Handbook on Interviews for Qualitative Analysis in The Human Reliability Analysis with Emphasis on Narratives

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Abstract: As a part of the technological improvement of probabilistic risk assessment (PRA) methods, it is necessary to improve human reliability analysis (HRA) in a manner that quantitatively assesses the probability of human errors. As a more realistic HRA methodology, the Nuclear Risk Research Center (NRRC) published "Guide for Qualitative Analysis in The Human Reliability Analysis (HRA) with Emphasis on Narratives." Of the techniques for collecting information described in the Guide, observations of training and interviews with personnel relevant to the task to be analyzed are both ways of collecting information from people, which require tips and know-how to efficiently obtain quality sources of information necessary for appropriately reflecting realities when conducting HRA.
The Handbook on Interviews is a systematic compilation of tips and know-how for efficiently obtaining correct information that is relevant to the actual situation at the plant, which HRA practitioners can refer to when interviewing personnel relevant to the task to be analyzed. The tips and know-how incorporate knowledge on interviewing methods obtained from HRA-related literature, such as the reports of the Halden Reactor Project, and from literature on interviewing methods in fields such as psychology, as well as from NRRC's own knowledge on interview methods obtained through HRA qualitative analysis applying the Guide.

Keywords: Human Reliability Analysis, Narrative, Interview

1. 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 for interviews is limited, HRA practitioners need tips and know-how to efficiently obtain accurate information concerning actual field conditions for task execution when performing HRA.

2. PURPOSE

NRRC compiled a handbook on interview methods (hereinafter the “Handbook”) 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]. The purpose of this paper is to present the contents of the handbook. The tips and know-how are based on the literature on HRA qualitative analysis by the Halden Reactor Project[1] [4][5], which contains many findings on interview methods, and incorporate findings from interview methods obtained by reviewing other HRA-related literature as well as literature concerning interview methods used in such fields as psychology and investigations of events triggered by human error. NRRC's own knowledge on interview methods obtained through HRA qualitative analysis applying the HRA Guide is also incorporated. Note that the Handbook is not a procedure or a manual for interviews; rather, it is a supplementary resource intended to help HRA practitioners to efficiently obtain information concerning actual field conditions by referring to it when conducting interviews.

3. INTERVIEW METHODS

The Handbook deals with two primary methods:

- Sheet-based interviews
- Talk-throughs [5][6][7]

(1) Sheet-based interviews

Sheet-based interviews are basically conducted in a question-and-answer format. However, there are cases in which it is assumed that opinions may conflict among several relevant personnel or that the relevant personnel may find it difficult to respond given the unusual nature of the task. In such cases, a discussion format rather than a question-and-answer format can be adopted for that part of the interview, in which opinions are freely exchanged.

Nowadays interviews may be held online, but keep in mind that discussion-format interviews are difficult to conduct over the Internet. This is because, whereas discussions are expected to deepen when a certain participant’s comment inspires or provides insight to another participant and prompts new comments, this phenomenon is said to occur less frequently in discussions among participants who join online via their computer screens [8]. For this reason, it is advisable to conduct interviews in person for content where differences of opinion may arise among the relevant personnel concerned or for special tasks that are difficult for even relevant personnel to answer easily.

(2) Talk-throughs

A talk-through is a method in which relevant personnel (e.g. operator/trainer/other personnel) describe the actions required in a task, explain what they are doing and their mental processes during each action in an actual or simulated task environment[2]. If such environments are unavailable, talk-throughs are held at a different location such as a conference room [7].

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[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] Partially modified talk-through description from Glossary of NUREG/CR-1278[6].

Holding talk-throughs is advisable when detailed procedures for tasks are lacking, or when procedures for tasks are available but HRA practitioners still do not have a sufficient understanding of the task (due to the excessive complexity of the task or other reasons). Talk-throughs are also worth performing to gain a deeper understanding both of the task and development of the accident scenario, even when HRA practitioners think they sufficiently understand the task.

In addition, when the scenario or task is complex, overreliance on the opinions of relevant personnel may adversely affect HRA results [9]. In such cases, since there is concern that the relevant personnel may not fully understand the scenario or task, it may be useful for HRA practitioners to clarify the details of the task together with the personnel by asking them to explain the task during the talk-through in order to collect realistic information.

