



2019

HAZOP Guidelines (Hazard & Operability)

GL-0006-E

KR

—Disclaimer :

Although all possible efforts have been made to ensure correctness and completeness of the contents contained in this guidelines, Korean Register of Shipping is not responsible for any errors or omissions made herein, nor held liable for any actions taken by any party as a result of information retrieved from this guidelines.

This guidelines is non-mandatory, but are intended to provide practical technical materials to ship owners, ship operators, shipyards, designers and manufacturers. It might be amended periodically or upgraded to rules and guidances as future technology develops and matures.



2019

HAZOP Guidelines (Hazard & Operability)

GL-0006-E

KR

—Disclaimer :

Although all possible efforts have been made to ensure correctness and completeness of the contents contained in this guidelines, Korean Register of Shipping is not responsible for any errors or omissions made herein, nor held liable for any actions taken by any party as a result of information retrieved from this guidelines.

This guidelines is non-mandatory, but are intended to provide practical technical materials to ship owners, ship operators, shipyards, designers and manufacturers. It might be amended periodically or upgraded to rules and guidances as future technology develops and matures.

APPLICATION OF “HAZOP Guidelines (Hazard & Operability)”

1. Unless expressly specified otherwise, the requirements in the Guidelines apply to HAZOP for which request of the Client is made on or after 01 January 2020.

TABLE OF CONTENTS

CHAPTER 1 General	1
Section 1 General	1
Section 2 Terms and Definitions	2
CHAPTER 2 HAZOP Implementation	4
Section 1 HAZOP Procedure	4
Section 2 HAZOP Team	5
Section 3 HAZOP Workshop	7
CHAPTER 3 HAZOP Report	12
Section 1 General	12
Section 2 Contents	12
ANNEX 1 Materials for HAZOP	14
ANNEX 2 Risk Matrix and Risk Acceptance Criteria	15
ANNEX 3 HAZOP Guidewords	17
ANNEX 4 Exemplary Templates for HAZOP	18

CHAPTER 1 GENERAL

Section 1 General

101. Application

1. This Guidelines prescribe the procedures and requirements of HAZOP which is used to identify hazards and to analyse risk in operation of process systems.

102. What is HAZOP?

1. HAZOP, which is an abbreviation to 'Hazard & Operability', is one of the qualitative risk analysis methods based on expert judgement, and identifies potential hazards or hazardous events likely to cause loss or damage to human, environment, or asset during the operation of target system in a systematic manner, and then draws and proposes risk reduction measures to lower the risk levels of hazards or hazardous events identified below an allowable level.

103. Purpose of HAZOP

1. To promote overall understanding of the design and operation concept of target system
2. To review the design and operation concept of target system, in terms of safety
3. To identify potential hazards and/or hazardous events likely to occur during the operation of target system, in a systematic manner
4. To review existing safeguards that are already considered in the design and operation concept of target system, in terms of their effectiveness
5. To devise additional safety actions that reduce the risks of identified hazards and/or hazardous events to the acceptable level, in a reasonable manner
6. To confirm whether any uncontrollable safety concern exists in the design and operation concept of target system or not

104. A HAZOP timing

1. To implement HAZOP, a well-defined system and procedure are required. To perform HAZOP efficiently, it is needed to be able to set deviated conditions and analyze the consequences, which may even require detailed design of the system and procedure. Also, the design of safety devices is often done in the detailed design stage. In general, HAZOP is performed after the basic design and before the detailed design, and the result is applied at the detailed design stage.

105. HAZOP concepts

1. HAZOP belongs to a qualitative risk analysis based on experts' judgement. Hence, if a rigorous assessment on risks is required, quantitative risk analyses may be needed in addition, separately from the HAZOP.
2. HAZOP may be understood as a comprehensive review on design and operation, and is conducted by various experts and stakeholders associated with the target system.
3. Through the HAZOP study, it is possible to obtain synthetic understanding on the design and operation of target system, and to explore a range of options for the safety improvement of target system in a effective and systematic manner.
4. If necessary, a qualitative evaluation using a risk matrix and risk acceptance criteria may be conducted while the HAZOP process, for the purpose of grasping the priority (or ranking) of the hazards or hazardous events identified in terms of their risk levels. Applying a qualitative risk evaluation, it is possible to concentrate on the hazards that have relatively higher risks and require attention, and to produce more effective risk reduction measures.

