# IEC 61882

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REDLINE VERSION

# INTERNATIONAL STANDARD

colour inside

## Hazard and operability studies (HAZOP studies) – Application guide



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# HAZARD AND OPERABILITY STUDIES (HAZOP STUDIES) – APPLICATION GUIDE

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International Standard IEC 61882 has been prepared by IEC technical committee 56: Dependability.

This second edition cancels and replaces the first edition published in 2001. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) clarification of terminology as well as alignment with terms and definitions within ISO 31000:2009 and ISO Guide 73:2009;
b) addition of an improved case study of a procedural HAZOP.

The text of this standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 56/1653/FDIS | 56/1666/RVD |

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.



The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.



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# INTRODUCTION

This standard describes the principles for and ~~procedures of~~ approach to guide word-driven risk identification. Historically this approach to risk identification has been called a hazard and operability study or HAZOP study for short. This is a structured and systematic technique for examining a defined system, with the objectives of:

- identifying ~~potential hazards~~ risks associated with the operation and maintenance of the system. The hazards or other risk sources involved ~~may~~ can include both those essentially relevant only to the immediate area of the system and those with a much wider sphere of influence, for example some environmental hazards;
- identifying potential operability problems with the system and in particular identifying causes of operational disturbances and production deviations likely to lead to non-conforming products.

An important benefit of HAZOP studies is that the resulting knowledge, obtained by identifying ~~potential hazards~~ risks and operability problems in a structured and systematic manner, is of great assistance in determining appropriate remedial measures.

A characteristic feature of a HAZOP study is the examination session during which a multi-disciplinary team under the guidance of a study leader systematically examines all relevant parts of a design or system. It identifies deviations from the system design intent utilizing a set of guide words. The technique aims to stimulate the imagination of participants in a systematic way to identify ~~hazards~~ risks and operability problems. A HAZOP study should be seen as an enhancement to sound design using experience-based approaches such as codes of practice rather than a substitute for such approaches.

Historically, HAZOP and similar studies were described as hazard identification as their primary purpose is to test in a systematic way whether hazards are present and, if so, understand both how they could result in adverse consequences and how such consequences could be avoided through process redesign. ISO 31000:2009 defines risk as the effect of uncertainty on objectives, with a note that an effect is a deviation from the expected. Therefore HAZOP studies, which consider deviations from the expected, their causes and their effect on objectives in the context of process design, are now correctly characterized as powerful risk identification tools.

There are many different tools and techniques available for the identification of ~~potential hazards and operability problems~~ risks, ranging from checklists, ~~fault~~ failure modes and effects analysis (FMEA)~~, Fault Tree Analysis (FTA)~~ to HAZOP. Some techniques, such as checklists and what-if/analysis, can be used early in the system life cycle when little information is available, or in later phases if a less detailed analysis is needed. HAZOP studies require more detail regarding the systems under consideration, but produce more comprehensive information on ~~hazards~~ risks and ~~errors~~ weaknesses in the system design.

The term HAZOP is sometimes associated, in a generic sense, with some other hazard identification techniques (e.g. checklist HAZOP, HAZOP 1 or 2, knowledge-based HAZOP). The use of the term with such techniques is considered to be inappropriate and is specifically excluded from this document.

Before commencing a HAZOP study, it should be confirmed that it is the most appropriate technique (either individually or in combination with other techniques) for the task in hand. In making this judgment, consideration should be given to the purpose of the study, the possible severity of any consequences, the appropriate level of detail, the availability of relevant data and resources and the needs of decision-makers.

This standard has been developed to provide guidance across many industries and types of system. There are more specific standards and guides within some industries, notably the process industries where the technique originated, which establish preferred methods of application for these industries. For details see the bibliography at the end of this standard.

# HAZARD AND OPERABILITY STUDIES (HAZOP STUDIES) – APPLICATION GUIDE

## 1 Scope

This International Standard provides a guide for HAZOP studies of systems using guide words. It gives guidance on application of the technique and on the HAZOP study procedure, including definition, preparation, examination sessions and resulting documentation and follow-up.

Documentation examples, as well as a broad set of examples encompassing various ~~industries~~ applications, illustrating HAZOP studies are also provided.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.



IEC 60050-192, *International electrotechnical vocabulary – Part 192: Dependability* (available at http://www.electropedia.org)

~~IEC 60300-3-9, *Dependability management – Part 3: Application guide – Section 9: Risk analysis of technological systems*~~

~~IEC 60812, *Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)*~~



~~IEC 61025, *Fault tree analysis (FTA)*~~

~~IEC 61160, *Formal design review*~~

## 3 Terms, definitions and abbreviations

### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC ~~60050-191~~ 60050-192 and the following apply.

NOTE Within this clause, the terms defined are in *italic* type.

