results
- (b) Field investigation and observation of training
- (c) Interviews with relevant personnel

From the aspect of understanding actual field conditions to perform HRA that appropriately reflects realities, the Guide considers items (b) and (c) as important information-collecting methods.

Of the three techniques for collecting information described in the HRA Guide, observations of training and interviews referred to in items (b) and (c) respectively are both ways of collecting information from people. Since time and opportunities for observations of training and interviews are limited, HRA practitioners need tips and know-how to efficiently obtain accurate information concerning actual field conditions.

And, so, NRRC compiled a handbook on interview methods that systematically organizes tips and know-how for conducting interviews with relevant personnel to efficiently obtain accurate information on the actual situation in the field [2][3]. Then, NRRC compiled a handbook on observation of training as well and integrated it with the handbook on interview methods [4].

II. PURPOSE

The purpose of this paper is to present the contents of the handbook on observation of training (hereinafter the “Handbook”) systematically compiles tips and know-how for obtaining correct information relevant to the actual situation in a plant, which HRA practitioners can refer to when observing training of the tasks. The tips and know-how of training observation are based on the literature on HRA qualitative analysis of the MTO (Man-Technology-Organisation) program of the Halden Reactor Project¹⁾ [5][6], which contains many relevant findings, and incorporate findings from training observation methods obtained by reviewing other HRA-related literature as well as literature on ergonomics methods of behavioral observations. In addition, findings about behavior observation interviewed from researchers of Norway’s Institute for Energy Technology (interview date: September 2, 2022), who are experienced in observing operator behavior in simulator experiments for operators²⁾, will be incorporated.

III. TRAINING OBSERVATION METHODS

Training observation targets operator training using training simulators and worker training for field operations. HRA practitioners visit the training center or plant to attend the training of the task to be assessed and observe operator and worker behavior such as cooperation, communication methods and use of procedure manuals. If necessary and possible, questions are asked after the training. This Q&A session helps verify PSF (Performance Shaping Factors) which affect behavior and decision making behind the behavior.

IV. Preparation of Training Observation

IV.A. Preparing resources and other materials used in interviews

(1) Prepare resources to explain an accident scenario and task

¹⁾ The project has been carried out under the auspices of the Organisation for Economic Co-operation and Development’s Nuclear Energy Agency (OECD/NEA). It is an international joint research project for the purpose of safely and reliably operating nuclear power plants and administered by Norway’s Institute for Energy Technology.

²⁾ Conducted in the MTO program (until 2020) of the Halden Reactor Project and the succeeding Halden HTO (Human-Technology-Organisation) Project (after 2021).

If necessary and possible, ask questions after observing training. If accident scenarios and tasks need to be explained with such questions, prepare resources to explain the following content about the accident scenarios and tasks to relevant personnel [1][6].

- Initiating events, initial conditions for systems and personnel (the status and condition of systems and personnel that have implications for accident scenario progression)
- Task situations (e.g. various constraints in settings where the task is executed)
- Time information (e.g. time limit for tasks)

(2) Prepare resources to be used during training observation and questions to be asked after training observation

Prepare resources that organize the tasks in chronological order (in a format where unclear points can be marked and questions can be noted) so that the training scenario can be followed during the observation.

List up items to be observed and prepare questions to be asked after the training observation by referencing examples of items and content of collected information presented in Chapter 4 of the HRA Guide (examples of items and survey contents pertaining to task structure information, time progression information, PSF information) and examples of evaluations provided in appendices to the HRA Guide [1]. In doing so, it is desirable to cooperate with people with good operation knowledge such as training personnel.

(3) Prepare supplementary resources for the Q&A session after training observation

Based on the documents collected in the “consideration of accident scenario and identification of tasks” phase, prepare materials that may be used as supplemental material to be presented to relevant personnel during the Q&A session after the training observation, such as procedures, relevant photos (e.g. facilities and tools used while tasks are underway), facility layout drawings, and event reports [7][8][9].

If necessary, also create figures and tables that would be helpful for the Q&A session after the training observation [7].

(4) Verify prepared resources and other materials

Verify that the resources and other materials prepared in items (1) to (3) for the Q&A session after the training observation use proper expressions (e.g. accuracy as to equipment name of facility, use of terms that relevant personnel can understand).

When buffer time is not enough for the Q&A session after the training observation, pick essential items that must be asked in the Q&A session [10].

If an HRA practitioner prepared resources and other materials alone, ask individuals such as other members of the HRA team to verify the materials.

(5) Other pre-training observation preparation

Re-verify documents on such topics as design and operation/maintenance management [5][6][11].

From the PRA perspective, re-verify the importance of the tasks that are to be assessed [12]. Understand the content of previous events, if relevant event reports are available [5][6][7].