Section 2 Terms and Definitions

201. Terms and definitions

1. accident: an unintended event that probably lead to loss or damage to human, environment, or asset. Accident is closely related to the hazard, and in some cases it may have the same meaning as the hazards.
2. additional safety action or safety action: a risk reduction measure that is not included in the target system at present and is recommended to be applied in the future. It is possible to consider various safety systems that need to be examined for their applicability to the target system, such as design revision, additional safety device, operation procedure revision, enhanced safety procedure and manual, enhanced maintenance, enhanced inspection, additional training, etc.
3. ALARP principle (as low as reasonably practicable): a principle stating that a risk should be reduced as low as reasonably practicable. This principle may be employed for evaluating a risk. It means that a risk reduction measure is justifiable provided that it is technically practicable and the costs for risk reduction are proportionate to the benefits obtained.
4. cause: a specific element or event that is likely to occur a hazard or accident
5. client: a person or company that commissions a HAZOP study in order to review and enhance the safety of target system
6. consequence: a negative outcome (or impact) of a hazard (or accident) occurrence. In general, it is presented by a resultant loss or damage to human, environment, or asset.
7. deviation : a phenomenon outside the intended process operating range. (e.g., higher pressure than the design range)
8. existing safeguard or safeguard: a risk reduction measure that is already included in the target system. It is possible to consider various safety systems currently existing in the target system, such as safe arrangement and layout, safety device, operation procedure, safety procedure and manual, maintenance manual, periodic inspection, training, etc.
9. frequency: the number of occurrences per unit time (e.g., 10 times per annum)
10. hazard: a potential to provoke a negative impact on human, environment, or asset. A hazard may occur from a range of causes, and result in a range of consequences.
11. hazardous event: a sequence of accident from a specific cause to a specific consequence. It is similar term to the accident scenario.
12. HAZOP facilitator: a person who presides over a HAZOP workshop, conducts a HAZOP study, and completes it.
13. HAZOP scribe: a person who records all the discussions and agreements being produced during the HAZOP workshop in a HAZOP worksheet. He also prepares documents related to HAZOP such as HAZOP report.
14. HAZOP team: a group of experts who take part in all or parts of HAZOP study. It mainly consists of the HAZOP workshop participants. Details of the HAZOP team, members, and their roles are described in **Ch.2 Sec.2** and **Sec.3**.
15. responsibility: a person or company that is responsible for responding to the additional safety actions identified and proposed
16. risk: the combination of the frequency and the consequence. When conducting a HAZOP study, risk can be determined by combining the frequency of the cause and the severity of the consequence.
17. risk reduction measure: a specific method to reduce risk. In general, there exists a preventive measure that can reduce the frequency of cause by means of preventing the occurrence of a hazard, or a mitigating measure that can reduce the severity of consequence by means of mitigating the impact of a hazard. It is analogous to a risk control measure.
18. severity: a degree of loss or damage to human, environment, or asset (e.g., a fatality, 1 million

USD loss of property, etc.)

19. SMEs (subject matter experts): persons who have sufficient experience and knowledge involved in the design, construction, installation, operation, and decommissioning of target system.

CHAPTER 2 HAZOP Implementation

Section 1 HAZOP Procedure

The outline of HAZOP procedure is shown in Fig. 2.1.

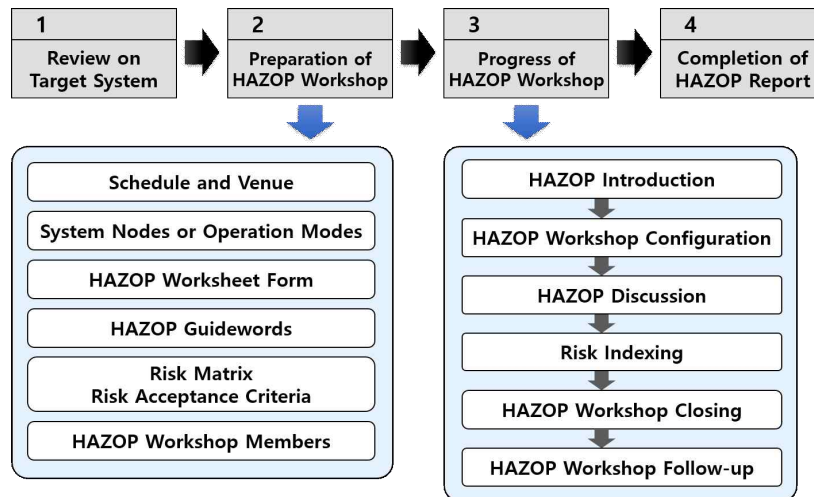


Fig. 2.1 HAZOP procedure

101. Target system review

1. The client and HAZOP facilitator complete administrative procedures to commence the HAZOP work.
2. Based on the documents, such as **Annex 1**, provided by the client, the HAZOP facilitator has a general idea of the design and operation concept of the target system.
3. The HAZOP facilitator establishes a HAZOP working plan.