**3.1.1**
**characteristic**
qualitative or quantitative property ~~of an element~~

EXAMPLE Pressure, temperature, voltage.

**3.1.2**
**consequence**
outcome of an event affecting objectives

Note 1 to entry: An event can lead to a range of consequences.

Note 2 to entry: A consequence can be certain or uncertain and can have positive or negative effects on objectives.

Note 3 to entry: Consequences can be expressed qualitatively or quantitatively.

Note 4 to entry: Initial consequences can escalate through knock-on effects.

[SOURCE: ISO Guide 73:2009, 3.6.1.3]

**3.1.3**
**control**
measure that is modifying *risk* (3.1.12)

Note 1 to entry: Controls include any process, policy, device, practice, or other actions which modify risk.

Note 2 to entry: Controls may not always exert the intended or assumed modifying effect.

[SOURCE: ISO Guide 73:2009, 3.8.1.1]

**3.1.4**
**design intent**
designer's desired, or specified range of behaviour for ~~elements and characteristics~~ properties which ensure that the item fulfills its requirements

~~**3.3**~~
~~**deviation**~~
~~departure from the design intent~~



**3.1.5**
~~**element**~~ **property**
constituent of a part which serves to identify the part's essential features

Note 1 to entry: The choice of ~~elements may~~ properties can depend upon the particular application, but ~~elements~~ properties can include features such as the material involved, the activity being carried out, the equipment employed, etc. Material should be considered in a general sense and includes data, software, etc.



**3.1.6**
**guide word**
word or phrase which expresses and defines a specific type of deviation from ~~an element~~ a property's design intent

**3.1.7**
**harm**
physical injury or damage to the health of people or damage to ~~property~~ assets or the environment

**3.1.8**
**hazard**
source of potential *harm* (3.1.7)

Note 1 to entry: Hazard can be a *risk source* (3.1.14).

[SOURCE: ISO Guide 73:2009, 3.5.1.4]

**3.1.9**
**level of risk**
magnitude of a *risk* (3.1.12) or combination of risks, expressed in terms of the combination of *consequences* (3.1.2) and their likelihood

[SOURCE: ISO Guide 73:2009, 3.6.1.8]

**3.1.10**
**manager**
person with responsibility for a project, activity or organization.

**3.1.11**
**part**
section of the system which is the subject of immediate study

Note 1 to entry: A part ~~may~~ can be physical (e.g. hardware) or logical (e.g. step in an operational sequence).

**3.1.12**
**risk**
~~combination of the probability of occurrence of harm and the severity of that harm~~
effect of uncertainty on objectives

Note 1 to entry: An effect is a deviation from the expected – positive and/or negative.

Note 2 to entry: Objectives can have different aspects (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process).

Note 3 to entry: Risk is often characterized by reference to potential events and *consequences* (3.1.2) or a combination of these.

Note 4 to entry: Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated likelihood of occurrence.

Note 5 to entry: Uncertainty is the state, even partial, or deficiency of information related to, understanding or knowledge of an event, its *consequence*, or likelihood.

[SOURCE: ISO Guide 73:2009, 1.1]



**3.1.13**
**risk identification**
process of finding, recognizing and describing *risks* (3.1.12)



Note 1 to entry: Risk identification involves the identification of *risk sources* (3.1.14), events, their causes and their potential *consequences* (3.1.2).

Note 2 to entry: Risk identification can involve historical data, theoretical analysis, informed and expert opinions, and stakeholder's needs.

[SOURCE: ISO Guide 73:2009, 3.5.1]

**3.1.14**
**risk source**
element which alone or in combination has the intrinsic potential to give rise to *risk* (3.1.12)

Note 1 to entry: A risk source can be tangible or intangible.

[SOURCE: ISO Guide 73:2009, 3.5.1.2]

**3.1.15**
**risk treatment**
process to modify *risk* (3.1.12)

Note 1 to entry: Risk treatment can involve:

– avoiding the risk by deciding not to start or continue with the activity that gives rise to the risk;
– taking or increasing risk in order to pursue an opportunity;
– removing the *risk source* (3.1.14);
– changing the likelihood;
– changing the *consequences* (3.1.2);

– sharing the risk with another party or parties (including contracts and risk financing); and
– retaining the risk by informed decision.

Note 2 to entry: Risk treatments that deal with negative consequences are sometimes referred to as "risk mitigation", "risk elimination", "risk prevention" and "risk reduction".

Note 3 to entry: Clarification of risk treatment and risk *control* (3.1.3) – a risk control is already in place whereas a risk treatment is an activity to improve risk controls. Hence, an implemented treatment becomes a control.