When holding a Q&A session after the training, understand the terms used in accident scenarios and tasks, and get used to talking about the scenarios and tasks in those terms before the Q&A session [11][13].

IV.B. Arranging training observation

(1) Select observation targets and coordinate the date, time and location of the visit

Request the plant contact to coordinate the date and time to visit the plant or training center so that HRA practitioners can visit according to the schedule of the training that includes the task to be assessed.

Even if the training schedule that includes the task to be observed conflicts with availability, general information can be obtained about operator behavior at the plant to be assessed, use of procedure manuals and interface of the control room by observing other trainings [6][7]. Thus, request coordination of training observation of a different task, as needed, if such information collection is beneficial even if it is training of a different task.

(2) Prepare observation methods

To observe behavior in detail and collect information, prepare videotaping and recording equipment. However, it is necessary to gain consent for videotaping and recording the observation in advance. It is very difficult to observe behavior in detail and take notes during the training without videotaping or recording the observation.

Many HRA practitioners are required as observers if the observation cannot be videotaped or recorded despite observation targets and information to be collected being a wide range. For example, assign an observer dedicated to recording time when focusing on information on the time required for a task, or assign an observer for each operator to be followed when observing multiple operators.

If there is narrative information (e.g. data of time until operators notice signs such as alarms) that is collectable with the training simulator system on the day of the training, request the plant contact to provide such information.

(3) Prepare knowledge on the plant

The more familiar HRA practitioners conducting the observation are with tasks to be assessed, control room, interface and the plant, the more reliable information can be collected through the observation. It is desirable for HRA practitioners with such knowledge to conduct the observation.

It is also beneficial to have training instructors knowledgeable about such information to be present at the training observation and Q&A session after the training observation, so request the plant contact to have training instructors attend the observation if possible.

V. OBSERVING TRAINING

In order to obtain necessary information within the allotted time and in step with the training observation objective, observe trainings while thoroughly bearing in mind the precautions of training observation (see VII. PRECAUTIONS OF TRAINING OBSERVATION). Note that trainings may not necessarily be observed according to the flow described in this Handbook due to conflicts with the training schedule, but in this case, observe trainings according to said flow as much as possible.

(1) Exchange greetings and explain the objective of training observation

Exchange greetings and self-introductions. Also, thank the observed personnel for setting aside time and cooperating with the training observation.

Explain that training observation is very important as a way to understand the actual conditions for HRA appropriately reflecting reality. Also, explain how information obtained through it will be utilized [5][7][14].

(2) Explain the recording methods

Explain how the training observation will be recorded (e.g. videotaped and notes taken) and how the recorded information will be handled.

Before videotaping or recording the observation, gain consent of the relevant personnel subject to training observation [7].

(3) Training observation

Even when videotaping and recording the observation, immediately take notes so that uncertainties and questions that arise during the observation are not forgotten [5][7].

When videotaping and recording the observation, record the time of important events instead of taking notes of everything, so that details can be confirmed with footage and audio later.

Also, it is beneficial to have training personnel accompany the training observation. They may help interpret what is going on in the training or point out operator behavior that might not be noticed by HRA practitioners [5].

(4) Participate in post-training debriefing

By attending the post-training debriefing between the operators and training personnel, HRA practitioners can gain insight on what the operators were thinking when they executed the task [5].

(5) Q&A after training observation

If it is possible to hold a Q&A session after the training observation, agree on the observed content among the observers (HRA practitioners, accompanying training personnel, etc.) beforehand to determine the focus of the questions.

Ask questions that were prepared in advance, and resolve the unclear points and questions that were noted during the observation. It is necessary to resolve the unclear points and questions as much as possible especially if the HRA practitioners cannot meet with the operators again or when the observation is not videotaped or recorded.

PSF (Performance Shaping Factors), which is considered to affect performance, can be confirmed by talking with operators in addition to observing training [5].

If there is interest in decision making, ask in the post-training Q&A session, “What were you thinking in this step?” Also have the operators explain what was happening during the training and how they responded to it, and later ask questions about decision making behind the response to extract the decision-making process.

(6) End training observation

Check with the operators and training personnel if they can be contacted via email or other means in case any clarification or additional information becomes necessary when compiling the results, or in case confirmation of any results is needed [5][7][15].

Thank the personnel for offering their time, and end the training observation.

VI. ORGANIZING TRAINING OBSERVATION RESULTS

Organize the collected information using figures and tables as appropriate [10], and check for any shortcomings or inconsistencies. When verifying information, endeavor to eliminate cognitive biases (see VII.(7) Eliminate cognitive biases) [8].

(1) Consolidate information using figures, tables, etc.

Consolidate the collected information. If the obtained information is complex, organize it using figures and tables [10]. This makes it easier to notice missing information and inconsistencies.