102. HAZOP workshop preparation

1. For the HAZOP workshop, the client should prepare the followings in advance. When requested by the client, the HAZOP facilitator may cooperate with him.
 - (1) HAZOP workshop schedule: two days or more may be required, depending on the complexity and scope of the target system.
 - (2) HAZOP workshop venue
 - (3) HAZOP workshop participants
 - (4) Equipment for HAZOP workshop
 - (5) Target system description
 - (6) If needed, risk matrix
 - (7) If needed, risk acceptance criteria
 - (8) If needed, HAZOP guidewords
2. The HAZOP facilitator should prepare the followings in advance. Based on prior consultation with the client, the HAZOP facilitator decides on (1), (2), and (3) below.
 - (1) Division of the target system (e.g., definition of system nodes or operation modes)
 - (2) Risk types

- (3) HAZOP worksheet template
- (4) HAZOP introduction
- (5) HAZOP scribe
- (6) List of HAZOP workshop participants, including their signatures

103. HAZOP workshop progress

1. Details of HAZOP workshop process are described separately in **Sec.3**.

104. HAZOP report completion

1. The HAZOP worksheet is completed after the HAZOP workshop and related follow-up actions.
2. The HAZOP facilitator draws up the results of hazard identification through analyzing the HAZOP worksheets.
3. The HAZOP facilitator prepares a HAZOP draft report through summarizing the HAZOP works done and the hazard identification results. Details of HAZOP report are separately described in **Ch.3**.
4. The HAZOP facilitator submits the HAZOP draft report to the client.
5. The client reviews the HAZOP draft report, and then sends his comments to the HAZOP facilitator back. The client should consider the followings mainly when reviewing the HAZOP draft report.
 - (1) Apparent typing and/or grammatical errors
 - (2) Text that needs to be amended in the description of target system
 - (3) Text that needs to be amended in the description of HAZOP workshop details and participants
 - (4) Needs to revise the description of HAZOP results
 - (5) Needs to revise the text of additional safety actions for clarifying their intention
6. Considering the comments on the HAZOP draft report from the client, the HAZOP facilitator revises the draft report and completes a HAZOP final report. The following items among the client's feedback can not be reflected in the HAZOP final report.
 - (1) Amendment to the HAZOP worksheet already completed
 - (2) Addition of new text that is not contained in the HAZOP worksheet
 - (3) Deletion of some text that exists in the HAZOP worksheet
 - (4) Revision of the risk matrix that is already agreed between the client and the HAZOP facilitator
 - (5) Revision of the risk acceptance criteria that is already agreed between the client and the HAZOP facilitator
 - (6) Changes to objective facts among the HAZOP results
7. The HAZOP facilitator ends off the HAZOP works after submitting the HAZOP final report to the client.
8. After the completion of all the HAZOP works, the HAZOP facilitator must not, in principle, present or distribute the HAZOP results to the outside. This is to protect the intellectual property rights of the client as well as to maintain the objectivity of the HAZOP facilitator on the HAZOP results.

Section 2 HAZOP Team

201. HAZOP team

1. The HAZOP team is organized as shown in **Fig. 2.2**.

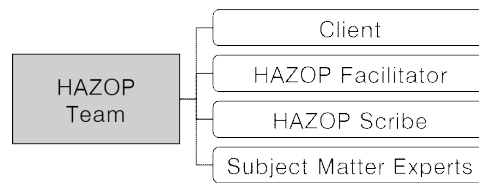


Fig. 2.2 HAZOP team

- (1) The appropriate arrangement of the participating experts (i.e., SMEs) in the HAZOP team is a key factor in successful HAZOP works, because hazard identification is determined by the opinions of them.
- (2) The selection of HAZOP team members should be balanced and not biased.
- (3) Since all or part of the HAZOP team attends the HAZOP workshop, the HAZOP team members are the same as the participants in the HAZOP workshop or are composed mainly of the participants in the HAZOP workshop. (Details of HAZOP workshop participants are described in **Sec.3**.)

202. Client

1. The client is a main body who commissions the HAZOP work.
2. As a main body of holding the HAZOP workshop, the client should arrange a meeting place and equipment.
3. The client should arrange the participating SMEs in the HAZOP workshop.
 - (1) In most cases, intellectual property rights of the target system belong to the client. Accordingly, for preventing intellectual property problems, it is appropriate that the client takes charge of selecting the participating SMEs in the HAZOP workshop.
4. The client should review the HAZOP worksheet and the HAZOP report, and then finally confirm those.

203. HAZOP facilitator

1. The HAZOP facilitator is a main body who conducts and completes the HAZOP work commissioned by the client.
2. The HAZOP facilitator presides over the HAZOP workshop, summarizes the discussion results after the workshop, and then prepare the HAZOP report.
3. The HAZOP facilitator should maintain an objective and neutral attitude consistently while performing the HAZOP works.
4. The primary role of the HAZOP facilitator is as follows.
 - (1) To prepare the HAZOP workshop materials mentioned in **Annex 1**.
 - (2) To introduce the details of meeting and HAZOP procedure to the participants at the beginning of the HAZOP workshop
 - (3) To facilitate the discussions and agreements of SMEs during the HAZOP workshop
 - (4) To draw up a HAZOP draft worksheet and circulate it for review
 - (A) The HAZOP draft worksheet should be reviewed by the SMEs who attended the HAZOP workshop.
 - (5) To finalize the HAZOP worksheet and submit it
 - (A) The HAZOP final worksheet should be submitted to the client.