[SOURCE: ISO Guide 73:2009, 3.8.1, modified — Note 3 to entry replaces the existing note 3]

### 3.2 Abbreviations

| | |
|---|---|
| ATP | automatic train protection |
| EER | escape, evacuation and rescue |
| ETA | event tree analysis |
| FMEA | failure mode and effects analysis |
| FTA | fault tree analysis |
| GPA | general purpose alarm |
| HAZOP | hazard and operability |
| LH | left hand |
| LOPA | layer of protection analysis |
| OIM | offshore installation manager |
| P&IDs | process and instrumentation diagrams |
| PAPA | prepare to abandon platform alarm |
| PA | public address |
| PES | programmable electronic system |
| PPE | personal protective equipment |
| QP | qualified person |
| RH | right hand |



## 4 ~~Principles~~ Key features of HAZOP

### 4.1 ~~Overview~~ General

A HAZOP study is a detailed process carried out by a dedicated team to identify ~~hazards~~ risks and operability problems. HAZOP studies deal with the identification of potential deviations from the design intent, examination of their possible causes and assessment of their consequences.

Key features of a HAZOP ~~examination~~ study include the following.

- The ~~examination~~ study is a creative process that proceeds by systematically using a series of guide words to identify potential deviations from the design intent and employing these ~~deviations as "triggering devices"~~ to stimulate team members to envisage how the deviation might occur and what might be the consequences.
- The ~~examination~~ study is carried out under the guidance of a trained and experienced study leader, who has to ensure comprehensive coverage of the system under study, using logical, analytical thinking. The study leader is preferably assisted by a recorder who records pertinent data associated with identified ~~hazards~~ risks and/or operational disturbances for ~~further~~ risk analysis, evaluation and ~~resolution~~ treatment.
- The ~~examination~~ study relies on specialists from various disciplines with appropriate skills and experience who display intuition and good judgement.

- The ~~examination~~ study should be carried out in an atmosphere of ~~positive~~ critical thinking in a frank and open atmosphere. ~~When a problem is identified, it is recorded for subsequent assessment and resolution.~~
- ~~Solutions to identified problems are not a primary objective of the HAZOP examination, but if made they are recorded for consideration by those responsible for the design.~~
- A HAZOP study produces minutes or software to record the deviations, their causes, consequences and recommended actions together with marked up drawings, documents or other representations of the system that indicate the associated minute number and where possible the recommended action.
- The development of risk treatment actions for identified risks or operability problems is not a primary objective of the HAZOP examination, but recommendations should be made where appropriate and recorded for consideration by those responsible for the design of the system.
- The initial HAZOP study might be done in a progressive fashion so that design changes can be incorporated but the completed HAZOP study has to correlate to the final design intent.
- Existing HAZOP studies should be reviewed at regular intervals to evaluate whether there have been any changes to the design intent or hazards and also during other stages in the life cycle such as the enhancement stage.

## 4.2 Principles of examination

The basis of a HAZOP study is a “guide word examination” which is a deliberate search for deviations from the design intent. To facilitate the examination, a system is divided into parts in such a way that the design intent or function for each part can be adequately defined. The size of the part chosen is likely to depend on the complexity of the system and the ~~severity~~ potential magnitude and significance of the ~~hazard~~ consequence. In complex systems or those where the level of ~~hazard~~ risk might be expected to be high, the parts are likely to be small in comparison to the system. In simple systems or those where the level of ~~hazard~~ risk might be expected to be low, the use of larger parts will expedite the study.



The design intent for a given part of a system is expressed in terms of ~~elements~~ properties, which convey the essential ~~features~~ characteristics of the part and which represent natural divisions of the part. The selection of ~~elements~~ properties to be examined is to some extent a subjective decision in that there ~~may~~ might be several combinations which will achieve the required purpose and the choice ~~may~~ can also depend upon the particular application. ~~Elements may~~ Parts can be discrete steps or stages in a procedure, clauses in a contract, individual signals and equipment items in a control system, equipment or components in a process or electronic system, etc.

In some cases it ~~may~~ might be helpful to express the function of a part in terms of:

– the input material taken from a source;

– an activity which is performed on that material;

– ~~a product~~ an output which is taken to a destination.

Thus the design intent will contain the following elements: ~~materials~~ inputs and outputs, functions, activities, sources and destinations, which can be viewed as ~~elements~~ properties of the part.

~~Elements~~ Properties can often be usefully defined further in terms of characteristics that can be either quantitative or qualitative. For example, in a chemical system, the ~~element “material” may~~ inputs could be defined further in terms of characteristics such as temperature, pressure and composition. For a transport activity, characteristics such as the rate of movement, the load or the number of passengers ~~may~~ might be relevant. For computer-based systems, ~~information rather than material is~~ communication, interfaces, and data processing are likely to be the ~~subject~~ characteristic of each part.