(2) Check for missing information

After the training observation ends, review the obtained information in further detail to check for information that might be missing or needs to be ascertained further [7][15]. If any information is missing, ask the relevant personnel to cooperate in an additional interview, cooperate in an additional training observation or provide information by email or other means.

If the HRA practitioners are not familiar with the tasks to be assessed, it is difficult to record everything that happened during the training observation. If possible, receive a copy of the timeline recording key actions and responses from the training personnel and match it to your own records (e.g. what was happen when a specific PSF was observed) [5].

(3) Check for contradictions in information

Check also for contradictions in the obtained information (e.g. inconsistencies among information obtained from multiple training observations). In the event contradictions are found, work to eliminate them by, for instance, collecting additional information from other relevant personnel for cross-checking [6][10][11][15][16]. As for how the contradictions are eventually addressed, document and record in a clear-cut and objective manner the content of decisions that were made [6][16].

VII. PRECAUTIONS OF TRAINING OBSERVATION

(1) Consider the impact of the observation on the observed personnel

The HRA practitioners conducting the observation may affect the observed personnel such as operators conducting the training [27]. When people become conscious of being observed, they are known to stop behaving normally (e.g. observed personnel try to behave in a way expected by the observer) [14][17].

Observed personnel may also be affected even through indirect observation with videotaping and recording and not just through direct observation by the HRA practitioners [14].

During the observation, HRA practitioners should place themselves where they would not attract attention from the observed personnel as much as possible [18]. When using videotaping and recording equipment, also place them where they would not attract attention from the observed personnel as much as possible.

(2) Pay attention to the impact of fatigue of the observer

Information collected toward the end of the observation tends to be less reliable than information collected early on [18]. Since the HRA practitioners conducting the observation are affected by reduced attention caused by fatigue [14], conduct observation paying close attention to such impact. Pay special attention if the observation takes a long time.

(3) Be careful of observer drift

If the definition of the behavior to be observed is vague, the observer may unintentionally change the observation and recording methods. This is known as observer drift [29].

HRA practitioners should clearly define the behavior to be confirmed (e.g. whether it is 3-way communication when referring to communication) of operators to be observed to confirm their behavior.

(4) Bear in mind the characteristics of indirect observation methods such as taping and recording

Recordings with a video camera are limited to the camera range and recordings with an audio recorder are limited to the microphone recording range, so events that are not videotaped or recorded cannot be analyzed [18][20].

Additionally, selection of the targets to be videotaped or recorded may be affected by cognitive bias as there is room for the subjectivity of the HRA practitioner who will be setting the equipment for such [14].

While indirect observation methods using videotaping and recording lets you repeatedly re-examine the records and transcribe what was spoken, it requires time and cost for such analysis [13][14][17][20]. Use indirect observation methods keeping in mind such time and cost.

(5) Bear in mind that the training objective and HRA objective are not aligned

HRA tries to understand potential errors in the task and their contributing PSF, but training is conducted to acquire necessary skills to succeed in the task [1][6]. HRA practitioners should collect narrative information from training observations bearing in mind such differences. For example, in the post-training Q&A session, training participants may feel discomfort, in some cases, when asked in detail questions that highlight human errors. In such cases, questions need to be asked bearing in mind to create a relaxed atmosphere conducive to conversation [2][3][4].

(6) Use tips and know-how for interviews in the post-training Q&A

In the post-training Q&A session, use tips and know-how for interviews organized in the handbook on interviews [2][3][4].

(7) Eliminate cognitive biases

Similarly to interviews, cognitive bias may occur during a training observation among the HRA practitioners who are the observers. Table I shows specific examples of cognitive bias in training observations.

TABLE I. Examples of cognitive bias that could occur during a training observation

| Types of cognitive bias | Description |
|--------------------------|--|
| Confirmation bias | If HRA practitioners have their own hypotheses, thoughts and inferences before an observation, their desire to obtain information that supports them affect information collection during the observation. [14]. [Example] HRA practitioners have their own hypotheses before an observation, so they only focus on behavior that supports such hypotheses and overlook other behavior. |
| Excessive generalization | It is assumed that there is a common narrative, without considering the differences of the accident scenario and the plant from the previous assessment. It is important to assess in a way that allows for incorporating the current state subject to the current assessment each time [6][16]. [Example] If there are training observations results by HRA practitioners of a previous task similar to the task to be observed this time, differences in operator behavior may be overlooked during the observation even if there are any, because HRA practitioners do not pay attention to them thinking that it is the same as before. |

XIII. CONCLUSIONS

The key to conducting HRA is to understand, through qualitative analysis, situations where tasks that appropriately reflect realities are executed. The NRRC of the CRIEPI has compiled qualitative analysis methods into an HRA Guide to collect plant-specific and accident scenario-specific conditions that affect human performance as “narratives.” Interviews and training observation are regarded as important techniques for collecting information to develop a narrative. As an attachment to the HRA Guide, this Handbook provides tips and know-how for methods of training observation employed when conducting HRAs.