- (6) To prepare a HAZOP draft report and circulate it for review
 - (A) The HAZOP draft report should be reviewed by the client.
- (7) To complete the HAZOP final report and submit it
 - (A) The HAZOP final report should be submitted to the client.

204. HAZOP scribe

1. The HAZOP scribe records all the discussions and agreements produced during the HAZOP workshop in the HAZOP worksheet.
2. The HAZOP scribe helps the HAZOP facilitator edit and modify the HAZOP worksheet.
3. The HAZOP scribe helps the HAZOP facilitator prepare a HAZOP report.

205. SMEs

1. The HAZOP works should involve every SME from all areas related to the target system development.
2. The SMEs should have sufficient experience and expertise in the design and operation of target system.
3. The SMEs should take an active part in the HAZOP workshop and discuss their opinions each other, based on the experience and expertise of them.

Section 3 HAZOP Workshop

301. HAZOP workshop participants

1. All or part of HAZOP team attends the HAZOP workshop.
2. All the results of HAZOP works are determined by the discussions and agreements between the client and the SMEs. Therefore, the validity of HAZOP results are directly dependent on the participation of appropriate SMEs related to the design and operation of target system.
3. The personal organization of HAZOP workshop is depicted like **Fig. 2.3** below, in terms of the roles of participants.
4. In order to facilitate discussion and decision-making during the HAZOP workshop, the client and SMEs may be divided into three groups or observers, if necessary.
5. The HAZOP workshop participants should take an active part in the discussion and decision-making during the HAZOP workshop.
6. All discussions are determined by the agreement between the three groups attending the HAZOP workshop. In the case that it is difficult to draw up an agreement between the three groups during the HAZOP workshop, the HAZOP facilitator may suggest compromises or alternatives and try to conclude the discussion after confirming the agreement of each group.
 - (1) Observers' opinion is just a reference and not included in the consensus related to the decision-making during the HAZOP workshop.
7. Each of the three groups should actively present his opinions for his own benefit and strive to provide a rational basis for their opinions to gain the consent of other groups. Moreover, each group should judge the opinions of other groups in a reasonable manner, and then accept the proper contents.
8. In the case that even one of the three groups is not made up, the HAZOP facilitator should inform the client that the HAZOP results may be biased, and such concern should be recorded in the HAZOP report.

9. After the HAZOP workshop, the participants, such as SMEs of the three groups, should review the draft of HAZOP worksheet and submit their comments and final consent.
10. All the HAZOP workshop attendees should enter their name, affiliation, position, and contact details in the participant list.

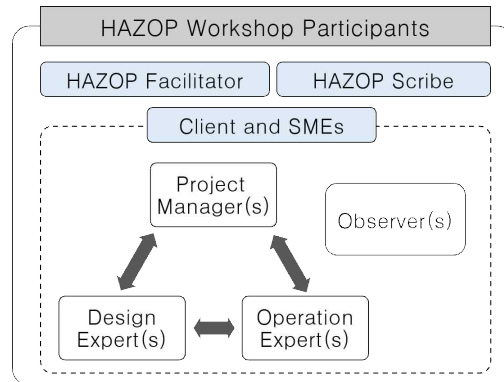


Fig. 2.3 HAZOP workshop organization

302. Roles of HAZOP workshop participants

1. The primary role of the HAZOP workshop participants is as follows.
2. HAZOP facilitator
 - (1) To cooperate with the client to prepare the HAZOP workshop
 - (2) To determine the groups attended and explain the roles and responsibilities of each group at the beginning of the HAZOP workshop
 - (3) To maintain an objective and neutral position throughout the HAZOP workshop
 - (4) To lead the HAZOP workshop and facilitate the discussions of participants
 - (5) To mediate between participants during the HAZOP workshop
 - (6) To determine principal issues on the basis of participants' agreement during the HAZOP workshop
3. HAZOP scribe
 - (1) To record every discussion and decision made during the HAZOP workshop in the HAZOP worksheet
 - (2) To complete the HAZOP worksheet after the HAZOP workshop
4. Project manager group
 - (1) Project manager group may consist of some of the client and SMEs.
 - (2) In general, this group is mainly composed of the experts from the client who are responsible for managing the target system development project (for example, ship owner, ship management company, shipping supervisor, safety manager, etc.).
 - (3) This group provides the information on the target system development.
 - (4) During the HAZOP workshop, it is possible for this group to support a more appropriate opinion in the middle position, if there exist disputes between the design expert group and the operation expert group.
5. Design expert group
 - (1) Design expert group may consist of some of the client and SMEs.
 - (2) In general, this group is mainly composed of the SMEs who are associated with design, construction, installation, and decommissioning of the target system (for example, shipyard, design company, equipment company, engineering company, etc.).