4. INTERVIEW PREPARATION

4.1. Preparing Resources and Other Materials Used in Interviews

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

It is necessary to reach a common understanding with interviewees about the tasks and accident scenarios about which they will be interviewed. Therefore, prepare resources to explain the following content to relevant personnel about the accident scenarios and tasks, which were considered through the “consideration of accident scenario and identification of tasks” phase, based on the information already integrated at this phase [1][7].

- Vis-à-vis 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 explain the purpose of the talk-through

When holding a talk-through, prepare to explain to relevant personnel what HRA practitioners are trying to understand during the talk-through [7].

For example, the following is assumed:

- Understanding of the overall scheme of task execution
- Accurate understanding of certain steps
- Survey of interfaces

If necessary, prepare a document summarizing why the information is important.

(3) Preparation of interview sheets

Prepare an interview sheet by referencing interview sheets that were used in previous interviews, examples of items and content of collected information are 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][10]. The main precautions in this process are listed in Table 1.

Also, if there are multiple interview-subject relevant personnel, HRA practitioners need to think in advance about whether they want all the relevant personnel to respond to questions in turn (question-and-answer format), or whether they want to have a discussion among the relevant personnel (discussion format). How to proceed with the discussion, such as the sequencing of questions, is important for encouraging comments during the discussion, so consider discussion methods in advance [14][15].

(4) Prepare supplementary resources for the interview

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 interview, such as procedures, relevant photos (e.g. facilities and tools used while tasks are underway), facility layout drawings, and event reports [7][16][17]. If necessary, also create figures and tables that would be helpful for the interview [7].

(5) Verify prepared resources and other materials

Verify that the resources and other materials prepared in items (1) to (4) 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 interview, pick essential items that must be asked [18].

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

(6) Other pre-interview preparation

Re-verify documents on such topics as design and operation/maintenance management collected in the "consideration of accident scenario and identification of tasks" phase [4][5][10].

Understand the terms used in accident scenarios and tasks, and get used to talking about the scenarios and tasks in those terms [10][12].

Table 1. Precautions to keep in mind when preparing interview sheets

Item	Content
Expressions	Carefully choose words to make it easy for relevant personnel to understand the content of the questions [11]
Order of questions	- Usually, order questions according to the task step sequence following general questions (it is also possible to start with questions that are easy to respond to [7]) - Ask additional questions on the spot for verification when HRA practitioners judge there is a need to further inquire or understand peripheral information during the interview, in addition to asking pre-arranged questions[3]
Use of open questions and closed questions depending on the situation	Open questions: Open questions are asked without providing any option for response: respondents answer freely. When used: - When you want to know the details of tasks for which procedure manuals have not been prepared - For a broad understanding of a wide range of information, including related information - When asking for concrete examples - If you want to encourage discussion among the relevant personnel Closed questions: Closed questions are asked by presenting limited responses to the respondents, such as "yes" or "no." When used: - When verifying basic matters - When verifying inferences, based on pre-obtained information
Final confirmation questions	Setting open questions at the end of the question items [7][12] The following open questions are set at the end of the questionnaire [8][13]: - "Is there anything you think we should know about the task, apart from what we have already asked you in the previous questions?" - "Is there any more information we should know?" Aim: - Some points that need to be understood may be lacking even when practitioners judge that they thoroughly understand the task - HRA practitioners may also end interviews prematurely, becoming unwittingly satisfied after asking only about topics they think are sufficient enough for the interview.

[3] The semi-structured interview method is an interview method that is not limited to questions prepared in advance, but allows a certain degree of freedom, such as asking additional questions depending on the subject's answers, checking the meaning of the answers, or asking new questions that come to mind during the interview, while proceeding with the interview according to the prepared questions [12].

From the PRA perspective, re-verify the importance of the tasks that are to be assessed [10]. Understand the content of previous events, if relevant event reports are available [4][5][7].

4.2. Arranging Interviews

(1) Select interview-subject relevant personnel

As for the interview-subject relevant personnel, thoroughly consider who (e.g. operators/ trainers[4]/ other personnel) is well acquainted with the topic and consult with contact personnel at the plant. Another method is to find additional interviewees by asking relevant personnel during their interview if they know any other personnel suitable for an interview [7].