ACKNOWLEDGMENTS

The members participating in the Level 1 PRA Sub-Working Group and Risk Assessment Working Group of the NRRC of the CRIEPI discussed and offered advice and provided a broad range of other considerations.

Researchers of Norway's Institute for Energy Technology cooperated in interviews.

Also, Yuko Hirotsu, former staff of the NRRC, greatly contributed to creating this Handbook.

We would like to express our gratitude to all of them.

REFERENCES

- [1] Kirimoto, Y; Nonose, K; Hirotsu, Y; Sasou, K.; Guide for Qualitative Analysis in The Human Reliability Analysis (HRA) with Emphasis on Narratives (FY 2023 Edition). CRIEPI REPORT(NR23005). 2024.
- [2] Hayase, K; Hirotsu, Y; Takeda, D. Handbook on Interviews for Qualitative Analysis of The Human Reliability Analysis (HRA) with Emphasis on Narratives. CRIEPI REPORT (NR22011). 2023.
- [3] Hayase, K; Takeda, D. Handbook on Interviews for Qualitative Analysis in The Human Reliability Analysis with Emphasis on Narratives. 17th International Conference on Probabilistic Safety Assessment and Management & Asian Symposium on Risk Assessment and Management (PSAM17&ASRAM2024). 2024.
- [4] Hayase, K; Takeda, D. Handbook on Interviews and training observation for Qualitative Analysis of The Human Reliability Analysis (HRA) with Emphasis on Narratives. CRIEPI REPORT NR23009. 2024.
- [5] Taylor, C. Improving Scenario Analysis for HRA: Handbook of Good Practices. Organisation for Economic Co-operation and Development. Halden Reactor Project, HWR-1145. 2015. (Available on request)
- [6] Taylor, C. Improving Scenario Analysis for Human Reliability Analysis. Organisation for Economic Co-operation and Development, Halden Reactor Project, HWR-1120. 2015. (Available on request)
- [7] Bye, A., et. al. The Petro-HRA Guideline, Revision 1, Vol.1&2. Institute for Energy Technology, IFE/E-2022/001&2. 2022.
- [8] Turner III, D. Qualitative interview design: A practical guide for novice investigators. The Qualitative Report 15 (3). 2010. 754–760.
- [9] Wilson, J.R.; Sharples, S. Evaluation of human work fourth edition. CRC Press. 2015.
- [10] Motozawa, T.; Takeda, Y.; Nomura, A.; Aonuma, S. Methods of Interviewing the people involved in an accident triggered by Human Error. JR EAST Technical Review No.29. 2009. (In Japanese)
- [11] Electric Power Research Institute (EPRI) and US Nuclear Regulatory Commission Office of Nuclear Regulatory Research (USNRC-RES). NUREG-1921 Supplement 1, Final Report, "EPRI/NRC-RES Fire Human Reliability Analysis Guidelines – Qualitative Analysis for Main Control Room Abandonment Scenarios". 2020.
- [12] US Nuclear Regulatory Commission (NRC). NUREG-2156, "The U.S. HRA Empirical Study- Assessment of HRA: Method Predictions against Operating Crew Performance on a U.S. Nuclear Power Plant Simulator ". June 2016.
- [13] Kirwan, B.; Ainsworth, L.K. A guide to task analysis. Taylor & Francis.1992.
- [14] Sharples, S. and Cobb, S. Methods for Collecting and Observing Participant Responses. Evaluation of human work fourth edition. CRC Press. 2015.
- [15] Boeing, Maintenance Error Decision Aid (MEDA) User's Guide. 2016.
- [16] USNRC. NUREG-2198, "The General Methodology of an Integrated Human Event Analysis System (IDHEAS-G)". May 2021.
- [17] Stanton, N. A. Human Factors Methods: A Practical Guide for Engineering and Design 2nd Edition. CRC Press. 2013.
- [18] Pershing, J.A., et. al. Observation methods for human performance technology. Handbook of human performance technology: third edition. Pfeiffer. 2006.
- [19] Dojo, Y. Chapter 6 Reliability and Validity of Observation Data. Miura, A (Supervisor); Sato, H (Ed.) I see! Psychological Observation Methods. Kitaohji Shobo. 2018. p.74-p.90.
- [20] Bisantz, A., et. al. Study and Analysis of Complex Cognitive Work. Evaluation of human work fourth edition. CRC Press. 2015.