- (3) This group provides the detailed experiences and information on the design and construction of target system (for example, component, arrangement, equipment, specification, performance, input data, output data, interfaces, construction, installation, decommissioning, analysis, calculation, etc.)
- (4) This group provides the information on the existing safety measures that are covered by the design concept of target system.
- (5) Based on their experiences and knowledge related to the design of target system, experts of this group suggest potential hazards or hazardous events.
- (6) Usually, this group considers the safety of the target system in a positive way, and tends to participate in the discussion from a defensive standpoint on the issues and questions raised.
- (7) Usually, this group is responsible for the additional safety actions proposed during the HAZOP workshop, which are mainly related to the design and construction of target system.

6. Operation expert group

- (1) Operation expert group may consist of some of the client and SMEs.
- (2) In general, this group is mainly composed of the SMEs who are associated with operation, inspection, and maintenance of the target system (for example, navigation officer, marine engineer, crew, worker onboard, etc.).
- (3) This group provides the detailed experiences and information on the operation and maintenance of target system.
- (4) This group provides the information on the existing safety measures that are covered by the operation concept of target system.
- (5) Based on their experiences and knowledge related to the operation and maintenance of target system or similar one, experts of this group suggest potential hazards or hazardous events.
- (6) Usually, this group considers the safety of the target system in a negative way, and tends to participate in the discussion from a conservative standpoint on the issues and questions raised.
- (7) Usually, this group is responsible for the additional safety actions proposed during the HAZOP workshop, which are mainly related to the operation and maintenance of target system.

7. Observer group

- (1) Observer group may consist of some of SMEs.
- (2) In general, the SMEs who are not directly involved in the target system development project are mainly included in this group as a third party: class surveyors, port state control officers, engineering companies, researchers and so on.
- (3) In the case of class surveyors, they can join the HAZOP workshop as observers.
- (4) This group attends the HAZOP workshop to observe the progress of the HAZOP discussions and to present his professional advices from an objective viewpoint.
- (5) SMEs of the above three groups may consider the opinions from this group, if necessary.

303. HAZOP workshop process

1. HAZOP workshop procedure is depicted in **Fig. 2.4** below. The workshop is proceeded in sequence according to the lead of the HAZOP facilitator.
2. HAZOP introduction
 - (1) To give an opening address
 - (2) To introduce the HAZOP workshop participants
 - (3) To present the venue and time table of the HAZOP workshop
 - (4) To present the purposes, process and outcomes of the HAZOP study
 - (5) To present the procedure of the HAZOP workshop