Multiple relevant personnel should be interviewed to avoid cognitive biases (see Chapter 7 (11) Eliminate cognitive biases) and gather a wide range of information [5][7].

In addition, relevant personnel who have a lot of experience and knowledge, such as those who are familiar with the tasks to be evaluated, are often busy with their work [7], so they are asked to spare valuable time to cooperate. In order to make the site contact understand the significance of cooperation with the interview, explain the purpose and outline of the interview when requesting cooperation [16]. Also, inform the contact personnel, as necessary, that the overall HRA analysis will provide great benefit in terms of efficiency and accuracy if relevant personnel with extensive experience and knowledge can be made available for the interview [7][19].

(2) Room arrangement and layout

HRA practitioners will ask the site contact to consider the following when arranging the location.

- Room: A quiet, calm place to talk (e.g. conference room or private room) [4][7][11][17]
- Seating arrangement: Arranging desks in an L-shape is advisable, instead of having HRA practitioners and the interview-subject relevant personnel sit directly across each other. This is because directly facing HRA practitioners may cause the relevant personnel to feel pressure [18].

When conducting online interviews, it is necessary to set a meeting via a web conference service, check the network connection environment, and check operation of such equipment including cameras and microphones. If necessary, ask the interview-subject relevant personnel to make similar preparations [21].

(3) Prepare recording methods

Prepare the recording methods (e.g. arrange a second person to act as a note-taker, or set up recording equipment) in order for HRA practitioners to concentrate on the interview [4][7].

(4) Divide roles among HRA practitioners

It is advisable to have having multiple HRA practitioners participate, if possible, with some primarily asking questions and others primarily offering assistance (e.g. checking that answers have been provided to all prepared questions, or asking supplementary questions) [7][11][18]. It is also advisable to have more than one HRA practitioner participate to avoid misunderstanding and cognitive biases held by HRA practitioners [5].

For multiple interviews, when different HRA practitioners are going to handle the interviews, the practitioners should verify with one another what they will focus on and ask in the interviews, and accordingly ensure the quality of their assessment to prevent different HRA practitioners giving different assessments.

(5) Provide resources to interview-subject relevant personnel

[4] Training personnel observe multiple operating crews and can be expected to provide information from an objective and balanced perspective [5].

Provide resources such as the interview sheet to be used in the interview to interview-subject relevant personnel [5][10][16]. Having relevant personnel confirm the specifics of the resources before the interview and having them respond in advance to topics they can answer in writing allows the limited interview time to be effectively and efficiently used and advance the interview.

5. CONDUCTING INTERVIEWS

The keys to obtaining necessary information within the allotted time and in step with the interview objective include building good communicative and trusting relationships with the interview-subject relevant personnel and eliminating cognitive biases, while paying attention to time management, such as allocation of interview time [7]. As such, conduct interviews while thoroughly bearing in mind the precautions (see Chapter 7).

(1) Exchange greetings and explain the interview objective

Exchange greetings and self-introductions. Also, thank the interviewee for setting aside time and cooperating with the interview.

Then, explain the following [5][8][19]:

- The importance of the interviews: The interviews are very important as a way to understand the actual conditions for HRA appropriately reflecting reality.
- How to answer: The personnel are required to not only answer questions but to proactively offer information, and explain the necessary content, volume, and level of detail regarding information provision [22].
- The accident scenario and tasks that are to be assessed using the resources prepared in section 4.1 (1)
- Interview focus: What the HRA practitioners wish to learn through the interview.
- Utilizing the information: How information obtained through it will be utilized.

When holding a talk-through, explain what the HRA practitioners are trying to understand through the talk-through based on the explanation prepared in section 4.1(2). Then explain that the HRA practitioner may ask questions as appropriate while the relevant personnel are providing explanations [12]

(2) Explain the recording methods

Explain how the interview will be recorded (notes taken by a note-taker or recorded using recording equipment). Before recording the interview, gain consent of the interview-subject relevant personnel [7][11].

(3) Questions (including talk-throughs)

For sheet-based interviews, ask questions using the interview sheet prepared in section 4.1(3) and proceed with the interview by confirming the responses given in advance.