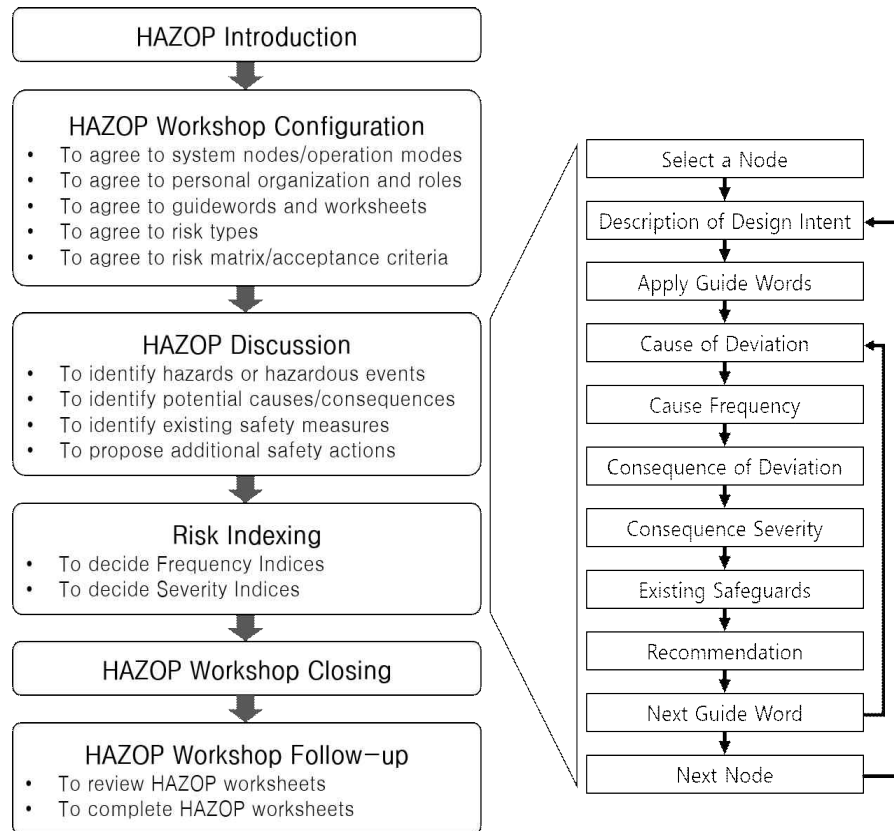


Fig. 2.4 HAZOP workshop procedure

(6) If needed, to present the basic principle of brain-storming

(7) If needed, to present the outline of the target system

3. HAZOP workshop configuration

(1) To agree to personal organization of the HAZOP workshop

(2) To present the roles of the HAZOP workshop participants

(3) To agree to the definition of system nodes or operation modes

(4) To agree to guidewords to be considered during the HAZOP workshop

(5) To agree to HAZOP worksheet to be used during the HAZOP workshop

(6) To agree to risk matrix to be used during the HAZOP workshop

(7) To agree to risk acceptance criteria to be used during the HAZOP workshop

4. HAZOP discussion

(1) To identify hazards or hazardous events likely to occur

(2) To explore potential causes and consequences of the identified hazards or hazardous events

(3) To identify existing safety measures to reduce the risk levels of the identified hazards or hazardous events

(4) To propose additional safety actions to reduce the risk levels of the identified hazards or hazardous events

(5) To records all the items discussed during the HAZOP workshop on the HAZOP worksheet

5. Risk indexing

(1) To discuss and determine the frequency indices of the identified hazards or hazardous events

(A) Frequency indices are determined with every regard to potential causes.

- (B) If there is existing safety measure to prevent the occurrence of hazards or hazardous events, related frequency indices can be lowered.
- (2) To discuss and determine the severity indices of the identified hazards or hazardous events
 - (A) Severity indices are determined with every regard to potential consequences.
 - (B) Severity indices are given to each risk type considered.
 - (C) If there is existing safety measure to mitigate the impact of hazards or hazardous events, related severity indices can be lowered.
- (3) To record the determined frequency/severity indices on the HAZOP worksheet appropriately

6. HAZOP workshop closing

- (1) To explain the follow-up activities after the HAZOP workshop
- (2) To give a closing address

7. HAZOP workshop follow-up

- (1) After concluding the HAZOP workshop, the HAZOP facilitator and scribe conduct several subsequent works described as below.
- (2) HAZOP provisional worksheet
 - (A) The HAZOP scribe prepares a HAZOP provisional worksheet by recording all the discussions and agreements being made during the HAZOP workshop.
 - (B) The provisional worksheet is completed right after the HAZOP workshop.
- (3) HAZOP draft worksheet
 - (A) After the HAZOP workshop, the HAZOP scribe modifies the HAZOP provisional worksheet and prepares a HAZOP draft worksheet.
- (4) HAZOP final worksheet
 - (A) The HAZOP facilitator circulates the HAZOP draft worksheet for the HAZOP workshop participants to review it only once.
 - (B) The observer group may be excluded from the review process of the draft worksheet.
 - (C) The HAZOP workshop participants reviews the draft worksheet and, if necessary, replies their comments to the HAZOP facilitator. In the case of no comments, the participants informs that they agree to the draft worksheet as is.
 - (D) Receiving all the agreement from the HAZOP workshop participants, the HAZOP facilitator finalize the HAZOP worksheet.
 - (E) If there exist comments on the draft worksheet from the HAZOP workshop participants, the HAZOP facilitator can revise the draft worksheet in accordance with the comments provided that a majority of the participants agrees to those.
 - (F) If the comments on the draft worksheet don't change the intent of the HAZOP workshop discussion (e.g., clear errors of typing and/or grammar, writing styles, etc.), the comments can be reflected on the HAZOP final worksheet without the participants' consent.
 - (G) In principle, the finalized HAZOP worksheet should not be revised further, excepting apparent typing and/or grammatical errors.

CHAPTER 3 HAZOP Report

Section 1 General

101. General

1. In principle, all the discussions, decisions, and results of HAZOP study should be documented appropriately.
2. The HAZOP report is prepared by the HAZOP facilitator and/or scribe.
3. The HAZOP facilitator and/or scribe make(s) a HAZOP draft report on the basis of the HAZOP final worksheet.
 - (1) The HAZOP facilitator sends the HAZOP draft report to the client and requests his review and comments on it.
 - (2) The client reviews the draft report and, if necessary, replies his comments to the HAZOP facilitator. In the case of no comments, the client informs that he agrees to the draft report as is.
4. Considering the comments from the client on the HAZOP draft report, the HAZOP facilitator should complete the HAZOP final report and then submit it to the client.
 - (1) If the client's comments are inconsistent with the HAZOP final worksheet (e.g., serious changes or deletion of the worksheet), the comments should not be reflected on the HAZOP final report.
 - (2) If the client's comments are related to the errors of the HAZOP draft report which are inconsistent with the HAZOP final worksheet, the comments can be reflected on the HAZOP final report.
 - (3) If the client's comments don't change the intent of the HAZOP final worksheet (e.g., apparent typing and/or grammatical errors, improper description on the HAZOP results, writing styles, etc.), the comments can be reflected on the HAZOP final report.
5. In principle, the HAZOP report is written in English. However, if requested by the client, the report may be written in Korean instead.

Section 2 Contents

201. HAZOP report contents

1. HAZOP report should cover the followings, as a minimum.
 - (1) Target system outlines
 - (2) HAZOP purpose and scope
 - (3) HAZOP methodology outlines
 - (4) Information of the HAZOP workshop participants
 - (5) Information of the HAZOP workshop
 - (6) Risk matrix and risk acceptance criteria (if applied)
 - (7) HAZOP results summary
 - (8) HAZOP worksheets
 - (9) Recommendation list

202. HAZOP results

1. As a result of HAZOP study, the HAZOP report should cover the followings;

- (1) description on the hazards or hazardous events identified,
- (2) description on the risk levels of the hazards or hazardous events identified, if necessary,
- (3) description on the classification of the hazards or hazardous events identified by their risk levels, if necessary, and
- (4) description on the appropriate measures to dealing with the hazards or hazardous events identified, if necessary.

203. HAZOP worksheets

1. All the issues and decisions made during the HAZOP workshop should be recorded in the HAZOP worksheet appropriately.
2. The HAZOP report should include the final version of HAZOP worksheet.
3. An exemplary form of HAZOP worksheet in **Annex 4**, and the HAZOP facilitator may use the form as is or modify it as appropriate if necessary.

204. Recommendation list

1. If further improvements to lower the risk are needed for the hazards and hazardous events identified in HAZOP, the recommendations are discussed and recorded in the worksheet.
2. All the recommendations should be listed and included in the HAZOP report.
3. An exemplary form of recommendation list in **Annex 4**, and the HAZOP facilitator may use the form as is or modify it as appropriate if necessary.

ANNEX 1 Materials for HAZOP

101. HAZOP workshop materials

1. In order to facilitate discussion and decision-making during the HAZOP workshop and make those consistent, it is needed to prepare the following materials in advance.
 - (1) HAZOP introduction
 - (2) HAZOP worksheet template
 - (3) If needed, HAZOP guidewords
 - (4) If needed, risk matrix
 - (5) If needed, risk acceptance criteria
2. The HAZOP facilitator should prepare the materials of **Annex 1 101 1. (1)** and **(2)**, and explain those to the attendees at the beginning of the HAZOP workshop.
3. The client should prepare the materials of **Annex 1 101 1. (3)**, **(4)** and **(5)**, and provide the HAZOP facilitator with those before the HAZOP workshop.
4. While the client is preparing the materials of **Annex 1 101 1. (3)**, **(4)** and **(5)**, the HAZOP facilitator may provide relevant assistance to him upon request.

102. Target system description

1. In order for the HAZOP workshop to be effective, it is needed to prepare relevant documents to understand the overall concept of design and operation of the target system.
2. The client should prepare the following documents and provide those to the HAZOP facilitator for use in his HAZOP works.
 - (1) Documents related to system design (e.g., building specification, design basis, etc.)
 - (2) Documents related to system operation and maintenance (e.g., building specification, operation concept, operation procedure, process flow diagram, etc.)
 - (3) Documents related to principal dimension, overall shape, and compartment arrangement (e.g., general arrangement, machinery arrangement, midship section drawing, structural drawing, etc.)
 - (4) Documents related to specification of essential equipment and facilities (e.g., building specification, equipment specification, equipment list, etc.)
 - (5) Documents related to arrangement of essential equipment and facilities (e.g., general arrangement, machinery arrangement, etc.)
3. In case of ship design, the following design documents may be needed.
 - (1) Building specification, stability calculation, general arrangement, machinery arrangement, midship section, process flow diagram, equipment specification, etc.
4. Details of the target system description documents enumerated in **102 2.** should be provided to the attendees by the client during the HAZOP workshop.
5. In the case that the target system description documents enumerated in **102 2.** are insufficient, the client should give an additional explanation for the target system to the attendees during the HAZOP workshop.

ANNEX 2 Risk Matrix and Risk Acceptance Criteria

101. Risk matrix

1. Risk matrix can be applied to a qualitative risk assessment.
2. Risk matrix is established based on the two features of hazard or hazardous event, such as frequency and severity of consequence.
3. Risk matrix should be defined in a way that the HAZOP workshop participants are able to agree with it and to use it quickly and consistently.
4. Risk level of a hazard or a hazardous event is determined based on combination of its frequency and severity.

102. Risk acceptance criteria

1. Based on the risk acceptance criteria, the risk levels of hazards or hazardous events identified are classified into two categories such as acceptable risk and unacceptable risk.
 - (1) Unacceptable risk: It corresponds to the risk levels being higher than the acceptance criteria, and the risk must be reduced. As the risk level is too high to allow it, additional safety actions are needed to lower the risk level below the acceptable criteria, irrespectively of costs. In some cases, the term of 'intolerable risk' can be used instead.
 - (2) Acceptable risk: It corresponds to the risk levels being lower than the acceptance criteria. This is divided into two sub-categories as follows.
 - (A) Manageable risk: Its risk levels are neither negligibly low nor intolerably high. For further risk reduction, additional safety actions should be considered in accordance with ALARP principle.
 - (B) Negligible risk: Its risk levels are sufficiently low to be neglected, and additional safety actions for risk reduction is not required.