When holding a talk-through, ask the relevant personnel to describe the actions required in the task being analyzed and their mental process during each action. At that time, inform the personnel as well of what, if anything, the HRA practitioner is particularly focusing on regarding the task. After explanations about the task, check for any unclear points. If the talk-through partially verifies topics provided on the answer column of the interview sheet, there is no need to verify that part in the sheet-based interview again. After receiving a full explanation of the task, confirm any points that are unclear.

The supplementary resources for the interview prepared in section 4.1(4) will be used as needed during sheet-based interviews and talk-throughs.

If a discussion on a specific topic among the interview-subject relevant personnel is expected, the HRA practitioners will encourage discussion using open questions and discussion methods such as the sequencing of questions arranged in section 4.1(3).

(4) Check for unmentioned topics

Encourage relevant personnel to respond freely if they have any information that should be provided apart from what they already discussed in the interview [4][7][12]. It is advisable to arrange a question item about this in the interview sheet (see section 4.1(3) Prepare interview questions).

(5) Check the information obtained

Before ending the interview, quickly check if all the important information has been covered [7]. Ask additional questions if any information is lacking. When multiple HRA practitioners conduct interviews, checking information and asking additional questions are mainly carried out by HRA practitioners offering assistance during the interviews as arranged in the preliminary division of roles described in section 4.2(4).

(6) End interview

Check with the interview-subject relevant personnel if they can be contacted via email or other means in case any clarification or additional information becomes necessary when compiling the interview results, or in case confirmation of any interview results is needed [4][7][11]. Thank the personnel for offering their time, and end the interview [4][7].

6. ORGANIZING INTERVIEW 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 Chapter 7 (11) Eliminate cognitive biases) [16].

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

Consolidate the collected information. If the obtained information is complex, organize it using figures and tables [18]. This makes it easier to notice missing information and inconsistencies.

(2) Check for missing information

After the interview ends, review the obtained information in further detail to check for information that might be missing or needs to be ascertained further [7][11]. If any information is missing, ask the relevant personnel to cooperate in an additional interview or provide information by email or other means.

(3) Check for contradictions in information

Check also for contradictions in the obtained information (e.g. inconsistencies among information obtained from multiple relevant personnel). In the event contradictions are found, work to eliminate them by, for instance, collecting additional information from other relevant personnel for cross-checking [4][10][11][18][23]. 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 [5][22].

7. INTERVIEW PRECAUTIONS

Provided below are interview precautions for collecting accurate and necessary information for assessment.

(1) Create a relaxed atmosphere

It goes without saying that the relevant personnel subject to an interview work with pride to prevent human errors and to successfully perform tasks [7]. They thus may feel discomfort in some cases, when asked, in detail, questions that highlight human errors. In such cases, there may be difficulty in getting the personnel to communicate, so have them understand the significance of the interview and then proceed with the interview in a relaxed atmosphere.

The key to achieving this is to have the relevant personnel understand it is crucial for them to provide valuable field information for the sake of making an assessment that appropriately reflects reality [5]. To gain trust from and provide a sense of security to relevant personnel, it also is important for HRA practitioners to be confident, humble, and relaxed, and to speak with a gentle and natural voice in a calm, slow, and clear manner [4][7][11].

(2) Avoid technical terms

When the relevant personnel are unfamiliar with PRA, HRA, or human factors, avoid using technical terms from such fields as much as possible [4][5][10][11]. If using such terms, give a thorough explanation to the personnel.

(3) Ask concise questions and offer feedback to responses to encourage comments

Make questions short, and ask them one at a time. Offer feedback (e.g. nod, acknowledge, repeat the individual's responses) to show that the HRA practitioner understands the relevant personnel's response and to encourage the individual to comment more [11][16][24].

(4) Pause before moving on to the next question

When switching to the next question, wait a moment to make it easy for relevant personnel to add any information they recall [7].

(5) Listen closely and constantly pay attention to the responses

Listen closely and constantly pay attention to responses provided by relevant personnel. When a particular response contains a topic that calls for related information or details, practitioners should express their interest in the personnel's comments and ask additional questions that were not in the prepared question list so that they accordingly gain the necessary information. If the response seemed to be unclear, encourage the relevant personnel to clarify their response [4][5][7]. If the relevant personnel appear to be finding it difficult to explain in words, ask them to describe using a non-verbal method such as drawing a figure [18].

(6) Flexibly respond to the reactions of relevant personnel

Flexibly respond to the reactions of relevant personnel to questions. Do not interject when the personnel are answering questions; wait until they finish speaking. If the response and the intended question do not align, switch to another question or attempt a course correction. If the relevant personnel do not immediately respond, give them time to think. If available, offer reference material from supplementary resources for the interview prepared in section 4.1(4) that may help personnel in forming their response. Note that if the personnel remain silent for a long time, that may mean they have no response; confirm this with the individual, then move to the next question [4][7][11][18]. In addition, in the course of checking questions to which answers have not been obtained during "Chapter 5(5) Check obtained information," if it is possible for the relevant personnel to take back the questions and obtain information, ask them to respond at a later date.

(7) Give all participating relevant personnel opportunities to respond

When more than one relevant personnel are interviewed, give all of them opportunities to respond [17]. Bear this in mind especially when responses are primarily coming from specific individual(s) among the relevant personnel.

Also, be mindful of whether peer pressure among the personnel may be causing them to refrain from proactively sharing their views.

(8) Pay attention to the relevant personnel's comprehension of closed questions

A closed question can be answered from among limited options, which means relevant personnel may respond without thoroughly understanding the content of the question. HRA practitioners should thus pay attention to whether relevant personnel are responding with a thorough understanding of the point of each question. If the personnel appear to lack sufficient understanding, offer supplementary explanations about the question.

It should be noted that the HRA practitioners' entering information input for the quantification method in advance in the interview sheet answer column and confirming it with the relevant personnel at the time of the interview (see Chapter 5(3) Questions (including talk-throughs)) also corresponds to a closed question. Therefore, pay attention to the relevant personnel's comprehension.

(9) Avoid inducing responses

HRA practitioners may, while preparing for questions, be able to assume what response will come to some extent, but they should be careful not to lead the relevant personnel in an attempt to obtain responses that align with their assumptions (see Chapter 7 (11) Eliminate cognitive biases). Be mindful of the possibility of unwittingly offering explanations in a way that leads relevant personnel to certain responses, especially when HRA practitioners need to offer supplementary explanations to help personnel better understand the essence of the question [10]. Also, be mindful that HRA practitioners' expressions of approval or disapproval to responses may lead personnel toward certain responses [4][7][25].

(10) Ask about human errors in an indirect way

Relevant personnel may assume that no human error would occur in the tasks being assessed, or that such errors are very unlikely [5][7]. However, in an interview, it may become necessary to have personnel do away with such assumptions for HRA practitioners to obtain information from them. Be considerate in such cases and make it easier for the personnel to discuss the possibility of human errors by asking indirect questions (e.g. "What are potential factors that may hinder your execution of tasks?"), instead of direct questions (e.g. "What human errors may occur?")[4][5][7].

(11) Eliminate cognitive biases

Cognitive bias is a phenomenon in which one's own assumptions, the surrounding environment, influences from others, and previous experiences interfere with logical thinking and cause one to make irrational judgments and choices [26]. Cognitive bias may occur during an interview either among the HRA practitioners (e.i. the interviewers) or the relevant personnel subject to the interview (e.i. the interviewee). The interviewer falling prey to the bias raises concern that the process of collecting and verifying accurate information may impair the accuracy of the obtained information, whereas if the interviewee has cognitive bias, accurate information may not be provided.

HRA practitioners thus are to understand the types of existing cognitive bias and how people act when they fall prey to such bias, so both consider the possibility of that happening and prevent such biases from arising among the practitioners [11]. They should also be mindful of whether the relevant personnel have fallen prey to a cognitive bias.

8. CONCLUSION

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 are regarded as an important technique for collecting information to develop a narrative. As an attachment to the HRA Guide, the Handbook [2][3] provides tips and know-how for interview methods employed when conducting HRAs. Both the HRA Guide and Handbook are applicable to quantification methods used in quantitative assessments. For HRA that appropriately reflects reality, qualitative analyses should be conducted based on the HRA Guide and the Handbook used when conducting interviews.

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