103. Example of risk matrix and risk acceptance criteria

1. The HAZOP facilitator generally uses the risk matrix and risk acceptance criteria provided by the client. Otherwise, the facilitator can utilize the following example as it is or modify it.

		Severity Indices				
		SI 1	SI 2	SI 3	SI 4	SI 5
Frequency Indices	FI 5	5	10	15	20	25
	FI 4	4 over	8	12	16	20
	FI 3	3	6	9	12	15
	FI 2	2	4	6	8	10 over
	FI 1	1	2	3	4 over	5

2. Risk index (RI) = Frequency index (FI) x Severity index (SI)
3. Unacceptable risk: the risk indices identified are greater than 10 (e.g., the dark grey colored cells in the above matrix).
4. Acceptable risk
 - (1) Manageable risk: the risk indices identified are greater than 4, and less than or equal to 10 (e.g., the grey colored cells in the above matrix).

- (2) Negligible risk: the risk indices identified are less than or equal to 4 (e.g., the white colored cells in the above matrix).

104. Example of frequency index

1. Frequency of hazards (or hazardous events) is defined by means of several discrete indices. The HAZOP facilitator generally uses the frequency indices provided by the client. Otherwise, the facilitator can utilize the following example as it is or modify it.

FI (Frequency Index) Classification		Description
5	Frequent	Likely to occur during the short-time operation of target system (e.g., likely to occur once per month, etc.)
4	Probable	Likely to occur during the long-time operation of target system (e.g., likely to occur once per year, etc.)
3	Occasional	Likely to occur over the lifetime operation of target system (e.g., likely to occur once per decades, etc.)
2	Rare	Unlikely but possible to occur in many systems similar to the target system (e.g., it has occurred in the related companies or industries.)
1	Improbable	Unlikely to occur in many systems similar to the target system (e.g., no experience in the related companies or industries.)

105. Example of severity index

1. Severity of the consequences of hazards (or hazardous events) is defined by means of several discrete indices. The HAZOP facilitator generally uses the severity indices provided by the client. Otherwise, the facilitator can utilize the following example as it is or modify it.

SI (Severity Index) Classification		Description		
		Human	Environment	Asset
1	Slight	Slight injuries (first-aid needed)	Slight effect (immediate restoration available)	Slight damage or failure (immediate repair)
2	Minor	Minor injuries (outpatient treatment needed)	Minor local effect (short-term restoration needed)	Minor local damage or failure (local repair available)
3	Major	Severe injuries (hospitalization needed/permanent disability)	Severe local effect (mid-term restoration needed)	Severe local damage or failure (external support needed/partial operation available)
4	Critical	Single fatality or multiple severe injuries	Extensive effect (long-term restoration needed)	Extensive damage or failure (operation unavailable)
5	Catastrophic	Multiple fatalities	Massive effect (almost impossible to be restored)	Total loss

ANNEX 3 HAZOP Guidewords

101. HAZOP Guidewords

1. Some guidewords can be used in the HAZOP workshop where necessary to facilitate the discussions among the participated SMEs.
2. HAZOP guidewords can be utilized as prompts to come up with the causes and consequences of hazards or hazardous events, and allow to have fast and efficient discussions during the HAZOP workshop.
3. HAZOP guidewords consist of combinations of deviations in process variables to discuss and identify hazards. The guidewords provided by the client can be used, or examples in the table below can be used or modified appropriately.

	No	Less	More	Reverse
Flow	✓	✓	✓	✓
Temperature		✓	✓	
Pressure		✓	✓	
Level	✓	✓	✓	

ANNEX 4 Exemplary Templates for HAZOP

101. Exemplary Templates for HAZOP

- The following exemplary templates may be used for a HAZOP study, and, if needed, those can be modified appropriately.

102. Example of HAZOP worksheet

HAZOP Worksheet Node : # Target : Function Drawing : #	Risk matrix			REC #	Recommendation	Responsibility
	L	S	R			
	Existing Safeguards					
	Consequences					
Causes						
Guidewords						

103. Example of recommendation list

Rec #	Node	Recommendation



HAZOP Guidelines (Hazard & Operability)

Published by

KR

36, Myeongji ocean city 9-ro, Gangseo-gu,
BUSAN, KOREA

TEL : +82 70 8799 7114

FAX : +82 70 8799 8999

Website : <http://www.krs.co.kr>

Copyright© 2019, **KR**

Reproduction of this Rules and Guidance in whole or in parts is prohibited without permission of the publisher.